Final Environmental Assessment/Analysis of Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the North Pacific Ocean, 2018/2019

Prepared for

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ABSTRACT

Researchers from Lamont-Doherty Earth Observatory (L-DEO) and the University of Hawaii, with funding from the U.S. National Science Foundation (NSF), in collaboration with researchers from United States Geological Survey (USGS), Oxford University, and GEOMAR Helmholtz Centre for Ocean Research Kiel (GEOMAR), propose to conduct two high-energy seismic surveys from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) in the North Pacific Ocean during 2018/2019. The NSF-owned *Langseth* is operated by Columbia University's L-DEO under an existing Cooperative Agreement. One proposed seismic survey would occur at the Main Hawaiian Islands in 2018, and another survey would take place at the Emperor Seamounts in the North Pacific in 2019. The proposed timing for the Hawaii survey is summer/early fall 2018; the timing for the Emperor Seamounts survey would likely be spring/early summer. Both surveys would use a 36-airgun towed array with a total discharge volume of ~6600 in^3. The survey at the Emperor Seamounts would take place in International Waters where water depths are 1500–6000 m. The Hawaii survey would occur within the U.S. Exclusive Economic Zone (EEZ), in water ~700 to >5000 m deep.

NSF, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The proposed seismic surveys would collect data in support of research proposals that have been reviewed under the NSF merit review process and identified as NSF program priorities. They would provide data necessary to gain fundamental insight into the formation of the Hawaiian-Emperor chain and contribute to a more comprehensive assessment of geohazards for the Hawaiian Islands region that could be used to evaluate earthquake, tsunami and submarine landslides hazards. No seismic data have ever been acquired across the Emperor Seamount chain.

This Final Environmental Assessment/Analysis (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) for the proposed NSF federal action within the Hawaiian EEZ and Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions", for the proposed NSF federal action at the Emperor Seamounts. As operator of the *Langseth*, L-DEO, on behalf of itself, NSF, and University of Hawaii, is requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental (i.e., not intentional) harassment of small numbers of marine mammals should this occur during the seismic surveys. The analysis in this document supports the IHA application process and provides additional information on marine species that are not addressed by the IHA application, including sea turtles, seabirds, fish, and invertebrates that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered/ threatened species was included, this document will also be used to support ESA Section 7 consultations with NMFS and the U.S. Fish and Wildlife Service (USFWS). Alternatives addressed in this EA consist of the Proposed Action with issuance of an associated IHA and the No Action alternative, with no IHA and no seismic surveys. This document tiers to the Programmatic Environmental Impact Statement/ Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (June 2011) and Record of Decision (June 2012), referred to herein as PEIS.

Numerous species of marine mammals could occur in the proposed survey areas in the North Pacific. Several of these species are listed as ***endangered*** under the ESA: the North Pacific right, sei, fin, blue, and sperm whales, the Western North Pacific Distinct Population Segments (DPS) of humpback whale and gray whales, the Hawaiian Islands Insular DPS of false killer whale, the Western DPS of Steller sea lion, and the Hawaiian monk seal. ESA-listed sea turtle species that could occur in the Hawaii survey area include the ***endangered*** hawksbill, leatherback, and loggerhead (North Pacific Ocean DPS) turtles, and the ***threatened*** green (Central North Pacific DPS) and olive ridley turtles. Listed seabirds that could be encountered in the survey areas include the ***endangered*** Hawaiian petrel, short-tailed albatross, and band-rumped storm petrel (Hawaii DPS); and the ***threatened*** Newell's shearwater (USFWS 2017). ESA-listed fish species that could occur in the Hawaii survey area include the ***threatened*** oceanic white tip shark and the Giant manta ray, and the ***endangered*** Sakhalin sturgeon could occur in the Emperor Seamounts survey area.

Potential impacts of the proposed seismic surveys on the environment would be primarily a result of the operation of the airgun array. A multibeam echosounder and sub-bottom profiler would also be operated during the surveys. Impacts from the Proposed Action would be associated with increased underwater anthropogenic sounds, which could result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned surveys is a monitoring and mitigation program designed to minimize potential impacts of the proposed activities on marine animals present during the proposed surveys, and to document, as much as possible, the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airgun arrays or the other types of sound sources to be used. However, a precautionary approach would still be taken, and the planned monitoring and mitigation measures would reduce the possibility of any effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals, sea turtles, and seabirds would include the following: ramp ups; typically two (but a minimum of one) dedicated observers maintaining a visual watch during all daytime airgun operations; two observers before and during ramp ups during the day; no start ups during poor visibility or at night unless the exclusion zone and passive acoustic monitoring (PAM) have been monitored for 30 min with no detections; PAM via towed hydrophones during both day and night to complement visual monitoring; and power downs (or if necessary shut downs) when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. The acoustic source would also be powered or shut down in the event an ESA-listed seabird would be observed diving or foraging within the designated exclusion zones. Observers would also watch for any impacts the acoustic sources may have on fish. L-DEO and its contractors are committed to applying these measures in order to minimize effects on marine mammals, sea turtles, seabirds, and fish, and other potential environmental impacts. Ultimately, survey operations would be conducted in accordance with all applicable international, U.S. federal, and state regulations, including IHA and Incidental Take Statement (ITS) requirements.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal and sea turtle that could be encountered would be expected to be limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals would be anticipated as falling within the MMPA definition of "Level B Harassment" for those species managed by NMFS. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish, the populations to which they belong, or their habitats. However, NSF is required to request, and NMFS may issue, Level A takes for some marine mammal species although Level A takes are very unlikely. No significant impacts would be expected on the populations of those species for which a Level A take is permitted.

LIST OF ACRONYMS

~	approximately
2-D	two-dimensional
3-D	three-dimensional
ADCP	Acoustic Doppler Current Profiler
AEP	Auditory Evoked Potential
AMVER	Automated Mutual-Assistance Vessel Rescue
BIA	Biologically Important Areas
CA	California
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species
dB	decibel
DPS	Distinct Population Segment
EA	Environmental Analysis
EBSA	Ecologically or Biologically Sensitive Marine Areas
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
ESA	(U.S.) Endangered Species Act
ETP	Eastern Tropical Pacific
EZ	Exclusion Zone
FM	Frequency Modulated
FONSI	Finding of no significant impact
GIS	Geographic Information System
GoM	Gulf of Mexico
h	hour
HAPC	Habitat Areas of Particular Concern
HIHWNMS	Hawaiian Islands Humpback Whale National Marine Sanctuary
hp	horsepower
Hz	Hertz
ICR	(Japan) Institute of Cetacean Research
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
IOC	Intergovernmental Oceanographic Commission of UNESCO
IODP	International Ocean Discovery Program
ITS	Incidental Take Statement
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
kHz	kilohertz
km	kilometer
kt	knot
L-DEO	Lamont-Doherty Earth Observatory
LFA	Low-frequency Active (sonar)
LME	Large Marine Ecosystem
LOBSTER	Longterm OBSs for Tsunami and Earthquake Research
m	meter
MBES	Multibeam Echosounder
MCS	Multi-Channel Seismic
MFA	Mid-frequency Active (sonar)

min	minute
MLCD	Marine Life Conservation Districts
MMA	Marine Managed Areas
MMPA	(U.S.) Marine Mammal Protection Act
MPA	Marine Protected Area
ms	millisecond
MUS	Management Unit Species
NMFS	(U.S.) National Marine Fisheries Service
nmi	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NPTZ	North Pacific Transition Zone
NRC	(U.S.) National Research Council
NSF	National Science Foundation
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OBIS	Ocean Biogeographic Information System
OBS	Ocean Bottom Seismometer
OBSIP	Ocean Bottom Seismograph Instrument Pool
OEIS	Overseas Environmental Impact Statement
OPAREA	(U.S. Navy) Operating Area
p or pk	peak
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PMNM	Papahānaumokuākea Marine National Monument
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
R/V	research vessel
rms	root-mean-square
s	second
SBP	Sub-bottom Profiler
SEL	Sound Exposure Level (a measure of acoustic energy)
SOSUS	(U.S. Navy) Sound Surveillance System
SPL	Sound Pressure Level
t	tonnes
TTS	Temporary Threshold Shift
U.K.	United Kingdom
U.S.	United States of America
UNEP	United Nations Environment Programme
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
μPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre
WCPFC	Western and Central Pacific Fisheries Commission
WHOI	Woods Hole Oceanographic Institute
WPFMC	Western Pacific Fishery Management Council
y	year

I PURPOSE AND NEED

This Final environmental assessment (EA) was prepared under the National Environmental Policy Act (NEPA) and the analysis per Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions" (EO 12114), referred to herein as the Final EA. The Final EA tiers to the Final Programmatic Environmental Impact Statement (PEIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The purpose of this Final EA is to provide the information needed to assess the potential environmental impacts associated with the Proposed Action, including the use of an airgun array during the proposed seismic surveys.

The Final EA provides details of the Proposed Action at the site-specific level and addresses potential impacts of the proposed seismic surveys on marine mammals, sea turtles, seabirds, fish, and invertebrates. The analysis in this document supported an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS), and Section 7 consultations under the Endangered Species Act (ESA). The IHA would allow the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals[1] during the proposed seismic surveys by Columbia University's Lamont-Doherty Earth Observatory (L-DEO) in the North Pacific Ocean during 2018/2019. Per NMFS requirement, small numbers of Level A takes are requested for the remote possibility of low-level physiological effects; however, because of the characteristics of the Proposed Action and proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely.

1.1 Mission of NSF

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

1.2 Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. The Hawaii-Emperor Seamount Chain is the most well-known example on Earth of hotspot magmatism, where volcanoes form far from the boundaries between tectonic plates above hot regions in the underlying mantle. The proposed seismic surveys would address many remaining questions about the fundamental earth processes that create the volcanoes of the Hawaii-Emperor Seamount Chain and similar seamount chains around the world, and how the enormous mass of these volcanoes is supported by the rock material below them. The study being proposed for the North Pacific Ocean includes one seismic survey at the Main Hawaiian Islands in the Central North Pacific and another seismic survey at

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

the Emperor Seamounts in the western North Pacific. The primary purpose of the surveys is to gain fundamental insight into the formation and evolution of the Hawaiian-Emperor Seamount chain. This volcanic chain is also associated with significant geohazards for Hawaii, including earthquakes, tsunamis and landslides; the proposed survey would provide important new constraints that could be used to better understand these hazards.

The proposed activities would collect data in support of research proposals that have been reviewed through the NSF merit review process and have been identified as NSF program priorities to meet NSF's critical need to foster an understanding of Earth processes.

1.3 Background of NSF-funded Marine Seismic Research

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

1.4 Regulatory Setting

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

- Executive Order 12114;
- National Environmental Protection Act (NEPA);
- Marine Mammal Protection Act (MMPA);
- Endangered Species Act (ESA);
- Coastal Zone Management Act (CZMA); and
- Magnuson-Stevens Fishery Conservation and Management Act – Essential Fish Habitat (EFH).

II ALTERNATIVES INCLUDING PROPOSED ACTION

In this Final EA, two alternatives are evaluated: (1) the proposed seismic surveys and associated issuance of an associated IHA and (2) No Action alternative. Additionally, two alternatives were considered but were eliminated from further analysis. A summary of the Proposed Action, the alternative, and alternatives eliminated from further analysis is provided at the end of this section.

2.1 Proposed Action

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

2.1.1 Project Objectives and Context

Teams of researchers from L-DEO, University of Hawaii, United States Geological Survey (USGS), Oxford University, and GEOMAR Helmholtz Centre for Ocean Research Kiel (GEOMAR), have proposed to conduct two seismic surveys using the *Langseth* in the North Pacific — one at the Main Hawaiian Islands in the Central North Pacific (Fig. 1) and the other at the Emperor Seamounts in the western North Pacific (Fig. 2). The following information provides an overview of the research project objectives associated with the surveys.

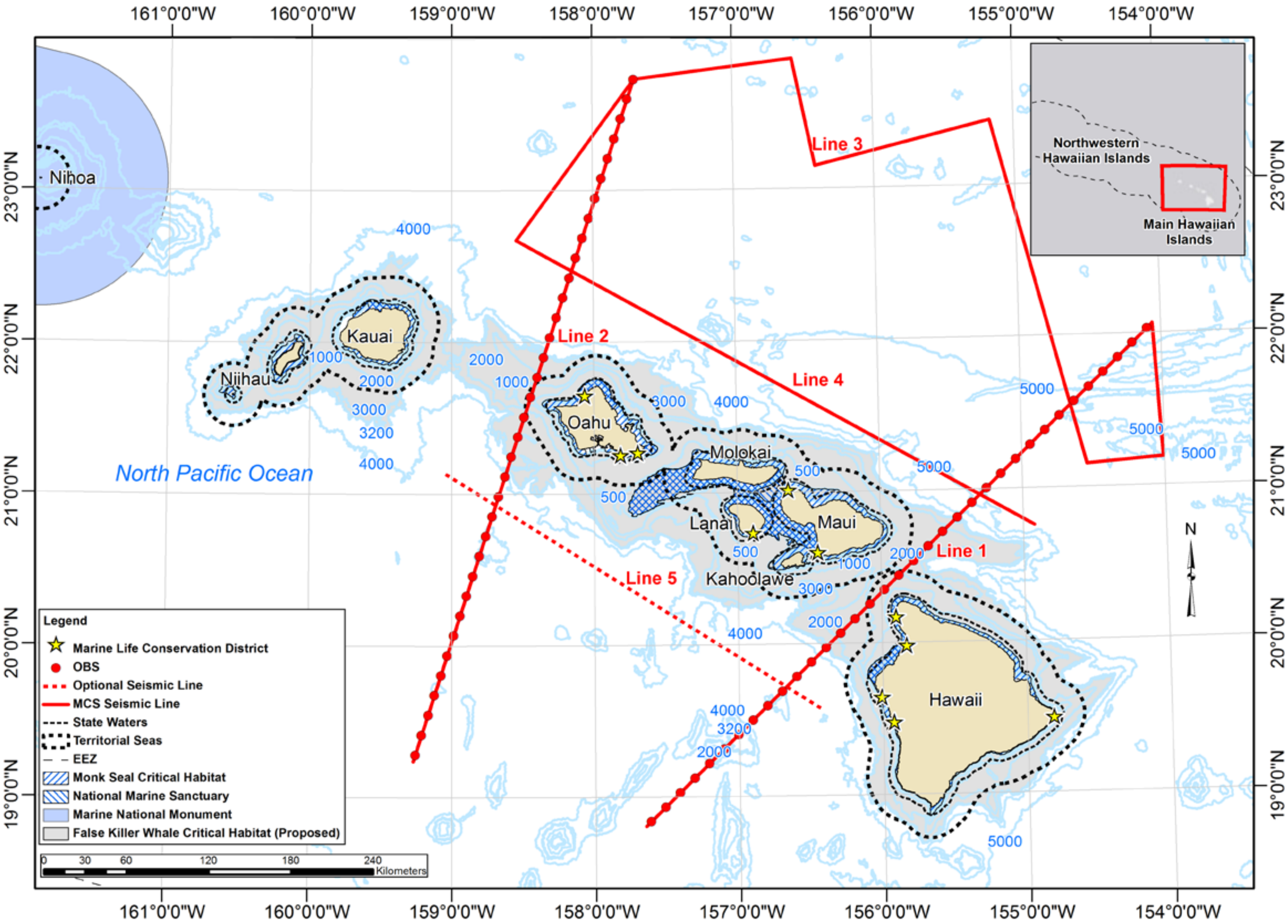

FIGURE 1. Location of the proposed 2018 seismic survey at the Main Hawaiian Islands, and proposed locations of ocean bottom seismometers (OBSs). The National Marine Sanctuary is the Hawaii Islands Humpback Whale National Marine Sanctuary. Marine National Monument is the Papahānaumokuākea Marine National Monument.

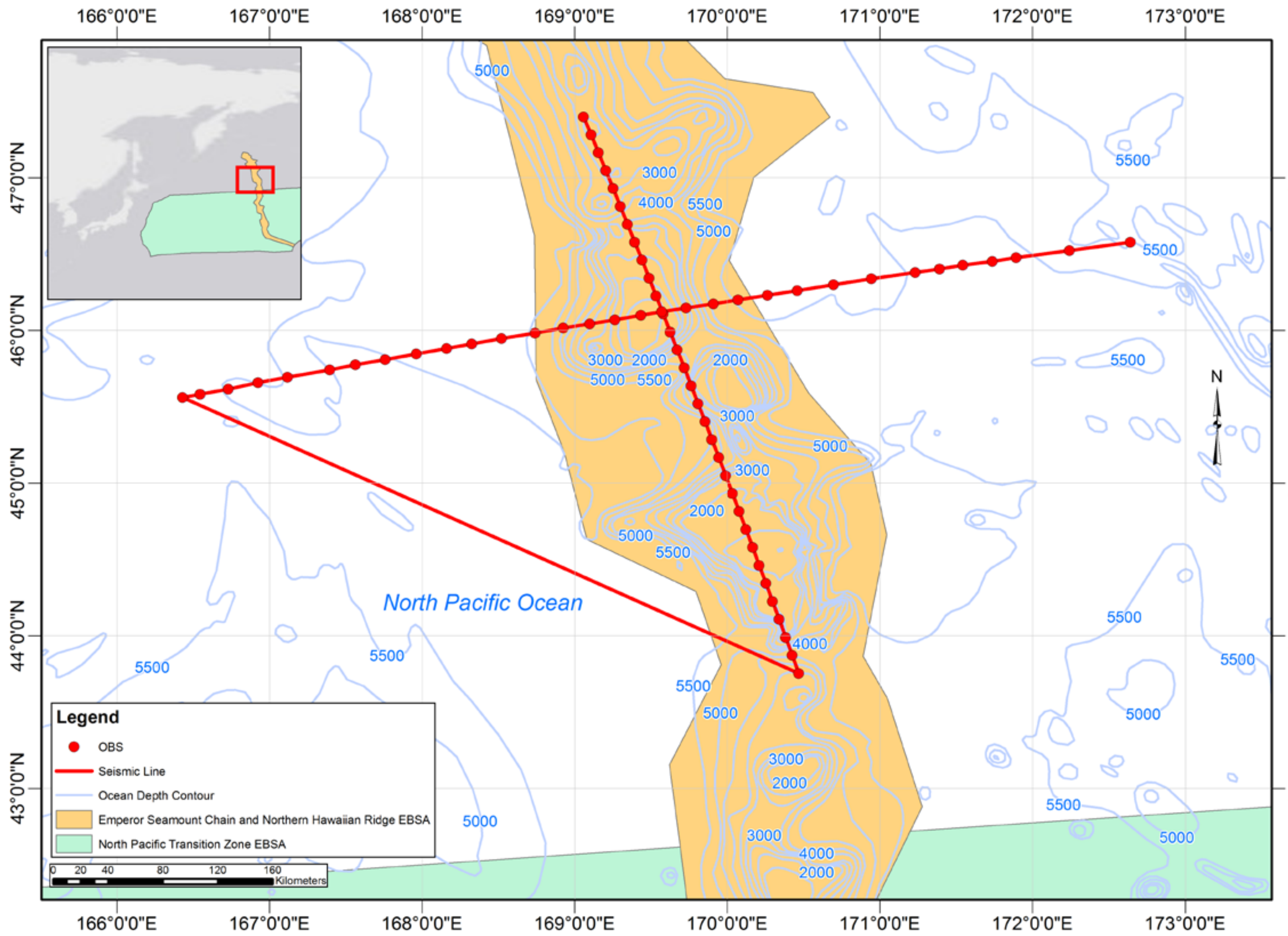

FIGURE 2. Location of the proposed 2019 seismic survey at the Emperor Seamounts in the western North Pacific Ocean, and the proposed locations of ocean bottom seismometers (OBSs). OBSs would be deployed and recovered along one line at a time.

The Hawaii-Emperor Seamount Chain is the most well-known example on Earth of hotspot magmatism, where volcanoes form far from plate boundaries above hot regions in the underlying mantle. Many questions remain about the fundamental earth processes that create the volcanoes of the Hawaii-Emperor Seamount chain and elsewhere, and how the enormous mass of these volcanoes is supported by the rock material below them. The proposed study would involve a seagoing expedition to seismically image the magmatic crust created by the hotspot and obtain critical information about the crust's volume, its composition, how it varies along the island chain, and how the tectonic plate deforms in response to the weight of the volcanoes. In addition to gaining fundamental insight into the formation of Hawaiian-Emperor Seamount chain, the study would also inform a more comprehensive assessment of geohazards for the Hawaiian Islands region. Seismic data would image faults within the volcanic edifice and in the surrounding oceanic crust that can be used to evaluate earthquake, tsunami, and submarine landslide hazards.

The main goal of the seismic program proposed by L-DEO, University of Hawaii, USGS, Oxford University, and GEOMAR is to address questions about the fundamental earth processes that create the volcanoes of the Hawaii-Emperor Seamount chain and elsewhere. To achieve the project goals, the Principal Investigators (PI) Drs. D. Shillington (L-DEO), T. Watts (Oxford University, L-DEO), and R. Dunn, G. Ito, and P. Wessel (University of Hawaii), propose to collect 2-D deep-penetration seismic reflection and wide-angle seismic refraction data on a series of long transects across the Hawaii-Emperor Seamount Chain to constrain the thickness of new crust created by magmatism and the way that the oceanic plate bends and deforms because of the addition of new crust. Although not funded through NSF, collaborators Dr. I. Grevenmeyer (GEOMAR) would work with the PIs to achieve the research goals, providing assistance, such as through logistical support (e.g., Ocean Bottom Seismometers or OBSs) and data acquisition and exchange. Likewise, personnel from the USGS, Drs. U. Brink and N. Miller, would collaborate on the program without receiving NSF funding; USGS would participate in planning, acquiring and analyzing data and using the results to inform hazards for Hawaii.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed Hawaii survey would occur within ~18–24°N, ~153–160°W, and the proposed Emperor Seamounts survey would occur within ~43–48°N, ~166–173°E. Representative survey tracklines are shown in Figures 1 and 2. As described further in this document, however, some deviation in actual track lines, including the order of survey operations, could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Thus, for the Emperor Seamounts survey, the tracklines could occur anywhere within the coordinates noted above and illustrated by the box in the inset map on Figure 2. The tracklines for the Hawaii survey could shift slightly (see § 2.1.2.2. below), but would stay within the coordinates noted above and the general vicinity of representative lines depicted in Figure 1. Water depths in the proposed Hawaii survey area range from ~700 to more than 5000 m. The water depths in the Emperor Seamounts survey area range from 1500–6000 m. The proposed Hawaii seismic survey would be conducted within the EEZ of Hawaii; the Emperor Seamounts survey would take place only within International Waters.

2.1.2.2 Description of Activities

The procedures to be used for the proposed marine geophysical surveys would be similar to those used during previous surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, the *Langseth*. The *Langseth* would tow an array of 36 airguns at a depth of 12 m as an energy source with a total volume of ~6600 in^3. The receiving system would consist of OBSs and a single hydrophone streamer 15 km in length. A longer streamer allows for accurate measurements of seismic velocities and provides a large amount of data redundancy for enhancing seismic images during data processing. The shot interval would be 50 m for multi-channel seismic (MCS) reflection lines and 150 m for OBS refraction lines.

There would be a total of four seismic transects for the Hawaii survey – two North (N)-South (S) tracklines (Lines 1 and 2), and two East (E)-West (W) tracklines (Lines 3 and 4). An optional trackline (Line 5) could be acquired instead of Line 4 (Fig. 1). Lines 1 and 2 would be acquired twice – seismic refraction data would be acquired first, followed by MCS reflection data. Only MCS reflection profiling would occur along Lines 3, 4, or 5. The location of the E-W tracklines (Lines 3, 4, or 5) could shift from what is currently depicted in Figure 1 depending on the science objectives; however, the E-W lines would remain in water >3200 m deep, outside of the critical habitat for false killer whales, if possible.

The *Langseth* would first deploy all 70 OBSs required for the refraction profiling – the vessel would transit from Honolulu to the north end of Line 2, deploy 35 OBSs along Line 2, ~15 km apart, and then transit to the south end of Line 1 to deploy 35 OBSs (~15 km apart) along Line 1. The streamer and airgun array would then be deployed. Refraction data would then be acquired from north to south on Line 1 followed by MCS profiling along the same line. If Lines 3 and 4 are to be surveyed (preferred option), MCS profiles would then be acquired along Line 3, followed by refraction data acquisition in a north-south direction along Line 2, followed by MCS profiles along Line 2 from south to north. The vessel would then acquire MCS profiles from the north end of Line 2 to the west end of Line 4, and along Line 4. After seismic acquisition ceases, the streamer, airgun source, and all OBSs would be recovered by the *Langseth*.

There would be three seismic transects for the Emperor Seamounts survey (Fig. 2). Data would be acquired twice along the two OBS lines – once for seismic refraction data and once for MCS reflection profiling. Only MCS reflection profiling would occur along the third transect that connects the two OBS lines. The *Langseth* would first acquire MCS reflection data for all three lines – from north to south, then along the connecting transect, and from west to east. After recovering the streamer and airgun array, the *Langseth* would deploy 32 OBSs required for the refraction profiling from east to west along the first line. After seismic acquisition along the first OBS line from west to east, the OBSs would be recovered and re-deployed along the second OBS line, which would then be surveyed from north to south. The *Langseth* would then recover all OBSs, the streamer, and the airgun array.

As the airgun arrays are towed along the survey lines, the OBSs would receive and store the returning acoustic signals internally for later analysis, and the hydrophone streamer would transfer the data to the on-board processing system. The Hawaii survey would use US Ocean Bottom Seismograph Instrument Pool (OBSIP) OBSs, and the Emperor Seamounts survey would use 7 OBSIP and 25 GEOMAR OBSs. The US OBSIP OBSs would be from Scripps Institution of Oceanography (SIO) or Woods Hole Oceanographic Institute (WHOI). The WHOI D2 OBSs have a height of ~1 m and a maximum diameter of 50 cm. The anchor is made of hot-rolled steel, weighs 23 kg, with dimension 2.5 × 30.5 × 38.1 cm. The SIO L-Cheapo OBSs have a height of ~1 m and a maximum diameter of ~1 m. The anchors are 36-kg iron grates with dimensions 7 × 91 × 91.5 cm. The 25 GEOMAR OBSs would consist of Longterm OBSs for Tsunami and Earthquake Research or LOBSTERs; 15 LOBSTER-6000 and 10 LOBSTER-ultradeep OBSs would likely be used. These OBSs are 165 cm long, 130 cm wide, and 72 cm high, with a titanium frame that weighs ~335 kg; they have a steel anchor.

To retrieve OBSs, an acoustic release transponder (pinger) is used to interrogate the instrument at a frequency of 8–11 kHz, and a response is received at a frequency of 11.5–13 kHz. The burn-wire release assembly is then activated, and the instrument is released to float to the surface from the anchor which is not retrieved.

A total of ~5657 km of transect lines would be surveyed in the North Pacific Ocean: ~3455 km during the Hawaii survey and ~2202 km during the Emperor Seamounts survey. There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. In the calculations for all areas (see § 4.1.1.5), 25% has been added in the form of operational days which is equivalent to adding 25% to the proposed line km to be surveyed. Most of the Hawaiian survey would occur in deep (>1000 m) water; only a small proportion (1.5%) would occur in intermediate water depths (100–1000 m). All of the Emperor Seamounts survey would take place in deep (>1000 m) water.

In addition to the operations of the airgun array, a multibeam echosounder (MBES), a sub-bottom profiler (SBP), and an Acoustic Doppler Current Profiler (ADCP) would be operated from the *Langseth* continuously during the seismic surveys, but not during transit to and from the survey areas. All planned geophysical data acquisition activities would be conducted by L-DEO with on-board assistance by the scientists who have proposed the studies. The vessel would be self-contained, and the crew would live aboard the vessel.

2.1.2.3 Schedule

The Hawaii survey would be expected to last for 36 days, including ~19 days of seismic operations, 11 days of equipment deployment/retrieval, ~3 days of operational contingency time (e.g., weather delays, etc.), and ~3 days of transit. The *Langseth* would leave out of and return to port in Honolulu during summer/early fall (likely mid-August) 2018. The Emperor Seamounts survey would be expected to last 42 days, including ~13 days of seismic operations, ~11 days of equipment deployment/retrieval, ~5.5 days of operational contingency time, and 12.5 days of transit. The *Langseth* would leave Honolulu and return to port likely in Adak or Dutch Harbor. The most likely timing for this cruise would be late spring/early summer 2019.

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

Seasonality of the proposed survey operations does not affect the ensuing analysis (including take estimates), because the best available species densities for any time of the year have been used. As higher densities of baleen whales would be encountered in the Emperor Seamounts survey area during the summer, we have used the highest densities available for the area (i.e., July–September) to determine conservative take estimates for baleen whales for a potential survey at any time of the year. Humpback whales are known to occur in Hawaii during the winter (December–April); thus, more individuals would be encountered if the proposed survey would occur at that time.

2.1.2.4 Vessel Specifications

The *Langseth* is described in § 2.2.2.1 of the PEIS. The vessel speed during all seismic operations would be ~4.1 kt (~7.6 km/h) to tow the 15-km long streamer.

2.1.2.5 Airgun Description

During both surveys, the *Langseth* would tow the full array, consisting of four strings with 36 airguns (plus 4 spares) and a total volume of ~6600 in^3. The airgun array is described in § 2.2.3.1 of the PEIS, and the airgun configuration is illustrated in Figures 2-11 to 2-12 of the PEIS. The 4-string array would be towed at a depth of 12 m, and the shot intervals would range from 50 m for MCS acquisition and 150 m for OBS acquisition.

2.1.2.6 Additional Acoustical Data Acquisition Systems

Along with the airgun operations, three additional acoustical data acquisition systems (an MBES, SBP, and ADCP) would be operated from the *Langseth* during the proposed surveys, but not during transits to/from the survey sites and ports. The ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. A Teledyne RDI 75 kHz Ocean Surveyor ADCP would be used to measure water current velocities. These sources are described in § 2.2.3.1 of the PEIS.

2.1.3 Monitoring and Mitigation Measures

Standard monitoring and mitigation measures for seismic surveys are described in § 2.4.1.1 and 2.4.2 of the PEIS and would occur in two phases: pre-cruise planning and operations. The following sections describe the efforts during both stages for the proposed activities. Numerous papers have been published recently with recommendations on how to reduce anthropogenic sound in the ocean (e.g., Simmonds et al. 2014; Wright 2014; Dolman and Jasny 2015). Some of those recommendations have been taken into account here.

2.1.3.1 Planning Phase

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

***Energy Source*.—**Part of the considerations for the proposed marine seismic surveys was to evaluate whether the research objectives could be met with a smaller energy source. The scientific objectives for the proposed surveys could not be met using smaller sources, as the primary aim of the project is deep imaging of the crust and upper-most mantle, for which a large, low-frequency airgun array is required.

***Survey Location and Timing*.—**The PIs worked with NSF to identify specific locations where seismic activities would not take place, such as critical habitat and marine protected areas, in order to avoid sensitive species and concentrations of marine mammals and still meet the research goals. For example, for the proposed Hawaii survey, the seismic transect lines were moved farther from shore to avoid exposing Hawaiian monk seal critical habitat and the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) to Level A and B source levels (see § III below).

When considering potential times to carry out the proposed surveys, key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the *Langseth*. Most marine mammal species are expected to occur in Hawaiian waters year-round, except for baleen whales that occur in the area on a seasonal basis. In particular, humpback whales use Hawaiian waters extensively during the winter (December–April). Thus, the likely timing (i.e., summer/early fall) for the proposed survey is advantageous for minimizing potential impacts on baleen whales. At the Emperor Seamounts survey area, it is expected that a greater number of baleen whales would occur there during the summer (July–September, with peak numbers during August). However, a summer timeframe for the surveys has more ideal weather conditions resulting in calmer waters than other times of the year, which is necessary for quality data collection. The likely timing of the Emperor Seamounts survey would be spring/early summer given key factors.

***Mitigation Zones*.—**During the planning phase, mitigation zones for the proposed marine seismic surveys were not derived from the farfield signature but calculated based on modeling by L-DEO for both the exclusion zones (EZ) for Level A takes and safety zones (160 dB re 1µPa$_{rms}$) for Level B takes. The background information and methodology for this are provided in Appendix A.

The proposed surveys would acquire data with the 36-airgun array at a maximum tow depth of 12 m. L-DEO model results are used to determine the 160-dB$_{rms}$ radius for the 36-airgun array and 40-in^3 airgun at a 12-m tow depth in deep water (>1000 m) down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor of 1.5. Table 1 shows the distances at which the 160-dB re 1µPa$_{rms}$ sound levels are expected to be received for the 36-airgun array and the single (mitigation) airgun. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals.

TABLE 1. Level B. Predicted distances to which sound levels ≥160-dB re 1 µPa$_{rms}$ could be received during the proposed surveys in the North Pacific Ocean. The 160-dB criterion applies to all hearing groups of marine mammals.

Source and Volume	**Tow Depth (m)**	**Water Depth (m)**	**Predicted distances (in m) to the 160-dB Received Sound Level**
Single Bolt airgun, 40 in^3	12	>1000 m	431[1]
		100–1000 m	647[2]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]
		100–1000 m	10,100[2]

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

The thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury) for marine mammals for impulsive sounds use dual metrics of cumulative sound exposure level (SEL$_{cum}$ over 24 hours) and peak sound pressure levels (SPL$_{flat}$). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2016a), the largest distance of the dual criteria (SEL$_{cum}$ or Peak SPL$_{flat}$) was used to calculate takes and Level A threshold distances. Here, SEL$_{cum}$ is used for LF cetaceans, and Peak SPL is used for all other hearing groups (Table 2).

Table 3 shows the distances at which the 175- and 195-dB re 1µPa$_{rms}$ sound levels are expected to be received for the 36-airgun array and a single airgun, based on L-DEO modeling; the 195-dB distance would be used as the EZ for sea turtles, as required by NMFS, and the 175-dB level is used by NMFS, as well as USN (2017), to determine behavioral disturbance for turtles.

TABLE 2. Level A threshold distances for different marine mammal hearing groups. As required by NMFS (2016a), the largest distance (in bold) of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances.

36-airgun array; 6600 in^3	Level A Threshold Distances (m) for Various Hearing Groups				
	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PTS SEL_{cum}	**320.2**	0	1.0	10.4	0
PTS Peak	38.9	**13.6**	**268.3**	**43.7**	**10.6**

TABLE 3. Sea turtle thresholds recommended by NMFS. Predicted distances to which sound levels ≥195- and 175-dB re 1 μPa_{rms} could be received during the proposed surveys in the North Pacific Ocean.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted distances (in m) to Received Sound Levels	
			195 dB	**175 dB**
Single Bolt airgun, 40 in^3	12	>1000 m	8[1] (100[3])	77[1]
		100–1000 m	11[2] (100[3])	116[2]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	181[1]	1864[1]
		100–1000 m	272[1]	2796[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] An EZ of 100 m would be used as the shut-down distance for sea turtles, as specified for low-energy sources in the PEIS.

This document has been prepared in accordance with the current NOAA acoustic practices, and the monitoring and mitigation procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), Wright and Cosentino (2015), and Acosta et al. (2017). Based on consultation with NMFS, it is anticipated that the IHA and BiOp will require protected species observers (PSOs) to establish and monitor a 500-m EZ for power downs and to monitor an additional 500-m zone beyond the EZ. A power down would require the reduction of the full array to a single 40-in^3 airgun. During operations, a 100-m EZ (Level A) and 430-m Level B zone would be established and monitored for shut downs of the single airgun (regardless of water depth). Enforcement of mitigation zones via power and shut downs would be implemented as described below.

2.1.3.2 Operational Phase

Marine mammals and sea turtles are known to occur in the proposed survey areas. However, the number of individual animals expected to be approached closely during the proposed activities are expected to be relatively small in relation to regional population sizes. To minimize the likelihood that potential impacts could occur to the species and stocks, monitoring and mitigation measures proposed during the operational phase of the proposed activities, which are consistent with the PEIS and past IHA and incidental take statement (ITS) requirements, include:

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

Five independently contracted PSOs would be on board the survey vessel with rotating shifts to allow two observers to monitor for marine species during daylight hours, and one observer to conduct PAM during day- and night-time seismic operations. The proposed operational mitigation measures are standard for all high-energy seismic cruises, per the PEIS, and are described in the IHA application, and therefore are not discussed further here.

Special mitigation measures were considered for these cruises and include:

1. Shut downs at any distance for a large whale with a calf or an aggregation of large whales.
2. Shut downs for melon-headed whale(s) in the range of the Kohala resident stock.
3. Shut downs for spinner or bottlenose dolphin(s) approaching or within the Level B zone in the habitat of the Main Hawaiian Islands (MHI) insular stocks if authorized takes have been met.
4. Shut downs when PAM alone (without visual sighting) confirms presence of marine mammal(s) (other than delphinids) in the 500-m exclusion zone.

With the proposed monitoring and mitigation provisions, potential effects on most, if not all, individuals would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individual marine mammals and on the associated species and stocks. Ultimately, survey operations would be conducted in accordance with all applicable U.S. federal regulations, including IHA and ITS requirements.

2.2 Alternative 1: No Action Alternative

An alternative to conducting the Proposed Action is the “No Action” alternative (Table 4). Under the “No Action” alternative, NSF would not support the research and L-DEO to conduct the proposed research operations. If the research operations were not conducted, the “No Action” alternative would result in no disturbance to marine mammals attributable to the Proposed Action. Although the No-Action Alternative is not considered a reasonable alternative because it does not meet the purpose and need for the Proposed Action, it is included and carried forward for analysis in § 4.3.

2.3 Alternatives Considered but Eliminated from Further Analysis

Table 4 provides a summary of the Proposed Action, alternative, and alternatives eliminated from further analysis.

2.3.1 Alternative E1: Alternative Location

The Hawaii-Emperor Seamount Chain is the best example in the world of a seamount chain formed above a hotspot and is therefore the ideal location to study intraplate magmatism and the response of oceanic plates to the addition of new crust by magmatism. The data that would be collected would add to the comprehensive assessment of geohazards for the Hawaiian Islands region, such as earthquake, tsunami, and submarine landslide hazards. Locations other than this particular seamount chain in the North Pacific would therefore not meet the necessary research conditions or research goals.

2.3.2 Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the PEIS, alternative technologies to the use of airguns were investigated to conduct high-energy seismic surveys. At this time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. Additional details about these technologies are given in the Final USGS EA (RPS 2014a).

TABLE 4. Summary of Proposed Action, Alternative Considered, and Alternatives Eliminated.

Proposed Action: Conduct marine geophysical surveys and associated activities in the North Pacific Ocean	Under this action, research activities are proposed to study earth processes and would involve 2-D seismic surveys. Active seismic portions of each survey would be expected to take ~20–22 days, additional operational days would be expected for transit; equipment deployment, maintenance, and retrieval; weather; marine mammal activity; and other contingencies. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in § III and IV. The standard monitoring and mitigation measures identified in the PEIS would apply, along with any additional requirements identified by regulating agencies in the U.S. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternative 1: No Action	Under this Alternative, no proposed activities would be conducted and seismic data would not be collected. While this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the Proposed Action. Geological data of scientific value and relevance increasing our understanding of the formation of the Hawaiian-Emperor Seamount chain, and adding to the comprehensive assessment of geohazards for the Hawaiian Islands region, such as earthquake, tsunami, and submarine landslide hazards, would not be collected. The collection of new data, interpretation of these data, and introduction of new results into the greater scientific community and applicability of these data to other similar settings would not be achieved. No permits and authorizations, including an IHA, would be needed from regulatory bodies, as the Proposed Action would not be conducted.
Alternative E1 Eliminated from Further Analysis: Alternative Location	The Hawaii-Emperor Seamount Chain is the best example in the world of a seamount chain formed above a hotspot and is therefore the ideal location to study intraplate magmatism and the response of oceanic plates to the addition of new crust by magmatism. The data that would be collected would add to the comprehensive assessment of geohazards for the Hawaiian Islands region, such as earthquake, tsunami, and submarine landslide hazards, would not be collected. The proposed science underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.
Alternative E2 Eliminated from Further Analysis: Use of Alternative Technologies	Under this alternative, L-DEO would use alternative survey techniques, such as marine vibroseis, that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the PEIS, § 2.6. At this time, however, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need.

III AFFECTED ENVIRONMENT

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

- *Air Quality/Greenhouse Gases*—Project vessel emissions would result from the proposed activity; however, these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the proposed survey areas;
- *Land Use*—All activities are proposed to occur in the marine environment. Thus, no changes to current land uses or activities in the proposed survey areas would result from the Project;
- *Safety and Hazardous Materials and Management*—No hazardous materials would be generated or used during the proposed activities. All Project-related wastes would be disposed of in accordance with international, U.S. state, and federal requirements;
- *Geological Resources (Topography, Geology and Soil)*—The proposed Project would result in very minor disturbance to seafloor sediments from OBS deployments during the surveys; small anchors would not be recovered. The proposed activity would not adversely affect geologic resources;
- *Water Resources*—No discharges to the marine environment that would adversely affect marine water quality are expected in the Project areas. Therefore, there would be no impacts to water resources resulting from the proposed Project activity;
- *Terrestrial Biological Resources*—All proposed Project activities would occur in the marine environment and would not impact terrestrial biological resources;
- *Visual Resources*—No visual resources would be expected to be negatively impacted as the proposed activities would be short-term and not visible from shore;
- *Socioeconomic and Environmental Justice*—Implementation of the proposed Project would not affect, beneficially or adversely, socioeconomic resources, environmental justice, or the protection of children. No changes in the population or additional need for housing or schools would occur. Because of the location of the proposed marine activities and distance from shore, human activities in the Emperor Seamounts survey area would be limited to commercial fishing and other vessel traffic. In the Hawaii survey area, activities would include recreational diving, fishing, and other vessel traffic. Diving, fishing, vessel traffic, and potential impacts are described in further detail in § III and IV. No other socioeconomic impacts would be expected as result of the proposed activities; and
- *Cultural Resources*—There are numerous cultural resources in the proposed Hawaii survey area. Traditional fisheries occur within the Hawaiian EEZ. Kealakekua Bay State Historical Park is located south of Kailua-Kona on the Big Island. The bay is historically important as

> Captain James Cook landed on the Big Island and was killed there (Hawaii Tourism Authority 2018). The national historic landmark of Pearl Harbor is located on the south coast of Oahu. There are also numerous shipwrecks in the vicinity of the proposed survey area (see § 3.8). Shipwrecks would be avoided when deploying OBSs, and airgun sounds would have no effects on solid structures; therefore, no significant impacts on shipwrecks would be expected (§ 3.8). No impacts to cultural resources would be expected.

3.1 Oceanography

The Hawaiian-Emperor seamount chain is mostly an underwater mountain range, but it reaches above sea level as the Hawaiian Islands. It consists of the Hawaiian Ridge and the Emperor Seamounts. The seamount chain contains numerous underwater volcanoes, seamounts, and atolls, and is nearly 6000 km long, stretching from the Aleutian Trench to Lo'ihi seamount near Hawaii (Torsvik et al. 2017).

The Hawaiian Islands consist of eight major islands to the southeast as well as the smaller Northwestern Hawaiian Islands. The Hawaiian survey would occur in the Main Hawaiian Islands, which are located within the North Pacific Subtropical Gyre (Luo et al. 2012). This large province comprises four prevailing ocean currents with the Hawaiian Islands located almost centrally. It is bounded to the north by the North Pacific Current, the North Equatorial Current to the south, the Kuroshio Current to the west, and the California Current to the east. Studies based at the Hawaii Ocean Time-series station ALOHA (~23°N, 158°W) have consistently shown that the North Pacific Subtropical Gyre is characterized by oligotrophic conditions in the upper waters, with a maximum winter-mixed layer depth of ~100 m (Luo et al. 2012). According to Luo et al. (2012), the primary productivity rates averaged ~500 mg C $m^{-2}d^{-1}$ during 1991–2009; according to Sea Around Us (2016a), the primary production is 225.5 mg $m^{-2}d^{-1}$.

The Emperor Seamounts are located in the Northwest Pacific High Seas (Sea Around Us 2016b). The Northwest Pacific High Seas include 9.69% of the World's seamounts and has a primary productivity of 344.7 mg $m^{-2}d^{-1}$ (Sea Around Us 2016b). When considering bioregions, the Emperor Seamounts are located in the West Pacific Subarctic Gyres Province (Longhurst 2007), or according to a newer classification of ocean provinces, they are located within or just to the east of the Cold Temperate Northwest Pacific Province (Spalding et al. 2007). The Kuroshio Extension, a warm-water surface current, jets eastward from Japan across the Pacific Basin. Free from coastal influence, the Kuroshio Current (called the Kuroshio Extension once offshore) forms a meandering, inertial jet and series of back-eddies that transports large amounts of heat energy into the North Pacific (Nishida and White 1982; Mizuno and White 1983; Qiu 2000; Yasuda 2003).

3.2 Protected Areas

In Hawaii, Marine Managed Areas (MMAs) have been designated to manage marine, estuarine, and anchialine resources, including marine life and their habitats (State of Hawaii 2018a). Marine Protected Areas (MPAs) are specific subsets of MMAs for the protection and conservation of habitats and ecosystems (State of Hawaii 2018a). In Hawaii, MPAs include the HIHWNMS, the Papahānaumokuākea Marine National Monument (PMNM), and 11 Marine Life Conservation Districts (MLCDs). MLCDs serve to conserve and replenish marine life, such as fish inhabiting coral reefs (State of Hawaii 2018a). Of the 11 MLCDS, three are located off Oahu, but only one, Pūpūkea, is located in the vicinity of proposed seismic Line 2 off the west coast. There are five MLCDs designated for the Big Island of Hawaii, four of which are on the west coast of the island (Kealakekua Bay, Lapakahi, Old Kona Airport, and Waialea Bay). Lapakahi is on the northwest coast of the island and is located closest to proposed seismic Line 1 off the west coast.

In addition, there are several Natural Area Reserves but none of these are located in marine waters near the proposed transect lines off the west coasts of Oahu or the Big Island (State of Hawaii 2018a,b). Ahihi-Kinau Natural Area Reserve on the south coast of Maui includes a coastal lava field and adjacent waters (327 ha) on the southwest coast of the island; it is a popular snorkel/dive site (MPAtlas 2018). Kahoolawe Island Reserve, south of Maui, includes the island of Kahoolawe and waters out to 2 n.mi. (MPAtlas 2018). The island used to be a former military range; any activities in this reserve have be authorized by the Kahoolawe Island Reserve Commission (MPAtlas 2018). Two coral conservation priority sites have also been identified on the northwest coasts of Maui and the Big Island (Levine and Feinholz 2015), but the proposed transect lines do not traverse these sites. In addition, there are numerous bottomfish restricted fishing areas in the region (MPAtlas 2018).

HIHWNMS was established in 1992 by the U.S. Congress to protect humpback whales and their habitat in Hawaii (NOAA 2018a). Protection is provided to the warm, shallow waters (from the shoreline to a depth of 100 fathoms or 183 m) around the four islands area of Maui, Penguin Bank; off the north shore of Kauai, the north and south shores of Oahu, and the north Kona and Koahal coast of the Big Island (NOAA 2018a). The sanctuary provides essential breeding, calving, and nursing areas necessary for the long-term recovery of the North Pacific humpback whale population. The proposed transect lines are located at least 10 km from the HIHWNMS (Fig. 1). There is also critical habitat for the Hawaiian monk seal and critical habitat for the false killer whale in Hawaiian waters (Fig. 1), which are described in more detail in the species accounts below.

Formerly known as the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, this area was declared the PMNM in 2006 (NOAA 2017a). In 2016, the PMNM was extended from 50 n.mi. from shore of the Northwestern Hawaiian Islands, to the 200-n.mi. limit, changing the area from ~140,000 mi^2 to 583,000 mi^2 (NOAA 2018b). Its purpose is to protect a coral reef ecosystem and important marine mammal and fish habitat (Hoyt 2011). It provides important habitat protection for species such as the green turtle and Hawaiian monk seal, as well as ~14 million seabirds (NOAA 2017a). Since its inception, the area has been designated as a “Particularly Sensitive Sea Area” by the International Maritime Organization and was pronounced a UNESCO World Heritage Site in 2010 (NOAA 2017a, 2018b). Commercial fishing and resource extraction are prohibited within the PMNM (NOAA 2018b). The PMNM is located >250 km west of the proposed survey area (Fig. 1).

Baird et al. (2015) described numerous Biologically Important Areas (BIAs) for cetaceans for the Hawaii region. Twenty BIAs were identified for resident populations of cetaceans based on sighting data, photo-identification, genetics, satellite tagging, and expert opinion, and one reproductive area for humpbacks was identified as a BIA; these are described in the following section for each marine mammal species. The BIAs range from ~700–23,500 km^2 in area (Baird et al. 2015).

The majority of the proposed seismic transect lines in the Emperor Seamounts survey area is located within the Emperor Seamount Chain and Northern Hawaiian Ridge Ecologically or Biologically Sensitive Marine Areas or EBSA (Fig. 2). This EBSA stretches for ~3000 km from the Aleutian Trench to the Northwestern Hawaiian Islands and includes the North Hawaiian Ridge outside of the U.S. EEZ and the Emperor Seamount Chain (CBD 2016a). The EBSA features a series of volcanic seamounts that have mostly flat plateaus and sloping sides with minimum depths of 300–2000 m (CBD 2016a). The Emperor Seamount Chain and North Hawaiian Ridge EBSA is home to commercial fisheries, and there is a relatively low diversity and density of cold-water corals on the seamounts (CBD 2016a).

The North Pacific Transition Zone (NPTZ) EBSA is located ~130 km from the Emperor Seamounts survey area. The NPTZ is an upper water column feature extending across the North Pacific. It shifts location seasonally, between 28º and 34ºN on the southern boundary and 40–43ºN on the northern boundary (CBD 2016b). The eddies and frontal zones in the NPTZ create a highly productive habitat with increased primary productivity in the form of a surface phytoplankton chlorophyll front that concentrates zooplankton and other prey. This zone is an important feeding area for loggerhead turtles; fish species such as albacore tuna, Pacific bluefin tuna, Pacific pomfret, blue shark, and Pacific saury; as well as elephant seals, flying squid, Laysan albatross, and black-footed albatross. The NPTZ also serves as a migratory corridor for loggerhead turtles and bluefin tuna (CBD 2016b).

3.3 Marine Mammals

Twenty-eight cetacean species, including 21 odontocetes (dolphins and small- and large-toothed whales) and seven mysticetes (baleen whales), and one pinniped species, could occur in the proposed Hawaii survey area (Table 5). In the Emperor Seamounts survey area, 27 marine mammal species could occur, including 15 odontocetes (dolphins and small- and large-toothed whales), eight mysticetes (baleen whales), and four pinniped species (Table 5). Of the marine mammal species/populations that may occur within or near the survey areas in the North Pacific Ocean, 10 are listed under the U.S. ESA as ***endangered***: the North Pacific right, sei, fin, blue, and sperm whales, the Western North Pacific DPSs of humpback and gray whales, the Hawaiian Islands Insular DPS of false killer whale, the Western DPS of Steller sea lion, and the Hawaiian monk seal.

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (June 2011), referred to herein as the NSF/USGS PEIS. The general distributions of marine mammals in the western North Pacific Ocean is discussed in § 3.6.3.7 and § 3.7.3.7 of the PEIS for the Mariana Islands, and in § 3.6.2.3, §3.7.2.3, and §3.8.2.3 for Southern California in the eastern North Pacific Ocean. The rest of this section deals specifically with their distribution within the proposed survey areas in the North Pacific. Information on the occurrence near the proposed survey areas, habitat, population size, and conservation status for each of the marine mammal species is presented in Table 5.

Although the harbor porpoise (*Phocoena phocoena*) and sea otter (*Enhydra lutris*) were considered for inclusion in this analysis, these species generally occur in nearshore areas and are not expected to occur in the offshore waters of the Emperor Seamounts survey area. Also, the ringed seal (*Pusa hispida*), spotted seal (*Phoca largha*), harbor seal (*Phoca vitulina*), walrus (*Odobenus rosmarus*), and bowhead whale (*Balaena mysticetus*) are not expected to occur in the Emperor Seamounts survey area.

3.3.1 Mysticetes

3.3.1.1 Gray Whale (*Eschrichtius robustus*)

Two separate populations of gray whales have been recognized in the North Pacific (LeDuc et al. 2002): the eastern North Pacific and western North Pacific (or Korean-Okhotsk) stocks. However, the distinction between these two populations has been recently debated owing to evidence that whales from the western feeding area also travel to breeding areas in the eastern North Pacific (Weller et al. 2012, 2013; Mate et al. 2015). Thus, it is possible that whales from both the *endangered* Western North Pacific and the delisted Eastern North Pacific DPS could occur in the proposed survey area in the western North Pacific.

TABLE 5. The habitat, abundance, and conservation status of marine mammals that could occur in or near the proposed seismic survey areas in the North Pacific Ocean.

Species	Occurrence in Area at Time of Survey		Habitat	Abun-dance in Hawaii [1]	Abun-dance in Hawaii [2]	Abund-ance in North Pacific or ETP	ESA [3]	IUCN [4]	CITES [5]
	Hawaii	Emperor Seamounts							
Mysticetes									
Gray whale	Absent	Rare	Mainly coastal	N.A.	N.A.	140[6]	EN[7]	CR[8]	I
North Pacific right whale	Rare	Un-common	Pelagic, coastal	N.A.	N.A.	400-500[9]	EN	EN	I
Humpback whale	Rare	Un-common	Mainly nearshore, banks	7120-10,425[10]	N.A.	21,063[11]	EN[12]	LC	I
Minke whale	Rare	Un-common	Pelagic, coastal	N.A.	N.A.	>22,000[13]	NL	LC	I
Bryde's whale	Un-common	Rare	Pelagic, coastal	798	1751	28,447[14]	NL	DD	I
Sei whale	Rare	Un-common	Mostly pelagic	178	391	27,197[15]	EN	EN	I
Fin whale	Rare	Un-common	Pelagic, slope	58	154	13,620-18,680[16]	EN	EN	I
Blue whale	Rare	Un-common	Pelagic, coastal	81	133	1647[17] 958[18]	EN	EN	I
Odontocetes									
Sperm whale	Un-common	Un-common	Pelagic, steep topography	3354	4559	29,674[19] 26,300[20]	EN	VU	I
Pygmy sperm whale	Un-common	Rare	Deep, off shelf	7138[21]	N.A.	N.A.	NL	DD	II
Dwarf sperm whale	Common	Rare	Deep, shelf, slope	17,519[21]	N.A.	11,200[22]	NL	DD	II
Cuvier's beaked whale	Common	Un-common	Slope, pelagic	1941	723	20,000[23]	NL	LC	II
Longman's beaked whale	Un-common	Absent	Pelagic	4571	7619	291[24]	NL	DD	II
Blainville's beaked whale	Un-common	Absent	Pelagic	2338	2105	25,300[25]	NL	DD	II
Stejneger's beaked whale	Absent	Un-common	Pelagic	N.A.	N.A.	25,300[25]	NL	DD	II
Ginkgo-toothed beaked whale	Rare	Absent	Pelagic	N.A.	N.A.	25,300[25]	NL	DD	II
Deraniyagala's beaked whale	Rare	Absent	Pelagic	N.A.	N.A.	25,300[25]	NL	DD	II
Hubb's beaked whale	Rare	Absent	Pelagic	N.A.	N.A.	25,300[25]	NL	DD	II
Baird's beaked whale	Absent	Un-common	Pelagic	N.A.	N.A.	25,300[25] 5029[26] 10,190[27]	NL	DD	I
Rough-toothed dolphin	Common	Absent	Mainly pelagic	6288	72,528	107,633[28]	NL	LC	II
Common bottlenose dolphin	Common	Absent	Coastal, shelf, deep	5950[29]	21,815	335,834[28] 168,792[30]	NL	LC	II

Species	Occurrence in Area at Time of Survey		Habitat	Abundance in Hawaii[1]	Abundance in Hawaii[2]	Abundance in North Pacific or ETP	ESA[3]	IUCN[4]	CITES[5]
	Hawaii	Emperor Seamounts							
Short-beaked common dolphin	Absent	Rare	Shelf and pelagic,	N.A.	N.A.	2,963,000[31]	NL	LC	II
Pantropical spotted dolphin	Common	Absent	Coastal, pelagic	15,917[29]	55,795	1,297,092[32] 438,064[30]	NL	LC	II
Spinner dolphin	Common	Absent	Coastal, pelagic	3351[29]	N.A.	1,797,716[34]	NL	DD	II
Striped dolphin	Uncommon	Uncommon	Off shelf	20,650[29]	61,201	964,362[28] 570,038[30]	NL	LC	II
Fraser's dolphin	Uncommon	Absent	Pelagic	16,992	51,491	289,300[23]	NL	LC	II
Pacific white-sided dolphin	Absent	Common	Continental slope and	N.A.	N.A.	988,333[35]	NL	LC	II
Northern right whale dolphin	Absent	Uncommon	Pelagic	N.A.	N.A.	307,784[35]	NL	LC	II
Risso's dolphin	Uncommon	Rare	Shelf, slope, mounts	7256	11,613	110,457[28] 83,289[30]	NL	LC	II
Melon-headed whale	Uncommon	Absent	Pelagic	5794[36]	8666	45,400[23]	NL	LC	II
Pygmy killer whale	Uncommon	Absent	Pelagic, coastal	3433	10,640	38,900[23]	NL	DD	II
False killer whale	Uncommon	Rare	Pelagic	1540[37]	N.A.	16,668[30]	EN[33]	DD	II
Killer whale	Rare	Uncommon	Widely distributed	101	146	8500[38]	NL	DD	II
Short-finned pilot whale	Common	Rare	Pelagic, high-relief	12,422	19,503	53,608[30]	NL	DD	II
Dall's porpoise	Absent	Common	Deep water	N.A.	N.A.	1,186,000[39]	NL	LC	II
Pinnipeds									
Hawaiian monk seal	Uncommon	Absent	Coastal	1,272	N.A.	N.A.	EN	EN	N.A.
Northern fur seal	Absent	Uncommon	Coastal and pelagic	N.A.	N.A.	1.1 million[40] 626,734[41]	NL	VU	N.A.
Steller sea lion	Absent	Rare	Coastal and pelagic	N.A.	N.A.	143,000[40] 50,883[42] 41,638[43]	E[46]	E[47]	N.A.
Northern elephant seal	Absent	Uncommon	Coastal and pelagic	N.A.	N.A.	210,000-239,000[44]	NL	LC	N.A.
Ribbon seal	Absent	Rare	Coastal and pelagic	N.A.	N.A.	240,000[40] 184,000[45]	NL	LC	N.A.

N.A. = Not available, not applicable, or not assessed; ETP = Eastern Tropical Pacific.

[1] Estimates presented in Carretta et al. (2017), unless otherwise noted. Most of the estimates provided by Carretta et al. (2017). were derived from summer-fall shipboard surveys in 2010 by Bradford et al. (2013).

[2] Based on summer-fall shipboard surveys in 2010 (Bradford et al. 2017).

[3] U.S. ESA (NMFS 2018a): EN = Endangered, NL = Not listed.

[4] Classification from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2018): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient.

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

[6] Weller et al. (2013).

[7] Only the Western North Pacific DPS is listed as endangered.

[8] The western subpopulation is listed as critically endangered; the global population is designated as least concern.
[9] North Pacific (Jefferson et al. 2015).
[10] Hawaii wintering area, 2004–2006 (Calambokidis et al. 2008).
[11] North Pacific, 2004–2006 (Barlow et al. 2011).
[12] Out of the 14 distinct population segments (DPS) of humpbacks, only the Western Pacific DPS is listed as endangered; the Hawaii DPS is not listed under the ESA (NMFS 2016b).
[13] North West Pacific and Okhotsk Sea (IWC 2018a).
[14] Western North Pacific (Hakamada et al. 2017).
[15] Central and Eastern North Pacific (Hakamada and Matsuoka 2015a).
[16] Ohsumi and Wada (1974).
[17] Eastern North Pacific Stock (Calambokidis 2013).
[18] Western Pacific Ocean (Hakamada and Matsuoka 2015b).
[19] Western North Pacific (Whitehead 2002).
[20] Northeastern Temperate Pacific; estimate based on visual sightings (Barlow and Taylor 2005).
[21] Barlow (2006).
[22] Wade and Gerrodette (1993); estimate for ETP mostly for *K. sima* but may also include *K. breviceps.*
[23] ETP (Wade and Gerrodette 1993).
[24] ETP (Ferguson and Barlow 2003).
[25] This estimate includes all species of the genus *Mesoplodon* in the ETP (Wade and Gerrodette 1993).
[26] Pacific coast of Japan (Kasuya 2009a).
[27] Western Pacific Ocean (Okamura et al. 2012).
[28] ETP for 2006 (Gerrodette et al. 2008).
[29] Pelagic stock.
[30] Western North Pacific (Miyashita 1993a).
[31] ETP (Gerrodette and Forcada 2002 *in* Hammond et al. 2008b).
[32] ETP for 2006 for the two offshore spotted dolphin stocks (Gerrodette et al. 2008).
[33] Only the Main Hawaiian Islands Insular DPS is listed as endangered.
[34] ETP for 2006 for the eastern and white belly spinner dolphin, stocks (Gerrodette et al. 2008).
[35] North Pacific (Miyashita 1993b).
[36] Hawaiian Islands Stock (Aschettino 2010).
[37] Hawaii pelagic stock (Bradford et al. 2015).
[38] ETP (Ford 2009).
[39] North Pacific (Buckland et al. 1993).
[40] North Pacific (Jefferson et al. 2015).
[41] Eastern Pacific stock (Muto et al. 2017).
[42] Estimate for the Western U.S. Stock, including Russia and Japan (Muto et al. 2017).
[43] Estimate for the Eastern U.S. Stock; not corrected for animals at sea (Muto et al. 2017).
[44] U.S. and Mexico (Lowry et al. 2014).
[45] Alaska stock (Muto et al. 2017).
[46] The Western U.S. stock or DPS is listed as endangered; the Eastern U.S. stock (DPS) is not listed.
[47] The Western Steller sea lion (*Eumetopias jubatus jubatus*) is listed as endangered under the IUCN Red List; globally, *E. jubatus* is considered near threatened.

The western population is known to feed in the Okhotsk Sea along the northeast coast of Sakhalin Island (Weller et al. 1999, 2002a, 2008), eastern Kamchatka, and the northern Okhotsk Sea in the summer and autumn (Vladimirov et al. 2008). Winter breeding grounds are not known; however, it has been postulated that wintering areas occur along the south coast of the Korean Peninsula, but it is more likely that they are located in the South China Sea, along the coast of Guangdong province and Hainan (Wang 1984 and Zhu 1998 *in* Weller et al. 2002a; Rice 1998). Winter records exist for Japan, North Korea, and South Korea (Weller et al. 2002a,b). Migration into the Okhotsk Sea may occur through the Sea of Japan via the Tatar Strait and/or La Perouse Strait (see Reeves et al. 2008). If migration timing is similar to that of the better-known eastern gray whale, southbound migration probably occurs mainly in December–January and northbound migration mainly in February–April, with northbound migration of newborn calves and their mothers probably concentrated at the end of that period. The eastern North Pacific gray whale breeds and winters in Baja, California, and migrates north to summer feeding grounds in the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1971; Jefferson et al. 2015).

In the western North Pacific, gray whales migrate along the coast of Japan (Weller et al. 2008), and records have been reported there from November through August, with the majority for March through

May (Weller et al. 2012). Although the offshore limit of this route is not well documented, gray whales are known to prefer nearshore coastal waters. However, some exchange between populations in the eastern and western North Pacific has been reported (Weller et al. 2012, 2013; Mate et al. 2015); thus, migration routes could include pelagic waters of the Pacific Ocean, including the proposed Emperor Seamounts survey area. Nonetheless, given their small population size and preference for nearshore waters, it is highly unlikely that any gray whales would be encountered during the proposed Emperor Seamounts survey during any time of the year. Additionally, during summer, most gray whales would be feeding near Sakhalin Island. The gray whale does not occur in Hawaiian waters.

3.3.1.2 North Pacific Right Whale (*Eubalaena japonica*)

North Pacific right whales summer in the northern North Pacific, primarily in the Okhotsk Sea (Brownell et al. 2001) and in the Bering Sea (Shelden et al. 2005; Wade et al. 2006). The eastern North Pacific stock that occurs in U.S. waters numbers only ~31 individuals (Wade et al. 2011), and critical habitat has been designated in the eastern Bering Sea and in the Gulf of Alaska, south of Kodiak Island (NMFS 2017b). Wintering and breeding areas are unknown, but have been suggested to include the Hawaiian Islands, Ryukyu Islands, and Sea of Japan (Allen 1942; Banfield 1974; Gilmore 1978; Reeves et al. 1978; Herman et al. 1980; Omura 1986). The Hawaiian Islands were not a major calving ground for right whales in the last 200 years, but mid-ocean whaling records of right whales during winter suggest that right whales may have wintered and calved far offshore in the Pacific Ocean (Scarff 1986, 1991; Clapham et al. 2004). In April 1996, a right whale was sighted off Maui, the first documented sighting of a right whale in Hawaiian waters since 1979 (Salden and Mickelsen 1999).

Whaling records indicate that right whales once ranged across the entire North Pacific Ocean north of 35ºN and occasionally occurred as far south as 20ºN (e.g., Scarff 1986, 1991). In the western Pacific, most sightings in the 1900s were reported from Japanese waters, followed by the Kuril Islands, and the Okhotsk Sea (Brownell et al. 2001). Significant numbers of right whales have been seen in the Okhotsk Sea during the 1990s, suggesting that the adjacent Kuril Islands and Kamchatka coast are a major feeding ground (Brownell et al. 2001). Right whales were also seen near Chichi-jima Island (Bonin Islands), Japan, in the 1990s (Mori et al. 1998). During 1994–2014, right whale sightings were reported off northern Japan, the Kuril Islands, and Kamchatka during April through August, with highest densities in May and August (Matsuoka et al. 2015). All sightings were north of 38ºN, and in July–August, the main distribution was north of 42ºN (Matsuoka et al. 2015). Right whale sightings were made within the Emperor Seamounts survey area during August, and adjacent to the survey area during May and July (Matsuoka et al. 2015). Ovsyanikova et al. (2015) also reported right whale sightings in the western Pacific Ocean during 1977–2014; although they also reported sightings off eastern Japan, the Kuril Islands, and southeast Kamchatka, including sightings to the west of the proposed Emperor Seamounts survey area, no sightings were reported within the proposed survey area. Sekiguchi et al. (2014) reported several sightings just to the north and west of the proposed survey area during June 2012.

Although there are a few historical records of North Pacific right whales in Hawaiian waters (Brownell et al. 2001), they are very unlikely to occur in the Hawaiian survey area, especially during the summer. However, right whales could be encountered in the Emperor Seamounts survey area during spring and summer, and likely fall. Individuals that could occur there would likely be from a western North Pacific stock rather than the eastern North Pacific stock.

3.3.1.3 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all oceans of the World (Clapham 2009), with recent genetic evidence suggesting three separate subspecies: North Pacific, North Atlantic, and Southern

Hemisphere (Jackson et al. 2014). Nonetheless, genetic analyses suggest some gene flow (either past or present) between the North and South Pacific (e.g., Jackson et al. 2014; Bettridge et al. 2015). Although considered to be mainly a coastal species, the humpback whale often traverses deep pelagic areas while migrating (e.g., Mate et al. 1999; Garrigue et al. 2015).

North Pacific humpback whales migrate between summer feeding grounds along the Pacific Rim and the Bering and Okhotsk seas, and winter calving and breeding areas in subtropical and tropical waters (Pike and MacAskie 1969; Rice 1978; Winn and Reichley 1985; Calambokidis et al. 2000, 2001, 2008). In the North Pacific, humpbacks winter in four different breeding areas: (1) along the coast of Mexico; (2) along the coast of Central America; (3) around the Main Hawaiian Islands; and (4) in the western Pacific, particularly around the Ogasawara and Ryukyu islands in southern Japan and the northern Philippines (Calambokidis et al. 2008; Fleming and Jackson 2011; Bettridge et al. 2015). These breeding areas are recognized as the Hawaii, Central America, Mexico, and Western Pacific DPSs (NMFS 2016b). The Western Pacific DPS is listed as ***endangered***, whereas the Hawaii DPS is not listed (NMFS 2016b). Calambokidis et al. (2008) estimated the Hawaii population at ~10,000 individuals and the Western Pacific population at ~1000 humpbacks.

There is potential for the mixing of the western and eastern North Pacific humpback populations, as several individuals have been seen in the wintering areas of Japan and Hawaii in separate years (Darling and Cerchio 1993; Salden et al. 1999; Calambokidis et al. 2001, 2008). Whales from these wintering areas have been shown to travel to summer feeding areas in British Columbia, Canada, and Kodiak Island, Alaska (Darling et al. 1996; Calambokidis et al. 2001), but feeding areas in Russian waters may be most important (Calambokidis et al. 2008). There appears to be a very low level of interchange between wintering and feeding areas in Asia and those in the eastern and central Pacific (Calambokidis et al. 2008; Baker et al. 2013).

In U.S. Pacific waters, four stocks are currently recognized: (1) California/Oregon/Washington, (2) Central North Pacific (feeding areas occur from Southeast Alaska to the Alaska Peninsula), (3) Western North Pacific (feeding occurs from the Aleutians, to the Bering Sea, and Russia), and (4) American Samoa (Carretta et al. 2017). Calambokidis et al. (2008) estimated that >50% of the population in the entire North Pacific winters in Hawaiian waters. Hawaii is the primary wintering area for whales from summer feeding areas in the Gulf of Alaska, Southeast Alaska, and northern British Columbia, Canada; some individuals from the Bering Sea feeding area also winter in Hawaii (Calambokidis et al. 2008). Even though photo-identification studies showed that Hawaii is connected to various feeding grounds in Alaska (Calambokidis et al. 2008), genetic data indicated that it was significantly different from most feeding areas, except the northern Gulf of Alaska and eastern Aleutians, and all other breeding areas (Baker et al. 2013).

Humpbacks use Hawaiian waters for breeding from December to April; peak abundance occurs from late-February to early-April (Mobley et al. 2001). Most humpbacks have been sighted there in water depths <180 m (Fleming and Jackson 2011), but Frankel et al. (1995) detected singers up to 13 km from shore at depths up to 550 m. During vessel-based line-transect surveys in the Hawaiian Islands EEZ in July–December 2002, one humpback whale was sighted on 21 November at ~20.3°N, 154.9°W just north of the Big Island (Barlow et al. 2004). Another sighting was made during summer–fall 2010 surveys, but the date and location of that sighting were not reported (Bradford et al. 2017). The HIHWNMS provides protection to humpbacks in the shallow waters (from the shoreline to a depth of 100 fathoms or 183 m) around the four islands area of Maui, Penguin Bank; off the north shore of Kauai, the north and south shores of Oahu, and the north Kona and Koahal coast of the Big Island (NOAA 2018a). These areas, as well as some of the waters surrounding them, are also considered BIAs (Baird et al. 2015). The proposed seismic lines are located at least 10 km from the HIHWNMS (Fig. 1). However, humpback whales are not expected to be encountered in the Hawaiian survey area during the summer.

During Japanese surveys in the western North Pacific from 1994–2014, humpbacks were seen off northern Japan, the Kuril Islands, and Kamchatka (Miyashita 2006; Matsuoka et al. 2015). Sightings were reported for the months of April through September, with lowest densities in April and September (Matsuoka et al. 2015). In May and June, sightings were concentrated east of northern Japan between 37° and 43°N; concentrations moved north of 45°N during July and August, off the Kuril Islands and Kamchatka (Mutsuoka et al. 2015). Humpback whales were encountered within the proposed Emperor Seamount study area in May, July, and August (Matsuoka et al. 2015).

Thus, humpbacks could be encountered in the Emperor Seamounts survey area during spring and summer, as individuals are migrating to northern feeding grounds at that time. They could also be encountered in the survey area during fall, on their southbound migration. Humpback whales are note expected to occur in the Hawaiii survey area during the time of the proposed survey.

3.3.1.4 Common Minke Whale (*Balaenoptera acutorostrata*)

The common minke whale has a cosmopolitan distribution ranging from the tropics and subtropics to the ice edge in both hemispheres (Jefferson et al. 2015). In the Northern Hemisphere, minke whales are usually seen in coastal areas, but can also be seen in pelagic waters during northward migrations in spring and summer, and southward migration in autumn (Stewart and Leatherwood 1985). In the North Pacific, the summer range extends to the Chukchi Sea; in the winter, minke whales move further south to within 2º of the Equator (Perrin and Brownell 2009). The International Whaling Commission (IWC) recognizes three stocks in the North Pacific: the Sea of Japan/East China Sea, the rest of the western Pacific west of 180ºN, and the remainder of the Pacific (Donovan 1991).

In U.S. Pacific waters, three stocks are recognized: Alaska, Hawaii, and California/Oregon/Washington stocks (Carretta et al. 2017). In Hawaii, the minke whale is thought to occur seasonally from November through March (Rankin and Barlow 2005). It is generally believed to be uncommon in Hawaiian waters; however, several studies using acoustic detections suggest that minke whales may be more common than previously thought (Rankin et al. 2007; Oswald et al. 2011; Martin et al. 2012). Acoustic detections have been recorded around the Hawaiian Islands during fall–spring surveys in 1997 and 2000–2006 (Rankin and Barlow 2005; Barlow et al. 2008; Rankin et al. 2008), and from seafloor hydrophones positioned ~50 km from the coast of Kauai during February–April 2006 (Martin et al. 2012). Similarly, passive acoustic detections of minke whales have been recorded at the ALOHA station (22.75°N, 158°W) from October–May for decades (Oswald et al. 2011).

A lack of sightings is likely related to misidentification or low detection capability in poor sighting conditions (Rankin et al. 2007). Two minke whale sightings were made west of 167°W, one in November 2002 and one in October 2010, during surveys of the Hawaiian Islands EEZ (Barlow et al. 2004; Bradford et al. 2013; Carretta et al. 2017). Numerous additional sightings in the EEZ were made by observers on Hawaii-based longline fishing vessels, including four near the proposed survey area to the north and south of the Main Hawaiian Islands (Carretta et al. 2017).

Minke whales have been seen regularly during Japanese sighting surveys in the western North Pacific during summer (Miyashita 2006; Hakamada et al. 2009), and one sighting was made in August 2010 in offshore waters off Japan during the Shatsky Rise cruise (Holst and Beland 2010). Minke whales were sighted within the Emperor Seamounts survey area in the greatest numbers in August, with the lowest numbers occurring during May and June (Hakamada et al. 2009).

Thus, minke whales could be encountered in the Emperor Seamounts survey area during spring and summer, and likely fall, but they are unlikely to be encountered in the Hawaiian survey area during the summer.

3.3.1.5 Bryde's Whale (*Balaenoptera edeni/brydei*)

Bryde's whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic, and Indian oceans, between 40°N and 40°S (Kato and Perrin 2009). It is one of the least known large baleen whales, and its taxonomy is still under debate (Kato and Perrin 2009). *B. brydei* is commonly used to refer to the larger form or "true" Bryde's whale and *B. edeni* to the smaller form; however, some authors apply the name *B. edeni* to both forms (Kato and Perrin 2009). Although there is a pattern of movement toward the Equator in the winter and the poles during the summer, Bryde's whale does not undergo long seasonal migrations, remaining in warm (>16°C) water year-round (Kato and Perrin 2009). Bryde's whales are known to occur in both shallow coastal and deeper offshore waters (Jefferson et al. 2015).

In the Pacific U.S., a Hawaii and an Eastern Tropical Pacific stock are recognized (Carretta et al. 2017). In Hawaii, Bryde's whales are typically seen offshore (e.g., Barlow et al. 2004; Barlow 2006), but Hopkins et al. (2009) reported a Bryde's whale within 70 km of the Main Hawaiian Islands. During summer–fall surveys of the Hawaiian Islands EEZ, 13 sightings were made in 2002 (Barlow 2006), and 32 sightings were reported during 2010 (Bradford et al. 2017). Bryde's whales were primarily sighted in the western half of the Hawaiian Islands EEZ, with the majority of sightings associated with the Northwestern Hawaiian Islands; none was made in the proposed survey area (Barlow et al. 2004; Barlow 2006; Bradford et al. 2013; Forney et al. 2015; Carretta et al. 2017).

Bryde's whales have been regularly seen during Japanese summer sighting surveys in the western North Pacific, south of 43°S (Hakamada et al. 2009, 2017), and individual movements have been tracked with satellite tags in offshore waters off Japan (Murase et al. 2016). No recent sightings have been made in the proposed Emperor Seamounts survey area, but commercial catches have been reported there (IWC 2007a).

Bryde's whale is likely to be rare in the Emperor Seamounts survey area, as its distributional range is generally to the south of this region. However, it could occur in the Hawaiian survey area at any time of the year.

3.3.1.6 Sei Whale (*Balaenoptera borealis*)

The sei whale occurs in all ocean basins (Horwood 2009), but appears to prefer mid-latitude temperate waters (Jefferson et al. 2015). 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).

During summer in the North Pacific, the sei whale can be found from the Bering Sea to the Gulf of Alaska and down to southern California, as well as in the western Pacific from Japan to Korea. In the U.S. Pacific, an Eastern North Pacific and a Hawaii stock are recognized (Carretta et al. 2017). In Hawaii, the occurrence of sei whales is considered rare (DoN 2005). However, six sightings were made during surveys in the Hawaiian Islands EEZ in July–December 2002 (Barlow 2006), including several along the north coasts of the Main Hawaiian Islands (Barlow et al. 2004). All sightings occurred in

November, with one sighting reported near proposed seismic Line 3 north of the Big Island (Barlow et al. 2004). Bradford et al. (2017) reported two sightings in the northwestern portion of the Hawaiian Islands EEZ during summer–fall surveys in 2010. Hopkins et al. (2009) sighted one group of three subadult sei whales northeast of Oahu in November 2007. Sei whale vocalizations were also detected near Hawaii during November 2002 (Rankin and Barlow 2007). Breeding and calving areas for this species in the Pacific are unknown, but those sightings suggest that Hawaii may be an important reproductive area (Hopkins et al. 2009).

Sei whales have been regularly seen during Japanese surveys during the summer in the western North Pacific (Miyashita 2006; Hakamada et al. 2009; Sasaki et al. 2013). Sei whales have been sighted in and near the Emperor Seamounts survey area, with the greatest numbers reported for July and August; few sightings were made during May and June (Hakamada et al. 2009).

Thus, sei whales could be encountered in the Emperor Seamounts survey area during spring and summer, and likely fall, but they are unlikely to be encountered in the Hawaiian survey area at any time of the year, especially during summer.

3.3.1.7 Fin Whale (*Balaenoptera physalus*)

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. 2015). A recent review of fin whale distribution in the North Pacific noted the lack of sightings across the pelagic waters between eastern and western winter areas (Mizroch et al. 2009). 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 (Jefferson et al. 2015). 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 winter from California southwards (Gambell 1985). In the U.S., three stocks are recognized in the North Pacific: California/Oregon/Washington, Hawaii, and Alaska (Northeast Pacific) (Carretta et al. 2017). 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, including near the Emperor Seamounts survey area (e.g., Moore et al. 2006; Stafford et al. 2007, 2009; Edwards et al. 2015). In the central North Pacific, call rates peak during fall and winter (Moore et al. 1998, 2006; Watkins et al. 2000a,b).

Sightings of fin whales have been made in Hawaiian waters during fall and winter (Edwards et al. 2015), but fin whales are generally considered uncommon at that time (DoN 2005). During spring and summer, their occurrence in Hawaii is considered rare (DoN 2005; see Edwards et al. 2015). There were five sightings of fin whales during summer–fall surveys in 2002, with sightings during every month except August (Barlow et al. 2004). Most sightings were made to the northwest of the Main Hawaiian Islands; one sighting was made during October southeast of Ohau (Barlow et al. 2004). Two sightings were made in the Northwestern Hawaiian Islands during summer–fall 2010 (Carretta et al. 2017; Bradford et al. 2017). Two additional sightings in the EEZ were made by observers on Hawaii-based longline fishing vessels, including one near proposed seismic Line 3 north of Maui (Carretta et al. 2017). Fin whale vocalizations have also been detected in Hawaiian waters, mainly during winter (Oleson et al. 2014, 2016).

In the western Pacific, fin whales are seen off northern Japan, the Kuril Islands, and Kamchatka during the summer (Miyashita 2006; Matsuoka et al. 2015). During Japanese sightings surveys in the western North Pacific from 1994–2014, the fin whale was sighted more frequently than the blue, humpback, or right whale (Matsuoka et al. 2015). During May–June, main distribution areas occurred from 35–40°N and moved north of 40°N during July and August; high densities were reported north of 45°N (Matsuoka et al. 2015). During these surveys, fin whales were seen in the proposed Emperor Seamounts survey area from May through September, with most sightings during August (Matsuoka et al. 2015). Summer sightings in the survey area during 1958–2000 were also reported by Mizroch et al. (2009) and during July–September 2005 (Miyashita 2006). Edwards et al. (2015) reported fin whale sightings within or near the Emperor Seamounts survey area from spring through fall.

Thus, fin whales could be encountered in the Emperor Seamounts survey area from spring through fall, but they are unlikely to be encountered in the Hawaiian survey area during summer.

3.3.1.8 Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson et al. 2015). 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. 2000b).

In the North Pacific, blue whale calls are detected year-round (Stafford et al. 2001, 2009; Moore et al. 2002, 2006; Monnahan et al. 2014). Stafford et al. (2009) reported that sea-surface temperature is a good predictor variable for blue whale call detections in the North Pacific. Although it has been suggested that there are at least five subpopulations in the North Pacific (Reeves et al. 1998), analysis of calls monitored from the U.S. Navy Sound Surveillance System (SOSUS) and other offshore hydrophones (e.g., Stafford et al. 1999, 2001, 2007; Watkins et al. 2000a; Stafford 2003) suggests that there are two separate populations: one in the eastern and one in the central North Pacific (Carretta et al. 2017). The Eastern North Pacific Stock includes whales that feed primarily off California from June–November and winter off Central America (Calambokidis et al. 1990; Mate et al. 1999). The Central North Pacific Stock feeds off Kamchatka, south of the Aleutians and in the Gulf of Alaska during summer (Stafford 2003; Watkins et al. 2000b), and migrates to the western and central Pacific (including Hawaii) to breed in winter (Stafford et al. 2001; Carretta et al. 2017). The status of these two populations could differ substantially, as little is known about the population size in the western North Pacific (Branch et al. 2016).

Blue whales are considered rare in Hawaii (DoN 2005). However, call types from both stocks have been recorded near Hawaii during August–April, although eastern calls were more prevalent; western calls were mainly detected during December–March, whereas eastern calls peaked during August and

September and were rarely heard during October–March (Stafford et al. 2001). No sightings were made in the Hawaiian Islands EEZ during surveys in July–December 2002 (Barlow et al. 2004; Barlow 2006). One sighting was made in the Northwestern Hawaiian Islands during August–October 2010 (Bradford et al. 2013). Three additional sightings in the EEZ were made by observers on Hawaii-based longline fishing vessels during 1994–2009, including one in offshore waters north of Maui (Carretta et al. 2017).

In the western North Pacific, blue whale calls have been detected throughout the year, but are more prevalent from July–December (Stafford et al. 2001). Numerous blue whale sightings have also been made in the western North Pacific during Japanese surveys during 1994–2014 (Miyashita 2006; Matsuoka et al. 2015). A northward migration pattern was evident, with the main distribution occurring from 35–40°N during May and June, and north of 40°N during July and August (Matsuoka et al. 2015). High densities were reported north of 45°N (Matsuoka et al. 2015). Blue whales were seen in the proposed Emperor Seamounts survey area during August and September and adjacent to the area during May and July (Matsuoka et al. 2015).

Thus, blue whales could be encountered in the Emperor Seamounts and Hawaii survey areas at any time of the year, but are more likely to occur in the Emperor Seamounts area during summer, and in the Hawaii survey area during winter.

3.3.2 Odontocetes

3.3.2.1 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the largest of the toothed whales, with an extensive worldwide distribution from the edge of the polar pack ice to the Equator (Whitehead 2009). Sperm whale distribution is linked to its social structure: mixed groups of adult females and juveniles of both sexes generally occur in tropical and subtropical waters at latitudes less than ~40° (Whitehead 2009). After leaving their female relatives, males gradually move to higher latitudes with the largest males occurring at the highest latitudes and only returning to tropical and subtropical regions to breed. Sperm whales generally are distributed over large areas that have high secondary productivity and steep underwater topography, in waters at least 1000 m deep (Jaquet and Whitehead 1996). They are often found far from shore, but can be found closer to oceanic islands that rise steeply from deep ocean waters (Whitehead 2009).

Sperm whale vocalizations have been recorded throughout the Central and Western Pacific Ocean (Merkens et al. 2016). Sperm whales are widely distributed in Hawaiian waters throughout the year (Mobley et al. 2000) and are considered a separate stock from the Oregon/Washington/California stock in U.S. waters (Carretta et al. 2017). Higher densities occur in deep, offshore waters (Forney et al. 2015). During summer–fall surveys of the Hawaiian Islands EEZ, 43 sightings were made in 2002 (Barlow 2006) and 41 were made in 2010 (Bradford et al. 2013). Sightings were widely distributed across the EEZ during both surveys; numerous sightings occurred in and near the proposed survey area (Barlow et al. 2004; Barlow 2006; Bradford et al. 2017). All sightings during surveys of the Main Hawaiian Islands in 2000–2012 were made in water >1000 m in depth, with most sightings in areas >3000 m deep (Baird et al. 2013). Sightings were made during surveys of the Big Island during all seasons, including near proposed seismic Line 1; no sightings were made off Oahu (Baird et al. 2013). Sperm whales were also detected acoustically off the west coast of the Big Island year-round (Klinck et al. 2012; Giorli et al. 2016).

Sperm whales have been regularly seen in the western North Pacific during Japanese surveys during summer (Miyashita 2006; Hakamada et al. 2009), and sightings were also made in offshore waters east of Japan and on the Shatsky Rise during a summer survey in 2010 (Holst and Beland 2010). During winter, few sperm whales are observed off the east coast of Japan (Kato and Miyashita 1998). Sperm whales have been sighted in and near the Emperor Seamounts survey area from May through August, with the greatest numbers occurring there during June–August (Miyashita 2006; Hakamada et al. 2009).

Thus, sperm whales could be encountered in the Emperor Seamounts and Hawaii survey areas at any time of the year, but are more likely to occur in the Emperor Seamounts area during summer.

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

The pygmy and dwarf sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2009). It has been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the Eastern Tropical Pacific or ETP (Wade and Gerrodette 1993). *Kogia* spp. are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). Although there are few useful estimates of abundance for pygmy or dwarf sperm whales anywhere in their range, they are thought to be fairly common in some areas.

Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998; Jefferson et al. 2015). However, several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf (Rice 1998; Wang et al. 2002; MacLeod et al. 2004). On the other hand, McAlpine (2009) and Barros et al. (1998) suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales.

Vocalizations of *Kogia* spp. have been recorded in the North Pacific Ocean (Merkens et al. 2016). An insular resident population of dwarf sperm whales occurs within ~20 km from the Main Hawaiian Islands throughout the year (Baird et al. 2013; Oleson et al. 2013). During small-boat surveys in 2000–2012, dwarf sperm whales were sighted in all water depth categories up to 5000 m deep, but the highest sighting rates were in water 500–1000 m deep (Baird et al. 2013). Of a total of 74 sightings during those surveys, most sightings were made off the Big Island, including near proposed seismic Line 1 (Baird et al. 2013). The area off the west coast of the Big Island is considered a BIA for dwarf sperm whales (Baird et al. 2015). Only one sighting was made off Oahu (Baird et al. 2013).

Only five sightings of pygmy sperm whales were made during the surveys, including several off the west coast of the Big Island; the majority of sightings were made in water >3000 m deep (Baird et al. 2013). The dwarf sperm whale was one of the most abundant species during a summer–fall survey of the Hawaiian EEZ in 2002 (Barlow 2006); during that survey, two sightings of pygmy sperm whales, five sightings of dwarf sperm whales, and one sighting of an unidentified *Kogia* sp. were made. All sightings were made in the western portion of the EEZ (Barlow et al. 2004; Barlow 2006). During summer–fall surveys of the Hawaiian EEZ in 2010, one dwarf sperm whale and one unidentified *Kogia* sp. were sighted (Bradford et al. 2017); no sightings were made in or near the proposed survey area (Carretta et al. 2017).

Although *Kogia* spp. have been seen during Japanese sighting surveys in the western North Pacific in August–September (Kato et al. 2005), to the best of our knowledge, there are no direct data available for the Emperor Seamounts survey area with respect to *Kogia* spp. Based on their distributional ranges, the pygmy sperm whale is more likely to occur in the proposed Emperor Seamounts survey area than the dwarf sperm whale.

3.3.2.3 Cuvier's Beaked Whale (*Ziphius cavirostris*)

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 likely the most abundant of all beaked whales (Heyning and Mead 2009). Cuvier's beaked whale is found in deep water over and near the continental slope (Jefferson et al. 2015).

Cuvier's beaked whale has been sighted during surveys in Hawaii (Barlow 2006; Baird et al. 2013; Bradford et al. 2017). Resighting and telemetry data suggest that a resident insular population of Cuvier's beaked whale may exist in Hawaii, distinct from offshore, pelagic whales (e.g. McSweeney et al. 2007; Baird et al. 2013; Oleson et al. 2013). During small-boat surveys around the Hawaiian Islands in 2000–2012, sightings were made in water depths of 500–4000 m off the west coast of the Big Island during all seasons (Baird et al. 2013). The waters around the Big Island are considered a BIA for Cuvier's beaked whale (Baird et al. 2015); proposed seismic Line 1 would traverse this area.

During summer–fall surveys of the Hawaiian Islands EEZ, three sightings of Cuvier's beaked whale were made in the western portion of the EEZ in 2002 (Barlow 2006) and 23 were made in the EEZ in 2010 (Bradford et al. 2013). It was one of the most abundant cetacean species sighted in 2002 (Barlow 2006). In 2010, most sightings were made in nearshore waters of the Northwestern Hawaiian Islands, but one was made on the west coast of the Big Island, and another was made far offshore and to the southwest of Kauai (Carretta et al. 2017). Cuvier's beaked whales were also reported near proposed seismic line 1 during November 2009 (Klinck et al. 2012). They have also been detected acoustically at hydrophones deployed near the Main Hawaiian Islands during spring and fall (Baumann-Pickering et al. 2014, 2016), including off the west coast of the Big Island (Klinck et al. 2012). Probable acoustic detections were also made at Cross Seamount, south of the Main Hawaiian Islands, at 18.72°N, 158.25°W (Johnston 2008).

Cuvier's beaked whale has been seen during Japanese sighting surveys in August–September in the western North Pacific (Kato et al. 2005). It has also been detected acoustically in the Aleutian Islands (Baumann-Pickering et al. 2014). There is very little information on this species for the Emperor Seamounts survey area, but what is known of its distribution and habitat preferences suggests that it could occur there.

3.3.2.4 Longman's Beaked Whale (*Indopacetus pacificus*)

Longman's beaked whale, also known Indo-Pacific beaked whale, used to be one of the least known cetacean species, but it is now one of the more frequently sighted beaked whales (Pitman 2009a). Longman's beaked whale occurs in tropical waters throughout the Indo-Pacific, with records from 30°S to 40°N (Pitman 2009a). Longman's beaked whale is most often sighted in waters with temperatures ≥26°C and depth >2000 m, and sightings have also been reported along the continental slope (Anderson et al. 2006; Pitman 2009a).

During small-boat surveys around the Hawaiian Islands in 2000–2012, a single sighting of Longman's beaked whale was made off the west coast of the Big Island during summer (Baird et al. 2013). During summer–fall surveys of the Hawaiian Islands EEZ, one sighting was made in 2002 and three were made in 2010; one sighting was made in offshore waters southwest of Ohau, and another was made at the edge of the EEZ southwest of the Big Island (Barlow et al. 2004; Barlow 2006; Bradford et al. 2013). Acoustic detections have been made at the Palmyra Atoll and the Pearl and Hermes Reef (Baumann-Pickering et al. 2014).

Longman's beaked whale has been seen during Japanese sighting surveys in August–September in the western North Pacific (Kato et al. 2005). However, what is known about its distribution and habitat preferences suggests that it does not occur in the Emperor Seamounts survey area.

3.3.2.5 Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans (Pitman 2009b). It has the widest distribution throughout the world of all mesoplodont species and appears to be common (Pitman 2009b). It is commonly sighted in some areas of Hawaii (Jefferson et al. 2015).

McSweeney et al. (2007), Schorr et al. (2009), Baird et al. (2013), and Oleson et al. (2013) have suggested the existence of separate insular and offshore Blainville's beaked whales in Hawaiian waters. During small-boat surveys around the Hawaiian Islands in 2000–2012, sightings were made in shelf as well as deep water, with the highest sighting rates in water 3500–4000 m deep, followed by water 500–1000 m deep (Baird et al. 2013). Sightings were made during all seasons off the Big Island, as well as off Oahu (Baird et al. 2013). The area off the west coast of the Big Island is considered a BIA for Blainville's beaked whale (Baird et al. 2015); proposed seismic Line 1 would traverse this BIA. During summer–fall shipboard surveys of the Hawaiian Islands EEZ, three sightings were made in 2002 and two were made in 2010, all in the western portion of the EEZ (Barlow et al. 2004; Barlow 2006; Bradford et al. 2013). In addition, there were four sightings of unidentified *Mesoplodon* there in 2002 (Barlow et al. 2004; Barlow 2006) and 10 in 2010 (Bradford et al. 2013).

Blainville's beaked whales have also been detected acoustically at hydrophones deployed near the Main Hawaiian Islands throughout the year (Baumann-Pickering et al. 2014, 2016; Henderson et al. 2016; Manzano-Roth et al. 2016), including off the west coast of the Big Island, near proposed seismic Line 1, during October–November 2009 (Klinck et al. 2012). Probable acoustic detections were also made at Cross Seamount, south of the Main Hawaiian Islands, at 18.72°N, 158.25°W (Johnston 2008). Blainville's beaked whale is expected to be absent from the Emperor Seamounts survey area.

3.3.2.6 Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)

Stejneger's beaked whale occurs in subarctic and cool temperate waters of the North Pacific (Mead 1989). Most records are from Alaskan waters, and the Aleutian Islands appear to be its center of distribution (Mead 1989). In the western Pacific Ocean, Stejneger's beaked whale has been seen during Japanese sighting surveys during August–September (Kato et al. 2005). Seasonal peaks in strandings along the western coast of Japan suggest that this species may migrate north in the summer from the Sea of Japan (Mead 1989). They have also been detected acoustically in the Aleutian Islands during summer, fall, and winter (Baumann-Pickering et al. 2014).

Given its distributional range (see Jefferson et al. 2015), Stejneger's beaked whale could occur in the Emperor Seamounts survey area. It does not occur in the Hawaiian survey area.

3.3.2.7 Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)

Ginkgo-toothed beaked whale is only known from stranding and capture records (Mead 1989; Jefferson et al. 2015). It is hypothesized to occupy tropical and warm temperate waters of the Indian and Pacific oceans (Pitman 2009b). Its distributional range in the North Pacific extends from Japan to the Galapagos Islands, and there are also records for the South Pacific as far south as Australia and New Zealand (Jefferson et al. 2015). Although its distributional range is thought to be south of Hawaii (Jefferson et al. 2015), vocalizations likely from this species have been detected acoustically at hydrophones deployed near the Main Hawaiian Islands and just to the south at Cross Seamount (18.72°N, 158.25°W), as well as at the Wake Atoll and Mariana Islands (Baumann-Pickering et al. 2014, 2016). However, no sightings have been made in Hawaiian waters (Barlow 2006; Baird et al. 2013; Bradford et al. 2017).

The ginkgo-toothed beaked whale could occur in the southern parts of the Hawaiian survey area, but it is not expected to occur in the Emperor Seamounts survey area.

3.3.2.8 Deraniyagala's Beaked Whale (*Mesoplodon hotaula*)

Deraniyagala's beaked whale is a newly recognized species of whale that recently has been described for the tropical Indo-Pacific, where it is thought to occur between ~15°N and ~10°S (Dalebout et al. 2014). Strandings have been reported for the Maldives, Sri Lanka, the Seychelles, Kiribati, and Palmyra Atoll (Dalebout et al. 2014), and acoustic detections have been made at Palmyra Atoll and Kingman Reef in the Line Islands (Baumann-Pickering et al. 2014). It is closely related to ginkgo-toothed beaked whale, but DNA and morphological data have shown that the two are separate species (Dalebout et al. 2014).

Although possible, Deraniyagala's beaked whale is unlikely to occur in the Hawaiian survey area, and its range does not include the Emperor Seamounts survey area.

3.3.2.9 Hubb's Beaked Whale (*Mesoplodon carlhubbsi*)

Hubb's beaked whale occurs in temperate waters of the North Pacific (Mead 1989). Most of the stranding records are from California (Willis and Baird 1998). Its distribution appears to be correlated with the deep subarctic current (Mead et al. 1982). Its range is believed to be continuous across the North Pacific (Macleod et al. 2006), although this has yet to be substantiated because very few direct at-sea observations exist.

Hubb's beaked whale was seen during Japanese sighting surveys in the western North Pacific during August–September (Kato et al. 2005). However, there is very little information on this species for the Emperor Seamounts survey area, but what is known of its distribution suggests that it is unlikely to occur there. Although not expected to occur in warm waters, possible vocalizations have been detected acoustically in the Hawaiian Islands and Wake Atoll, but no detections were made in the Aleutians (Baumann-Pickering et al. 2014). Although possible, Hubb's beaked whale is unlikely to occur in the Hawaiian survey area.

3.3.2.10 Baird's Beaked Whale (*Berardius bairdii*)

Baird's beaked whale has a fairly extensive range across the North Pacific north of 30˚N, and strandings have occurred as far north as the Pribilof Islands (Rice 1986). Two forms of Baird's beaked whales have been recognized – the common slate-gray form and a smaller, rare black form (Morin et al. 2017). The gray form is seen off Japan, in the Aleutians, and on the west coast of North America, whereas the black from has been reported for northern Japan and the Aleutians (Morin et al. 2017). Recent genetic studies suggest that the black form could be a separate species (Morin et al. 2017).

Baird's beaked whale is currently divided into three distinct stocks: Sea of Japan, Okhotsk Sea, and Bering Sea/eastern North Pacific (Balcomb 1989; Reyes 1991). The whales occur year-round in the Okhotsk Sea and Sea of Japan (Kasuya 2009a). Baird's beaked whales sometimes are seen close to shore, but their primary habitat is over or near the continental slope and oceanic seamounts in waters 1000–3000 m deep (Jefferson et al. 1993; Kasuya and Ohsumi 1984; Kasuya 2009a).

Off Japan's Pacific coast, Baird's beaked whales start to appear in May, numbers increase over the summer, and decrease toward October (Kasuya 2009a). During this time, they are nearly absent in offshore waters (Kasuya 2009a). Kato et al. (2005) also reported the presence of Baird's beaked whales in the western North Pacific in August–September. They have also been detected acoustically in the Aleutian Islands (Baumann-Pickering et al. 2014).

Baird's beaked whale could be encountered at the Emperor Seamounts survey area, but its distribution does not include Hawaiian waters.

3.3.2.11 Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is distributed worldwide in tropical to warm temperate oceanic waters (Miyazaki and Perrin 1994; Jefferson 2009). In the Pacific, it occurs from central Japan and northern Australia to Baja California, Mexico, and southern Peru (Jefferson 2009). It generally occurs in deep, oceanic waters, but can be found in shallower coastal waters in some regions (Jefferson et al. 2015).

The rough-toothed dolphin is expected to be one of the most abundant cetaceans in the Hawaiian survey area, based on previous surveys in the area (Barlow et al. 2004; Barlow 2006; Baird et al. 2013; Bradford et al. 2017). Higher densities are expected to occur in deeper waters around the Hawaiian Islands than in far offshore waters of the Hawaiian EEZ (Forney et al. 2015). During small-boat surveys around the Hawaiian Islands in 2000–2012, it was sighted in water as deep as 5000 m, with the highest sighting rates in water >3500 m deep, throughout the year (Baird et al. 2013). Sightings were made off the Big Island as well as Oahu (Baird et al. 2013). The area west of the Big Island is considered BIA (Baird et al. 2015); proposed seismic Line 1 would traverse this area. During summer–fall surveys of the Hawaiian Islands EEZ, rough-toothed dolphins were observed throughout the EEZ, including near the proposed survey area to the north and south of the Main Hawaiian Islands; in total, there were 18 sightings in 2002 and 24 sightings in 2010 (Barlow 2006; Barlow et al. 2004; Bradford et al. 2017). Acoustic detections have also been made in Hawaiian waters (Rankin et al. 2015).

In the western North Pacific Ocean, rough-toothed dolphins have been seen during Japanese sighting surveys during August–September (Kato et al. 2005). However, there is very little information on this species for the Emperor Seamounts survey area, but what is known of its distribution suggests that it is unlikely to occur there.

3.3.2.12 Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin occurs in tropical, subtropical, and temperate waters throughout the World (Wells and Scott 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).

The bottlenose dolphin is expected to be one of the most abundant cetaceans in the Hawaiian survey area, based on previous surveys in the region (Barlow 2006; Baird et al. 2013; Bradford et al. 2017). Higher densities are expected to occur around the Hawaiian Islands than in far offshore waters of the Hawaiian EEZ (Forney et al. 2015). Photo-identification studies have shown that there are distinct resident populations at the four island groups in Hawaii (Kuai & Niihau, Oahu, the 4-island region, and the Big Island); the 1000-m isobath serves as the boundary between these resident insular stocks and the Hawaii pelagic stock (Martien et al. 2012). The areas where the insular stocks are found are also considered BIAs (Baird et al. 2015). Proposed seismic Lines 1 and 2 would traverse the BIAS to the west of Oahu and west of the Big Island.

During small-boat surveys around the Hawaiian Islands in 2000–2012, the bottlenose dolphin was sighted in water as deep as 4500 m, but the highest sighting rates occurred in water <500 m deep (Baird et al. 2013). Sightings were made during all seasons off the Big Island, including near proposed seismic Line 1, and off Oahu (Baird et al. 2013). Common bottlenose dolphins were also observed during summer–fall surveys of the Hawaiian EEZ, mostly in nearshore waters but also in offshore waters, including in and near the proposed survey area among the Main Hawaiian Islands, and to the north and south of the islands (see map in Carretta et al. 2017). Fifteen sightings were made in 2002 (Barlow 2006), and 19 sightings were made in 2010 (Bradford et al. 2017).

In the western North Pacific Ocean, common bottlenose dolphins have been sighted off the east coast of Japan during summer surveys in 1983–1991 (Miyashita 1993a). Although only part of the proposed Emperor Seamounts survey area was surveyed during the month of August, no sightings were made within or near the survey area (Miyashita 1993a). Offshore sightings to the south of the proposed survey area were made during September (Miyashita 1993a), and there is also a record just to the southwest of the survey area during summer (Kanaji et al. 2017). The distributional range of the common bottlenose dolphin does not appear to extend north to the Emperor Seamounts survey area; thus, it is not expected to be encountered during the survey.

3.3.2.13 Short-beaked Common Dolphin (*Delphinus delphis*)

The common dolphin is found in tropical and warm temperate oceans around the World (Perrin 2009a). 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 seamounts (Evans 1994). There are two species of common dolphins: the short-beaked common dolphin (*D. delphis*) and the long-beaked common dolphin (*D. capensis*). The short-beaked common dolphin is mainly found in offshore waters, and the long-beaked common dolphin is more prominent in coastal areas.

During Japanese sighting surveys in the western North Pacific in August–September, both long- and short-beaked common dolphins have been seen (Kato et al. 2005). Kanaji et al. (2017) reported one record to the southwest of the proposed survey area during summer. There are also bycatch records of short-beaked common dolphins near the Emperor Seamounts survey area during summer and winter (Hobbs and Jones 1993). Based on information regarding the distribution and habitat preferences, only the short-beaked common dolphin could occur there.

Neither the short-beaked nor long-beaked common dolphin are expected to occur in the Hawaiian survey area. No sightings of either species have been made during surveys of the Hawaii Islands (Barlow 2006; Baird et al. 2013; Bradford et al. 2017).

3.3.2.14 Pantropical Spotted Dolphin (*Stenella attenuata*)

The pantropical spotted dolphin is one of the most abundant cetaceans and is distributed worldwide in tropical and some subtropical waters (Perrin 2009b), between ~40°N and 40°S (Jefferson et al. 2015). It is found primarily in deeper waters, but can also be found in coastal, shelf, and slope waters (Perrin 2009b). There are two forms of pantropical spotted dolphin: coastal and offshore. The offshore form inhabits tropical, equatorial, and southern subtropical water masses; the pelagic individuals around the Hawaiian Islands belong to a stock distinct from those in the ETP (Dizon et al. 1991; Perrin 2009b). Spotted dolphins are commonly seen together with spinner dolphins in mixed-species groups, e.g., in the ETP (Au and Perryman 1985), off Hawaii (Psarakos et al. 2003), and in the Marquesas Archipelago (Gannier 2002).

The pantropical spotted dolphin is expected to be one of the most abundant cetaceans in the proposed Hawaiian survey area based on previous surveys in the region (Baird et al. 2013; Barlow 2006; Bradford et al. 2017). Higher densities are expected to occur around the Main Hawaiian Islands than elsewhere in the Hawaiian EEZ (Forney et al. 2015). The Main Hawaiian Islands insular spotted dolphin stock consists of two separate stocks at Oahu and 4-Islands (which extend 20 km seaward), and one stock off the Big Island, up to 65 km from shore (Carretta et al. 2017). Spotted dolphins outside of these insular stocks are part of the Hawaii pelagic stock (Carretta et al. 2017).

During small-boat surveys around the Hawaiian Islands in 2000–2012, the pantropical spotted dolphin was sighted in all water depth categories, with the lowest sighting rate in water <500 m (Baird et al. 2013). It was observed during all seasons, including off the Big Island and Oahu (Baird et al. 2013). It was also seen during summer–fall surveys of the Hawaiian Islands EEZ including in the proposed survey area, with sightings to the north, south, and around the Main Hawaiian Islands (see map in Carretta et al. 2017); 14 sightings were made in 2002 (Barlow 2006), and 12 sightings were made in 2010 (Bradford et al. 2017). The areas off southwest Oahu, south of Lanai, and west of the Big Island are considered BIAs (Baird et al. 2015); proposed seismic Line 1 traverses the BIA west of the Big Island. One sighting was made in July 2010 in the northwestern portion of the Hawaiian EEZ during the Shatsky Rise cruise (Holst and Beland 2010).

In the western Pacific, pantropical spotted dolphins occur from Japan south to Australia; they have been hunted in drive fisheries off Japan for decades (Kasuya 2007). A sighting of three individuals was made in offshore waters east of Japan in August 2010 during the Shatksy Rise cruise (Holst and Beland 2010). Pantropical spotted dolphins were also sighted off the east coast of Japan during summer surveys in 1983–1991, with the highest densities in offshore waters between 30ºN and 37ºN (Miyashita 1993a). Although only part of the proposed Emperor Seamounts survey area was surveyed during the month of August, no sightings were made within or near the survey area; offshore sightings to the south of the proposed survey area were made during August and September (Miyashita 1993a). The distributional range of the pantropical spotted dolphin does not appear to extend north to the Emperor Seamounts survey area; thus, it is not expected to be encountered during the survey.

3.3.2.15 Spinner Dolphin (*Stenella longirostris*)

The spinner dolphin is pantropical in distribution, including oceanic tropical and sub-tropical waters between 40ºN and 40ºS (Jefferson et al. 2015). It is generally considered a pelagic species (Perrin 2009b), but can also be found in coastal waters and around oceanic islands (Rice 1998). In Hawaii, spinner dolphins belong to the offshore stock (*S.l. longirostris*; Gray's spinner) that is separate from animals in the ETP (Dizon et al. 1991).

The spinner dolphin is expected to be one of the most abundant cetaceans in the Hawaiian survey area, based on previous surveys in the region (Barlow 2006; Baird et al. 2013; Bradford et al. 2017). Higher densities are expected to occur around in offshore waters south of the Hawaiian Islands (Forney et al. 2015). There are six separate stocks managed within the Hawaiian EEZ – the Hawaii Island (Big Island), Oahu/4-islands, Kauai/Niihau, Pearl & Hermes Reef, Midway Atoll/Kure, and Hawaiian pelagic stocks (Carretta et al. 2017); individuals from three of these stocks (Hawaii pelagic, Hawaii Island, Oahu/4-Islands) are expected to overlap with the proposed survey area. The boundaries of these stocks are out to 10 n.mi. from shore; these regions are also considered BIAs (Baird et al. 2015). Proposed seismic Line 1 traverses the BIA west of the Big Island of Hawaii.

During small-boat surveys around the Hawaiian Islands in 2000–2012, it was sighted in water as deep as 3000 m, with the highest sighting rates in water <500 m deep (Baird et al. 2013). It was seen during all months, including off the west coast of the Big Island and off Oahu (Baird et al. 2013). Spinner dolphins were also sighted in the proposed survey area during summer–fall surveys of the Hawaiian Islands EEZ, including south of Ohau (see map in Carretta et al. 2017); eight sightings were made in 2002 (Barlow 2006) and four were made in 2010 (Bradford et al. 2013).

Kato et al. (2005) noted that spinner dolphins were seen during Japanese sighting surveys in the western North Pacific in August–September. To the best of our knowledge, there are no data on the occurrence of spinner dolphins near the Emperor Seamounts survey area. However, the survey area is located to the north of the known range of the spinner dolphins.

3.3.2.16 Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50°N to 40°S (Perrin et al. 1994a; Jefferson et al. 2015). It is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling (Archer 2009). It occurs primarily in pelagic waters, but has been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2015).

The striped dolphin is expected to be one of the most abundant cetaceans in the proposed Hawaiian survey area, based on previous surveys in the region (Barlow 2006; Baird et al. 2013; Bradford et al. 2017). Higher densities are expected to occur around in offshore waters of the Hawaiian EEZ (Forney et al. 2015). During small-boat surveys around the Hawaiian Islands in 2000–2012, sightings were made in water depths of 1000–5000 m, with the highest sighting rates in water deeper than 3000 m (Baird et al. 2013). Sightings were made during all seasons, including near proposed seismic Line 1 off the Big Island (Baird et al. 2013). It was also sighted within the proposed survey area during summer–fall shipboard surveys of the Hawaii Islands EEZ, including north and south of the Main Hawaiian Islands (see map in Carretta et al. 2017); 15 sightings were made in 2002 (Barlow 2006) and 25 sightings were made in 2010 (Bradford et al. 2013).

In the western North Pacific, the striped dolphin was one of the most common dolphin species seen during Japanese summer sighting surveys (Miyashita 1993a). During these surveys, densities were highest in offshore areas between 35ºN and 40ºN, and in coastal waters of southeastern Japan (Miyashita 1993a). Although only part of the proposed Emperor Seamounts survey area was surveyed during the month of August, no sightings were made within the survey area; sightings near the proposed survey area, south of 41ºN, were made during August (Miyashita 1993a). Kanaji et al. (2017) reported on another record during summer to the southwest of the survey area. One winter bycatch record was reported just to the south of the survey area for October 1990 to May 1991 (Hobbs and Jones 1993). Based on its distributional range and habitat preferences, the striped dolphin could be encountered in the Emperor Seamounts survey area.

3.3.2.17 Fraser's Dolphin (*Lagenodelphis hosei*)

Fraser's dolphin is a tropical oceanic species distributed between 30°N and 30°S that generally inhabits deeper, offshore water (Dolar 2009). It occurs rarely in temperate regions and then only in relation to temporary oceanographic anomalies such as El Niño events (Perrin et al. 1994b). In the ETP, it was sighted at least 15 km from shore in waters 1500–2500 m deep (Dolar 2009).

Fraser's dolphin is one of the most abundant cetaceans in the offshore waters of the Hawaiian Islands EEZ (Barlow 2006; Bradford et al. 2017). Summer–fall shipboard surveys of the EEZ resulted in two sightings of Fraser's dolphin in 2002 and four in 2010, all in the western portion of the EEZ (Barlow 2006; Bradford et al. 2013; Carretta et al. 2017). During small-boat surveys around the Hawaiian Islands in 2000–2012, only two sightings were made off the west coast of the Big Island, one during winter and one during spring in water deeper than 1000 m.

Fraser's dolphin was seen during Japanese sighting surveys in the western North Pacific during August–September (Kato et al. 2005). However, its range does not extend as far north as the Emperor Seamounts survey area. Thus, Fraser's dolphin is not expected to occur in the Emperor Seamounts survey area, but it could be encountered in deep water of the Hawaii survey area.

3.3.2.18 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

The Pacific white-sided dolphin is found throughout the temperate North Pacific, in a relatively narrow distribution between 38°N and 47°N (Brownell et al. 1999). It is common both on the high seas and along the continental margins (Leatherwood et al. 1984; Dahlheim and Towell 1994; Ferrero and Walker 1996). Pacific white-sided dolphins often associate with other species, including cetaceans (especially Risso's and northern right whale dolphins; Green et al. 1993), pinnipeds, and seabirds.

Pacific white-sided dolphins were seen throughout the North Pacific during surveys conducted during 1983–1990 (Buckland et al. 1993; Miyashita 1993b). Sightings were made in the western Pacific during the summer (Buckland et al. 1993; Miyashita 1993b), as well as during spring and fall (Buckland et al. 1993). Pacific white-sided dolphins were observed in the southern portion of the Emperor Seamounts survey area, south of 45°S, as well as at higher latitudes just to the east (Buckland et al. 1993; Miyashita 1993b). Bycatch in the squid driftnet fishery has also been reported for the Emperor Seamounts survey area (Hobbs and Jones 1993; Yatsu et al. 1993). Thus, Pacific white-sided dolphins could be encountered in the Emperor Seamounts survey area, but they are not known to occur as far south as Hawaii.

3.3.2.19 Northern Right Whale Dolphin (*Lissodelphis borealis*)

The northern right whale dolphin is found in cool temperate and sub-arctic waters of the North Pacific, ranging from 34–55°N (Lipsky 2009). It occurs from the Kuril Islands south to Japan and eastward to the Gulf of Alaska and southern California (Rice 1998). The northern right whale dolphin is one of the most common marine mammal species in the North Pacific, occurring primarily on the outer continental shelf, slope waters, and oceanic regions, where water depths are >100 m (see Green et al. 1993; Barlow 2003; Carretta et al. 2017). The northern right whale dolphin does, however, come closer to shore where there is deep water, such as over submarine canyons (Jefferson et al. 2015).

Northern right whale dolphins were seen throughout the North Pacific during surveys conducted during 1983–1990, with sightings made in the western Pacific primarily during the summer (Buckland et al. 1993; Miyashita 1993b). Northern right whale dolphins were observed in the southern portion of the Emperor Seamounts survey area, south of 45°S (Buckland et al. 1993; Miyashita 1993b). Bycatch records for the Emperor Seamounts survey area have also been reported (Hobbs and Jones 1993; Yatsu et al. 1993). One sighting was made just to the east of the survey area, at a more northerly latitude (Miyashita 1993b). Thus, northern right whale dolphins could be encountered in the Emperor Seamounts survey area, but their distribution does not range as far south as the Hawaiian Islands.

3.3.2.20 Risso's Dolphin (*Grampus griseus*)

Risso's dolphin is primarily a tropical and mid-temperate species distributed worldwide (Kruse et al. 1999). It occurs between 60ºN and 60ºS, where surface water temperatures are at least 10ºC (Kruse et al. 1999). Water temperature appears to be an important factor affecting its distribution (Kruse et al. 1999). Although it occurs from coastal to deep water, it shows a strong preference for mid-temperate waters of the continental shelf and slope (Jefferson et al. 2014).

During small-boat surveys around the Hawaiian Islands in 2000–2012, sighting rates were highest in water >3000 m deep (Baird et al. 2013). Sightings were made during all seasons off the west coast of the Big Island, including near proposed seismic Line 1; no sightings were made off Oahu (Baird et al. 2013). During summer–fall surveys of the Hawaiian Islands EEZ, seven sightings were made in 2002 (Barlow 2006) and 10 were made in 2010 (Bradford et al. 2017); several sightings occurred within the proposed survey area south of the Main Hawaiian Islands (see map in Carretta et al. 2017).

Risso's dolphins were regularly seen during Japanese summer sighting surveys in the western North Pacific (Miyashita 1993a), and one individual was seen in the offshore waters east of Japan on 18 August 2010 during the Shatksy Rise cruise (Holst and Beland 2010). Occurrence in the western North Pacific appears to be patchy, but high densities were observed in coastal waters, between 148ºE–157ºE, and east of 162ºE (Miyashita 1993a). Although only part of the proposed Emperor Seamounts survey area was surveyed during the month of August, no sightings were made within the survey area; however, sightings were made south of 41ºN (Miyashita 1993a). As its regular northern range extends to the southernmost portion of the Emperor Seamounts survey area, and one record has been reported outside of its range in the Aleutian Islands (Jefferson et al. 2014), the occurrence of Risso's dolphin is expected to be rare in the Emperor Seamounts survey area.

3.3.2.21 Melon-headed Whale (*Peponocephala electra*)

The melon-headed whale is an oceanic species found worldwide in tropical and subtropical waters from ~40°N to 35°S (Jefferson et al. 2015). It is commonly seen in mixed groups with other cetaceans (Jefferson and Barros 1997; Huggins et al. 2005). It occurs most often in deep offshore waters and occasionally in nearshore areas where deep oceanic waters occur near the coast (Perryman 2009). In the North Pacific, it is distributed south of central Japan and southern California, as well as across the Pacific, including Hawaii.

Photo-identification and telemetry studies have revealed that there are two distinct populations of melon-headed whales in Hawaiian waters—the Hawaiian Islands stock and the Kohala resident stock associated with the west coast of the Big Island (Aschettino et al. 2012; Oleson et al. 2013; Carretta et al. 2017). During small-boat surveys around the Hawaiian Islands in 2000–2012, sightings were made during all seasons in all water depths up to 5000 m, including sightings off the west coasts of the Big Island and Oahu (Baird et al. 2013). There are numerous records near the proposed seismic transect off the west coast of the Big Island (Carretta et al. 2017); this area is considered a BIA (Baird et al. 2015). Forney et al. (2107) reported that this small resident population may be particularly sensitive to noise exposure. Seismic transects through the Kohala resident stock range would be planned to occur during daylight, if possible.

During summer–fall surveys of the Hawaiian Islands EEZ in 2002 and 2010, there was a single sighting each year; neither was located near the proposed survey area (Barlow et al. 2004; Bradford et al. 2017). Satellite telemetry data revealed distant pelagic movements, associated with feeding, nearly to the edge of the Hawaiian Islands EEZ (Oleson et al. 2013).

Melon-headed whales have been seen during Japanese sighting surveys in the western North Pacific in August–September (Kato et al. 2005). However, their distributional range does not extend to the Emperor Seamounts survey area. Thus, melon-headed whale is expected to occur in the proposed Hawaiian survey area, but not in the Emperor Seamounts survey area.

3.3.2.22 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale has a worldwide distribution in tropical and subtropical waters (Donahue and Perryman 2009), generally not ranging south of 35°S (Jefferson et al. 2015). In warmer water, it is usually seen close to the coast (Wade and Gerrodette 1993), but it is also found in deep waters. In the North Pacific, it occurs from Japan and Baja, California, southward and across the Pacific Ocean, including Hawaii.

A small resident population inhabits the waters around the Main Hawaiian Islands (Oleson et al. 2013), where it generally occurs within ~20 km from shore (Baird et al. 2011). During small-boat surveys around the Hawaiian Islands in 2000–2012, sightings were made during all seasons in water up to 3000 m deep, off the west coasts of Oahu and the Big Island (Baird et al. 2013), including near proposed seismic Lines 1 and 2. The waters off the west and southeast coasts of the Big Island are considered a BIA (Baird et al. 2015). Pygmy killer whales were also recorded during summer–fall surveys of the Hawaiian Islands EEZ: three sightings in 2002 (Barlow et al. 2004; Barlow 2006) and five in 2010 (Bradford et al. 2017), including some within the study area to the north and south of the Main Hawaiian Islands (Carretta et al. 2017).

Kato et al. (2005) reported the occurrence of this species during Japanese sighting surveys in the western North Pacific in August–September. However, its distributional range indicates that the pygmy killer whale is unlikely to occur in the Emperor Seamounts survey area.

3.3.2.23 False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found worldwide in tropical and temperate waters, generally between 50ºN and 50ºS (Odell and McClune 1999). It is widely distributed, but generally uncommon throughout its range (Baird 2009). It is gregarious and forms strong social bonds, as is evident from its propensity to strand en masse (Baird 2009). The false killer whale 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). In the North Pacific, it occurs from Japan and southern California, southward and across the Pacific, including Hawaii.

Telemetry, photo-identification, and genetic studies have identified three independent populations of false killer whales in Hawaiian waters: Main Hawaiian Islands Insular, Northwestern Hawaiian Islands, and Hawaii pelagic stocks (Chivers et al. 2010; Baird et al. 2010, 2013; Bradford et al. 2014; Carretta et al. 2017). The population inhabiting the Main Hawaiian Islands is thought to have declined dramatically since 1989; the reasons for this decline are still uncertain, although interactions with longline fisheries have been suggested (Reeves et al. 2009; Bradford and Forney 2014). Higher densities likely occur in the western-most areas of the Hawaiian EEZ (Forney et al. 2015).

During 2008–2012, 26 false killer whales were observed hooked or entangled by longline gear within the Hawaiian Islands EEZ or adjacent high-seas waters, and 22 of those were assessed as seriously injured; locations of false killer whale and unidentified blackfish takes observed included the proposed survey area (Bradford and Forney 2014). Critical habitat has been designated for the endangered insular population of the false killer whale in Hawaii; in general, this includes waters between the 45- and 3200-m isobaths in the Main Hawaiian Islands (NMFS 2018b).

High-use areas in Hawaii include the north half of the Big Island, the northern areas of Maui and Molokai, and southwest of Lanai (Baird et al. 2012). These areas are considered BIAs (Baird et al. 2015), and proposed seismic Line 1 to the west of the Big Island traverses the BIA. Individuals are found up to 122 km from shore (Baird et al. 2012). Satellite-tagged false killer whales were also recorded using the areas off the western Big Island and west of Oahu during summer 2008 and fall 2009 (Baird et al. 2012). During small-boat surveys around the Hawaiian Islands in 2000–2012, the highest sighting rates occurred in water >3500 m deep (Baird et al. 2013). Sightings were made during all seasons, including off the west coast of the Big Island and Oahu (Baird et al. 2013). During summer–fall surveys of the Hawaiian Islands EEZ, two sightings were made in 2002 (Barlow et al. 2004; Barlow 2006) and 14 were made in 2010 (Bradford et al. 2017), including two within the study area, south of the Main Hawaiian Islands (see map in Carretta et al. 2017). False killer whales were also detected acoustically off the west coast of the Big Island and off Kauai (Baumann-Pickering et al. 2015).

False killer whales have been seen during Japanese summer sighting surveys in the western Pacific Ocean (Miyashita 1993a), and a sighting of four individuals was made in offshore waters east of Japan in August 2010 during the Shatksy Rise cruise (Holst and Beland 2010). The distribution in the western Pacific was patchy, with several high-density areas in offshore waters (Miyashita 1993a). Although only part of the proposed Emperor Seamounts survey area was surveyed during the month of August, no sightings were made within the survey area; however, one sighting was made just to the southeast of the survey area (Miyashita 1993a). Jefferson et al. (2015) did not show its distributional range to include the Emperor Seamounts region.

False killer whale is expected to occur in the proposed Hawaiian survey area, but it is likely rare, if present at all, in the Emperor Seamounts survey area.

3.3.2.24 Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the World (Ford 2009). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). High densities of the species occur in high latitudes, especially in areas where prey is abundant. Killer whale movements generally appear to follow the distribution of their prey, which includes marine mammals, fish, and squid.

Killer whales are rare in the Hawaii Islands EEZ. Baird et al. (2006) reported 21 sighting records in Hawaiian waters between 1994 and 2004. During small-boat surveys around the Hawaiian Islands in 2000–2012, a single sighting was made during spring in water <2000 m deep off the west coast of the Big Island (Baird et al. 2013). During summer–fall surveys of the Hawaiian Islands EEZ, two sightings were made in 2002 (Barlow et al. 2004; Barlow 2006) and one was made in 2010 (Bradford et al. 2017); none was made within the proposed survey area (Barlow et al. 2004; Bradford et al. 2017; Carretta et al. 2017). Numerous additional sightings in and north of the EEZ have been made by observers on longliners, some at the edge of the EEZ north of the Main Hawaiian Islands (Carretta et al. 2017).

Very little is known about killer whale abundance and distribution in the western Pacific Ocean outside of Kamchatka. However, they are common along the coast of Russia, Sea of Okhotsk, and Sea of Japan, Sakhalin Island, and Kuril Islands (Forney and Wade 2006). Kato et al. (2005) reported sightings of this species during Japanese sighting surveys in the western North Pacific in August–September. However, there is very little information on killer whales for the Emperor Seamounts survey area, but based on information regarding the distribution and habitat preferences, they are likely to occur there (see Forney and Wade 2006).

Killer whales are expected to occur in both the proposed Hawaiian and Emperor survey areas.

3.3.2.25 Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The short-finned pilot whale is found in tropical and warm temperate waters; it is seen as far south as ~40ºS and as far north as 50ºN (Jefferson et al. 2015). It is generally nomadic, but may be resident in certain locations, including Hawaii. Pilot whales occur on the shelf break, over the slope, and in areas with prominent topographic features (Olson 2009). Based on genetic data, Van Cise et al. (2017) suggested that two types of short-finned pilot whales occur in the Pacific – one in the western and central Pacific, and one in the Eastern Pacific; they hypothesized that prey distribution rather than sea surface temperature determine their latitudinal ranges.

During surveys of the Main Hawaiian Islands during 2000–2012, short-finned pilot whales were the most frequently sighted cetacean (Baird et al. 2013). Higher densities are expected to occur around the Hawaiian Islands rather than in far offshore waters of the Hawaiian EEZ (Forney et al. 2015). Photo-identification and telemetry studies indicate that there may be insular and pelagic populations of short-finned pilot whales in Hawaii (Mahaffy 2012; Oleson et al. 2013). Genetic research is also underway to assist in delimiting population stocks for management (Carretta et al. 2017). During small-boat surveys around the Hawaiian Islands in 2000–2012, pilot whales were sighted in water as deep as 5000 m, with the highest sighting rates in water depths of 500–2500 m (Baird et al. 2013). Sightings were made during all seasons, mainly off the west coasts of the Big Island and Ohau (Baird et al. 2013). The waters off the west coast of the Big Island are considered a BIA (Baird et al. 2015); proposed seismic tLine 1 traverses the BIA. During summer–fall surveys of the Hawaiian Islands EEZ, 25 sightings were made in 2002 (Barlow 2006) and 36 were made in 2010 (Bradford et al. 2017), including within the proposed survey area, north, south, and between the Main Hawaiian Islands (see Carretta et al. 2017). Short-finned pilot whales were also detected acoustically off the west coast of the Big Island and off Kauai (Baumann-Pickering et al. 2015).

Stock structure of short-finned pilot whales has not been adequately studied in the North Pacific, except in Japanese waters, where two stocks have been identified based on pigmentation patterns and head shape differences of adult males (Kasuya et al. 1988). The southern stock of short-finned pilot whales has been observed during Japanese summer sightings surveys (Miyashita 1993a) and is morphologically similar to pilot whales found in Hawaiian waters (Carretta et al. 2017). Distribution of short-finned pilot whales in the western North Pacific appears to be patchy, but high densities were observed in coastal waters of central and southern Japan and in some areas offshore (Miyashita 1993a). A sighting of three individuals was made in offshore waters east of Japan in August 2010 during the Shatksy Rise cruise (Holst and Beland 2010). Although only part of the proposed Emperor Seamounts survey area was surveyed during the month of August, no sightings were made within or near the survey area; offshore sightings to the south of the proposed survey area were made during the month of September (Miyashita 1993a). Although Jefferson et al. (2015) did not include the Emperor Seamounts region in its distributional range, Olson (2009) did.

Short-finned pilot whales are expected to occur in the proposed Hawaiian survey area; their occurrence in the Emperor Seamounts survey area is expected to be rare.

3.3.2.26 Dall's Porpose (*Phocoenoides dalli*)

Dall's porpoise is only found in the North Pacific and adjacent seas. It is widely distributed across the North Pacific over the continental shelf and slope waters, and over deep (>2500 m) oceanic waters (Hall 1979), ranging from ~30–62ºN (Jefferson et al. 2015). In general, this species is common throughout its range (Buckland et al. 1993). It is know to approach vessels to bowride (Jefferson 2009b).

In the western North Pacific, there are two different color morphs which are also considered sub-species: the *truei*-type (*P. d. truei*) and the *dalli*-type (*P. d. dalli*) (Jefferson et al. 2015). They can be distinguished from each other by the extent of their white thoracic patches—the *truei*-type has a much broader patch, which extends nearly the length of the body. Both types could be encountered in the proposed Emperor Seamounts survey area.

Dall' porpoise was one of the most common cetaceans in the bycatch of the central and western North Pacific high-seas driftnet fisheries, but that source of mortality is not thought to have substantially depleted their abundance in the region (Hobbs and Jones 1993). Dall's porpoises were seen throughout the North Pacific during surveys conducted during 1987–1990 (Buckland et al. 1993), including in the western Pacific during the summer (Buckland et al. 1993; Kato et al. 2005). The observed range included the entire Emperor Seamounts survey area (Buckland et al. 1993). Records of both types within the Emperor Seamounts survey area, in particular for April–July, have also been reported by Kasuya (1982), and bycatch records in the proposed survey area have also been reported (Hobbs and Jones 1993; Yatsu et al. 1993). Thus, Dall's porpoise could be encountered in the Emperor Seamounts survey area, but its distribution does not range as far south as the Hawaiian Islands.

3.3.3 Pinnipeds

3.3.3.1 Hawaiian Monk Seal (*Neomonachus schauinslandi*)

The Hawaiian monk seal only occurs in the Central North Pacific. It is distributed throughout the Hawaiian Island chain, with most of the population occurring in the Northwestern Hawaiian Islands (within the PMNM), and a small but increasing number residing in the Main Hawaiian Islands (Baker et al. 2011). Baker et al. (2016) reported an abundance of 1309 monk seals for 2014 and 1324 seals for 2015. Six main breeding subpopulations are located at the Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals (Baker et al. 2011). Most births occur from February to August, with a peak in April to June, but births have been reported any time of the year (Gilmartin and Forcada 2009). Hawaiian monk seals show high site fidelity to natal islands (Gilmartin and Forcada 2009; Wilson et al. 2017). They mainly occur within 50 km of atolls/islands (Parrish et al. 2000; Stewart et al. 2006; Wilson et al. 2017) and within the 500-m isobath (e.g., Parrish et al. 2002; Wilson et al. 2017). Secondary occurrence may occur in water as deep as 1000 m, but occurrence beyond the 1000-m isobath is rare (DoN 2005). Nonetheless, tagged monk seals have been tracked in water >1000 m deep (Wilson et al. 2017).

Hawaiian monk seals are benthic foragers that feed on marine terraces of atolls and banks; most foraging occurs in water depths <100 m deep but occasionally to depths up to 500 m (Parrish et al. 2002; Stewart et al. 2006). Stewart et al. (2006) used satellite tracking to examine the foraging behavior of monk seals at the six main breeding colonies in the Northwestern Hawaiian Islands. Foraging trips varied by sex and by age and ranged from <1 km up to 322 km from haul-out sites. Wilson et al. (2017) reported foraging trips of up to 100 km. Satellite tracking of Hawaiian monk seals revealed that home ranges in Main Hawaiian Islands were much smaller than those in the Northwestern Hawaiian Islands (NMFS 2007, 2014a); home ranges for most seals were <2000 km^2 (Wilson et al. 2017).

Critical habitat has been designated based on preferred pupping and nursing areas, significant haul-out areas, and marine foraging areas out to a depth of 200 m (NMFS 2017b). In the Main Hawaiian Islands, critical habitat generally includes marine habitat from the seafloor to 10 m above the seafloor, from the 200-m isobath to the shoreline and 5 m inland, with some exceptions for specific areas (NMFS 2017b). For the Big Island of Hawaii, Maui, and Oahu (islands adjacent to the proposed transects), all marine habitat and inland habitat is included as critical habitat (NMFS 2017b). The seismic transects are located at least 10 km from monk seal critical habitat (Fig. 1).

Hawaiian monk seals have been reported throughout the Main Hawaiian Islands, including the west coast of Oahu, the east coast of Maui, and the north coast of the Big Island (Baker and Johanos 2004; DoN 2005). Tagged seals showed movements among the Main Hawaiian Islands, and were reported to occur near and crossing proposed seismic Lines 1 and 2 off the west coast of Oahu and the Big Island

(Wilson et al. 2017). However, the core area of occurrence around Oahu was reported to be off the south coast, not the west coast (Wilson et al. 2017). Thus, monk seals could be encountered during the proposed survey, especially in nearshore portions (<1000 m deep), as well as areas near the islands where water depth is greater than >1000 m.

3.3.3.2 Northern Fur Seal (*Callorhinus ursinus*)

The northern fur seal is endemic to the North Pacific Ocean and occurs from southern California to the Bering Sea, Okhotsk Sea, and Honshu Island, Japan (Muto et al. 2017). During the breeding season, most of the worldwide population of northern fur seals inhabits the Pribilof Islands in the southern Bering Sea (Lee et al. 2014; Muto et al. 2017). The rest of the population occurs at rookeries on Bogoslof Island in the Bering Sea, in Russia (Commander Islands, Robben Island, Kuril Islands), on San Miguel Island in southern California (NMFS 1993; Lee et al. 2014), and on the Farallon Islands off central California (Muto et al. 2017). In the U.S., two stocks are recognized—the Eastern Pacific and the California stocks (Muto et al. 2017). The Eastern Pacific stock ranges from the Pribilof Islands and Bogoslof Island in the Bering Sea during summer to California during winter (Muto et al. 2017).

When not on rookery islands, northern fur seals are primarily pelagic but occasionally haul out on rocky shorelines (Muto et al. 2017). During the breeding season, adult males usually come ashore in May–August and may sometimes be present until November; adult females are found ashore from June–November (Carretta et al. 2017; Muto et al. 2017). After reproduction, northern fur seals spend the next 7–8 months feeding at sea (Roppel 1984). Once weaned, juveniles spend 2–3 years at sea before returning to rookeries. Animals may migrate to the Gulf of Alaska, off Japan, and the west coast of the U.S. (Muto et al. 2017); in particular, adult males from the Pripilof Islands have been shown to migrate to the Kuril Islands in the western Pacific (Loughlin et al. 1999). The southern extent of the migration is ~35ºN.

Northern fur seals were seen throughout the North Pacific during surveys conducted during 1987–1990, including in the western Pacific during the summer (Buckland et al. 1993). The observed range included the entire Emperor Seamounts survey area (Buckland et al. 1993). They have also been reported as bycatch in squid and large-mesh fisheries during summer in the Emperor Seamounts survey area (Hobbs and Jones 1993; Yatsu et al. 1993). Tracked adult male fur seals that were tagged on St. Paul Island in the Bering Sea in October 2009, wintered in the Bering Sea or northern North Pacific Ocean, and approached near the eastern-most extent of the Emperor Seamounts survey area; females migrated to the Gulf of Alaska and the California Current (Sterling et al. 2014). Tagged pups also approached the eastern portion of the Emperor Seamounts survey area during November (Lea et al. 2009). Thus, northern fur seals could be encountered in the Emperor Seamounts survey area; only juveniles would be expected to occur there during the summer. Their distribution does not range as far south as the Hawaiian Islands.

3.3.3.3 Steller Sea Lion (*Eumetopias jubatus*)

The Steller sea lion occurs along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984). They are distributed around the coasts to the outer shelf from northern Japan through the Kuril Islands and Okhotsk Sea, through the Aleutian Islands, central Bering Sea, southern Alaska, and south to California (NMFS 2016c). There are two stocks or DPSs of Steller sea lions – the Western and the Eastern DPS which are divided at the 144°W longitude (NMFS 2016c). The Western DPS is listed as *endangered* and includes animals that occur in Japan and Russia (NMFS 2016c; Muto et al. 2017); the Eastern DPS was delisted from *threatened* in 2013 (NMFS 2013a). Critical habitat has been designated 20 n.mi. around all major haul-outs and rookeries, as well as three large foraging areas

(NMFS 2017b); there is no critical habitat within the proposed survey area. Only individuals from the Western DPS are expected to occur in the proposed survey area. It is uncertain whether individuals that breed in Asia are genetically different enough to warrant a separate stock of Steller sea lion (Muto et al. 2017).

Rookeries of Steller sea lions from the Western DPS are located on the Aleutian Islands and along the Gulf of Alaska, as well as the east coast of Kamchatka, Commander Islands, and Kuril Islands (Burkanov and Loughlin 2005; Fritz et al. 2016; Muto et al. 2017). Breeding adults occupy rookeries from late-May to early-July (NMFS 2008). Non-breeding adults use haulouts or occupy sites at the periphery of rookeries during the breeding season (NMFS 2008). Pupping occurs from mid-May to mid-July (Pitcher and Calkins 1981) and peaks in June (Pitcher et al. 2002). Territorial males fast and remain on land during the breeding season (NMFS 2008). Females with pups generally stay within 30 km of the rookeries in shallow (30–120 m) water when feeding (NMFS 2008). Tagged juvenile sea lions showed localized movements near shore (Briggs et al. 2005). Loughlin et al. (2003) reported that most (88%) at-sea movements of juvenile Steller sea lions in the Aleutian Islands were short (<15 km) foraging trips. The mean distance of juvenile sea lion trips at sea was 16.6 km and the maximum trip distance recorded was 447 km. Long-range trips represented 6% of all trips at sea, and trip distance and duration increase with age (Loughlin et al. 2003; Call et al. 2007). Although Steller sea lions are not considered migratory, foraging animals can travel long distances outside of the breeding season (Loughlin et al. 2003; Raum-Suryan et al. 2002).

There is little information available on at-sea occurrence of Steller sea lions in the northwestern Pacific Ocean. Even though Steller sea lions are unlikely to occur in the proposed offshore survey area based on their known distributional range and habitat preference, it is possible that they could be encountered during the Emperor Seamounts survey area.

3.3.3.4 Northern Elephant Seal (*Mirounga angustirostris*)

Northern elephant seals breed in California and Baja California, primarily on offshore islands (Stewart et al. 1994), from December–March (Stewart and Huber 1993). Adult elephant seals engage in two long northward migrations per year, one following the breeding season, and another following the annual molt, with females returning earlier to molt (March–April) than males (July–August) (Stewart and DeLong 1995). Juvenile elephant seals typically leave the rookeries in April or May and head north, traveling an average of 900–1000 km. Hindell (2009) noted that traveling likely takes place in water depths >200 m.

When not breeding, elephant seals feed at sea far from the rookeries, ranging as far north as 60°N, into the Gulf of Alaska and along the Aleutian Islands (Le Boeuf et al. 2000). Some seals that were tracked via satellite-tags for no more than 224 days traveled distances in excess of 10,000 km during that time (Le Beouf et al. 2000). Northern elephant seals that were satellite-tagged at a California rookery have been recorded traveling as far west as ~166.5–172.5°E, including the proposed Emperor Seamount survey area (Le Boeuf et al. 2000; Robinson et al. 2012; Robinson 2016 *in* OBIS 2018; Costa 2017 *in* OBIS 2018). Occurrence in the survey area was documented during August and September; during July and October, northern elephant seals were tracked just to the east of the survey area (Robinson et al. 2012). Post-molting seals traveled longer and farther than post-breeding seals (Robinson et al. 2012).

Thus, northern elephant seals could be encountered in the Emperor Seamounts survey area during summer and fall. Although there are rare records of northern elephant seals in Hawaiian waters, they are unlikely to occur in the proposed survey area.

3.3.3.5 Ribbon Seal (*Histriophoca fasciata*)

Ribbon seals occur in the North Pacific and adjacent Arctic Ocean, ranging from the Okhotsk Sea, to the Aleutian Islands and the Bering, Chukchi, and western Beaufort seas. Ribbon seals inhabit the Bering Sea ice front from late-March to early-May and are abundant in the northern parts of the ice front in the central and western parts of the Bering Sea (Burns 1970; Burns 1981). In May to mid-July, when the ice recedes, some of the seals move farther north (Burns 1970; Burns 1981) to the Chukchi Sea (Kelly 1988c). However, most likely become pelagic and remain in the Bering Sea during the open-water season, and some occur on the Pacific Ocean side of the Aleutian Islands (Boveng et al. 2008). Of 10 seals that were tagged along the cost of the Kamchatka Peninsula in 2005, most stayed in the central and eastern Bering Sea, but two were tracked along the south side of the Aleutian Islands; 8 of 26 seals that were tagged in the central Bering Sea in 2007 traveled to the Bering Strait, Chukchi Sea, and Arctic Basin (Boveng et al. 2008). Although unlikely ribbon seals could be encountered in the proposed Emperor Seamounts survey area.

3.4 Sea Turtles

Five species of sea turtles could occur in or near the proposed survey areas. ESA-listed sea turtle species that could occur in the Hawaii survey area include the ***endangered*** hawksbill, leatherback, and loggerhead (North Pacific Ocean DPS) turtles, and the ***threatened*** green (Central North Pacific DPS) and olive ridley turtles. In the Emperor Seamounts survey area, only leatherback and loggerhead (North Pacific Ocean DPS) turtles are expected to occur. Under the IUCN Red List (IUCN 2018), the hawksbill turtle is listed as *critically endangered*, the green turtle is listed as *endangered*, and the leatherback, olive ridley, and loggerhead turtles are listed as *vulnerable*. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the PEIS. General distribution of sea turtles in the western North Pacific Ocean is discussed in § 3.4.3.7 of the PEIS for the Mariana Islands, and in § 3.4.2.3 for Southern California in the eastern North Pacific Ocean. The rest of this section deals specifically with their distribution within the proposed survey areas in the North Pacific.

3.4.1 Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is the most widely distributed sea turtle, ranging far from its tropical and subtropical breeding grounds to feed (Plotkin 2003). It is found from 71°N to 47°S, and nesting occurs from 38°N to 34°S (Eckert et al. 2012). The largest nesting sites for leatherbacks in the Pacific Ocean occur on the beaches of Birdshead Peninsula in Papua, Indonesia (Dutton et al. 2007; Hitipeuw et al. 2007; Benson et al. 2008). In the western Pacific, leatherbacks also nest in New Guinea, the Solomon Islands, and Vanuatu, with fewer nesting in Fiji, Malaysia, and Australia (NMFS and USFWS 2013a). Nesting leatherbacks have also been discovered in Japan (Kamezaki et al. 2002). In the eastern Pacific, leatherbacks nest along the west coast of Mexico and Central America (Marquez 1990); critical habitat has been designated off the U.S. west coast (NMFS 2017b).

After nesting, female leatherbacks typically migrate from tropical waters to temperate areas, where higher densities of jellyfish occur in the summer (NMFS 2016d). Leatherbacks tend to feed in areas of high productivity, such as current fronts and upwelling areas, along continental margins, and in archipelagic waters (Morreale et al. 1994; Lutcavage 1996). Hatchling leatherbacks are pelagic, but nothing is known about their distribution for the first four years (Musick and Limpus 1997). Leatherbacks are highly pelagic and are known to swim more than 11,000 km each year (Eckert 1998). They are one of the deepest divers in the ocean, with dives deeper than 4000 m (Spotila 2004). The leatherback dives continually and spends short periods of time on the surface between dives (Eckert et al. 1986). During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 5 m of the surface (Eckert 2002).

Adult leatherbacks appear to migrate along bathymetric contours from 200–3500 m (Morreale et al. 1994). They appear to use the Kuroshio Extension (north of Hawaii) during migrations from Indonesia to the high seas and the eastern Pacific (Benson et al. 2008). The westward migration, from foraging grounds along the west coast of North America to western Pacific nesting sites, is believed to be south of Hawaii (Eckert pers. comm. *in* DoN 2005). It is not known whether most leatherbacks in the central Pacific Ocean come from eastern or western Pacific nesting sites, but individuals from both nesting areas occur in Hawaiian waters (Dutton et al. 1998; 2000a,b).

Although leatherbacks do not nest at U.S. Pacific Islands, they are regularly sighted in the offshore waters of Hawaii throughout the year (Nitta and Henderson 1993; DoN 2005), including the proposed survey area (Ganong 2012 *in* OBIS 2018; Benson et al. 2011; Howell et al. 2015). Leatherbacks have been caught incidentally in the Hawaiian longline fishery to the north and south of the Hawaiian Islands (McCracken 2000; DoN 2005), including near the proposed survey area. Most leatherbacks are taken as bycatch during April and May, with the fewest numbers caught in late summer/early fall and in February–March (Kobayashi and Polovina 2005).

Although nesting is limited in Japan, leatherbacks are sighted off the coast at various times of the year (Sea Turtle Association of Japan 2018). Given the patchy distribution of high biomass areas associated with the Kuroshio Extension and bifurcation, combined with the apparent leatherback migration corridor along oceanic fronts in the North Pacific (Polovina et al. 2000; Benson et al. 2011), leatherbacks could occur occasionally in the southern Emperor Seamounts survey area to feed. However, to the best of our knowledge, leatherbacks have not been seen in the Emperor Seamounts survey area north of 40°N, nor have they been caught by longliners fishing the Kuroshio Extension (e.g., Yokota et al. 2006). Satellite-tagged leatherback turtles were tracked near the proposed survey area at 166–173°E but south of 40°N (Ganong 2012 *in* OBIS 2018; Benson et al. 2011).

3.4.2 Loggerhead Turtle (*Caretta caretta*)

The loggerhead is a widely distributed species, occurring in coastal tropical and subtropical waters. Loggerhead turtle nesting in the Pacific Ocean is restricted to the western region; the two main nesting stocks in Japan and Australia/New Caledonia have been identified as genetically distinct (NMFS and USFWS 2007a). The nesting season is typically from May–August (USFWS 2003). In Japan, loggerheads mainly nest along the southern coast and the Ryukyu Islands (Conant et al. 2009), including Honshu, Shikoku, and Kyushu (Conant et al. 2009; Sea Turtle Association of Japan 2018). Surveys for nesting turtles conducted on Okinawa and adjacent islands of the central Ryukyus between 1995 and 1996 found 47 clutches belonging to loggerheads (Kikukawa et al. 1996). Loggerhead nesting along the Japanese coast occurs from April–August, with a peak in July. All loggerheads in the North Pacific originate at Japanese nesting beaches (Hatase et al. 2002).

Juvenile loggerheads in the Pacific Ocean have a very long pelagic phase that can last decades (Briscoe et al. 2016). Telemetry studies, mark-recapture data, demographics, diet analysis, and oceanographic patterns suggest that North Pacific loggerhead turtles, mostly hatched in southern Japan, are transported as hatchlings and juveniles to the North Pacific by the Kuroshio Current (Kobayashi et al. 2008). Juveniles are then likely entrained by the Kuroshio Extension, as tracked individuals have been carried eastward to the Kuroshio Extension Bifurcation Region north of Hawaii (Polovina et al. 2006). Juvenile loggerheads appear to linger in this area for months to forage in nutrient-rich surface waters from fall to winter, and spring (Polovina et al. 2006).

Generally, between the ages of 7 and 12, juvenile loggerheads move to nearshore foraging areas (NMFS 2017). For example, some loggerheads seen feeding along Baja California have been tracked genetically and by satellite telemetry; these have been shown to come from Japanese breeding sites (Bowen et al. 1995; Resendiz et al. 1998; Nichols et al. 2000). Apparently, loggerheads gather along the Baja coast to capitalize on an abundance of nutrient-rich prey, like pelagic red crabs, that accumulate in local zones of upwelling (Bowen et al. 1995). Loggerheads feed in all marine habitats, including coastal bays and estuaries, shallow water along the continental shelves, and the high seas (Bowen et al. 1995; Yokota et al. 2006; Reich et al. 2009). Adult loggerheads feed on a variety of benthic fauna like conchs, crabs, shrimp, sea urchins, sponges, and fish.

Once sexually mature, loggerheads depart feeding grounds near California and begin their long, slow journey back to natal beaches in Japan (Bowen et al. 1995; Nichols et al. 2000). During migration through the open sea they feed primarily in surface waters on jellyfish, pteropods, floating mollusks and egg clusters, flying fish, and squid (Polovina et al. 2003, 2004). Traveling <2 km/h, loggerheads appear to migrate along nutrient-rich, oceanic fronts in the North Pacific (Nichols et al. 2000; Polovina et al. 2000; Kobayashi et al. 2008). This preferred route, counter the North Pacific Current and past the Hawaiian Islands, returns loggerheads to pelagic waters where they are susceptible as bycatch to local longliners seeking tuna, swordfish, and sharks (Lewison et al. 2004). In the central Pacific, loggerheads are mainly found in pelagic waters, and this region is thought to be an important foraging area for juvenile loggerheads (Brisco et al. 2016). They are rarely sighted near the islands of Hawaii, but are seen in offshore waters north of Hawaii throughout the year (McCracken 2000; DoN 2005; Kobayashi and Polovina 2005). Bycatch takes in the longline fishery have also been reported for the offshore waters north of Hawaii, with most taken during January and February (McCracken 2000; Kobayashi and Polovina 2005). Satellite-tagged loggerheads have been located near and within the proposed Hawaii survey area (Nichols et al. 2000; Polovina et al. 2004; Kobayashi et al. 2008; Briscoe et al. 2016; Parker et al. 2015 *in* OBIS 2018).

After returning to Japan to breed, adult loggerheads tend to remain in the western Pacific, migrating annually between nesting beaches in Japan and feeding grounds in the South and East China seas (Sato et al. 1997; Nichols 2005; Parker et al. 2005). Loggerheads were seen within the proposed Emperor Seamounts survey area during August and September of 2010, 2011, and 2012 (Parker et al. 2015 *in* OBIS 2018). Bycatch has also been reported in the Kuroshio Extension near the proposed survey area, south of 40°N (Yokota et al. 2006).

3.4.3 Hawksbill Turtle (*Eretmochelys imbricata*)

The hawksbill is the most tropical of all sea turtles, with nesting occurring between ~30ºN and ~30ºS (Eckert 1995). In the western Pacific, major hawksbill turtle nesting areas can be found in Australia, Indonesia, Papua New Guinea, and the Philippines (NMFS and USFWS 2013b). In the central Pacific, nesting is widespread, occurring at scattered locations in low numbers (NMFS 2014b). Hawksbill turtles are typically associated with clear, coastal waters of mainland and island shelves, seagrass pastures, and coral reefs (Márquez 1990).

Hawksbills nest on low- and high-energy beaches, often sharing high-energy locations with green turtles. They most commonly perform short-distance movements between nesting beaches and offshore feeding banks, although long-distance movements are also known (NMFS and USFWS 2013b). Post-hatchlings are believed to be pelagic for several years, taking shelter in *Sargassum* associated with convergence zones (NMFS and USFWS 2013b); they re-enter coastal waters after a few years (NMFS

2014b). In the Pacific, the pelagic habitat of hawksbill juveniles is unknown (NMFS 2014b).

In Hawaii, hawksbills nest primarily on the east coast of the Big Island, but a few nest on Maui and Molokai; only ~20 females nest in Hawaii every year (NMFS and USFWS 2013b). Nesting typically occurs from May through December (NMFS 2014b). DoN (2005) did not report any records of hawksbills for the offshore waters of Hawaii but noted that the main area of occurrence is within the 100-m isobath. Similarly, Van Houtan et al. (2016) concluded from strandings, bycatch, and simulations that, in Hawaii, this species spends the first 4 years of its life in coastal waters. Hawksbill turtles are not taken as bycatch in the longline fishery (McCracken et al. 2000; Kobayashi and Polovina 2005. Hawksbill turtles could occur in the proposed Hawaii survey area, especially in coastal areas; however, they are not expected to occur in the Emperor Seamounts survey area.

3.4.4 Olive Ridley Turtle (*Lepidochelys olivacea*)

The olive ridley has a large range in tropical and subtropical regions in the Pacific, Indian, and south Atlantic oceans (NMFS 2014c) and is generally found between 40ºN and 40ºS. It is primarily a pelagic species (NMFS 2014c), capable of feeding at considerable depths (80–300 m), although ~90% of its time is spent at depths <100 m (Eckert et al. 1986; Polovina et al. 2003). In the western Pacific, olive ridley turtle nesting colonies occur in Australia, Brunei, Malaysia, Indonesia, and Vietnam (Shanker and Pilcher 2003; NMFS and USFWS 2014).

The largest nesting area is along the northeast coast of India; the second largest nesting area is in the eastern Pacific in southern Mexico and northern Costa Rica. No nesting occurs in the U.S. Pacific Islands (NMFS and USFWS 2014). In the eastern Pacific, most olive ridleys nest synchronously in huge colonies called “arribadas”, with several thousand females nesting at the same time; others nest alone, out of sequence with the arribada (Kalb and Owens 1994). Olive ridleys nest throughout the year in the eastern Pacific (NMFS and USFWS 2014). Females and males begin to aggregate near their nesting beaches two months before the nesting season (Arenas and Hall 1992). However, Pitman (1990) observed olive ridleys mating at sea, as far as 1850 km from the nearest mainland, during every month of the year except March and December. There was a sharp peak in offshore mating activity during August and September, corresponding with peak breeding activity in mainland populations. Of 324 olive ridleys that were captured during surveys in the ETP (including offshore waters to 155ºW), 50 were involved in mating (Kopitsky et al. 2002).

Outside of the breeding season, the turtles disperse, but little is known of their behavior. The post-nesting migration routes of olive ridleys tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters ranging from Mexico to Peru, and more than 3000 km out into the central Pacific (Plotkin et al. 1994a). However, movements of turtles tagged in Central America were highly dissociated from each other, indicating that olive ridleys are “nomadic epipelagic foragers that prey on patchily distributed food” (Morreale et al. 2007). Neither males nor females migrate to one specific foraging area, but exhibit a nomadic movement pattern and occupy a series of feeding areas in the oceanic waters (Plotkin et al. 1994a,b). In the high seas of the ETP, the olive ridley is the most abundant sea turtle; it can be seen foraging or mating in groups exceeding 1000 called flotillas (Pitman 1990; Arenas and Hall 1992; Kopitsky et al. 2000).

Individuals from both the eastern and western Pacific nesting populations feed in the central North Pacific (Dutton et al. 2000b). However, olive ridleys from the western Pacific have been associated with the Kuroshio Extension Bifurcation region (~35°N), whereas olive ridleys from the eastern Pacific region occur farther south (south of ~28°N) in the center of the North Pacific subtropical gyre (Polovina et al.

2004). Satellite telemetry showed locations of olive ridley turtles near the Hawaii survey area (Polovina et al. 2004). Olive ridleys have been taken as bycatch in the Hawaiian longline fishery in offshore waters to the north and south of Hawaii throughout the year (McCracken 2000; Kobayashi and Polovina 2005), including near and within the proposed survey area. They are sighted in particularly high densities in the offshore waters south of Hawaii (DoN 2005; Parker et al. 2015 *in* OBIS 2018).

Presumably, olive ridleys are attracted to offshore areas of high productivity (e.g., current front and back-eddies of the Kuroshio Extension and bifurcation), e.g., akin to loggerheads (Polovina et al. 2006). However, to the best of our knowledge, olive ridleys have not been seen in the proposed Emperor Seamounts survey area, nor have they been caught by longliners fishing the Kuroshio Extension (e.g., Yokota et al. 2006). However, they are known to occur off the coast of Japan at various times of the year (Sea Turtle Association of Japan 2018).

3.4.5 Green Turtle (*Chelonia mydas*)

The green turtle is widely distributed in tropical and subtropical waters near continental coasts and around islands, ranging from ~30°N to 30°S (NMFS 2016e). Major nesting sites in the western Pacific include Raine Island off eastern Australia, where ~25,000 females nest, Indonesia, Malaysia, and the Philippines (Shanker and Pilcher 2003; NMFS and USFWS 2007d).

In the central Pacific, green turtles are found around most tropical islands, including Hawaii (NMFS 2016e). In Hawaii, most green turtles (~400 females) breed and nest at French Frigate Shoals, Northwestern Hawaiian Islands, from April through October (DoN 2005; NMFS and USFWS 2007d). Green turtles can undertake long migrations from foraging areas to nesting sites (NMFS 2016e). Turtles that feed around the Main Hawaiian Islands migrate to the Northwest Hawaiian Islands to nest (NMFS 2016e). However, tagging data have not revealed movements of turtles between Hawaii and other areas in the Pacific (Seminoff et al. 2015).

Mature females typically show nest-site fidelity and return to their natal beaches to nest repeatedly (NMFS and USFWS 2007d). Hatchlings swim to offshore areas where they are pelagic for several years (NMFS and USFWS 2007d). Subsequently, most green turtles travel to nearshore areas where they live in bays and along protected shorelines, and feed on algae and seagrass (NMFS 2016e). While in oceanic habitats near Hawaii, green turtles feed on jellyfish and other pelagic prey (Parker and Balazs 2008). Juvenile and sub-adult green turtles can travel thousands of kilometers before they return to breeding and nesting grounds (Carr et al. 1978).

In nearshore waters of Hawaii, the green turtle is the most common turtle species. Some green turtles have been sighted or taken as bycatch in fisheries operations in offshore waters of Hawaii (McCracken 2000; DoN 2005; Koboyashi and Polovina 2005), including near and within the proposed survey area. Most bycatches occur in May–July (Koboyashi and Polovina 2005). Green turtles in oceanic waters around Hawaii are most likely to be juvenile turtles in their pelagic life stage or reproductive turtles migrating between Hawaiian Islands (DoN 2005).

In Japan, green turtles nest at Okinawa and adjacent islands of the central Ryukyus, as well as in the Ogasawara Islands (Chan et al. 2007). In 1995 and 1996, surveys of Okinawa and the central Ryukyus, Japan, found five clutches belonging to green turtles (Kikukawa et al. 1996). The nesting period in this area seems to range from mid-May to mid-July (Kikukawa et al. 1996). Satellite telemetry showed that the foraging grounds of adult green turtles nesting at Wan-an Island, Taiwan, included the coastal waters off northern Taiwan, Nanao Island, Huidong, Hong Kong, Donsha Archipelago, Hainan Island, east coast of Leizhou Peninsula, northern Philippines, Ryukyu Archipelago (Japan), and Koshiki in southern Japan (Cheng et al. 2000; Cheng and Chen 1997). One post-nesting green turtle from Wan-an Island and another from Gangkou Sea Turtle National Reserve spent time in the nearshore waters of Okinawa Island, Japan (Cheng 2000a; Song et al. 2002). The northeastern waters of Okinawa Island are also known foraging sites for green turtles. However, to the best of our knowledge, green sea turtles have not been seen in the Emperor Seamounts survey area, nor have they been caught by longliners fishing the Kuroshio Extension (e.g., Yokota et al. 2006). The Emperor Seamounts are likely too far north and offshore to be inhabited by green turtles.

3.5 Seabirds

Four seabird species that are listed under the ESA could occur in or near proposed survey areas: Newell's shearwater (*Puffinus [auricularis] newelli*), Hawaiian petrel (*Pterodroma sandwichensis*), short-tailed albatross (*Phoebastria albatrus*), and the Hawaii DPS of the band-rumped storm-petrel (*Oceanodroma castro*). General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of seabird families is given in § 3.5.1 of the PEIS. Hawaiian petrel and short-tailed albatross are listed as ***endangered*** under the ESA and as *vulnerable* on the IUCN Red list of Threatened Species, and Newell's shearwater is listed as ***threatened*** under the ESA and *endangered* on the IUCN Red list of Threatened Species (IUCN 2018). Band-rumped storm-petrel is listed under the ESA as ***endangered***; it is listed as *least concern* on the IUCN Red List of Threatened Species.

Several other aquatic bird species that are listed under the ESA occur in the general vicinity of the proposed survey areas, but are not expected to be encountered during the proposed surveys. Steller's eider (*Polysticta stelleri*) is listed as ***threatened*** under the ESA and *vulnerable* on the IUCN Red list of Threatened Species (IUCN 2018). This species winters in coastal marine waters of the Aleutian Islands but is not known to frequent areas away from these coastlines such as the Emperor Seamounts region (Frederickson 2001). Hawaiian duck (*Anas wyvilliana*) is listed as ***endangered*** under the ESA and *endangered* by the IUCN (2018). This species is limited to fresh waters and no longer occurs in coastal areas (Engilis et al. 2002). Laysan duck (*A. laysanensis*) is listed as ***endangered*** under the ESA and *critically endangered* by the IUCN (2018). This species occasionally occurs on the shores of Laysan Island in Hawaii, but is not expected to occur beyond the intertidal zone (Moulton et al. 1996). Hawaiian goose (*Branta [Nesochen] sandvicensis*) is listed as ***endangered*** under the ESA and as *vulnerable* by the IUCN (2018). This species is primarily terrestrial and uses fresh water bodies, but is not expected to occur in marine waters (Banko et al. 1999). Hawaiian coot (*Fulica [americana] alai*) is listed as ***endangered*** under the ESA and as *vulnerable* by the IUCN (2018). Hawaiian common gallinule (*Gallinula galeata sandvicensis*) is listed as ***endangered*** under the ESA and *least concern* by the IUCN (2018). These two species' habitats are primarily freshwater wetlands and also include estuaries and lagoons (Bannor and Kiviat 2002; Pratt et al. 2002). However, these species do not occur in truly marine waters.

3.5.1 Newell's Shearwater

Newell's shearwater has experienced substantial population declines in recent decades (Ainley et al. 1997); based on pelagic surveys in the 1990s, the population size was estimated at 84,000 individuals (Spear et al. 1995). Radar surveys at Kauai from 1993–2013 showed the number of breeding individuals has declined 13% per year (Raine et al. 2017a). Based on at-sea surveys from 1998–2011, the population is now estimated to be 27,011 individuals (Raine et al. 2017a). The majority (90%) of Newell's shearwater nest on Kauai, and smaller colonies are found on other islands in Hawaii; some nesting may also occur in French Polynesia (Birdlife International 2018). Eggs are laid in June, and young fledge by

November (Mitchell et al. 2005). They are common in Hawaii during the breeding season (March–September) but uncommon from October through February (King 1970; Spear et al. 1995). Newell's shearwater is known to forage near ocean fronts in the Equatorial Counter Current up to 1300 km from colonies during spring and autumn (Spear et al. 1995). It's at-sea distribution is mainly concentrated to the east and south of the Hawaiian Islands (Spear et al. 1995; WPRFMC 2018). King (1970) reported sightings in and near the proposed survey area during March–October 1964. DoN (2005) also reported sightings in the proposed survey area.

This species is expected to occur in the Hawaiian survey area throughout the year, but not in the Emperor Seamount survey area.

3.5.2 Hawaiian Petrel

The Hawaiian petrel has an estimated population size of 19,000 (Spear et al. 1995). However, the population of Hawaiian petrels is declining, mainly because of predation by introduced vertebrates, including mongooses, cats, and goats (USWFS 2005). Radar surveys at nesting areas on Kauai from 1993–2011 revealed a decline in the number of breeding individuals of 6% per year (Raine et al. 2017a). The Hawaiian petrel is endemic to Hawaii, where it nests at high elevation. Known nesting habitats include lava cavities, burrows on cliff faces or steep slopes, and beneath ferns (USFWS 2005). The majority of eggs are laid in May and June, and most young fledge in December (Mitchell et al. 2005). Hawaiian petrels can travel up to 1300 km away from colonies during foraging trips; at-sea densities decrease with distance from the colony (Spear et al. 1995). DoN (2005) reported sightings near the survey area off the west coast of the Big Island. King (1970) reported that the highest densities of dark-rumped petrels (likely to be Hawaiian petrels) are found north of Hawaii at ~25°N; several sightings within and near the proposed survey area were made during October 1964–June 1965. Spear et al. (1995) showed the distribution of dark-rumped petrels to be concentrated in the southern portion of the Main Hawaiian Islands (below 20°N) during spring and autumn.

This species is only expected to occur in the Hawaiian survey area from May–October, but not at the Emperor Seamount survey area (Onley and Scofield 2007).

3.5.3 Short-tailed Albatross

Historically, millions of short-tailed albatrosses bred in the western North Pacific Ocean on islands off the coast of Japan. This species was the most abundant albatross in the North Pacific. However, the entire population was nearly extirpated during the last century by feather hunters at Japanese breeding colonies. In addition, the breeding grounds of the remaining birds were threatened by volcanic eruptions in the 1930s; this species was believed to be extinct in 1949 until it was rediscovered in 1951 (BirdLife International 2018). However, this population is increasing, and the most recent population estimate is 4200 individuals (Birdlife International 2018). Current threats to this population include volcanic activity on Torishima, commercial fisheries, and pollutants (USFWS 2008).

Currently, nearly all short-tailed albatrosses breed on two islands off the coast of Japan: Torishima and Minami-kojima (UWFWS 2008; BirdLife International 2018). Single nests have been found in recent years on other islands, including Kita-Kojima, Senkaku; Yomejima Island; and Midway Island, Hawaii; however, nesting attempts in Hawaii have not been successful (USFWS 2008). During the breeding season (December–May), the highest densities are found around Japan (BirdLife International 2018). Parents forage primarily off the east coast of Honshu Island, where the warm Kuroshio and the cold Oyashio currents meet (USFWS 2008). However, albatrosses have been seen as far south (23°N) as the Northwestern Hawaiian Islands between November and April (USFWS 2008). After the breeding season, short-tailed albatrosses roam much of the North Pacific Ocean; females spend more time offshore from Japan and Russia, while males and juveniles spend more time around the Aleutian Islands and Bering Sea (Suryan et al. 2007). Post-breeding dispersal occurs from April through November (Suryan et al. 2007; USWFS 2008). They are considered a continental shelf-edge specialist (Piatt et al. 2006). However, Suryan et al. (2007) reported that short-tailed albatrosses occasionally transit the northern boundary of the Kuroshio Extension in May while en route to the Aleutians and Bering Sea, but that they do not spend much time in the area. Nonetheless, this species occurs in the Emperor Seamounts during and after post-breeding dispersal from April–November (USWFS 2008; Suryan et al. 2007; Howell 2012). Given the relatively small population size, the large pelagic range of this species, and the far offshore location of the survey area, the occurrence of short-tailed albatross in the Emperor Seamounts survey area would be considered rare at the time of the survey. The species has also been recorded on rare occasions in the Hawaiian Islands (DoN 2005; USFWS 2008; Birdlife International 2018).

3.5.4 Band-rumped Storm-Petrel

The band-rumped storm-petrel is widespread in the Atlantic and Pacific oceans (USFWS 2005). However, populations nesting on different archipelagos appear to be genetically isolated from each other and, as a result, may represent separate species (Smith et al. 2007). In the Pacific, it breeds off eastern Japan, on Kauai and Lehua Islet, Hawaii, and on the Galapagos Islands (USFWS 2005; Raine et al. 2017b). It used to be abundant in Hawaii, but the population size for Kauai in 2002 was estimated at only 171–221 breeding pairs (Wood et al. 2002). There is no more recent estimate of the total population size nesting in Hawaii (USFWS 2016). The decline is suspected to be attributable to predation by invasive species (USFWS 2005). Nesting habitats include natural cavities or burrows; eggs are laid in May–June and young fledge in late-September to mid-November (USFWS 2005; Raine et al. 2017b). The band-rumped storm-petrel is highly pelagic, with its range in the central Pacific extending from the Main Hawaiian Islands to the Northwestern Hawaiian Islands and the Equatorial Counter Current (USFWS 2005). This species is expected to occur in the Hawaiian survey area year-round, but not the Emperor Seamounts survey area. DoN (2005) reported numerous sightings in the Main Hawaiian Islands, including off the west coast of the Big Island.

3.6 Fish, Essential Fish Habitat, and Habitat Areas of Particular Concern

3.6.1 ESA-Listed Fish Species

Two ESA-listed fish species could occur in the Hawaiian survey area: the ***threatened*** oceanic white tip shark (*Carcharhinus longimanus*) and the Giant manta ray (*Manta birostris*). Although the scalloped hammerhead shark (*Sphyrna lewini*) occurs in the central Pacific, only the Central and Southwest Atlantic, Eastern Atlantic, Eastern Pacific, and Indo-West Pacific DPSs are listed under the ESA (NMFS 2018a). Although the ***threatened*** Indo-West Pacific DPS occurs off the coast of Japan, it is unlikely to occur in the offshore Emperor Seamounts survey area. However, one ESA-listed fish species, the ***endangered*** Sakhalin sturgeon (*Acipenser mikadoi*), could occur in the Emperor Seamounts survey area. No other candidate or proposed marine fish or marine invertebrates species could occur in the survey areas.

3.6.1.1 Giant Manta Ray

Giant manta rays are migratory and cold-water tolerant, with highly fragmented populations sparsely distributed in the tropical, subtropical, and temperate waters of the world (NOAA 2017b). Giant manta rays are the largest living ray in the world (NOAA 2017b) and tend to be solitary (DoW 2015).

This species filter-feeds virtually exclusively on plankton (DoW 2015). Regional population sizes are small and have generally declined in known areas except where specifically protected (NOAA 2017b). It could occur within or near the proposed Hawaii survey area.

3.6.1.2 Oceanic Whitetip Shark

The oceanic white tip shark is an offshore pelagic species inhabiting surficial waters in the open ocean, occurring worldwide typically between 20ºN and 20ºS but also at higher latitudes during the summer months (NOAA 2016). Oceanic whitetip sharks are aggressive and persistent, and prey on bony fishes such as tunas, barracuda, white marlin, dolphinfish, lancetfish, oarfish, threadfish and swordfish, along with threadfins, stingrays, sea turtles, seabirds, gastropods, squid, crustaceans, and mammalian carrion (NOAA 2016). It could occur within or near the proposed Hawaii survey area, but not at the Emperor Seamounts survey area.

3.6.1.3 Sakhalin Sturgeon

The Sakhalin sturgeon is native to the northwest Pacific Ocean and occurs off Japan, Russia, and North Korea (Shmigirilov et al. 2007; NOAA 2015). It is found at sea from the Sea of Japan to the Sea of Okhotsk and along the coast of Kamchatka Peninsula to the Bering Strait (Shmigirilov et al. 2007; NOAA 2015). The only remaining spawning location is thought to be the Tumnin River, Russia (Shmigirilov et al. 2007), were 10–30 sturgeon spawn (NOAA 2015). The regular distribution range is unlikely to include far offshore waters; thus, the Sakhalin sturgeon is unlikely to occur in the Emperor Seamounts survey area.

3.6.2 Essential Fish Habitat

Under the 1976 *Magnuson Fisheries Conservation and Management Act* (renamed *Magnuson Stevens Fisheries Conservation and Management Act* in 1996), Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NOAA 2018c).

The entire Hawaiian Islands EEZ is EFH for one or more species or life stages of fish or invertebrates (NOAA 2018d). The Western Pacific Fishery Management Council (WPFMC) manages major fisheries within the EEZ. The WPFMC also manages the Management Unit Species (MUS), or fishery resources, in the EEZ, and designates EFH. The life stages and associated habitats for those species with EFH in the proposed Hawaiian survey area are described in Table 6. EFH in Hawaii includes the water column from the surface to a maximum depth of 1000 m and the ocean floor from shore down to a depth of 700 m, depending on the MUS/Groups (Table 6). It also includes several precious coral beds which are located off the west coast of the Big Island, between Maui and Lanai, off the east and west coasts of Oahu, Kauai, and in the Northwestern Hawaiian Islands (DoN 2005; NOAA 2018) (Fig. 3).

3.6.3 Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPCs) are a subset of EFH that provide important ecological functions, are especially vulnerable to degradation, or include habitat that is rare (NOAA 2018). There are several HAPCs for bottomfish within the Hawaiian Islands EEZ (Fig. 4). Only Ka'ena Point, off the west coast of Oahu, is located in the vicinity of the proposed seismic survey. An additional six HAPCs have been designated within the Hawaiian Islands EEZ (Fig. 4). Several other HAPCs have been proposed but not designated yet (WPRFMC 2016a).

TABLE 6. Management Unit Species (Groups) with Essential Fish Habitat (EFH) overlapping the proposed survey area within the Hawaiian Islands EEZ (Source: NOAA 2018d).

Management Unit Species (Groups)	Life stage and Habitat	
	Eggs & Larvae	Juvenile & Adult
Bottomfish	Water column to 400 m depth from the shore to the edge of the EEZ	Water column and bottom from shore to 400 m depth
Seamount Groundfish	Water column to a depth of 200 m in EEZ waters within 29°–35°N, 171°E–179°W	Water column and bottom from 200–600 m depth, within 29°–35°N, 171°E–179°W
Pelagics	Water column to 200 m depth from the shore to the edge of the EEZ	Water column to 1000 m from the shore to the edge of the EEZ
Precious Corals	Known precious coral beds in the Hawaiian Islands: Keahole point, between Milolii and South Point, the Auau Channel, Makapuu, Kaena Point, southern border of Kauai, Wespac bed, Brooks bank bed, and 180 Fahom Bank	
Coral Reef Ecosystem	Water column and bottom down to 100 m from shore to the edge of the EEZ	
Crustaceans (Lobsters/crab)	Water column to 150 m depth from shore to the edge of the EEZ	Bottom from shore to 100 m depth
Crustaceans (Deepwater shrimp)	Outer reef slopes, 300–700 m	Outer reef slopes, 550–700 m

Ka'ena Point—This HAPC for bottomfish is located off the north side of the western tip of Oahu. It covers an area of 48 km^2 between 21.6ºN and 21.8ºN, 158.2ºW and 158.3ºW. This area is small and has relatively little topographic complexity; however, it was recommended as an HAPC because it contains nursery areas for Onaga red snapper (*Etelis coruscans*) and Ehu red snapper (*E. carbunculus*). In addition, juvenile pink snapper (*Pristipomoides filamentosus*) have been found during fishing surveys closer to shore (WPRFMC 2016a). Ka'ena Point has also been identified as a potential coral reef ecosystem HAPC (WPRFMC 2016b). In addition, a precious coral bed is located ~10–15 km northwest of the point, although this is outside of the Ka'ena Point HAPC (Fig. 3).

Kane'ohe—This HAPC is 8 km^2 and located on the east side of Oahu. It is an important nursery area for *P. filamentosus*; at least seven species of bottomfish occur as well.

Makapu'u Point—Makapu'u Point is located on the east side of Oahu and covers 44 km^2. It contains nursery grounds for three species of bottomfish. In addition, there is a high density of brittle corallid and priminoid corals in the lower 50 m of the bottomfish range and several stands of large gold coral (*Gerardia* sp.).

Penguin Bank—Penguin Bank is a large area (393 km^2) extending west of Molokai. Ten species of bottomfish are present and it may contain a nursery ground for Onaga red snapper.

Pailolo Channel—This HAPC covers 96 km^2 between Molokai and Maui is occupied by juvenile Onaga and Ehu red snapper, and lavender jobfish (*P. sieboldii*); it also contains deepwater coral beds.

N. Kaho'olawe—Situated northeast of Kaho'olawe, this HAPC is a large (73 km^2) drowned reef terrace. Juvenile Onaga and Ehu red snapper occur in a dense bed of *Corallium niveum*.

Hilo—The largest of the HAPCs (845 km^2), it is located outside Hilo Bay on the east side of the Big Island. Seven species of bottomfish have been recorded there; it is a nursery area for pink snapper.

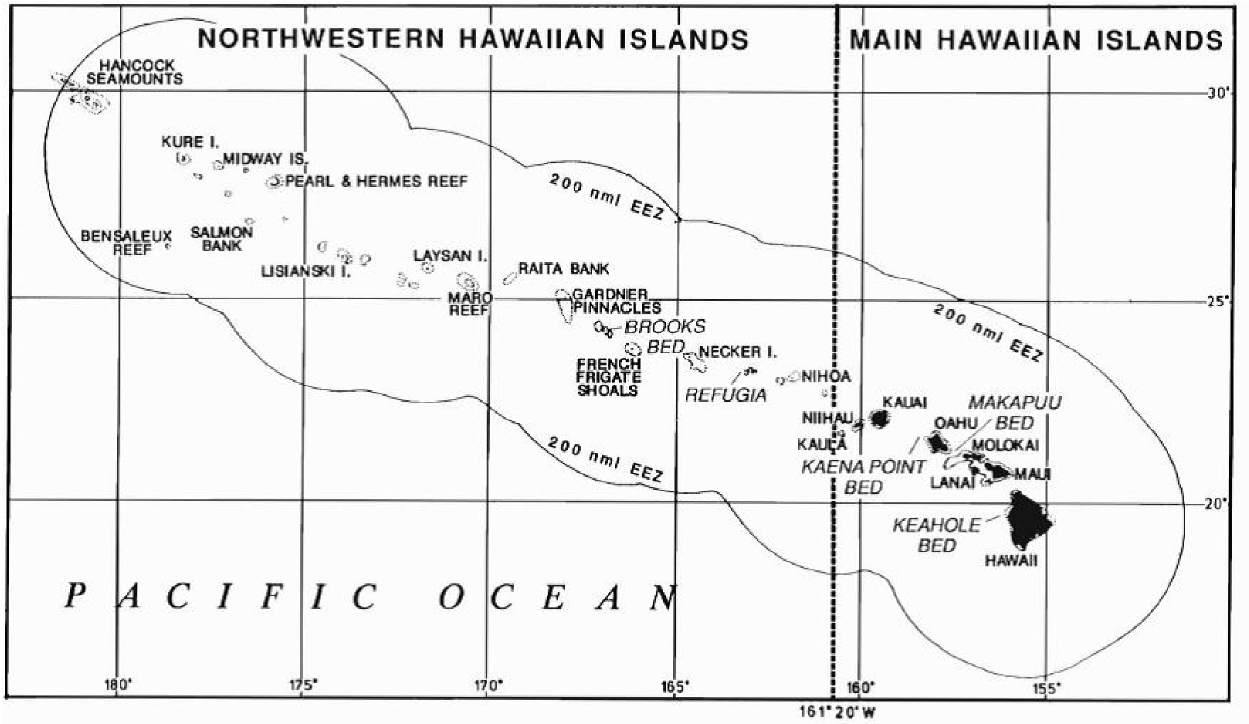

FIGURE 3. Precious coral beds in the Hawaiian Islands (Source: Grigg 1993).

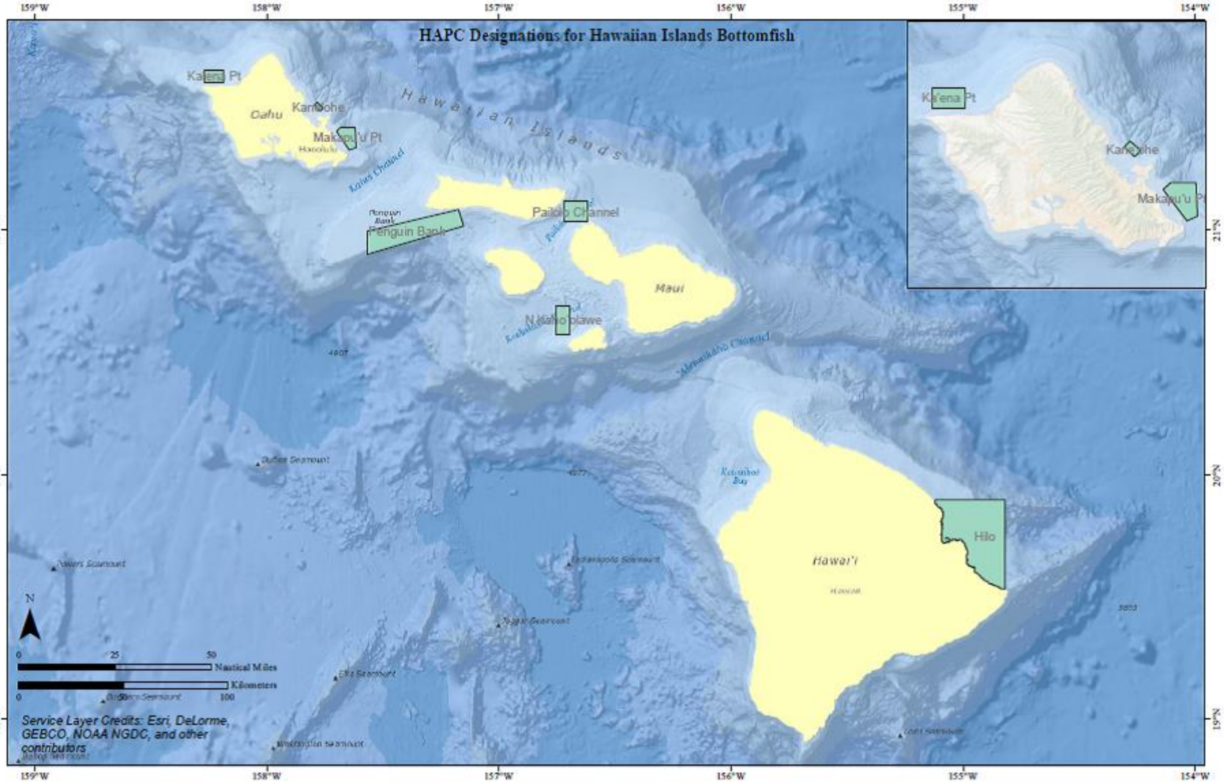

FIGURE 4. Habitat Areas of Particular Concern (HAPC) for Hawaii Bottomfish (Source: WPRFMC 2016a).

3.7 Fisheries

In Hawaii, complex habitats, high species diversity, as well as native and introduced cultural practices have led to a variety of fishing practices including large-scale commercial, recreational, and subsistence fisheries (Boehlert 1993). In the offshore waters of the Emperor Seamounts region, only commercial fisheries are expected to occur.

3.7.1 Commercial Fisheries

The Western and Central Pacific Fisheries Commission (WCPFC) developed five fishery ecosystem plans for the Pacific Islands, including one for Hawaii (WCPFC 2009). In Hawaii, commercial fisheries are often dependent on, and target, deep water, slope species or highly migratory species such as billfish and tunas (Boehlert 1993). In addition to pelagic fisheries, Hawaii also has bottomfish, crustacean, precious coral, and coral reef fisheries (WCRFMC 2009).

Between 1950 and 2010, the majority (88%) of landings in the Hawaiian Islands EEZ consisted of large pelagic species such as tunas, and 12% consisted of bottomfish such as scads and snappers (Gibson et al. 2015). Predominant species caught included bigeye tuna, *Thunnus obesus*; albacore tuna, *T. alalunga*; yellowfin tuna, *T. albacares*; skipjack tuna, *Katsuwonus pelamis*; blue marlin, *Makaira nigricans*; bigeye scad, *Selar crumenophthalmus*; common dolphinfish, *Coryphaena hippurus*; mackerel scad, *Decapterus macarellus*; green jobfish, *Aprion virescens*; deepwater longtail red snapper, *Etelis coruscans*; as well as Hawaiian pink snapper, swordfish, goatfishes, jacks, and pompanos (Gibson et al. 2015).

Approximately 16,600 t of seafood were landed in Hawaii in 2015; finfish accounted for nearly all landings (NMFS 2017c). Tunas were the predominant fish group caught in 2015, making up 64% of landings (NMFS 2017c). Other important commercial fish species include lobster, common dolphinfish, marlin, moonfish or opahs, pomfret, scad, snappers, swordfish, and wahoo (*Acanthocybium solandri*) (NMFS 2017c).

In 2016, there were 127 U.S. longline vessels that harvested fish in the EEZ of the Main Hawaiian Islands during 575 trips (NOAA 2017c). Tuna (mainly bigeye tuna, but also yellowfin, skipjack, and albacore) made up most of the catches, followed by pomfret, billfishes (blue and striped marlin, shortbill spearfish, and swordfish), and dolphinfish; wahoo and oilfish were also taken (NOAA 2017c).

Besides the pelagic species that make up the main part of the commercial fisheries, pink snapper and Onaga red snapper are harvested most frequently in the bottomfish fishery; lobsters and Kona crabs are harvested by the crustacean fishery. Corals that are harvested include black, pink, gold, and bamboo corals; and the most common species taken in the coral reef fishery include bigeye and mackerel scad, but surgeon fish, tangs, goatfish, squirrelfish, and parrotfish, as well as octopus are also taken (WCPFC 2009).

The Emperor Seamouts survey area is located on the high seas of the Pacific, Northwest (Sea Around Us 2018). In 2015, ~1.5 million tons of fish were harvested from this region. The majority of the catch (227,000 t) was Pacific saury, followed by jacks and pompanos; marine crabs, shrimps, and lobsters; and Japanese anchovy (Sea Around Us 2018). Other species taken included squid; porgies and seabreams; albacore and skipjack tuna; crabs, lobsters, shrimp, and prawns; sharks, rays, and skates; and flathead grey mullet (Sea Around Us 2018). Most fishing in the area was by Chinese vessels, followed by Taiwan (Sea Around Us 2018). Commercial fishing that occurs within the Emperor Seamount Chain and North Hawaiian Ridge EBSA target North Pacific armorhead (*Pseudopentaceros wheeleri*) and splendid alfonsin (*Beryx splendens*) (CBD 2016a).

3.7.2 Recreational and Subsistence Fisheries

Marine recreational (for sport or pleasure) and subsistence (for food) fishing is an important activity for many residents of Hawaii. "Fishing tourism" is also an important part of Hawaii's economy. Most non-commercial fishing, including subsistence fishing, is viewed as recreational fishing as subsistence fishers do not rely on fishing for food (Smith 1993 *in* Gibson et al. 2015). Between 1950 and 2010, 13% of the recreational catch was made up of bigeye scad; other species caught included yellowstripe goatfish, *Mulloidichthys flavolineatus*, bluestripe herring, *Herklotsichthys quadrimaculatus*; convict surgeonfish, *Acanthurus triostegus*; skipjack and yellowfin tunas; and flagtails (Gibson et al. 2015). Recreational anglers in Hawaii took 1.4 million fishing trips in 2015, totalling ~5.2 million fish (NMFS 2016f). The most commonly caught species were yellowstripe goatfish, bluefin trevally, yellowfin tuna, skipjack tuna, and yellowfin goatfish; by weight, the biggest harvests were for yellowfin tuna, skipjack tuna, dolphinfish, wahoo, giant trevally, and yellowfin goatfish (NMFS 2016f).

3.7.3 Aquaculture

In Hawaii, algae sales accounted for 63% of the value of aquaculture sales in 2011, followed by 26% seedstock, broodstock, and fingerlings; finfish and shellfish made up 4 and 1%, respectively (State of Hawaii 2018c). Most aquaculture activity occurs on land, but there are also open ocean fish farms in Hawaii. Under the current Hawaii Ocean leasing law, farms can operate in state waters within 3 mi from shore (State of Hawaii 2018c). There is at least one such fishfarm (Blue Ocean Mariculture) in the offshore waters of Kona off the Big Island (State of Hawaii 2018c) and likely one additional farm (Kampachi Farms 2017). Food & Water Watch (2010) indicated a fish farm on the south coast of Oahu.

3.8 Recreational SCUBA Diving and Shipwrecks

There are numerous SCUBA diving sites around the Main Hawaiian Islands, including off the west coasts of Oahu and the Big Island, and off the south and east coasts of Maui (see Fig. 5-5 *in* DoN 2005; Skin Diver 2018). Diving in Hawaii takes place year-round, and most diving occurs in water <40 m deep. Diving is popular at numerous shipwrecks that are located along the coast of Hawaiian waters; there are also several shipwrecks farther offshore, including to the west of Ohau (see Fig. 2-23 *in* DoN 2005). MLCDs are popular locations for snorkeling and diving (State of Hawaii 2018a).

IV ENVIRONMENTAL CONSEQUENCES

4.1 Proposed Action

4.1.1 Direct Effects on Marine Mammals and Sea Turtles and Their Significance

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

This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic surveys. A description of the rationale for NSF's estimates of the numbers of individuals exposed to received sound levels ≥160 dB re 1 µPa$_{\text{rms}}$ is also provided. Acoustic modeling for the Proposed Action was conducted by L-DEO, consistent with past EAs and determined to be acceptable by NMFS for use in the calculation of estimated Level A and B takes under the MMPA.

4.1.1.1 Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2015, 2016; Kunc et al. 2016; National Academies of Sciences, Engineering, and Medicine 2017; Weilgart 2017a). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

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

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

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

noted the potential for masking effects from seismic surveys on large whales.

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

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

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013a). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2017).

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner. The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales

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

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m.

Dunlop et al. (2015) reported that migrating humpback whales in Australia responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3, although an increase in distance from the airgun(s) was noted for both sources (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Overall, the results showed that humpbacks were more likely to avoid active small airgun sources (20 and 140 in^3) within 3 km and received levels of at least 140 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$ (Dunlop et al. 2017a). Responses to ramp up and use of a large 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c). Humpbacks reduced their southbound migration, or deviated from their path thereby avoiding the active array, when they were within 4 km of the active large airgun source, where received levels were >135 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$ (Dunlop et al. 2017b). These results are consistent with earlier studies (e.g., McCauley et al. 2000).

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

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

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

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

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

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) and in 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b). Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed during the seismic programs conducted in 2010 (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The lack of strong avoidance or other strong responses during the 2001 and 2010 programs was presumably in part a result of the comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs above ~163 dB re 1 $µPa_{rms}$ (Johnson et al. 2007; Nowacek et al. 2012, 2013b).

In contrast, preliminary data collected during a seismic program in 2015 showed some displacement of animals from the feeding area and responses to lower sound levels than expected (Gailey et al. 2017; Sychenko et al. 2017).

Gray whales in British Columbia, Canada, exposed to seismic survey sound levels up to ~170 dB re 1 μPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

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

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

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population continued to feed off Sakahalin Island every summer, despite seismic surveys in the region. In addition, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years. Pirotta et al. (2018) used a dynamic state model of behavior and physiology to assess the consequences of disturbance (e.g., seismic surveys) on whales (in this case, blue whales). They found that the impact of localized, acute disturbance (e.g., seismic surveys) depended on the whale's behavioral response, with whales that remained in the affected area having a greater risk of reduced reproductive success than whales that avoided the disturbance. Chronic, but weaker disturbance (e.g., vessel traffic) appeared to have less effect on reproductive success.

Toothed Whales

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

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

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

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

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

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010). Winsor et al. (2017) outfitted sperm whales in the Gulf of Mexico with satellite tags to examine their spatial distribution in relation to seismic surveys. They found no evidence of avoidance or changes in orientation by sperm whales to active seismic vessels. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Foraging behavior can also be altered upon exposure to airgun sound (e.g., Miller et al. 2009), which according to Farmer et al. (2017), could have significant consequences on individual fitness. Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity and periods with airgun operations (Sidorovskaia et al. 2014).

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

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007). Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013b) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013b).

Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012c) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013c). Van Beest et al. (2018) exposed five harbor porpoise to a single 10 in^3 airgun for 1 min at 2–3 s intervals at ranges of 420–690 m and levels of 135–147 dB $\mu Pa^2 \cdot s$.

One porpoise moved away from the sound source but returned to natural movement patters within 8 h, and two porpoises had shorter and shallower dives but returned to natural behaviors within 24 h.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans. NMFS is currently developing new guidance for predicting behavioral effects (Scholik-Schlomer 2015). As behavioral responses are not consistently associated with received levels, some authors have made recommendations on different approaches to assess behavioral reactions (e.g., Gomez et al. 2016; Harris et al. 2017).

Pinnipeds

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

Sea Turtles

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

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

Based on available data, it is likely that sea turtles will exhibit behavioral changes and/or avoidance within an area of unknown size near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate would likely have the greatest impact. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of the year. However, a number of mitigation measures can, on a case-by-case basis, be considered for application in areas important to sea turtles (e.g., Pendoley 1997; van der Wal et al. 2016).

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

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a, 2016a,b, 2017; Ketten 2012; Supin et al. 2016).

Studies have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

Studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 μPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b, 2017) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise. When a porpoise was exposed to 10 and 20 consecutive shots (mean shot interval ~17 s) from two airguns with a SEL_{cum} of 188 and 191 $\mu Pa^2 \cdot s$, respectively, significant TTS occurred at a hearing frequency of 4 kHz and not at lower hearing frequencies that were tested, despite the fact that most of the airgun energy was <1 kHz; recovery occurred within 12 min post exposure (Kastelein et al. 2017).

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016, 2017).

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

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

For the harbor porpoise, Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{\text{eq-fast}}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, according to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Simulation modeling to assess the risk of sound exposure to marine mammals (gray seal and harbor porpoise) showed that SEL is most strongly influenced by the weighting function (Donovan et al. 2017). Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

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

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. However, Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS.

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

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

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

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

Since 1991, there have been 64 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2017d). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=110E5E8F-3A65-4BEC-9D25-5D843A0284D3), it was Dr. Knapp's (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico.

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

Sea Turtles

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

The U.S. Navy has proposed the following criteria for the onset of hearing impairment for sea turtles: 232 dB re 1 µPa SPL (peak) and 204 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} (weighted) for PTS; and 226 dB peak and 189 dB weighted SEL for TTS (USN 2017). Although it is possible that exposure to airgun sounds could cause mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014), especially because sea turtles appear to be resistant to explosives (Ketten et al. 2005 *in* Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or >207 dB_{peak} for sounds from seismic airguns; however, these criteria were largely based on impacts of pile-driving sound on fish.

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

4.1.1.2 Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed surveys. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the expected potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

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

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

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

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including low-frequency, mid-frequency, and high-frequency active sonars (see review by Southall et al. 2016). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

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

Deng et al. (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by gray seals to echosounders with frequencies of 200 and 375 kHz. Short-finned pilot whales increased their heading variance in response to an EK60 echosounder with a resonant frequency of 38 kHz (Quick et al. 2017), and significantly fewer beaked whale vocalizations were detected while an EK60 echosounder was active vs. passive (Cholewiak et al. 2017).

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

4.1.1.3 Other Possible Effects of Seismic Surveys

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

Vessel noise from the *Langseth* could affect marine animals in the proposed survey areas. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels, and Putland et al. (2017) also reported reduced sound levels with decreased vessel speed. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20–300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels have been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Increased levels of ship noise also affect foraging by porpoise (Teilmann et al. 2015; Wisniewska et al. 2018). Wisniewska et al. (2018) suggest that a decrease in foraging success could have long-term fitness consequences.

Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Dunlop 2015; Erbe et al. 2015; Jones et al. 2017; Putland et al. 2017). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011, 2012, 2016a,b; Castellote et al. 2012; Melcón et al. 2012; Azzara et al. 2013; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Bittencourt et al. 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Tenessen and Parks 2016). Similarly, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017); however, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 km away and could affect the behavior of a marine mammal at a distance of 52 km in the case of tankers.

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

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels (e.g., Anderwald et al. 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015) and blue whales (Lesage et al. 2017). Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels. Tyson et al. (2017) suggested that a juvenile green sea turtle dove during vessel passes and remained still near the sea floor.

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

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

Entanglement of sea turtles in seismic gear is also a concern (Nelms et al. 2016). There have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore from West Africa (Weir 2007); however, these tailbuoys are significantly different than those used on the *Langseth.* In April 2011, a dead olive ridley turtle was found in a deflector foil of the seismic gear on the *Langseth* during equipment recovery at the conclusion of a survey off Costa Rica, where sea turtles were numerous. Such incidents are possible, but that was the only case of sea turtle entanglement in seismic gear for the *Langseth*, which has been conducting seismic surveys since 2008, or for its predecessor, R/V *Maurice Ewing*, during 2003–2007. Towing the seismic equipment during the proposed surveys is not expected to significantly interfere with sea turtle movements, including migration.

4.1.1.4 Mitigation Measures

Several mitigation measures are built into the proposed seismic surveys as an integral part of the planned activity. These measures include the following: ramp ups; typically two, however a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers for 30 min before and during ramp ups; PAM during the day and night to complement visual monitoring; and power downs (or if necessary shut downs) when mammals or turtles are detected in or about to enter designated EZ. These mitigation measures are described in § 2.4.4.1 of the PEIS and summarized earlier in this document, in § II (2.1.3). The fact that the airgun array, because of its design, would direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure.

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

4.1.1.5 Potential Numbers of Cetaceans Exposed to Received Sound Levels ≥160 dB

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

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

For the proposed Hawaii survey, we used densities from Bradford et al. (2017), as required by NMFS. For cetacean species not included by Bradford et al. (2017), including *Kogia* spp. and spinner dophin, we used the NOAA CetSound website to estimate exposures (NOAA 2018e). CetMap (https://cetsound.noaa.gov/cda), a mapping tool on the CetSound website, presents habitat-based density models for cetaceans in Hawaiian waters which were based on all appropriate surveys conducted within the Hawaiian EEZ. Details of the determination of the density for the Hawaiian monk seal are provided in Appendix B. Density estimates were not available for humpback and minke whales and were assumed to be zero, because these species are unlikely to occur in the survey area during the temporal scope of the study. As North Pacific right whales are extremely rare and very unlikely to occur in Hawaiian waters, they were not considered further.

For the proposed Emperor Seamounts survey, there are few published data, so we used mostly gray literature available from IWC scientific reports to compute densities based on parts of surveys that occurred within or adjacent to the survey area (e.g., Buckland et al. 1993; Miyashita 1993a; Hakamada et al. 2009; Matsuoka et al. 2009; Hakamada and Matsuoka 2015). It was necessary to use different densities for the Hawaii and Emperor Semounts surveys, as there are major differences in the distribution and abundance of marine mammals in the two areas due to different oceanographic conditions. Details of the density calculations for each species or species group that could occur in the Emperor Seamounts survey area can be found in Appendix B. Densities for gray and Bryde's whales was assumed to be zero in the Emperor Seamounts survey area, because these species are unlikely to occur there; gray whales generally do not occur that far offshore, and the distribution of Bryde's whale does not extend as far north as the survey area.

All densities were corrected for trackline detection probability bias [$f(0)$] and availability [$g(0)$]

bias by the authors, or in the case of the gray literature data, by using values provided either by the authors, or if those were not provided, from comparable surveys conducted by NMFS. For the Hawaiian EEZ survey area, Bradford et al. (2017) used *g*(0) values estimated by Barlow (2015), whose analysis indicated that *g*(0) had previously been overestimated, particularly for high sea states. There is some uncertainty related to the estimated density data and the assumptions used in their calculations, as with all density data estimates. However, the approach used here is based on the best available data. The calculated exposures that are based on these densities are best estimates for the proposed surveys.

The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all marine mammals. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Tables 7 and 8 show the density estimates calculated as described above and the estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the proposed seismic surveys in the North Pacific if no animals moved away from the survey vessel (see Appendix C for more details). The *Requested Take Authorization* is given in the right-most column of Tables 7 and 8.

For all species, including those for which densities were not available or expected to be low, we have included a *Requested Take Authorization* for at least the mean group size for species where that number was higher than the calculated take. For the proposed Hawaii survey, species (and relevant sources) for which the *Requested Take Authorization* was increased to mean group size include the minke whale (Jackson et al. 2008), humpback whale (Mobley et al. 2001), and killer whale (Bradford et al. 2017). For the proposed Emperor Seamounts survey, species (and relevant sources) for which the *Requested Take Authorization* was increased to mean group size include the pygmy sperm, dwarf sperm, and false killer whales (Barlow 2006); Risso's dolphin, short-finned pilot whale, and Bryde's whale (Bradford et al. 2017); and short-beaked common dolphin (Barlow 2016). For Stejneger's and Baird's beaked whales, the *Requested Take Authorization* was increased to the upper end of group sizes that could be encountered (Jefferson et al. 2015). For species that are very unlikely to occur in the survey area, the *Requested Take Authorization* was increased to 1 individual for the gray whale and 5 individuals for the Steller sea lion and ribbon seal

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

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

TABLE 7. Densities and estimates of the possible numbers of marine mammals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed Hawaii seismic survey, as well as number of takes authorized after consultation with NMFS (see Appendix E).

Species	Estimated Density[1] (#/1000 km^2)	Calculated Take, Daily Method[2]		Level A + Level B as % of Pop.[5]	Requested Takes[6]	Level A+B Takes Authorized by NMFS	
		Level A[3]	Level B[4]			Level A	Level B
LF Cetaceans							
Humpback whale	0	0	0	0	**2**[7]	0	2
Minke whale	0	0	0	0	**1**[7]	0	1
Bryde's whale	0.97[8]	3	61	0.23	**64**	2	45
Sei whale	*0.22*[8]	*1*	*13*	*0.05*	***14***	0	11
Fin whale	*0.06*	*0*	*4*	*0.02*	***4***	*0*	*4*
Blue whale	*0.05*	*0*	*3*	*0.13*	***3***	*0*	*5*
MF Cetaceans							
Sperm whale	*1.86*	*0*	*122*	*0.47*	***122***	0	123
Cuvier's beaked whale	0.30	0	20	0.10	**20**	0	20
Blainville's beaked whale	0.86	0	57	0.22	**57**	*0*	*57*
Ginkgo-toothed beaked whale	0.63[9]	0	41	0.16	**41**	0	124
Deraniygala's beaked whale	0.63[9]	0	41	0.16	**41**	0	124
Hubbs beaked whale	0.63[9]	0	41	0.16	**41**	0	124
Longman's beaked whale	3.11	0	205	4.48	**205**	0	205
Rough-toothed dolphin	29.63	3	1946	1.81	**1949**	0	1949
Common bottlenose dolphin	8.99	1	590	0.18	**591**	0	592
Pantropical spotted dolphin	23.32	3	1531	0.12	**1534**	0	1534
Spinner dolphin	6.99[10]	1	459	0.03	**460**	0	460
Striped dolphin	25.0	3	1641	0.17	**1644**	0	1644
Fraser's dolphin	21.04	2	1382	0.48	**1384**	0	1381
Risso's dolphin	4.74	1	311	0.28	**312**	0	312
Melon-headed whale	3.54	0	233	0.51	**233**	0	810
Pygmy killer whale	4.35	1	285	0.74	**286**	0	286
False killer whale	*0.60*	*0*	*39*	*0.24*	***39***[11]	*0*	*60*[12]
Killer whale	0.06	0	4	0.05	**5**[7]	0	5
Short-finned pilot whale	7.97	1	523	0.98	**524**	0	524
HF Cetaceans							
Pygmy sperm whale	2.91[10]	7	184	2.68	**191**	7	184
Dwarf sperm whale	7.14[10]	16	454	2.68	**470**	16	454
Phocid Seals							
Hawaiian Monk Seal	*0.05*	*0*	*3*	*0.27*	***3***	*0*	*3*

Species in italics are listed under the ESA as endangered.

[1] Most densities from Bradford et al. (2017), except for the monk seal (see Appendix B for details), and otherwise as noted.

[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area to levels ≥160 dB re 1 μPa_{rms} on one selected day (see text) multiplied by the number of survey days (12 days for mixed-depth lines; 7 days for deep lines), times 1.25; daily ensonified area = full 160-dB area minus ensonified area for the appropriate PTS thresholds. [3] Level A takes if there were no mitigation measures. [4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds. [5] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population in the North Pacific, ETP, or Hawaii (see Table 5). [6] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated. [7] Requested take authorization (Level B only) increased to mean group size (see text and Appendix B for sources). [8] From Bradford et al. (2017), but added proportion for 'Sei or Bryde's whale' density. [9] From Bradford et al. (2017) for '*Unidentified Mesoplodon'* proportioned equally among *Mesoplodon* spp., except *M. densirostris*. [10] From CetMap.

[11] Includes 6 individuals from the endangered Main Hawaiian Islands insular stock (population size estimated at 151) and 33 from the Hawaiian pelagic stock (population size estimated 906) (see Carretta et al. 2017). [12] Includes 20 individuals from the endangered Main Hawaiian Islands insular stock and 40 from the Hawaiian pelagic stock.

TABLE 8. Densities and estimates of the possible numbers of individuals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed Emperor Seamounts seismic survey in the northwest Pacific Ocean during 2019, as well as number of takes authorized after consultation with NMFS (see Appendix E).

Species	Estimated Density[1] (#/1000 km^2)	Calculated Take, Daily Method[2]		Level A + Level B as % of Pop.[5]	Requested Takes[6]	Level A+B Takes Authorized by NMFS	
		Level A[3]	Level B[4]			Level A	Level B
LF Cetaceans							
Gray whale	*0*	*0*	*0*	*0*	***1***[7]	*0*	*2*
North Pacific right whale	*0.54*	*1*	*22*	*5.11*	***23***	*0*	*2*
Humpback whale	*0.41*	*1*	*16*	*0.08*	***17***	*2*	*16*
Minke whale	2.48	5	99	0.47	**104**	5	98
Bryde's whale	0	0	0	0	**2**[8]	0	2
Sei whale	*2.93*	*5*	*117*	*0.45*	***122***	*3*	*11*
Fin whale	*0.93*	*2*	*37*	*0.24*	***39***	*0*	*8*
Blue whale	*0.13*	*0*	*5*	*0.19*	***50***[9]	*0*	*5*
MF Cetaceans							
Sperm whale	*10.97*	*1*	*456*	*1.54*	***457***	*0*	*90*
Cuvier's beaked whale	6.80	1	283	1.42	**284**	0	225
Stejneger's beaked whale	N.A.	-	-	-	**15**[10]	0	21
Baird's beaked whale	N.A.	-	-	-	**20**[10]	0	121
Short-beaked common dolphin	N.A.	-	-	-	**180**[8]	0	180
Striped dolphin	9.21	1	383	0.04	**384**	0	384
Pacific white-sided dolphin	68.81	5	2865	0.29	**2870**	0	2870
Northern right whale dolphin	3.37	0	141	0.05	**141**	0	141
Risso's dolphin	N.A.	-	-	-	**27**[8]	0	1126
False killer whale	N.A.	-	-	-	**10**[8]	0	417
Killer whale	3.00	0	125	1.47	**125**	0	1253
Short-finned pilot whale	N.A.	-	-	-	**41**[8]	0	1713
HF Cetaceans							
Pygmy sperm whale	N.A.	-	-	-	**1**[8]	0	121
Dwarf sperm whale	N.A.	-	-	-	**2**[8]	0	298
Dall's porpoise	35.46	56	1443	0.12	**1479**	56	1423
Otariids							
Northern fur seal	3.56	0	149	0.01	**149**	0	149
Steller sea lion	*N.A.*	-	-	-	***5***[7]	*0*	*0*
Phocid Seals							
Northern elephant seal	8.31	2	345	0.15	**347**	0	343
Ribbon seal	N.A.	-	-	-	**5**[7]	0	5

Species in italics are listed under the ESA as endangered. N.A. (-) is not available

[1] See text and Appendix B for density sources. [2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area to levels ≥160 dB re 1 µPa$_{rms}$ on one selected day (see text) multiplied by the number of survey days (13), times 1.25; daily ensonified area = full 160-dB area minus ensonified area for the appropriate PTS threshold. [3] Level A takes if there were no mitigation measures. [4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds. [5] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population in the North Pacific, ETP, or Hawaii (see Table 5). [6] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated. [7] Requested take authorization (Level B only) increased to 1 for cetaceans and 5 for pinnipeds. [8] Requested take authorization (Level B only) increased to mean group size (see text and Appendix B for sources). [9] Requested take authorization is based on feeding aggregation size given in Sears and Perrin (2009). [10] Requested take authorization increased to upper end of group size that could be encountered (Jefferson et al. 2008).

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 µPa$_{\text{rms}}$ (Level B) for marine mammals on one or more occasions have been estimated using a method required by NMFS for calculating the marine area that would be within the Level B threshold was around the operating seismic source, along with the expected density of animals in the area. This method developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day (180 km) with a proportion of depth intervals (100–1000 m and >1000 m) and associated radii that is roughly similar to that of the entire survey. The area expected to be ensonified on that day was determined by entering the planned survey lines into a MapInfo GIS, using GIS to identify the relevant areas by "drawing" the applicable 160-dB (Table 1) and PTS threshold buffers (Table 2) around each line. The ensonified areas were then multiplied by the number of survey days (19 days for Hawaii, 13 days for Emperor Seamounts) increased by 25%; this is equivalent to adding an additional 25% to the proposed line km (see Appendix D for more details). The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the *Langseth* approaches.

Per NMFS requirement, estimates of the numbers of cetaceans and pinnipeds that could be exposed to seismic sounds with received levels equal to Level A thresholds for various hearing groups (see Table 2), if there were no mitigation measures (power downs or shut downs when PSOs observed animals approaching or inside the EZs), are also given in Tables 7 and 8. Those numbers likely overestimate actual Level A takes because the predicted Level A EZs are small and mitigation measures would further reduce the chances of, if not eliminate, any such takes. In addition, most marine mammals would move away from a sound source before they are exposed to sound levels that could result in a Level A take. During the Emperor Seamounts survey where they could be present, Dall's porpoise could be more susceptible to exposure to sound levels that exceed the PTS threshold than other marine mammals, as it is known to approach vessels to bowride. However, Level A takes are considered highly unlikely for most marine mammal species that could be encountered in the proposed survey areas.

Hawaii Survey

The estimate of the number of marine mammals that could be exposed to seismic sounds with received levels ≥160 dB re 1 µPa$_{\text{rms}}$ in the Hawaii survey area is 10,233 cetaceans and 3 pinnipeds (Table 7). That total includes 152 marine mammals listed as ***endangered*** under the ESA: 122 sperm whales, 14 sei whales, 4 fin whales, 3 blue whales, and 6 false killer whales (Main Hawaiian Islands insular stock) representing 0.47%, 0.05%, 0.02%, 0.13%, and 0.24% of their regional populations, respectively, and 3 Hawaiian monk seals or 0.3% of the population. In addition, 405 beaked whales could be exposed. Most (88%) of the cetaceans potentially exposed would be delphinids; the rough-toothed dolphin, striped, pantropical spotted, and Fraser's dolphins are expected to be the most common delphinid species in the area, with estimates of 1949, 1644, 1534, and 1384 exposed to ≥160 dB re 1 µPa$_{\text{rms}}$, respectively (0.12–1.81% of their regional populations).

Emperor Seamounts Survey

The estimate of the number of marine mammalss that could be exposed to seismic sounds with received levels ≥160 dB re 1 µPa$_{\text{rms}}$ in the Emperor Seamounts survey area is 6180 cetaceans and 496 pinnipeds (Table 8). That total includes 663 cetaceans listed as ***endangered*** under the ESA: 457 sperm whales, 122 sei whales, 39 fin whales, 23 North Pacific right whales, 17 humpback whales (Western North Pacific DPS), and 5 blue whales, representing 1.54%, 0.45%, 0.24% 5.11%, 0.08%, and 0.19%, of their regional populations, respectively. We have also requested additional takes for ***endangered*** species that are unlikely to occur in the survey area, including 1 gray whale and 5 Steller sea lions. In addition, 284 beaked whales, 1479 Dall's porpoise, and 3 *Kogia* spp. could be exposed. More than half (59%) of the cetaceans potentially exposed would be delphinids; the Pacific white-sided is expected to be the most common delphinid species in the area, with an estimate of 2870 exposed to ≥160 dB re 1 µPa$_{rms}$, respectively (0.29% of the regional populations). After the Pacific white-sided dolphin, the Dall's porpoise is expected to be the most commonly encountered species with an estimated 1479 individuals or 0.12% individuals exposed. In addition to the cetaceans, 149 northern fur seals and 347 northern elephant seals, or 0.01% and 0.15%, respectively, of their populations might be exposed to seismic sounds with received levels ≥160 dB re 1 µPa$_{rms}$.

4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

The proposed seismic surveys would involve towing a 36-airgun array with a total discharge volume of 6600 in^3, which introduces pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

Marine Mammals.—In § 3.6.7, § 3.7.7, and § 3.8.7, the PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some mysticete, odontocete, and pinniped species and that Level A effects were highly unlikely. NMFS required the calculation of and request for potential Level A takes for the Proposed Action (following a different methodology than used in the PEIS and most previous analyses for NSF-funded seismic surveys). For recently NSF-funded seismic surveys, NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (NMFS 2015, 2016g,h, 2017a,f).

In this analysis, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed programs have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause Level A and/or B harassment are low percentages of the regional population sizes (Tables 7–8). However, the relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on marine mammals would be anticipated from the proposed activities, and they are not likely to adversely affect ESA-listed marine mammal species.

In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The Level B estimates are thought to be conservative; thus, not all animals detected within this threshold distance would be expected to have been exposed to actual sound levels >160 dB.

***Sea Turtles*.—**In § 3.4.7, the PEIS concluded that with implementation of the proposed monitoring and mitigation measures, no significant impacts of airgun operations are likely to sea turtle populations in any of the analysis areas, and that any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related sea turtle injuries or mortality. Given the proposed activity, no significant impacts on sea turtles would be expected.

4.1.2 Direct Effects on Marine Invertebrates, Fish, Fisheries, EFH, and Their Significance

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. Relevant new studies on the effects of sound on marine invertebrates, fish, and fisheries that have been published since the release of the PEIS are summarized below. Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2015; Carroll et al. 2016), including how particle motion rather than sound pressure levels affect invertebrates and fishes that are exposed to sound (Hawkins and Popper 2017; Popper and Hawkins 2018). In addition, vibrations from sounds may also have an effect on the epibenthos, but sensitivities are largely unknown (Roberts and Elliott 2017). However, activities directly contacting the seabed, such as drilling and pile-driving, would be expected to have a greater impact than sound from an airgun array, although water depth would also factor into the degree of impact.

4.1.2.1 Effects of Sound on Marine Invertebrates

Effects of anthropogenic sounds on marine invertebrates are varied, ranging from no overt reactions to behavioral/physiological responses, injuries, or mortalities (Aguilar de Soto 2016; Carroll et al. 2016; Edmonds et al. 2016; Weilgart 2017b). The available information suggests that invertebrates, particularly crustaceans, may be relatively resilient to airgun sounds (Day et al. 2016a,b). Fewtrell and McCauley (2012) exposed captive squid (*Sepioteuthis australis*) to pulses from a single airgun; the received sound levels ranged from 120–184 dB re 1 dB re 1 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses were seen at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$; the squid were seen to discharge ink or change their swimming pattern or vertical position in the water column.

Solé et al. (2013a,b) exposed four cephalopod species held in tanks to low-frequency (50–400 Hz) sinusoidal wave sweeps (with a 1-s sweep period for 2 h) with received levels of 157 ± 5 dB re 1 μPa and peak levels up to 175 dB re 1 μPa. Besides exhibiting startle responses, all four species examined received damage to the statocyst, which is the organ responsible for equilibrium and movement. The animals also showed stressed behavior, decreased activity, and loss of muscle tone (Solé et al. 2013a). To examine the contribution from near-field particle motion from the tank walls on the study, Solé et al. (2017) exposed common cuttlefish (*Sepia officinalis*) in cages in their natural habitat to 1/3 octave bands with frequencies centered at 315 Hz and 400 Hz and levels ranging from 139–141 re 1 μPa^2. The study animals still incurred acoustic trauma and injury to statocysts, despite not being held in confined tanks with walls.

When New Zealand scallop (*Pecten novaezelandiae*) larvae were exposed to recorded seismic pulses, significant developmental delays were reported, and 46% of the larvae exhibited body abnormalities; it was suggested that the malformations could be attributable to cumulative exposure (Aguilar de Soto et al. 2013). Their experiment used larvae enclosed in 60-mL flasks suspended in a 2-m diameter by 1.3-m water depth tank and exposed to a playback of seismic sound at a distance of 5–10 cm.

There have been several *in situ* studies that have examined the effects of seismic surveys on scallops. Although most of these studies showed no short-term mortality in scallops (Harrington et al. 2010; Parry et al. 2002; Przeslawski et al. 2016, 2017), one study (Day et al. 2016a,b, 2017) did show adverse effects including an increase in mortality rates. Przeslawski et al. (2016, 2017) studied the potential impacts of an industrial seismic survey on commercial (*Pecten fumatus*) and doughboy (*Mimachlamys asperrima*) scallops. *In situ* monitoring of scallops took place in the Gippsland Basin, Australia, using dredging, and autonomous underwater vehicle deployment before the seismic survey, as well as two, and ten months after the survey. The airgun array used in the study was a single 2530 in^3 array made up of 16 airguns operating at 2000 psi with a maximum SEL of 146 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$ at 51 m depth. Overall, there was little to no detectable impact of the seismic survey on scallop health as measured by scallop shell size, adductor muscle diameter, gonad size, or gonad stage (Przeslawski et al. 2016). No scallop mortality related to airgun sounds was detected two or ten months after the seismic survey (Przeslawski et al. 2016, 2017).

Day et al. (2016a,b, 2017) exposed scallops (*P. fumatus*) and egg-bearing female spiny lobsters (*Jasus edwardsi*) at a location 10–12 m below the surface to airgun sounds. The airgun source was started ~1–1.5 km from the study subjects and passed over the animals; thus, the scallops and lobsters were exposed to airgun sounds as close as 5–8 m away and up to 1.5 km from the source. Three different airgun configurations were used in the field: 45 in^3, 150 in^3 (low pressure), and 150 in^3 (high pressure), each with maximum peak-to-peak source levels of 191–213 dB re 1 μPa; maximum cumulative SEL source levels were 189–199 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$. Exposure to seismic sound was found to significantly increase mortality in the scallops, especially over a chronic time scale (i.e., months post-exposure), although not beyond naturally occurring rates of mortality (Day et al. 2017). Non-lethal effects were also recorded, including changes in reflex behavior time, other behavioral patterns, and haemolymph chemistry (Day et al. 2016b, 2017). The female lobsters were maintained until the eggs hatched; no significant differences were found in the quality or quantity of larvae for control versus exposed subjects, indicating that the embryonic development of spiny lobster was not adversely affected by airgun sounds (Day et al. 2016a,b). However, there were non-lethal effects, including changes in reflex behavior time and haemolymph chemistry, as well as apparent damage to statocysts; no mortalities were reported for control or exposed lobsters (Day et al. 2016a,b).

Fitzgibbon et al. (2017) also examined the impact of airgun exposure on spiny lobster through a companion study to the Day et al. (2016a,b, 2017) studies; the same study site, experimental treatment methodologies, and airgun exposures were used. The objectives of the study were to examine the haemolymph biochemistry and nutritional condition of groups of lobsters over a period of up to 365 days post-airgun exposure. Overall, no mortalities were observed across both the experimental and control groups; however, lobster total haemocyte count decreased by 23–60% for all lobster groups up to 120 days post-airgun exposure in the experimental group when compared to the control group. A lower haemocyte count increases the risk of disease through a lower immunological response. The only other haemolyph parameter that was significantly affected by airgun exposure was the Brix index of haemolymph at 120 and 365 days post-airgun exposure in one of the experiments involving egg-laden females. Other studies conducted in the field have shown no effects on Dungeness crab larvae or snow crab embryos to seismic sounds (Pearson et al. 1994; DFO 2004; Morris et al. 2018).

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

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

McCauley et al. (2017) conducted a 2-day study to examine the potential effects of sound exposure of a 150 in^3 airgun on zooplankton off the coast of Tasmania; they concluded that exposure to airgun sound decreased zooplankton abundance compared to control samples, and caused a two- to three-fold increase in adult and larval zooplankton mortality. They observed impacts on the zooplankton as far as 1.2 km from the exposure location – a much greater impact range than previously thought; however, there was no consistent decline in the proportion of dead zooplankton as distance increased and received levels decreased. The conclusions by McCauley et al. (2017) were based on a relatively small number of zooplankton samples, and more replication is required to increase confidence in the study findings. Richardson et al. (2017) presented results of a modeling exercise intended to investigate the impact of exposure to airgun sound on zooplankton over a much larger temporal and spatial scale than that employed by McCauley et al. (2017). The exercise modeled a hypothetical survey over an area 80 km by 36 km during a 35-day period. Richardson et al. (2017) postulated that the decrease in zooplankton abundance observed by McCauley et al. (2017) could have been due to active avoidance behavior by larger zooplankton. The modeling results did indicate that there would be substantial impact on the zooplankton populations at a local spatial scale but not at a large spatial scale; zooplankton biomass recovery within the exposure area and out to 15 km occurred 3 days after completion of the seismic survey.

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

Heyward et al. (2018) monitored corals *in situ* before and after exposure to a 3D seismic survey; the maximum SEL and $SPL_{0\text{-pk}}$ were 204 dB re 1 $µPa^2·s$ and 226 dB re 1 µPa. No macroscopic effects on soft tissues or the skeleton were noted days or months after the survey.

4.1.2.2 Effects of Sound on Fish

Potential impacts of exposure to airgun sound on marine fishes have been reviewed by Popper (2009), Popper and Hastings (2009a,b), Fay and Popper (2012), and Weilgart (2017b); they include pathological, physiological, and behavioral effects. Radford et al. (2014) and Putland et al. (2017) noted that masking of key environmental sounds or social signals could also be a potential negative effect from sound. Popper et al. (2014) presented guidelines for seismic sound level thresholds related to potential effects on fish. The effect types discussed include mortality, mortal injury, recoverable injury, temporary threshold shift, masking, and behavioral effects. Seismic sound level thresholds were discussed in relation to fish without swim bladders, fish with swim bladders, and fish eggs and larvae. Hawkins and Popper (2017) cautioned that particle motion as well as sound pressure should be considered when assessing the effects of underwater sound on fishes.

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

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

Miller and Cripps (2013) used underwater visual census to examine the effect of a seismic survey on a shallow-water coral reef fish community in Australia. The census took place at six sites on the reef before and after the survey. When the census data collected during the seismic program were combined with historical data, the analyses showed that the seismic survey had no significant effect on the overall abundance or species richness of reef fish. This was in part attributed to the design of the seismic survey (e.g., ≥400 m buffer zone around reef), which reduced the impacts of seismic sounds on the fish communities by exposing them to relatively low SELs (<187 dB re 1 $\mu Pa^2 \cdot s$).

Fewtrell and McCauley (2012) exposed pink snapper (*Pagrus auratus*) and trevally (*Pseudocaranx dentex*) to pulses from a single airgun; the received sound levels ranged from 120–184 dB re 1 dB re 1 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses were seen in the fish at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$; the fish swam faster and formed more cohesive groups in response to the airgun sounds.

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

Radford et al. (2016) conducted experiments examining how repeated exposures of different sounds to European seabass (*Dicentrarchus labrax*) can reduce the fishes' response to that sound. They exposed post-larval seabass to playback recordings of seismic survey sound (single strike SEL 144 dB re 1 $\mu Pa^2 \cdot s$) in large indoor tanks containing underwater speakers. Their findings indicated that short-term exposure of seismic sound increased the ventilation rate (i.e., opercular beat rate [OBR]) of seabass that were not previously exposed to seismic relative to seabass in controlled, ambient sound conditions. Fish that were reared in tanks that were repeatedly exposed to seismic sound over a 12-week period exhibited a reduced OBR response to that sound type, but fish exposed over the same time period to pile-driving noise displayed a reduced response to both seismic and pile-driving noise. An increased ventilation rate is indicative of greater stress in seabass; however, there was no evidence of mortality or effects on growth of the seabass throughout the 12-week study period.

Przeslawski et al. (2016) studied the potential behavioral impacts of an industrial seismic survey in the Gippsland Basin, Australia, on three shark species: tiger flathead (*Neoplatycephalus richardsoni*), gummy shark (*Mustelus antarcticus*), and swellshark (*Cephaloscylum laticeps*). Sharks were captured and tagged with acoustic tags before the survey and monitored for movement via acoustic telemetry within the seismic area. The energy source used in the study was a single 2530 in^3 array made up of 16 airguns operating at 2000 psi with a maximum SEL of 146 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$ at 51 m depth. Flathead and gummy sharks were observed to move in and around the acoustic receivers while the airguns in the survey were active; however, most sharks left the study area within 2 days of being tagged. The authors of the study did not attribute this behavior to avoidance, possibly because the study area was relatively small. Overall, there was little conclusive evidence of the seismic survey impacting shark behavior, though flathead shark did show increases in swim speed that was regarded by the authors as a startle response to the airguns operating within the area.

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

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

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

4.1.2.3 Effects of Sound on Fisheries

Handegard et al. (2013) examined different exposure metrics to explain the disturbance of seismic surveys on fish. They applied metrics to two experiments in Norwegian waters, during which fish distribution and fisheries were affected by airguns. Even though the disturbance for one experiment was greater, the other appeared to have the stronger SEL, based on a relatively complex propagation model. Handegard et al. (2013) recommended that simple sound propagation models should be avoided and that the use of sound energy metrics like SEL to interpret disturbance effects should be done with caution. In this case, the simplest model (exposures per area) best explained the disturbance effect.

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

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

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

Przeslawski et al. (2016) studied the potential impacts of an industrial seismic survey in the Gippsland Basin, Australia, on catches in the Danish seine and gillnet fishing sectors for 15 fish species. Catch data were examined from 3 years before the seismic survey to six months after completion of the survey in an area 13,000 km^2 which encompassed survey area. Overall, no significant adverse impacts of the seismic survey on catch rates were noted. Six of the 15 species were actually found to have increased catch rates.

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

Morris et al. (2018) conducted a two-year (2015–2016) BACI study examining the effects of 2-D seismic exploration on catch rates of snow crab (*Chionoecetes opilio*) along the eastern continental slope (Lilly Canyon and Carson Canyon) of the Grand Banks of Newfoundland, Canada. The airgun array used was operated from a commercial seismic exploration vessel; it had a total volume of 4880 in^3, horizontal zero-to-peak SPL of 251 dB re 1 µPa, and SEL of 229 dB re 1 µPa^2·s. The closest approach of the survey vessel to the treatment site in 2015 (year 1 of the study) was 1465 m during 5 days of seismic operations; in 2016 (year 2), the vessel passed within 100 m of the treatment site but the exposure lasted only 2 h.

Overall, the findings indicated that the sound from the commercial seismic survey did not significantly reduce snow crab catch rates during days or weeks following exposure. Morris et al. (2018) attributed the natural temporal and spatial variations in the marine environment as a greater influence on observed differences in catch rates between control and experimental sites than exposure to seismic survey sounds.

4.1.2.4 Conclusions for Invertebrates, Fish, and Fisheries

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

Interactions between the proposed survey and fishing operations in the proposed survey areas are expected to be limited. Two possible conflicts in general are the *Langseth*'s streamer entangling with fishing gear and the temporary displacement of fishers from the proposed survey areas. Fishing activities could occur within the proposed survey areas; however, a safe distance would need to be kept from the *Langseth* and the towed seismic equipment. Conflicts would be avoided through communication with the fishing community during the surveys. PSOs would also watch for any impacts the acoustic sources may have on fish during the survey.

Given the proposed activity, no significant impacts on marine invertebrates, marine fish, and their fisheries would be expected, and the proposed project is not likely to adversely affect ESA-listed species. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality. NSF consulted with NMFS regarding EFH and HAPC for the proposed Hawaii Project Area. NMFS concluded in the EFH consultation that while the proposed action may affect EFH and HAPC, any adverse effects would be localized and transitory and therefore not significant (Appendix F).

4.1.3 Direct Effects on Seabirds and Their Significance

The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) has recently been investigated, and the peak hearing sensitivity was found to be between 1500 and 3000 Hz (Crowell 2016). The best sensitivity of underwater hearing for great cormorants was found to be at 2 kHz, with a hearing threshold of 71 dB re 1 μPa_{rms} (Hansen et al. 2017). Great cormorants were also found to respond to underwater sounds and may have special adaptations for hearing underwater (Johansen et al. 2016; Hansen et al. 2017). African penguins (*Spheniscus demersus*) outfitted with GPS loggers showed strong avoidance of preferred foraging areas and had to forage further away and increase their foraging effort when a seismic survey was occurring within 100 km of the breeding colony (Pichegru et al. 2017). However, the birds resumed their normal behaviors when seismic operations concluded.

Potential effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the PEIS. The PEIS concluded that there could be transitory disturbance, but that there would be no significant impacts of NSF-funded marine seismic research on seabirds or their populations. The acoustic source would be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ. Given the proposed activity, no significant impacts on seabirds would be expected, and the proposed activities are not likely to adversely affect ESA-listed seabird species. In decades of seismic surveys carried out by the

Langseth and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related seabird injuries or mortality.

4.1.4 Indirect Effects on Marine Mammals, Sea Turtles, Seabirds and Fish and Their Significance

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

During the proposed seismic surveys, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed surveys would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned. No significant indirect impacts on marine mammals, sea turtles, seabirds, or fish would be expected.

4.1.5 Direct Effects on Recreational SCUBA Divers and Dive Sites and Their Significance

The proposed survey areas are in water depths too great (>700 m) for recreational diving, and relatively far (>14 km) from shore. Thus, there would be no significant impacts expected on, or conflicts with, divers or diving activities in shallow waters.

4.1.6 Cumulative Effects

According to Nowacek et al. (2015), cumulative impacts have a high potential of disturbing marine mammals. Wright and Kyhn (2014) proposed practical management steps to limit cumulative impacts, including minimizing exposure by reducing exposure rates and levels. The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research, including the combined use of airguns with MBES, SBP, and acoustic pingers. However, the PEIS also stated that, “A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the areas of the proposed seismic surveys that may result in cumulative impacts to environmental resources.” Here we focus on activities (e.g., research, vessel traffic, and fisheries) that could impact animals specifically in the proposed survey areas.

4.1.6.1 Past and Future Research Activities

Seismic data were acquired across the Hawaii seamount chain in 1981. While these data provide very useful information, the resolution and depth of penetration of these data are inadequate to address the goals of the proposed program. In 1982, L-DEO and the Hawaii Institute of Geophysics conducted seismic surveys around Oahu (Brink and Brocher 1987). More recently, targeted seismic surveys have also been carried out that focused on small regions and shallow structures, and thus also cannot provide the information on crustal structure needed for the proposed program (e.g., Park et al. 2007). The Japan Agency for Marine-Earth Science and Technology (JAMSTEC), in collaboration with the University of Hawaii, conducted a marine seismic survey north of Hawaii during summer 2017. This survey covered the northern-most part of the proposed Hawaii seismic survey. An IODP expedition occurred along the Emperor Seamounts chain in 2001 and seismic profiles using a watergun were obtained at several drill sites (Kerr et al. 2005). However, no seismic data have ever been acquired across the Emperor Seamount chain.

In Hawaii, the North Pacific Acoustic Laboratory (NPAL) used sound transmission from an underwater projector to examine sound propagation, ocean processes that affect sound speed, and ambient noise (Applied Physics Laboratory-University of Washington 2006). The project used a low-frequency (75 Hz) projector with a source level of 195 dB re 1 μPa that was installed ~14.7 km north of Kauai (DoN 2005). Signals were transmitted for 20 min every 4 hrs, every four days, and arrays around the North Pacific received the acoustic transmissions (DoN 2005). This program was operational until 2006.

4.1.6.2 Naval Activities

The proposed Hawaii survey area is located within the U.S. Navy's Hawaiian Islands Operating Area or OPAREA (DoN 2005), which is part of the Navy's Hawaii Range Complex (HRC). The Pacific Missile Range Facility (PMRF) on Kauai is also considered part of the OPAREA (DoN 2008). The Hawaiian Islands OPAREA "supports the Navy and U.S. Marine Corps tactical training by providing air, surface, and subsurface space for operations such as gunnery, rocket and missile firing, ordnance delivery and recovery, sonar/radar testing, vessel and submarine transit, and undersea warfare exercises (DoN 2000 *in* DoN 2005). Military exercises have the potential to effect marine mammals, sea turtles, seabirds, fish, and marine invertebrates through entanglements, strikes, or harassment by noise (e.g., Manzano-Roth et la. 2016). Testing and training exercises by the Navy have been occurring in the OPAREA for years; the possible number of events per year are shown in DoN (2008). For example, underwater detonations and sonar operations take place in water ~10–30 m deep at the Puuloa Underwater Range site off southern Oahu (Shannon et al. 2016). The limited duration of the proposed seismic survey (~22 days of seismic operations) would be expected to result in only a negligible increase in overall disturbance effects on marine animals and would result in no increase in serious injuries or mortality to marine mammals, sea turtles, or seabirds. L-DEO would coordinate with the Navy to avoid any space-use conflict.

4.1.6.3 Vessel Traffic

Vessel traffic in and around the proposed Hawaii survey area would primarily consist of commercial shipping, recreational vessels, and ferries; in the Emperor Seamounts survey area, all vessel traffic would be commercial shipping. Live vessel traffic information is available from MarineTraffic (2018), including vessel names, types, flags, positions, and destinations. Various types of vessels were in the general vicinity of the proposed survey area (mostly in and around the Hawaiian Islands, especially Oahu) when MarineTraffic (2018) was accessed on 23 February 2018, including cargo vessels/container ships (3), a bulk carrier vessel (1), a crude oil tanker (1), military vessels (2), tugs or pilot vessels (9), pleasure craft vessels (3), and several fishing vessels (17). All the vessels mentioned above had U.S. flags with the exception of the bulk carrier vessel (Hong Kong), the crude oil tanker (Greece), and one of the container vessels (Singapore).

Based on 2017 vessel traffic density information (MarineTraffic 2018), the majority of commercial vessels travel in shipping lanes between the Hawaiian Islands. However, according to vessel traffic density maps, there are also commercial shipping lanes in open waters that travel from Honolulu to ports in Seattle, San Francisco and Los Angeles. These lanes pass through the proposed Hawaiian Islands survey area. According to MarineTraffic (2018), there are at least 13 ports of entry for the Main Hawaiian Islands; 2 on Hawaii, 2 on Maui, 6 on Oahu, and 3 on Kauai.

Live vessel traffic information from MarineTraffic (2018) for the Emperor Seamounts survey area showed 5 cargo vessels in the vicinity when accessed on 23 February 2018. Vessel density information shows that there are regular transits through the area by vessels travelling between Asia and North America, with the density of vessel tracks greatest in the northern portion of the survey area (MarineTraffic 2018).

The total transit distance of ~15,000 km (including transit to and from port, and OBS deployment/ recovery) by the *Langseth* would be small relative to total transit length for vessels operating in the general regions around the proposed survey areas. Thus, the addition of the seismic source vessel traffic to existing shipping and fishing operations (see below) is expected to result in a only a minor increase in overall ship traffic.

4.1.6.4 Fisheries Interactions

The commercial fisheries in the general area of the proposed surveys are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles involve noise, potential entanglement, and removal of prey items (e.g., Reeves et al. 2003).

Entanglement in fishing gear can lead to serious injury or mortality of some marine mammals. Large whales as well as small cetaceans have become entangled in fishing gear in the waters of Hawaii (Forney and Kobayashi 2007; Bradford and Forney 2014, 2017). From 2010–2014, 46 and 54 cetaceans were taken as bycatch in the deep-set and shallow-set fisheries off Hawaii, respectively (Bradford and Forney 2017). Of the 46 interactions with the deep-set fishery, 25 involved false killer whales, 6 unidentified cetaceans, 4 blackfish, 3 common bottlenose dolphins, 1 pygmy killer whale, 1 Risso's dolphin, 1 short-finned pilot whale, 1 pygmy sperm whale, 1 humpback whale, 1 sperm whale, 1 rough-toothed dolphin, 1 striped dolphin; most were serious injuries, although 5 deaths were also reported (Bradford and Forney 2017). Just under 50% of the interactions occurred inside the Hawaiian Islands EEZ; these were distributed roughly evenly on the north and south side of the main Hawaiian Islands (Bradford and Forney 2017).

Of the 54 interactions with the shallow-set fishery, 20 involved Risso's dolphins, 11 common bottlenose dolphins, 5 striped dolphins, 3 false killer whales, 2 unidentified cetaceans, 2 short-beaked common dolphins, 2 northern elephant seals, 2 unidentified Mesoplodonts, 1 blackfish, 1 humpback, 1 rough-toothed dolphin, 1 Blainville's beaked whale, 1 unidentified beaked whale and 1 unidentified eared seal; most were serious injuries but 6 deaths were also reported (Bradford and Forney 2017). Most of the interactions took place outside of the EEZ, north of the Main Hawaiian Islands; only 4 occurred around the Hawaiian Archipelago (Bradford and Forney 2017). Additionally, between 1976 and 2014, there were at least 140 interactions between Hawaiian monk seals and fisheries in the Main Hawaiian Islands (NMFS 2016i).

In Japan, the trap-net fishery has taken 100 minke whales, and occasional gray and humpback whales (Kasuya 2007). The endangered Western North Pacific gray whale also experiences mortality from entrapment or entanglement in fishing gear. In recent years, there have been several mortalities of gray whales undergoing migration due to coastal net fisheries, particularly off Japan (Weller et al. 2008; Kato et al. 2016). Parsons and Jefferson (2000) reported eight of 64 cetaceans examined post-mortem from the waters near Hong Kong exhibited wounds consistent with fisheries bycatch suggesting possible high incidence of cetacean interaction with fishing gear. Off the east coast of Taiwan, entanglement of marine mammals in drift gillnets occurs frequently (Perrin et al. 2005); between 27,000 and 41,000 cetaceans are thought to be taken incidentally by fisheries each year. The high seas driftnet fishery has also taken thousands of cetaceans as bycatch (Hobbs and Jones 1993). The most commonly species taken during the 1989–1991 fisheries included northern right whale dolphins, Pacific white-sided dolphin, northern fur seal, Dall's porpoise, common dolphin, and striped dolphin; some of these were taken within the proposed Emperor Seamounts survey area.

Incidental capture in commercial fishing gear is also a major threat to sea turtles throughout the Pacific Ocean, including coastal waters of southeast Asia (Frazier et al. 1998), offshore of Hawaii (Skillman and Balazs 1992; Polovina et al. 2000; Beverly and Chapman 2007; McCracken 2000), and the Kuroshio Extension (Polovina et al. 2000; Lewison et al. 2004; Kaplan 2005; Yokota et al. 2006). The sea turtle species caught most frequently on pelagic longlines are loggerheads and leatherbacks (Lewison et al. 2004). Olive ridley and green turtles are also caught in the Hawaii-based longline fishery (Beverly and Chapman 2007). Lewison et al. (2004) estimated that 30,000–75,000 loggerheads were taken as bycatch in longlines in 2000 in the Pacific; the estimate for leatherbacks was lower (20,000–40,000). In 2002, 2003, and 2004, only loggerheads were caught in the Kuroshio Extension by the longliners (Yokota et al. 2006). Nishimura and Nakahigashi (1990) estimated that Japanese research and training vessels captured over 21,200 turtles historically in the western Pacific and South China Sea, of which an estimated 12,296 were killed.

From 1994–1999, ~147 loggerhead, 40 leatherback, 32 olive ridley, and 10 green turtles were taken as bycatch in the Hawaiian fisheries (McCracken 2010). In 2004, NMFS (2004) set restrictions on types of fishing gear and the number of annual fishery interactions with leatherback and loggerhead sea turtles. The NOAA TurtleWatch product has been in place since 2006 to help reduce bycatch of loggerhead and leatherback turtles in the Hawaii-based longline fishery by decreasing fishing effort in areas where turtles concentrate (Howell et al. 2015), including the northern portion of the Hawaii survey area. Prior to the North Pacific drift net fishery moratorium, as many as 4000 loggerheads were taken annually in the North Pacific, and 16,000 turtles of all species in the west Pacific (Bowen et al. 1995). Finkbeiner et al. (2011) estimated that before the regulations came into effect in 2004, ~700 sea turtle/fishery interactions occurred in the Hawaiian pelagic longline fishery annually; after the regulations, ~100 interactions annually were estimated. Gilman et al. (2007) reported that since those longline regulations came into effect, capture rates of leatherback and loggerhead turtles in Hawaii decreased by 83% and 90%, respectively.

Entanglement in fishing gear and hooking can also lead to mortality of seabirds. Before any regulations were in place, thousands of Laysan and black-footed albatross were killed by longliners in Hawaiian waters (Manville 2005). In 2016, NMFS (2018c) reported 144 and 65 seabird/longline fishery interactions for Hawaiian deep-set and shallow-set fisheries, respectively. No interactions between fisheries and short-tailed albatross, Newell's shearwater, Hawaiian petrel or band-rumped storm petrel have ever been documented (NMFS 2018c).

There might also be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey areas. The proposed operations in the survey areas would be limited (up to 36 days), and the addition of the proposed surveys to existing commercial fishing operations is expected to result in only a negligible increase in overall disturbance effects on marine mammals and sea turtles. The addition of the *Langseth*'s operations to existing fishing operations would result in no increase in serious injuries or mortality in marine mammals or sea turtles.

4.1.6.5 Whaling and Harvesting

Whales and small cetaceans have been hunted for centuries in the western North Pacific. Legal harvesting of cetaceans still occurs in Japan and Russia (IWC 2018b). Japan joined the IWC in 1951, and currently conducts whaling under scientific permit; the former USSR (now Russian Federation) joined in

1948 and is engaged in aboriginal subsistence whaling. China and Korea are also members of the IWC.

In Japan, the fishery for cetaceans includes small-type whaling, drive fishery for dolphins, and hand harpoon fishery for dolphins and porpoises (Kasuya 2007, 2009b). In 2007, the quota was 66 Baird's beaked whale, 36 for each of two populations of short-finned pilot whales, and 20 Risso's dolphins (Kasuya 2009b). Drive fisheries for seven different dolphin species still occur on the Izu and Kii coasts; the quota is ~3000 dolphins (Kasuya 2007, 2009b). Dolphins and porpoises are also taken in harpoon fisheries; in 2007/2008, 366 vessels were in operation, with quotas of ~17,000 Dall's porpoises, 246 Risso's dolphins, 190 Pacific white-sided dolphins, 172 striped dolphins, 95 bottlenose dolphins, and 70 pantropical spotted dolphins, 500 short-finned pilot whales, and 50 false killer whales (Kasuya 2009b).

Although the IWC banned commercial whaling in 1985/1986, Japan still conducts large-type whaling. The Japan Institute of Cetacean Research (ICR) started whaling for scientific purposes in the 1987/1988 Antarctic season and in 1994 in the North Pacific (IWC 2018b). In the North Pacific, approximately 220 minke whales, 50 Bryde's whales, 100 sei whales, and 10 sperm whales are taken annually (IWC 2018b). In 1986, the Republic of Korea also took 69 minke whales in the North Pacific under a 'scientific' permit (IWC 2018b). No commercial whaling has taken place in Russia since the moratorium; however, aboriginal subsistence whaling for eastern North Pacific gray whales still continues in the North Pacific by natives of Chukotka, Russia; catch limits are imposed by the IWC (2018b). Northern fur seals were also harvested historically at the Pribilof Islands (NMFS 1993).

Historically cetaceans were hunted in southern Taiwan; baleen whales as well as beaked and killer whales were taken. Up until 1990, a drive fishery of false killer whales occurred in the Penghu Islands, Taiwan, where dozens of whales were taken. Although killing and capturing of cetaceans has been prohibited in Taiwan since August 1990 under the Wildlife Conservation Law (Zhou et al. 1995; Chou 2004), illegal harpooning still occurs (Perrin et al. 2005). From 1993 to 1995, ~600 cetaceans were taken by harpoon per year in Nanfang Ao, in northeast Taiwan, despite this practice being outlawed since 1990 under the Wildlife Conservation Law (Zhou et al. 1995; Chou 2004; Perrin et al. 2005).

In China, a considerable number of sea turtles were harvested before they were listed as a protected species in 1988 (Liang et al. 1990 *in* Chan et al. 2007). Both the eggs and nesting turtles were harvested for consumption from nesting sites such as those at Gangkou and the Xisha Archipelago (Chan et al. 2007). Green turtles were also intensively fished, mostly during summer and autumn, in the Xisha Archipelago (Frazier et al. 1988). Direct beach harvesting for meat was common in Taiwan in the early 1970s, especially along the east coast, resulting in the mortality of most of the nesting green turtles (Chan et al. 2007). Similar to green turtles, the population of hawksbill turtles in China declined dramatically in recent decades due to overharvesting. The direct harvesting of sea turtles and egg poaching is prohibited in protected nesting sites; however, illegal capture still occurs (Chan et al. 2007).

4.1.6.6 Tourism

Hawaii is home to numerous tour operators offering whale-watching, dolphin swims, deep-sea fishing or other charter cruises to tourists. Whale-watching trips that primarily focus on humpbacks run between December and April. There are ~five humpback whale watching areas in the nearshore waters of Oahu, one at Molokai, six along the west coast of Maui, and five along the west coast of the Big Island (DoN 2005). However, many operators continue year-round focusing on dolphins and humpbacks, when present. In 1999, there were 52 vessels that offered humpback whale watching in the Main Hawaiin Islands, with 87 trips per day (Utech 2000). Vessels do several trips a day lasting ~2 hrs each (Utech 2000). Most vessels stay within 3 km from shore and within the HIWNMS (DoN 2005). There are also four dolphin swim tour sites along the west coast of the Big Island, one off the west coast of Oahu, and one on the south coast of Maui (DoN 2005). There are at least a dozen whale-watching and dolphin tour boats operating in the vicinity of the proposed transect lines off of Oahu and the Big Island.

No tourism occurs in the Emperor Seamount survey area, due to the region's far offshore location.

4.1.7 Unavoidable Impacts

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

4.1.8 Coordination with Other Agencies and Processes

This Final EA has been prepared by LGL on behalf of L-DEO and NSF pursuant to NEPA and Executive Order 12114. Potential impacts to marine mammals, endangered species, and critical habitat have also been assessed in the document. The Draft EA was used to support the ESA Section 7 consultation process with NMFS and USFWS and other regulatory processes, such as the EFH and CZMA. The Draft EA was also used as supporting documentation for an IHA application submitted by L-DEO, on behalf of itself, NSF, and the University of Hawaii, to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for the proposed seismic surveys. NSF posted the Draft EA on the NSF website for a 30-day public comment period from 16 April 2018 through 16 May 2018; no comments were received during, or after, that time period. During the public comment period associated with the PEIS, the Office of Hawaiian Affairs (OHA) requested to be directly notified of future NSF activities prior to commencement. In compliance with that request, NSF sent an email to OHA on 16 April 2018 to inform OHA of the Proposed Action and availability of the Draft EA public comment period.

NSF coordinated with NMFS to complete the Final EA prior to issuance of an IHA and Biological Opinion/ITS to accommodate NMFS' need to adopt NSF's Final EA as part of the NMFS NEPA process associated with issuing authorizations. NSF had enhanced coordination with NMFS throughout the IHA and ESA consultation processes to facilitate this streamlined approach. In addition to federal environmental regulatory requirements, NSF and L-DEO coordinated with the Navy to avoid space-use conflicts.

(a) Endangered Species Act (ESA)

The Draft EA was used during the ESA Section 7 consultation process with NMFS and USFWS. On 20 April 2018, NSF submitted a letter of concurrence request to USFWS that the proposed activity may affect but was not likely to adversely affect the ***endangered*** Hawaiian petrel, short-tailed albatross, and band-rumped storm petrel; and the ***threatened*** Newell's shearwater. On 13 July 2018, USFWS provided a letter of concurrence (Appendix H) that the proposed activity "may affect" but was not likely to "adversely affect" these species under their jurisdiction. Mitigation measures for these species would include power downs/shut downs for diving or foraging ESA-listed seabirds within the exclusion zones. On 15 March 2018, NSF submitted a formal ESA Section 7 consultation request, including the Draft EA, to NMFS for the proposed activity. As previously noted, NSF had enhanced coordination with NMFS during the consultation process. Based on this enhanced coordination, NSF anticipates that a Biological

Opinion and ITS will be issued for the proposed activity with a finding of "may affect but not likely to adversely affect" threatened and endangered species. As part of its decision-making process for the Proposed Action, NSF will take into consideration the Biological Opinion and ITS issued by NMFS and the results of the entire environmental review process.

(b) Marine Mammal Protection Act (MMPA)

The Draft EA was also used as supporting documentation for an IHA application submitted on 16 March 2018 by L-DEO on behalf of itself, NSF, and the researchers, to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals during the proposed seismic survey. On 28 June 2018, NMFS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period. Public comments were received from six entities during that process; NMFS considered the comments and will provide responses as required per the IHA process. As previously noted, NSF had enhanced coordination with NMFS during the IHA application process. Based on this enhanced coordination, NSF anticipates that an IHA will be issued for the proposed activity. As part of its decision-making process for the Proposed Action, NSF will take into consideration the IHA issued by NMFS and the results of the entire environmental review process.

(c) Coastal Zone Management Act (CZMA)

On 14 May 2018, the Hawaii CZM Program conditionally concurred "with the NSF determination that the proposed activity is consistent to the maximum extent practicable with the enforceable policies of the Hawaii CZM Program" (Appendix H). The conditions include that the: (1) proposed activity shall be conducted as represented in the consistency determination; (2) proposed monitoring and mitigation measures as presented in the Draft EA shall be implemented; and (3) State of Hawaii listed species shall be provided protections consistent with provisions of the Hawaii CZM Program.

(d) Essential Fish Habitat (EFH)

Water column EFH was identified to occur within the proposed survey area and HAPCs within the vicinity. Although NSF anticipated no significant impacts to EFH and HAPC, as the Proposed Action may affect EFH and HAPC, in accordance with the Magnuson-Stevens Fishery Conservation and Management Act, NSF requested consultation with NMFS on 25 April 2018. In an email dated 3 May 2018 (Appendix F), NMFS concurred with NSF's determination that the proposed project may affect EFH and HAPC, but that any adverse effects would be localized and transitory and therefore would not be significant. As such, NMFS did not provide additional conservation recommendations for Proposed Action, thus satisfying the requirements of both sections 305(b)(2)(A) and sections 305(b)(2)(B) of the Magnuson-Stevens Act.

4.2 No Action Alternative

An alternative to conducting the proposed activity is the "No Action" Alternative, i.e., do not conduct the research and operations. If the research and operations were not conducted, the "No Action" alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed activity; however, valuable data about the marine environment and an opportunity for international scientific collaboration would be lost. Research that would contribute to our understanding of the formation of the Hawaiian-Emperor Seamount chain, and adding to the comprehensive assessment of geohazards for the Hawaiian Islands region, such as earthquake, tsunami, and submarine landslide hazards, would not be collected. The No Action Alternative would not meet the purpose and need for the proposed activity.

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LIST OF APPENDICES

APPENDIX A: DETERMINATION OF MITIGATION ZONES

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for both the exclusion zones (EZ) for Level A takes and safety zones (160 dB re 1µPa$_{rms}$) for Level B takes. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS) as a function of distance from the 36-airgun array and for a single 1900LL 40-in^3 airgun, which would be used during power downs; all models used a 12-m tow depth. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

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

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

The proposed surveys would acquire data with the 36-airgun array at a maximum tow depth of 12 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Fig. A-1). The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the PEIS). Measurements have not been reported for a 40-in^3 airgun; thus, L-DEO model results are used to determine the 160-dB$_{rms}$ radius for the 40-in^3 airgun at a 12-m tow depth in deep water (Fig. A-2).

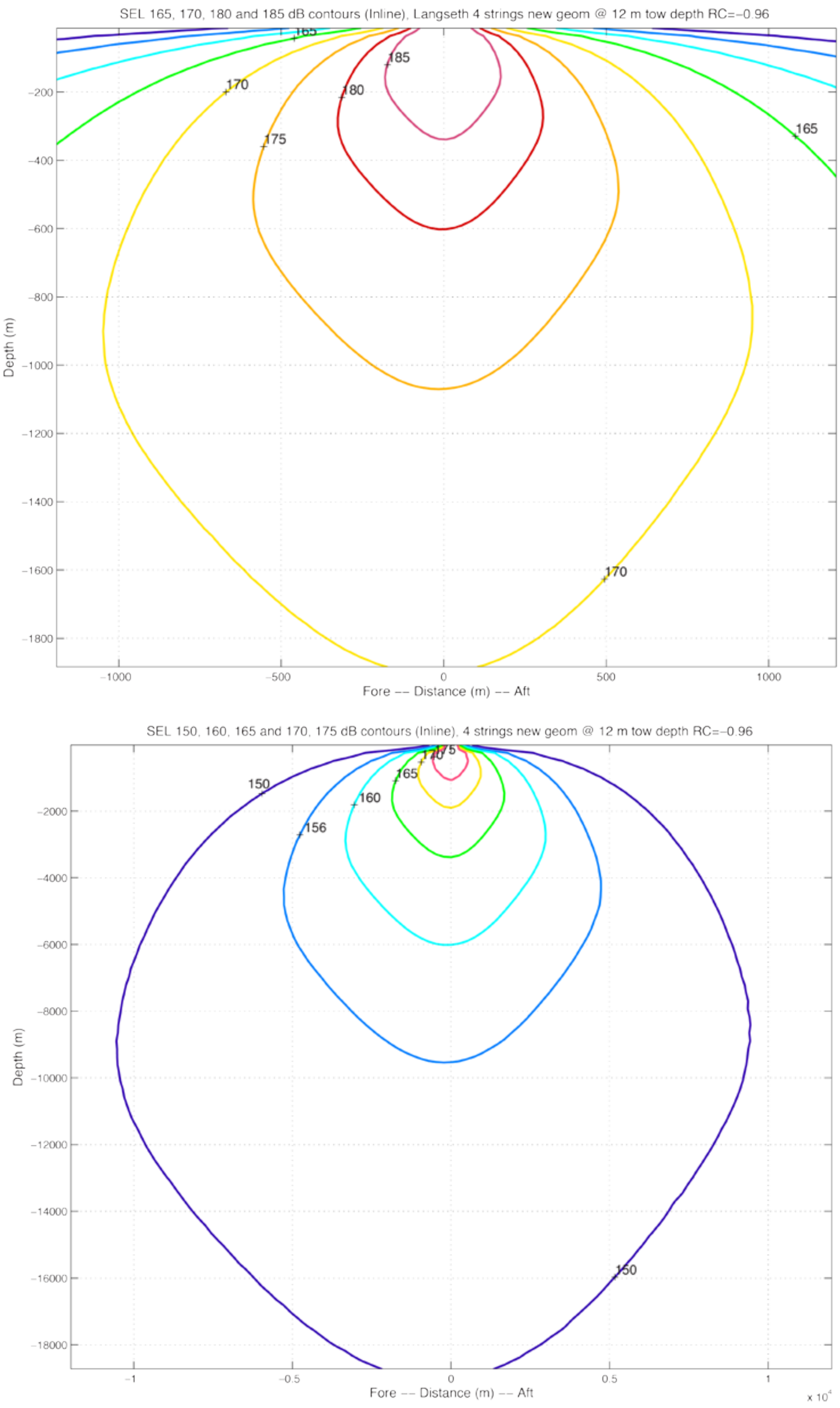

FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth planned for use during the proposed surveys in the North Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

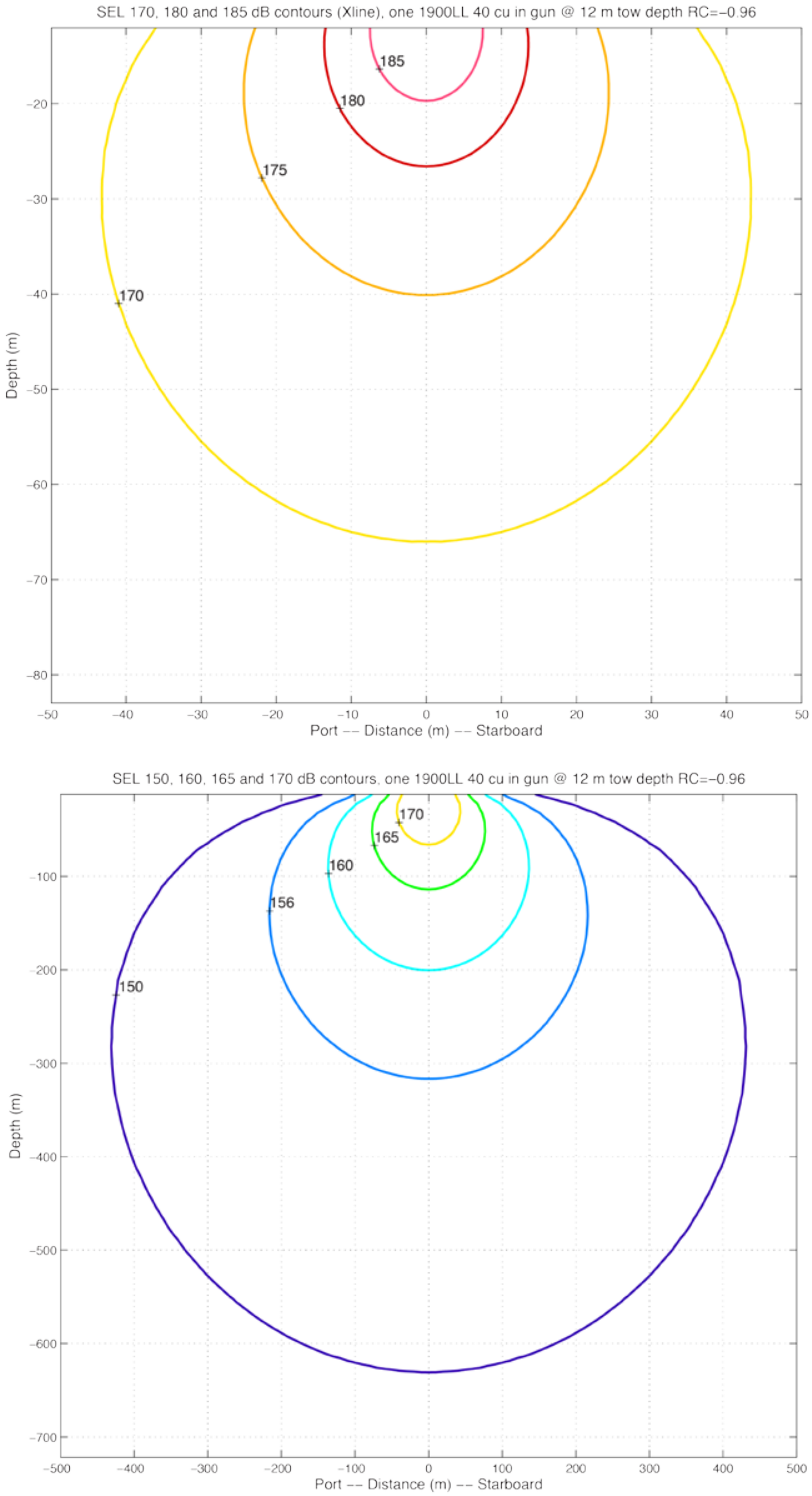

FIGURE A-2. Modeled deep-water received SELs from a single 40-in^3 airgun towed at a 12-m depth, which is planned for use as a mitigation airgun during the proposed surveys in the North Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

Table A-1 shows the distances at which the 160-dB re 1µPa$_{rms}$ sound levels are expected to be received for the 36-airgun array and the single (mitigation) airgun. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals. A recent retrospective analysis of acoustic propagation of *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, data collected by Crone et al. (2017) during a survey off New Jersey in 2014 and 2015 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by the *Langseth* hydrophone streamer were 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[2] have confirmed that the L-DEO model generated conservative EZs, resulting in significantly larger EZs than required by National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS).

In July 2016, NMFS released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016). The new guidance established new thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The new noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors, as summarized by Finneran (2016). For impulsive sources, onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL$_{cum}$ and SPL$_{flat}$, respectively. The new guidance incorporates marine mammal auditory weighting functions (Fig. A-3) and dual metrics of cumulative sound exposure level (SEL$_{cum}$ over 24 hours) and peak sound pressure levels (SPL$_{flat}$). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by NMFS (2016), the largest distance of the dual criteria (SEL$_{cum}$ or Peak SPL$_{flat}$) was used to calculate takes and Level A threshold distances. The new guidance did not alter the current threshold, 160 dB re 1µPa$_{rms}$, for Level B harassment (behavior).

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

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

TABLE A-1. Level B. Predicted distances to which sound levels ≥160-dB re 1 μPa$_{rms}$ could be received during the proposed surveys in the North Pacific Ocean. The 160-dB criterion applies to all hearing groups of marine mammals.

Source and Volume	**Tow Depth (m)**	**Water Depth (m)**	**Predicted distances (in m) to the 160-dB Received Sound Level**
Single Bolt airgun, 40 in^3	12	>1000 m	431[1]
		100–1000 m	647[2]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]
		100–1000 m	10,100[2]

[1] Distance is based on L-DEO model results.

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

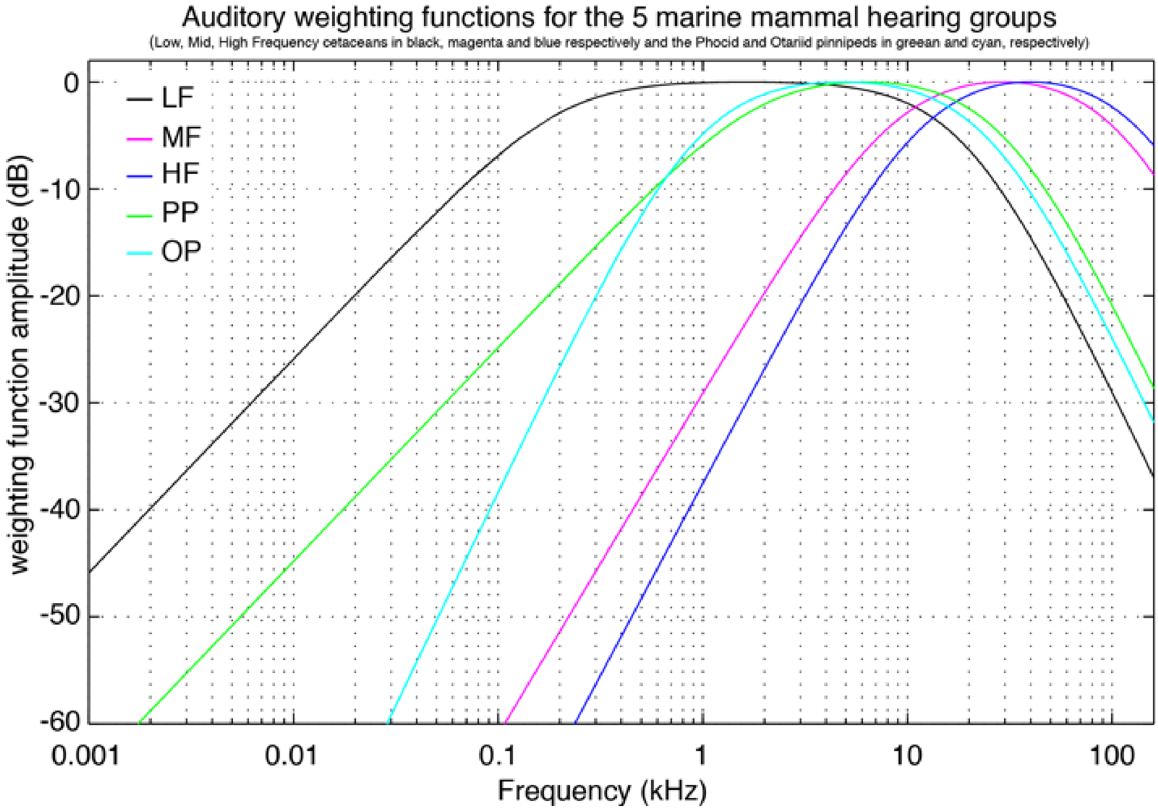


FIGURE A-3. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance Spreadsheet.

(Tolstoy et al. 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the large array effect near the source and is calculated as a point source, the farfield signature is not an appropriate measure of the sound source level for large arrays.

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

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on overriding the default values and calculating individual adjustment factors (dB) based on the modified farfield and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (source velocity and duty) after Sivle et al. (2014). A source velocity of 2.109 m/s and a 1/Repetition rate of 23.7054 s were used as inputs to the NMFS User Spreadsheet for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the 36-airgun array and the single 40-in^3 mitigation airgun.

For the LF cetaceans during operations with the 36-airgun array, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest. We first ran the modeling for a single shot without applying any weighting function; we then ran the modeling for a single shot with the LF cetacean weighting function applied to the full spectrum. The difference between these values provides an adjustment factor of -12.91 dB assuming a propagation of $20\log_{10}$(Radial distance) (Table A-2).

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

For the 36-airgun array, the results for single shot SEL source level modeling are shown in Table A-2. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 36-airgun array are shown in Table A-3. Figure A-4 shows the impact of weighting functions by hearing group. Figures A-5–A-7 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-8 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

The thresholds for Peak SPL_{flat} for the 36-airgun array, as well as the distances to the PTS thresholds, are shown in Table A-4. Figures A-9–A-11 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot. A summary of the Level A threshold distances are shown in Table A-5.

TABLE A-2. Results for single SEL source level modeling for the 36-airgun array with and without applying weighting functions to the five hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

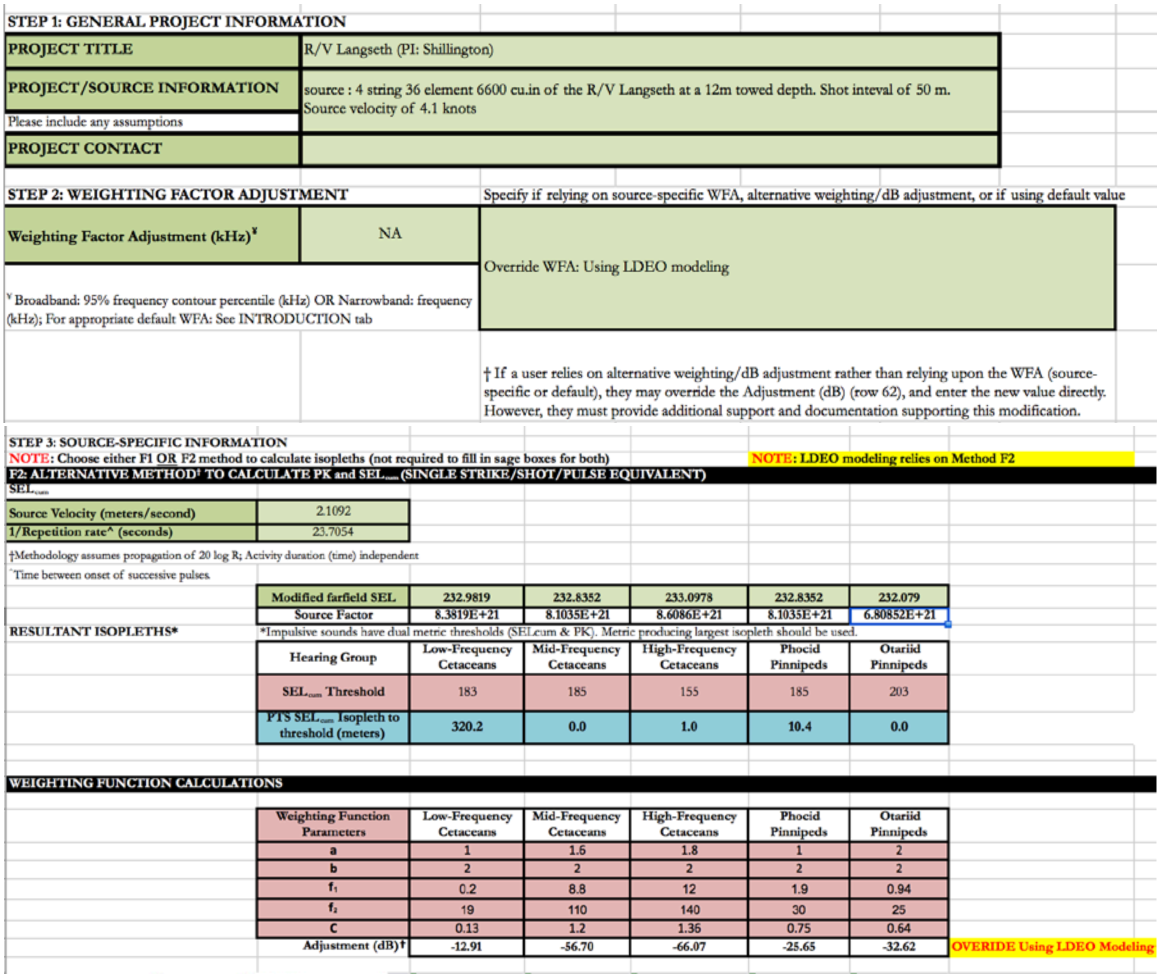
SEL_{cum} Threshold	**183**	**185**	**155**	**185**	**203**
Radial Distance (m) (no weighting function)	315.5691	246.4678	8033.2	246.4678	28.4413
Modified Farfield SEL	232.9819	232.8352	233.0978	232.8352	232.0790
Radial Distance (m) (with weighting function)	71.3752	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-12.91	N.A.	N.A.	N.A.	N.A.

* Propagation of 20 log R. N.A. means not applicable or not available.

For the single 40 in^3 mitigation airgun, the results for single shot SEL source level modeling are shown in Table A-6. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 40 in^3 airgun are shown in Table A-7. Figure A-12 shows the impact of weighting functions by hearing group for the single mitigation airgun. Figures A-13–A-14 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-15 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans. The thresholds for Peak SPL_{flat} for the 40 in^3 airgun, as well as the distances to the PTS thresholds, are shown in Table A-8. Figures A-16–A-17 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot. A summary of the Level A threshold distances are shown in Table A-9.

Table A-10 shows the distances at which the 175- and 195-dB re 1µPa_{rms} sound levels are expected to be received for the 36-airgun array, and a single airgun, based on L-DEO modeling. The 195-dB distance would be used as the EZ for sea turtles, as required by NMFS. The 175-dB level is used by NMFS, based on data from the USN (2017), to determine behavioral disturbance for turtles.

TABLE A-3. Results for single shot SEL source level modeling for the 36-airgun array with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.



STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V Langseth (PI: Shillington)
PROJECT/SOURCE INFORMATION Please include any assumptions	source : 4 string 36 element 6600 cu.in of the R/V Langseth at a 12m towed depth. Shot inteval of 50 m. Source velocity of 4.1 knots
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

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

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

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

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

STEP 3: SOURCE-SPECIFIC INFORMATION

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

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.1092
1/Repetition rate^ (seconds)	23.7054

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

^Time between onset of successive pulses.

Modified farfield SEL	232.9819	232.8352	233.0978	232.8352	232.079
Source Factor	8.3819E+21	8.1035E+21	8.6086E+21	8.1035E+21	6.80852E+21

RESULTANT ISOPLETHS*

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

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	**320.2**	**0.0**	**1.0**	**10.4**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-12.91	-56.70	-66.07	-25.65	-32.62	**OVERIDE Using LDEO Modeling**

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

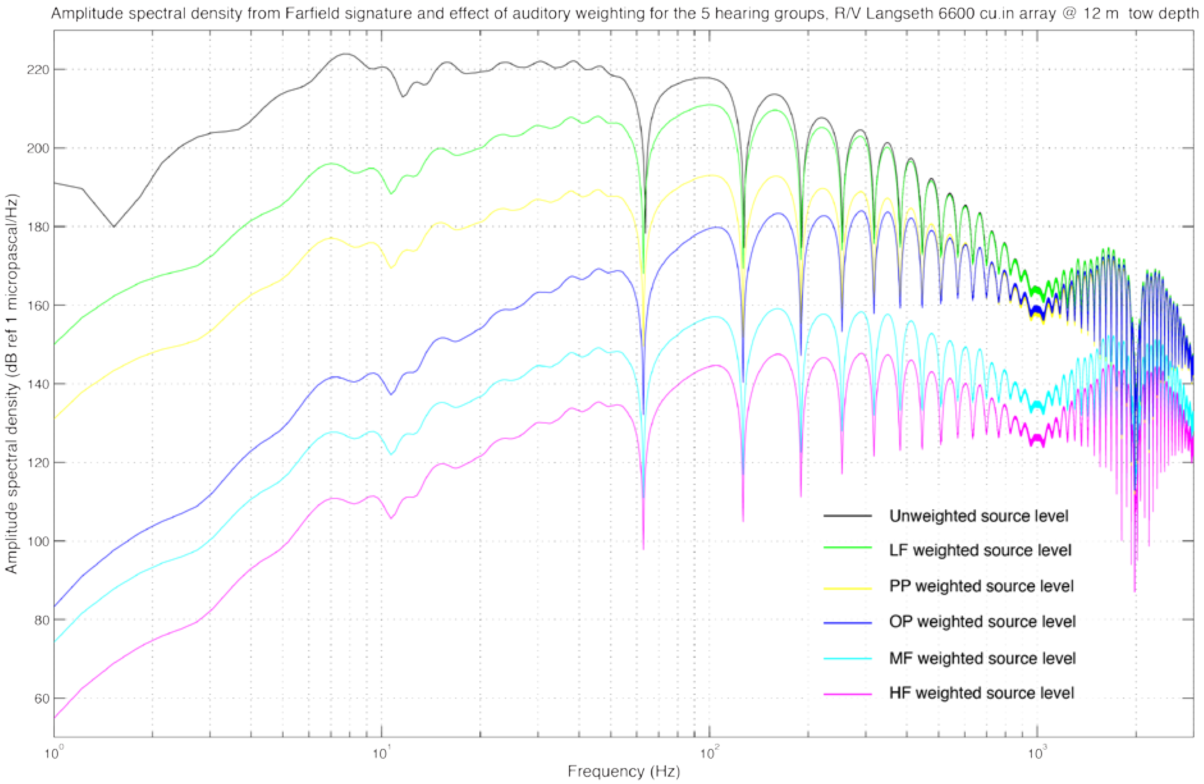


FIGURE A-4. Modeled amplitude spectral density of the 36-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

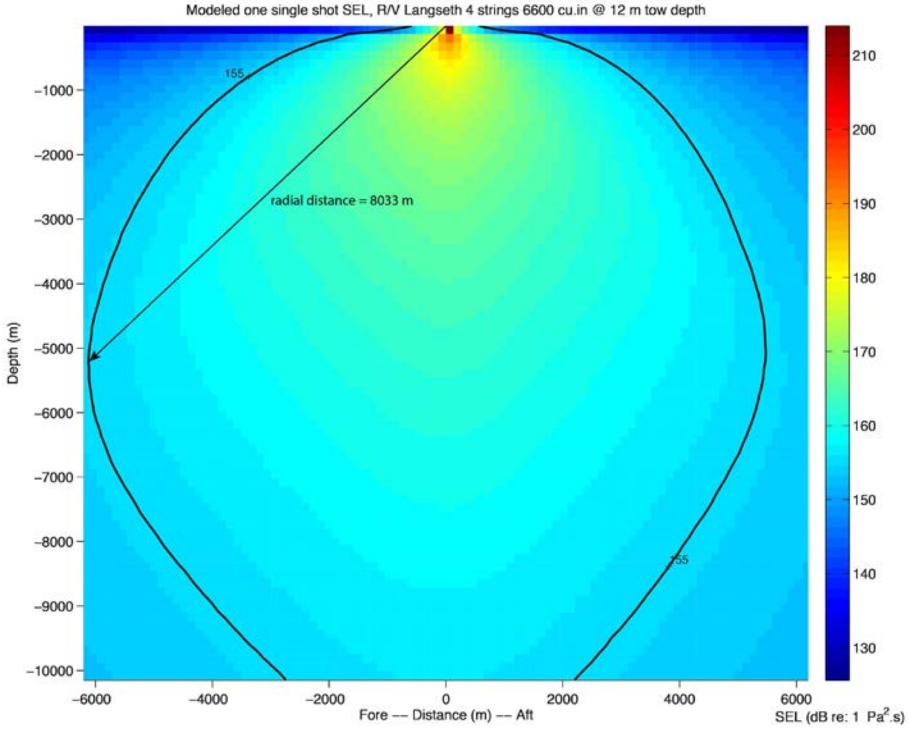


FIGURE A-5. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 155-dB SEL isopleth (8033 m). Radial distance allows us to determine the modified farfield SEL using a propagation of 20log$_{10}$(radial distance).

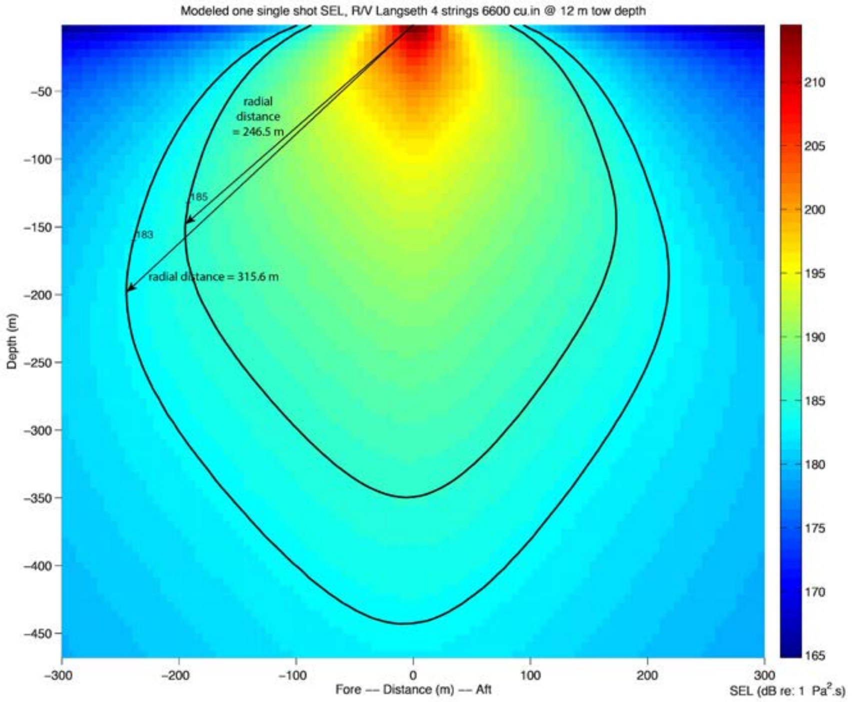


FIGURE A-6. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths (315.6 and 246.5 m, respectively).

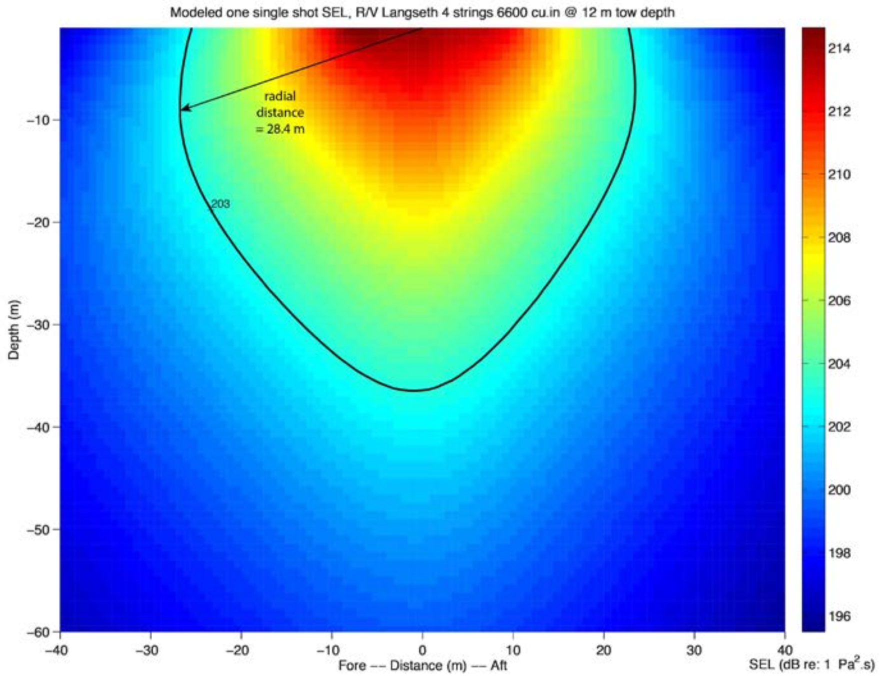


FIGURE A-7. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 203-dB SEL isopleth (28.4 m).

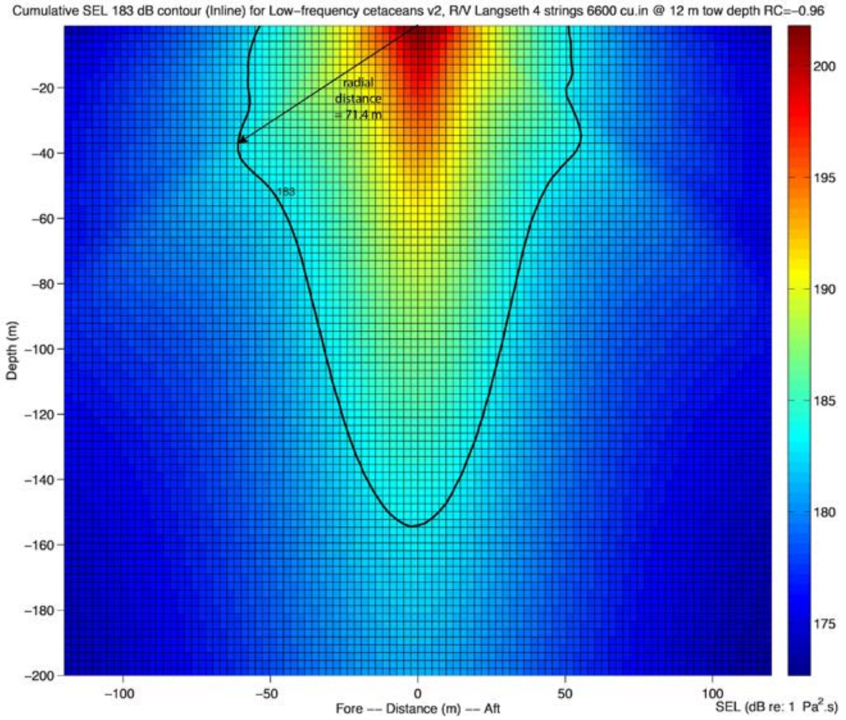


FIGURE A-8. Modeled received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-6 and this figure (71.4 m) allows us to estimate the adjustment in dB.

TABLE A-4. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 36-airgun array during the proposed surveys in the North Pacific Ocean.

Hearing Group	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
Peak Threshold	**219**	**230**	**202**	**218**	**232**
Radial Distance to Threshold (m)	45.00	13.566	364.666	51.590	10.615
Modified Farfield Peak SPL	252.06	252.65	253.24	252.25	252.52
PTS Peak Isopleth (Radius) to Threshold (m)	38.9	13.6	268.3	43.7	10.6

N.A. means not applicable or not available.

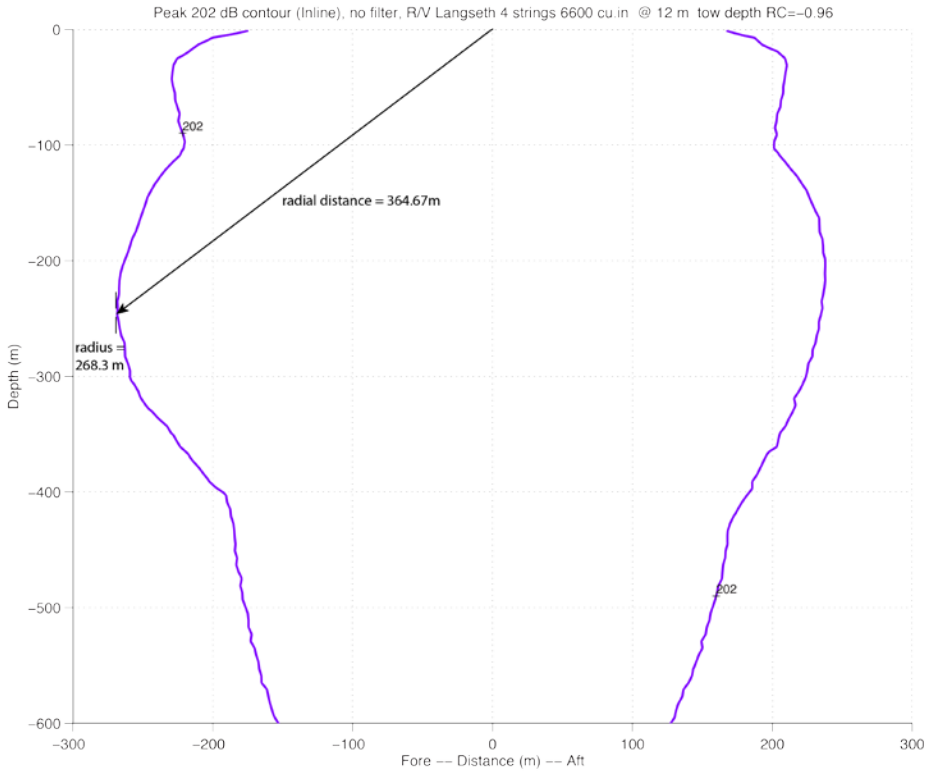


FIGURE A-9. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distance to the 202-dB Peak isopleths.

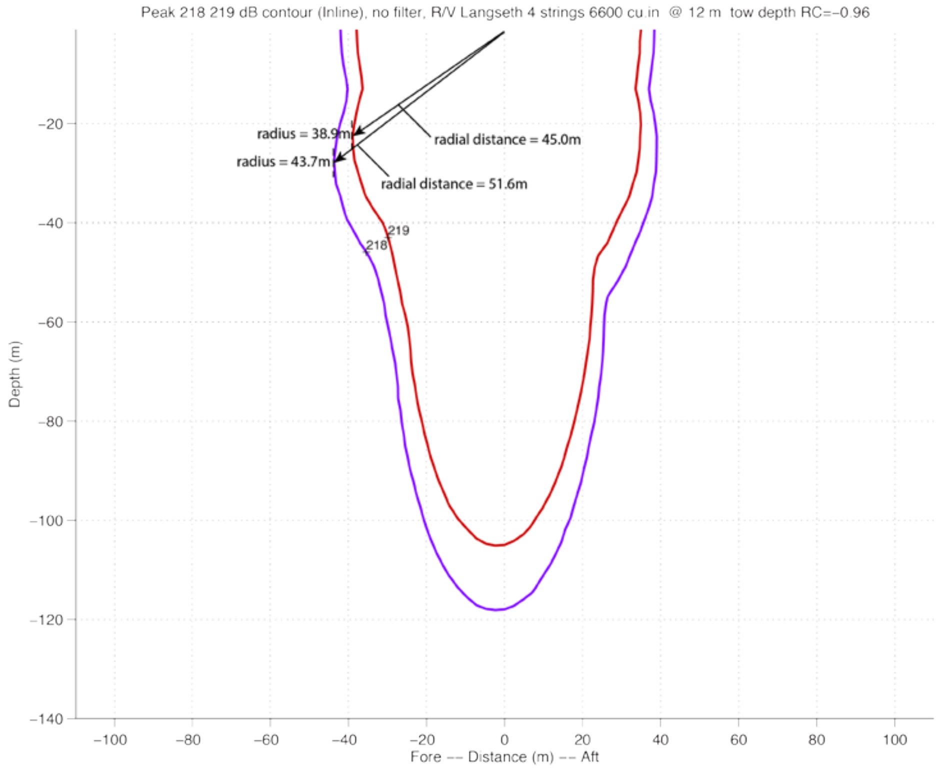


FIGURE A-10. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

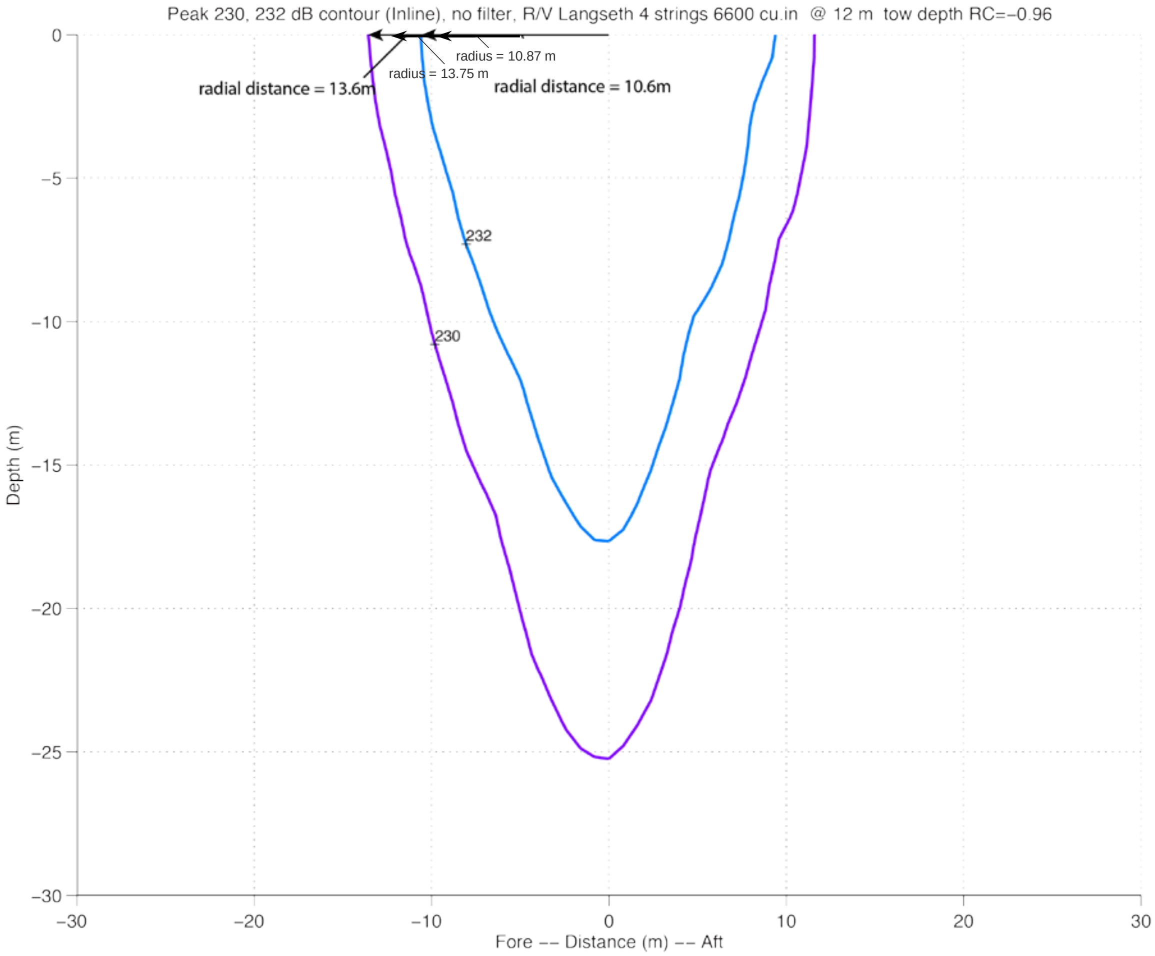


FIGURE A-11. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

TABLE A-5. Level A threshold distances for different marine mammal hearing groups for the 36-airgun array. As required by NMFS (2016), the largest distance (in bold) of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances.

	Level A Threshold Distances (m) for Various Hearing Groups				
36-airgun array; 6600 in^3	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PTS SEL_{cum}	**320.2**	0	1.0	10.4	0
PTS Peak	38.9	**13.6**	**268.3**	**43.7**	**10.6**

TABLE A-6. Results for single shot SEL source level modeling for the 40 in^3 airgun with and without applying weighting function to the various hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	**183**	**185**	**155**	**185**	**203**
Distance (m) (no weighting function)	9.9893	7.8477	294.0371	7.8477	0.9278
Modified Farfield SEL*	202.9907	202.8948	204.3680	202.8948	202.3491
Distance (m) (with weighting function)	2.3852	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-12.44	N.A.	N.A.	N.A.	N.A.

*Propagation of 20 log R. N.A. means not applicable or not available.

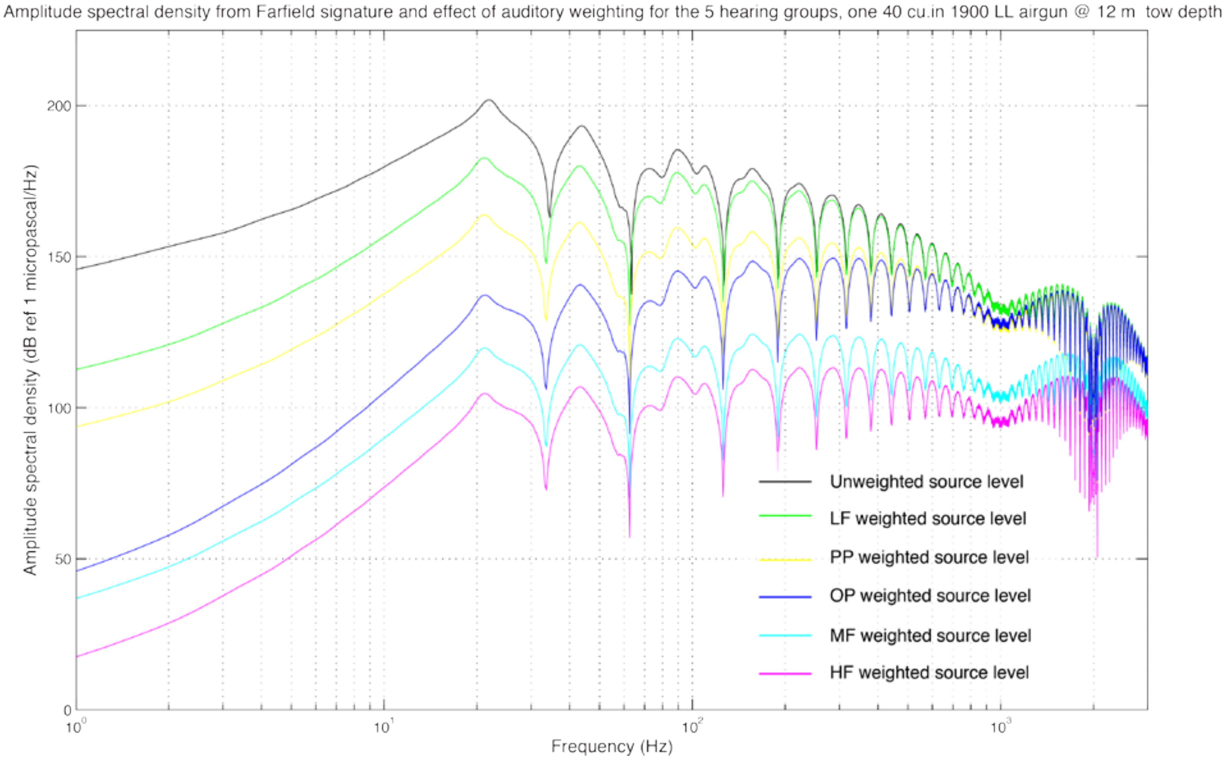
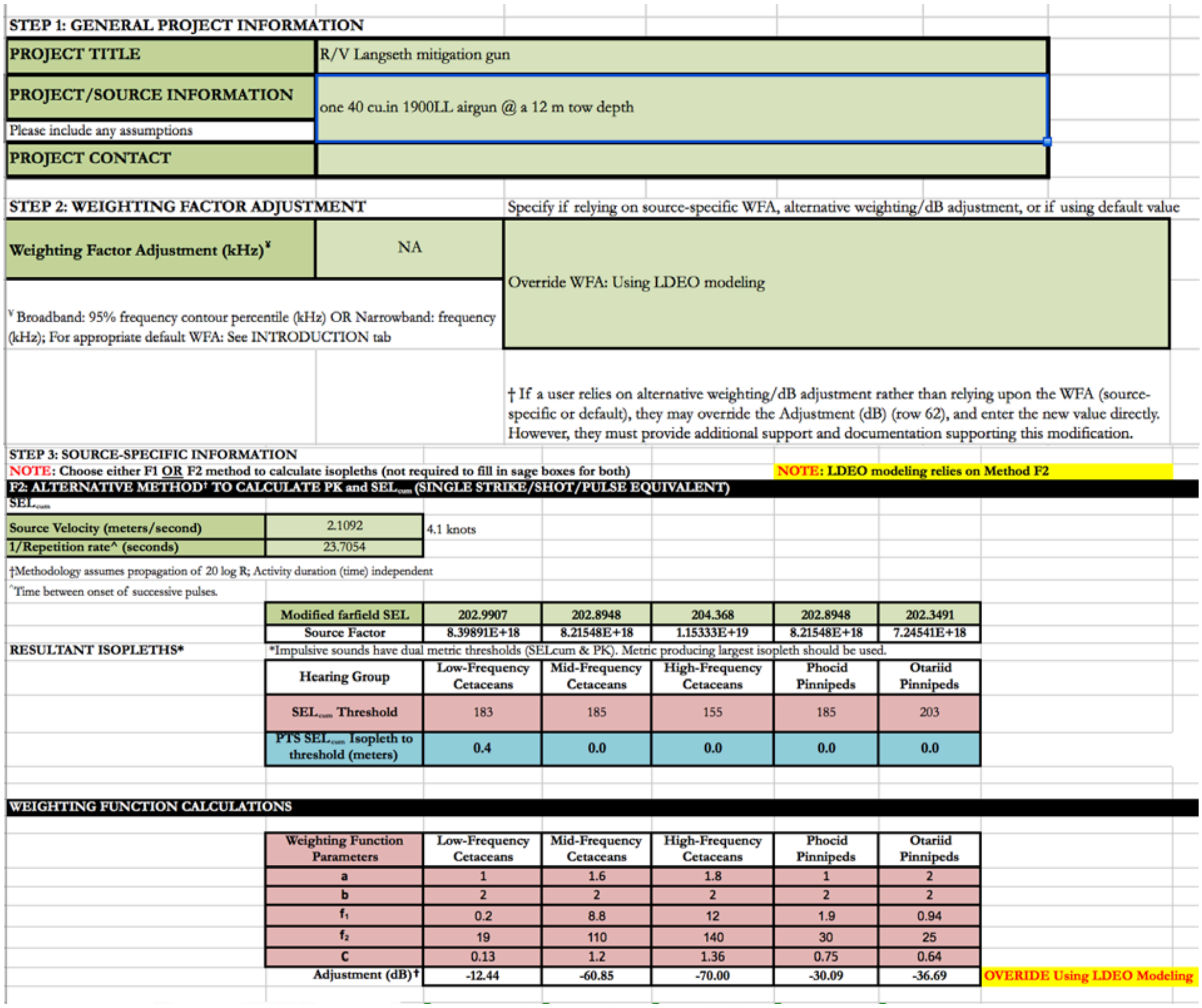


FIGURE A-12. Modeled amplitude spectral density of the 40-in^3 airgun farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

TABLE A-7. Results for single shot SEL source level modeling for the single 40-in^3 mitigation airgun with weighting function calculations for the SEL$_{cum}$ criteria, as well as resulting isopleths to thresholds for various hearing groups.



STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V Langseth mitigation gun
PROJECT/SOURCE INFORMATION Please include any assumptions	one 40 cu.in 1900LL airgun @ a 12 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

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

Weighting Factor Adjustment (kHz)$^{¥}$	NA

Override WFA: Using LDEO modeling

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

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

STEP 3: SOURCE-SPECIFIC INFORMATION

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

NOTE: LDEO modeling relies on Method F2

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

SEL$_{cum}$

Source Velocity (meters/second)	2.1092	4.1 knots
1/Repetition rate^ (seconds)	23.7054	

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

^Time between onset of successive pulses.

Modified farfield SEL	**202.9907**	**202.8948**	**204.368**	**202.8948**	**202.3491**
Source Factor	**8.39891E+18**	**8.21548E+18**	**1.15333E+19**	**8.21548E+18**	**7.24541E+18**

RESULTANT ISOPLETHS*

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

Hearing Group	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
SEL$_{cum}$ Threshold	183	185	155	185	203
PTS SEL$_{cum}$ Isopleth to threshold (meters)	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-12.44	-60.85	-70.00	-30.09	-36.69	**OVERIDE Using LDEO Modeling**

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of 20*log$_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure A-12).

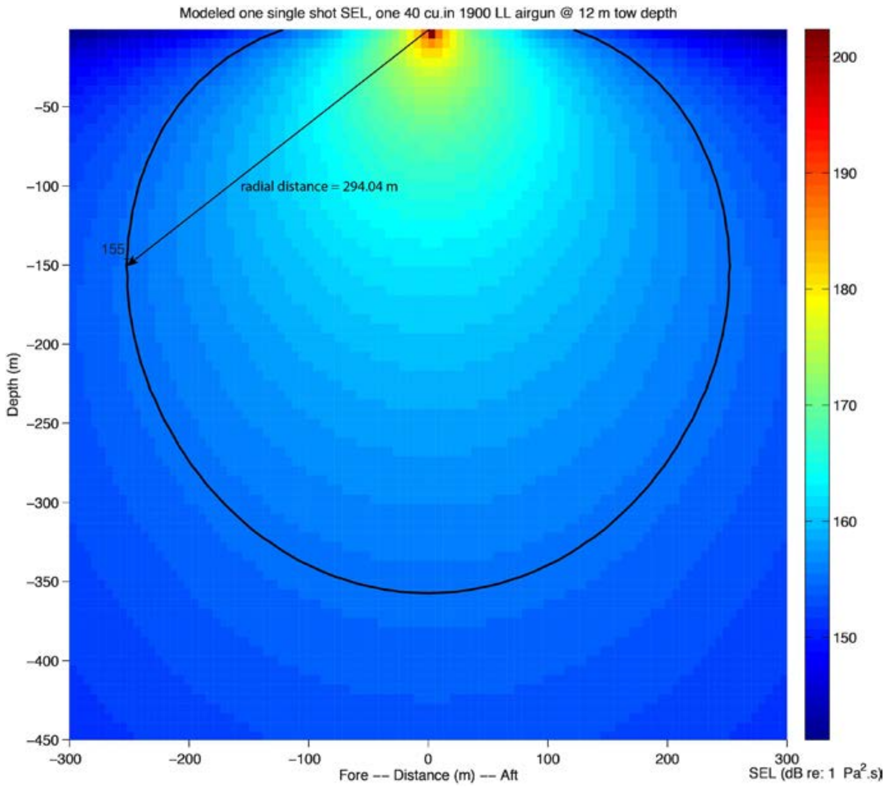


FIGURE A-13. Modeled received sound levels (SELs) in deep water from one 40-in^3 airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (294.04 m).

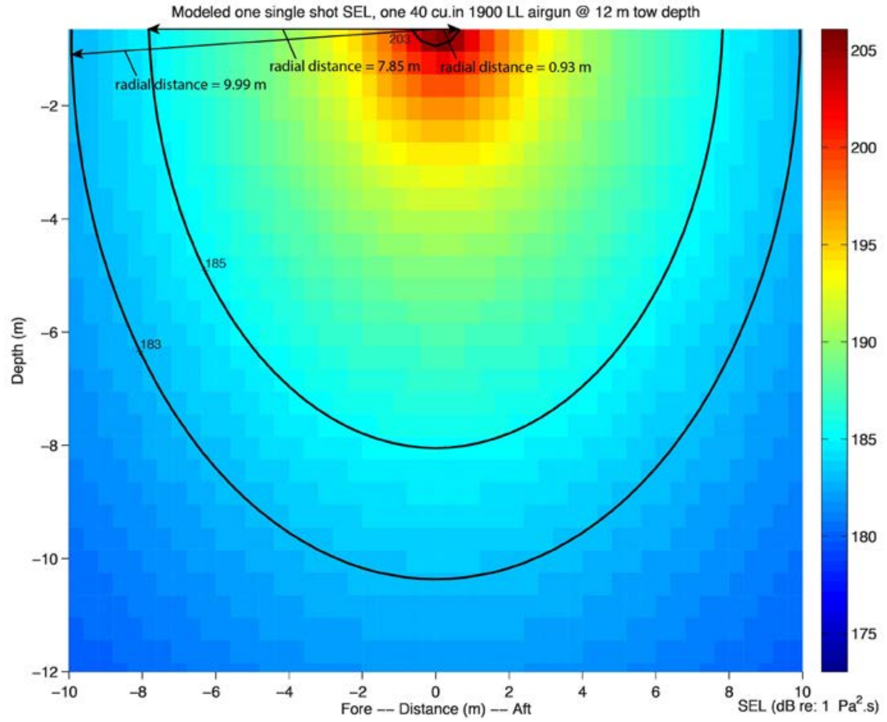


FIGURE A-14. Modeled received sound levels (SELs) in deep water from one 40-in^3 airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183–185 dB and 203 dB SEL isopleths.

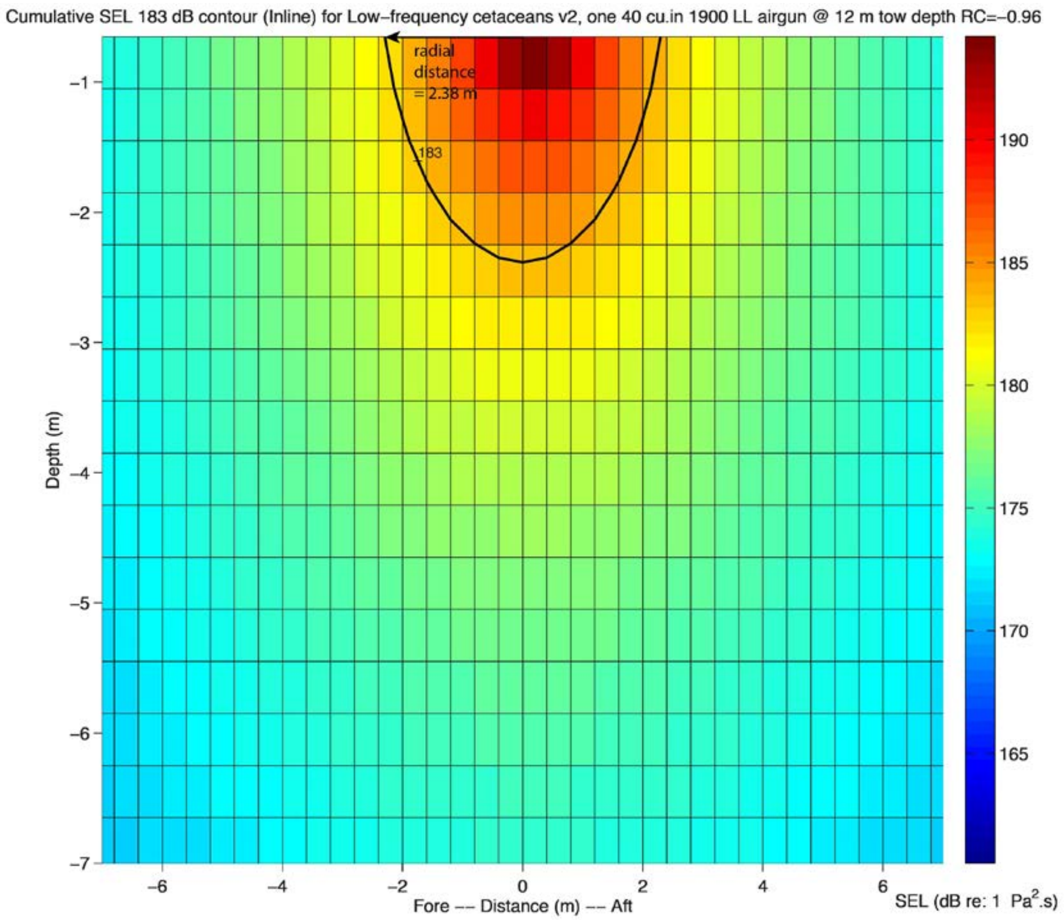


FIGURE A-15. Modeled received sound exposure levels (SELs) from one 40-in^3 mitigation at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL$_{cum}$ isopleth for one shot. The difference in radial distances between Fig. A-14 and this figure allows us to estimate the adjustment in dB.

TABLE A-8. NMFS Level A acoustic thresholds (Peak SPL$_{flat}$) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 40-in^3 airgun during the proposed seismic surveys in the North Pacific Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Peak Threshold	**219**	**230**	**202**	**218**	**232**
Radial Distance to Threshold (m)	1.764	N.A.	12.471	1.98	N.A.
Modified Farfield Peak	223.9300	N.A.	223.9185	223.9465	N.A.
PTS Peak Isopleth (Radius) to Threshold (m)	1.76	N.A.	12.5	1.98	N.A.

N.A. means not applicable or not available.

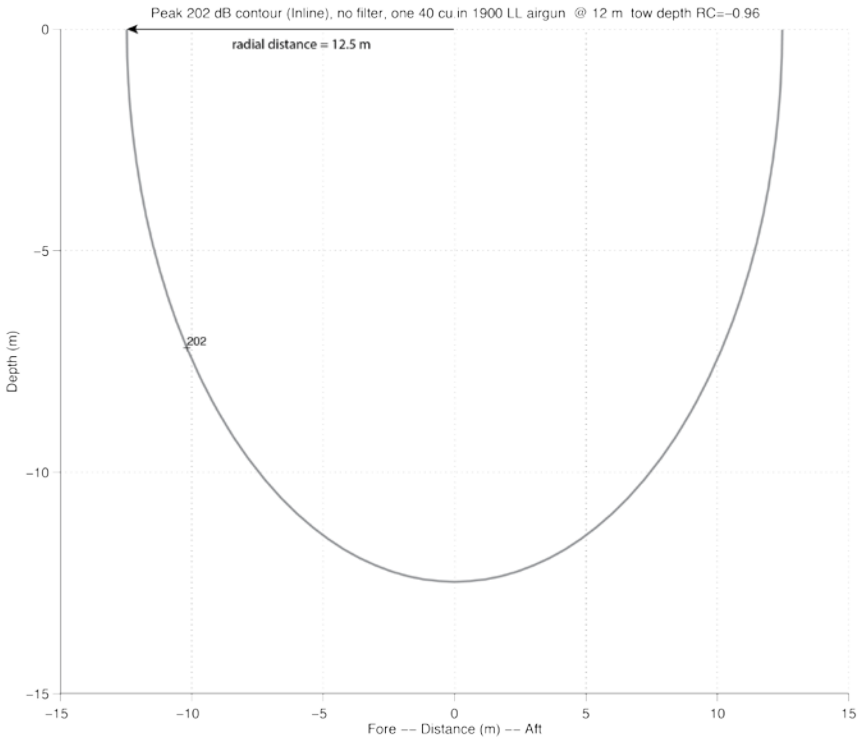


FIGURE A-16. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB Peak isopleth.

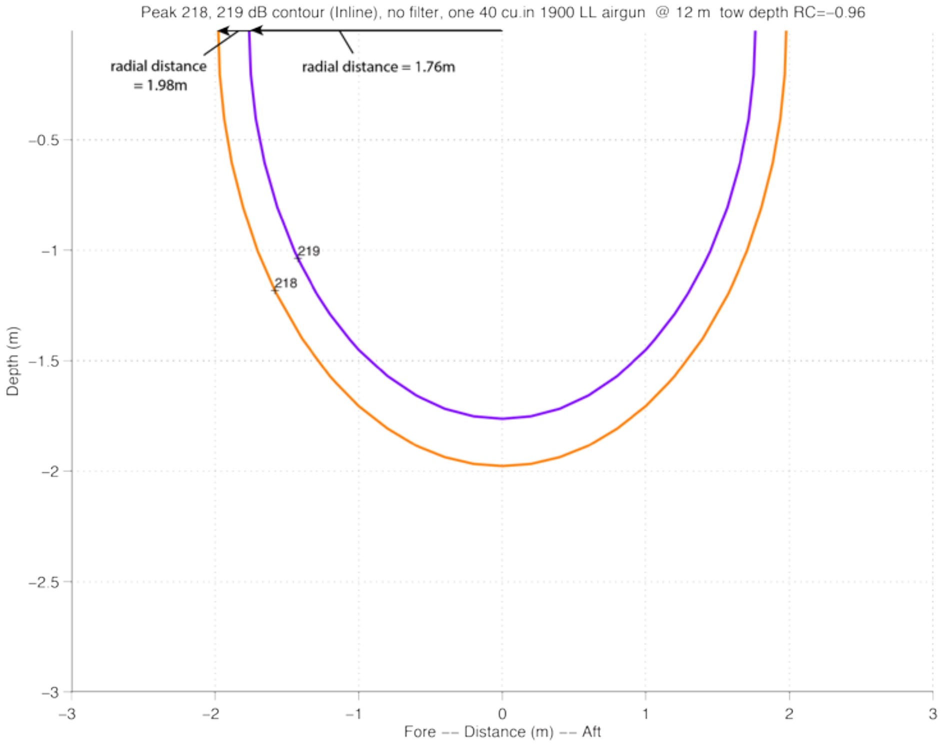


FIGURE A-17. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distances from the source geometrical center to the 218 and 219-dB Peak isopleths.

TABLE A-9. Level A threshold distances for different marine mammal hearing groups for a single airgun.

	Level A Threshold Distances (m) for Various Hearing Groups				
Single 40 in^3 airgun	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PTS SEL$_{cum}$	0.4	0	0	0	0
PTS Peak	1.76	N/A	12.5	1.98	N/A

Note: N/A = not available.

TABLE A-10. Sea turtle thresholds recommended by NMFS. Predicted distances to which sound levels ≥195- and 175-dB re 1 µPa$_{rms}$ could be received during the proposed surveys in the North Pacific Ocean.

Source and Volume	**Tow Depth (m)**	**Water Depth (m)**	**Predicted distances (m) to Received Sound Levels**	
			195 dB	**175 dB**
Single Bolt airgun, 40 in^3	12	>1000 m	8[1] (100[3])	77[1]
		100–1000 m	11[2] (100[3])	116[2]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	181[1]	1864[1]
		100–1000 m	272[2]	2796[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5× correction factor between deep and intermediate water depths.
[3] An EZ of 100 m would be used as the shut-down distance, as specified for low-energy sources in the PEIS, for sea turtles.

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APPENDIX B: MARINE MAMMAL DENSITIES

Procedures Used to Estimate Densities of Marine Mammals

Hawaiian Survey Area

In the proposed survey area in the Hawaiian EEZ, densities from Bradford et al. (2017) were used, when available. For the pygmy sperm whale, dwarf sperm whale, and spinner dolphin, densities from CetMap (NOAA 2018) were used because densities were not provided by Bradford et al. (2017). For the humpback, minke, and killer whales, the calculated take was increased to mean group size, based on Bradford et al. (2017).

For Hawaiian monk seals, we determined density by dividing the number of animals expected to occur in the Hawaiian EEZ in water depths >200 m. According to the U.S. Navy (DoN 2017), 90% of the population may be found within the 200-m isobath; therefore 10% of the population (127 of 1272 animals; Carretta et al. 2017) is expected to occur outside of the 200-m isobath. The area within the Hawaii EEZ bu outside of the 200-m isobath was estimated by the U.S. Navy to be 2,461,994 km^2 (DoN 2017). Thus, we estimated the average density of monk seals at sea where they could be exposed to seismic sounds as 127/2,461,994 km^2 = 0.0000517/km^2. No haul-out factors were used to adjust this density, as it is unlikely that animals would haul out beyond the 200-m isobath.

Emperor Seamounts Survey Area

There is a marked change in marine mammal distribution from warm-water species to temperate and sub-arctic species to the south of the proposed Emperor Seamounts survey area as illustrated in the distribution maps in Matsuoka et al. (2009, 2015), Hakamada and Matsuoka (2015), and Hakamada et al. (2017). As there are very few published data on the densities of cetaceans or pinnipeds in the area, we used mostly gray literature available from IWC scientific reports to compute densities based on parts of those surveys that were in and adjacent to the proposed seismic survey area. Had we used the overall densities provided in the reports for their entire survey area, in most cases we would have underestimated densities in the proposed survey area with the exception of warm-water species which are not usually found that far north.

For Pacific white-side dolphin, northern right whale dolphin, Dall's porpoise, and northern fur seal, we used densities from Buckland et al. (1993). Forney and Wade (2006) reported a density of 0.3/100 km^2 (Figure 12.1) for killer whales at latitudes 43–48°N where the proposed survey would be conducted. In the absence of other data for Cuvier's beaked whale, we used the density (whales/1000 km^2) provided by Barlow (2006) for offshore areas of the Hawaiian EEZ. Although Miyashita (1993) published data on the abundance of striped, Pantropical spotted, bottlenose, and Risso's dolphins, and false killer and short-finned pilot whales in the Northwest Pacific Ocean as far north as 41°N, the distributional range of the Pantropical spotted and bottlenose dolphins does not extend as far north as the proposed survey area. For the other species, we used data from 40–41°N, 160–180°E to calculate densities and estimate the numbers of individuals that could be exposed to seismic sounds during the proposed survey. Risso's dolphin, false killer whale, and short-finned pilot whale are expected to be rare in the proposed survey area, and the calculated densities were zero. Thus, we used the mean group size from Bradford et al. (2017) for Risso's dolphin and short-finned pilot whale, and the mean group size of false killer whales from Barlow (2006), for the *Requested Take Authorization*.

The short-beaked common dolphin is expected to be rare in the Emperor Seamounts survey area; thus, there are no density estimates available. We used the mean group size (rounded up) for the California Current from Barlow (2016) for the *Requested Take Authorization*. The density of Bryde's whale in the proposed survey area was assumed to be zero, based on information from Hakamada et al. (2009, 2017) and

Forney et al. (2015); its known distribution range does not appear to extend that far north. For this species, we rounded up the mean group size from Bradford et al. (2017) for the *Requested Take Authorization.*

The densities for the remaining species were obtained from calculations using data from the papers presented to the IWC. For blue, fin, humpback, and North Pacific right whales we used a weighted mean density from Matsuoka et al. (2009) for the years 1994–2007 and Hakamada and Matsuoka (2015) for the years 2008–2014. We used Matusoka et al. (2009) instead of Matsuoka et al. (2015), as the later document did not contain all of the necessary information to calculate densities. We used densities for their Block 9N which coincides with the proposed Emperor Seamounts survey area. The density for each survey period was weighted by the number of years in the survey period; that is, 14 years for Matsuoka et al. (2009) and 7 years for Hakamada and Matsuoka (2015), to obtain a final density for the 21-year period. For minke, sei, and sperm whales we used the estimates of numbers of whales in survey blocks overlapping the Emperor Seamounts survey area from Hakamada et al. (2009); densities were estimated by dividing the number of whales in Block 9N by the area of Block 9N which are given in their Table 6. We increased the *Requested Take Authorization* for blue whales to 50 individuals (Sears and Perrin 2009), in case an aggregation would be encountered during the proposed survey.

Finally, no northern elephant seals have been reported during any of the above surveys although Buckland et al. (1993) estimated fur seal abundance during their surveys. Telemetry studies, however, indicate that elephant seals do forage as far west as the proposed Emperor Seamounts survey area. Here, we have assumed a density of 0.00831/1000 km^2, which is 10% of that used by LGL Limited (2017) for an area off the west coast of the U.S. However, densities fo northern elephant seals in the region are expected to be much less than densities of northern fur seals.

Table B-1 summarizes the densities for marine mammals in the Emperor Seamounts survey area and the data sources used.

TABLE B-1. Densities of marine mammals in the Emperor Seamounts survey area in the western North Pacific Ocean. Species listed as "Endangered" under the ESA are in italics.

Species	Density (#/1000 km^2)	Source
LF Cetaceans		
Gray whale	0	Hakamada et al. (2009); Forney et al. (2015)
North Pacific right whale	*0.54*	Matsuoka et al. (2009); Hakamada and Matsuoka (2015)
Humpback whale	*0.41*	Matsuoka et al. (2009); Hakamada and Matsuoka (2015)
Minke whale	2.48	Hakamada et al. (2009)
Bryde’s whale	0	Hakamada et al. (2009, 2017); Forney et al. (2015)
Sei whale	*2.93*	Hakamada et al. (2009)
Fin whale	*0.93*	Matsuoka et al. (2009); Hakamada and Matsuoka (2015)
Blue whale	*0.13*	Matsuoka et al. (2009); Hakamada and Matsuoka (2015)
MF Cetaceans		
Sperm whale	*10.97*	Hakamada et al. (2009)
Cuvier’s beaked whale	6.80	Barlow (2006)
Stejneger’s beaked whale	N.A.	N.A.
Baird's beaked whale	N.A.	N.A.
Striped dolphin	9.21	Miyashita (1993)
Pacific white-sided dolphin	68.81	Buckland et al. (1993)
Northern right-whale dolphin	3.37	Buckland et al. (1993)
Risso’s dolphin	0	Miyashita (1993)
False killer whale	0	Miyashita (1993)
Killer whale	3.00	Forney and Wade (2006)
Short-finned pilot whale	0	Miyashita (1993)
HF Cetaceans		
Pygmy sperm whale	N.A.	N.A.
Dwarf sperm whale	N.A.	N.A.
Dall’s porpoise	35.46	Buckland et al. (1993)
Otariids		
Northern fur seal	3.56	Buckland et al. (1993)
Steller sea lion	N.A.	N.A.
Phocid Seals		
Northern elephant seal	8.31	LGL Limited (2017)
Ribbon seal	N.A.	N.A.

N.A. means not available.

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APPENDIX C: MARINE MAMMAL TAKE CALCULATIONS

Table C-1. Take calculations for the Emperor Seamounts Survey

Species	Estimated Density (#/1000 km^2)	Regional Population Size	Hearing Group	NMFS Level B 160 dB Ensonified Area (km^2)	Level A Ensonified Area (km^2)	Total Takes	Level A Takes	Level B Takes	% of Pop. (Total Takes)
Mysticetes									
Gray whale	0.00	140	LF	41,702.4	1,878.4	0	0	0	0
North Pacific right whale	0.54	450	LF	41,702.4	1,878.4	23	1	22	5.11
Humpback whale	0.41	21,063	LF	41,702.4	1,878.4	17	1	16	0.08
Minke whale	2.48	22,000	LF	41,702.4	1,878.4	104	5	99	0.47
Bryde's whale	0.00	28,447	LF	41,702.4	1,878.4	0	0	0	0
Sei whale	2.93	27,197	LF	41,702.4	1,878.4	122	5	117	0.45
Fin whale	0.93	16,150	LF	41,702.4	1,878.4	39	2	37	0.24
Blue whale	0.13	2,605	LF	41,702.4	1,878.4	5	0	5	0.19
Odontocetes									
Sperm whale	10.97	29,674	MF	41,702.4	79.6	457	1	456	1.54
Pygmy sperm whale	N.A.	7,138	HF	41,702.4	1,573.2	N.A.	N.A.	N.A.	N.A.
Dwarf sperm whale	N.A.	17,519	HF	41,702.4	1,573.2	N.A.	N.A.	N.A.	N.A.
Cuvier's beaked whale	6.80	20,000	MF	41,702.4	79.6	284	1	283	1.42
Stejner's beaked whale	N.A.	25,300	MF	41,702.4	79.6	N.A.	N.A.	N.A.	N.A.
Baird's beaked whale	N.A.	25,300	MF	41,702.4	79.6	N.A.	N.A.	N.A.	N.A.
Short-beaked common dolphin	N.A.	2,963,000	MF	41,702.4	79.6	N.A.	N.A.	N.A.	N.A.
Striped dolphin	9.21	964,362	MF	41,702.4	79.6	384	1	383	0.04
Pacific white-sided dolphin	68.81	988,333	MF	41,702.4	79.6	2,870	5	2,865	0.29
Northern right whale dolphin	3.37	307,784	MF	41,702.4	79.6	141	0	141	0.05
Risso's dolphin	N.A.	110,457	MF	41,702.4	79.6	N.A.	N.A.	N.A.	N.A.
False killer whale	N.A.	16,668	MF	41,702.4	79.6	N.A.	N.A.	N.A.	N.A.
Killer whale	3.00	8,500	MF	41,702.4	79.6	125	0	125	1.47
Short-finned pilot whale	N.A.	53,608	MF	41,702.4	79.6	N.A.	N.A.	N.A.	N.A.
Dall's porpoise	35.46	1,186,000	HF	41,702.4	1,573.2	1,479	56	1,423	0.12
Pinnipeds									
Northern fur seal	3.56	1,100,000	OT	41,702.4	62.0	149	0	149	0.01
Steller sea lion	N.A.	143,000	OT	41,702.4	62.0	N.A.	N.A.	N.A.	N.A.
Northern elephant seal	8.31	224,500	PW	41,702.4	255.7	347	2	345	0.15
Ribbon seal	N.A.	240,000	PW	41,702.4	255.7	N.A.	N.A.	N.A.	N.A.

N.A. means not available.

Table C-2. Take calculations for the Hawaii Survey

Species	Density (#/1000 km^2)	Regional Population Size	Hearing Group	NMFS Level B 160 dB Ensonified Area (km^2)	Level A Ensonified Area (km^2)	Total Takes	Level A Takes	Level B Takes	% of Pop. (Total Takes)
Mysticetes									
Humpback whale	0	21,063	LF	65,778.5	2,745.4	0	0	0	0
Minke whale	0	22,000	LF	65,778.5	2,745.4	0	0	0	0
Bryde's whale	0.97	28,447	LF	65,778.5	2,745.4	64	3	61	0.23
Sei whale	0.22	27,197	LF	65,778.5	2,745.4	14	1	13	0.05
Fin whale	0.06	16,150	LF	65,778.5	2,745.4	4	0	4	0.02
Blue whale	0.05	2,605	LF	65,778.5	2,745.4	3	0	3	0.13
Odontocetes									
Sperm whale	1.86	26,300	MF	65,778.5	116.3	122	0	122	0.47
Pygmy sperm whale	2.91	7,138	HF	65,778.5	2,299.3	191	7	184	2.68
Dwarf sperm whale	7.14	17,519	HF	65,778.5	2,299.3	470	16	454	2.68
Cuvier's beaked whale	0.30	20,000	MF	65,778.5	116.3	20	0	20	0.10
Longman's beaked whale	3.11	4,571	MF	65,778.5	116.3	205	0	205	4.48
Blainville's beaked whale	0.86	25,300	MF	65,778.5	116.3	57	0	57	0.22
Ginkgo-toothed beaked whale	0.63	25,300	MF	65,778.5	116.3	41	0	41	0.16
Deraniygala's beaked whale	0.63	25,300	MF	65,778.5	116.3	41	0	41	0.16
Hubb's beaked whale	0.63	25,300	MF	65,778.5	116.3	41	0	41	0.16
Rough-toothed dolphin	29.63	107,633	MF	65,778.5	116.3	1,949	3	1,946	1.81
Common bottlenose dolphin	8.99	335,834	MF	65,778.5	116.3	591	1	590	0.18
Pantropical spotted dolphin	23.32	1,297,092	MF	65,778.5	116.3	1,534	3	1,531	0.12
Spinner dolphin	6.99	1,797,716	MF	65,778.5	116.3	460	1	459	0.03
Striped dolphin	25.00	964,362	MF	65,778.5	116.3	1,644	3	1,641	0.17
Fraser's dolphin	21.04	289,300	MF	65,778.5	116.3	1,384	2	1,382	0.48
Risso's dolphin	4.74	110,457	MF	65,778.5	116.3	312	1	311	0.28
Melon-headed whale	3.54	45,400	MF	65,778.5	116.3	233	0	233	0.51
Pygmy killer whale	4.35	38,900	MF	65,778.5	116.3	286	1	285	0.74
False killer whale	0.60	16,668	MF	65,778.5	116.3	39	0	39	0.24
Killer whale	0.06	8,500	MF	65,778.5	116.3	4	0	4	0.05
Short-finned pilot whale	7.97	53,608	MF	65,778.5	116.3	524	1	523	0.98
Pinnipeds									
Hawaiian monk seal	0.49	1,272	PW	65,778.5	373.8	32	0	32	2.55

APPENDIX D: ENSONIFIED AREAS FOR MARINE MAMMAL TAKE CALCULATIONS

Survey	**Criteria**	**Daily Ensonified Area (km^2)**	**Total Survey Days**	**25% Increase**	**Total Ensonified Area (km^2)**	**Relevant Isopleth (m)**
Hawaii:multi-depth line (intermediate water)	160 dB	538.5	12	1.25	8076.9	10,100
Hawaii:multi-depth line (deep water)	160 dB	2349.8	12	1.25	35246.4	6,733
Hawaii:multi-depth line (total)	***160 dB***	***2888.2***	***12***	***1.25***	**43323.3**	6,733
Hawaii:deep-water line	***160 dB***	***2566.3***	***7***	***1.25***	***22455.1***	6,733
Hawaii: all lines (total)	***160 dB***				**65778.5**	
Hawaii	LF Cetacean	115.6	19	1.25	2745.4	320.2
Hawaii	MF Cetacean	4.9	19	1.25	116.3	13.6
Hawaii	HF Cetacean	96.8	19	1.25	2299.3	268.3
Hawaii	Phocid	15.7	19	1.25	373.8	43.7
Emperor Seamounts	**160 dB**	**2566.3**	**13**	**1.25**	**41702.4**	6,733
Emperor Seamounts	LF Cetacean	115.6	13	1.25	1878.4	320.2
Emperor Seamounts	MF Cetacean	4.9	13	1.25	79.6	13.6
Emperor Seamounts	HF Cetacean	96.8	13	1.25	1573.2	268.3
Emperor Seamounts	Phocid	15.7	13	1.25	255.7	43.7
Emperor Seamounts	Otariid	3.8	13	1.25	62.0	10.6

APPENDIX E: NMFS TAKE AUTHORIZATION METHODOLOGY[3]

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[3] NMFS may make changes to their analysis before issuing an IHA.

Estimated Take

This section provides an estimate of the number of incidental takes authorized through this IHA, which will inform both NMFS' consideration of whether the number of takes is "small" and the negligible impact determination.

Harassment is the only type of take expected to result from these activities. Except with respect to certain activities not pertinent here, section 3(18) of the MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

Authorized takes would primarily be by Level B harassment, as use of seismic airguns has the potential to result in disruption of behavioral patterns for individual marine mammals. There is also some potential for auditory injury (Level A harassment) for mysticetes and high frequency cetaceans (i.e., kogiidae spp.), due to larger predicted auditory injury zones for those functional hearing groups. The required mitigation and monitoring measures are expected to minimize the severity of such taking to the extent practicable.

Auditory injury is unlikely to occur for mid-frequency species given very small modeled zones of injury for those species (13.6 m). Moreover, the source level of the array is a theoretical definition assuming a point source and measurement in the far-field of the source (MacGillivray, 2006). As described by Caldwell and Dragoset (2000), an array is not a point source, but one that spans a small area. In the far-field, individual elements in arrays will effectively work as one source because individual pressure peaks will have coalesced into one relatively broad pulse. The array can then be considered a "point source." For distances within the near-field, *i.e.*, approximately 2-3 times the array dimensions, pressure peaks from individual elements do not arrive simultaneously because the observation point is not equidistant from each element. The effect is destructive interference of the outputs of each element, so that peak pressures in the near-field will be significantly lower than the output of the largest individual element. Here, the 230 dB peak isopleth distances would in all cases be expected to be within the near-field of the array where the definition of source level breaks down. Therefore, actual locations within this distance of the array center where the sound level exceeds 230 dB peak SPL would not necessarily exist. In general, Caldwell and Dragoset (2000) suggest that the near-field for airgun arrays is considered to extend out to approximately 250 m.

As described previously, no mortality is anticipated or authorized for this activity. Below we describe how the take is estimated.

Described in the most basic way, we estimate take by considering: 1) acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; 2) the area or volume of water that will be ensonified above these levels in a day; 3) the density or occurrence of marine mammals within these ensonified areas; and 4) and the number of days of activities. Below, we describe these components in more detail and present the exposure estimate and associated numbers of authorized takes.

Acoustic Thresholds

Using the best available science, NMFS has developed acoustic thresholds that identify the received level of underwater sound above which exposed marine mammals would be reasonably expected to be behaviorally harassed (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment).

Level B Harassment for non-explosive sources – Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is also informed to varying degrees by other factors related to the source (*e.g.*, frequency, predictability, duty cycle), the environment (*e.g.*, bathymetry), and the receiving animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Southall *et al.*, 2007, Ellison *et al.* 2012). Based on the best available science and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, NMFS uses a generalized acoustic threshold based on received level to estimate the onset of behavioral harassment. NMFS predicts that marine mammals are likely to be behaviorally harassed in a manner we consider to fall under Level B harassment when exposed to underwater anthropogenic noise above received levels of 160 dB re 1 μPa (rms) for non-explosive impulsive (*e.g.*, seismic airguns) sources. L-DEO's activity includes the use of impulsive seismic sources. Therefore, the 160 dB re 1 μPa (rms) criteria is applicable for analysis of level B harassment.

Level A harassment for non-explosive sources - NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS, 2016) identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive). The Technical Guidance identifies the received levels, or thresholds, above which individual marine mammals are predicted to experience changes in their hearing sensitivity for all underwater anthropogenic sound sources, reflects the best available science, and better predicts the potential for auditory injury than does NMFS' historical criteria.

These thresholds were developed by compiling and synthesizing the best available science and soliciting input multiple times from both the public and peer reviewers to inform the final product, and are provided in Table 2 below. The references, analysis, and methodology used in the development of the thresholds are described in NMFS 2016 Technical Guidance. As described above, L-DEO's activity includes the use of intermittent and impulsive seismic sources.

Table 2. Thresholds Identifying the Onset of Permanent Threshold Shift in Marine Mammals

Hearing Group	**PTS Onset Thresholds**	
	Impulsive*	**Non-impulsive**
Low-Frequency (LF) Cetaceans	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	$L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	$L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	$L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	$L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	$L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	$L_{E,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	$L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	$L_{E,OW,24h}$: 219 dB

Note: *Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (Lpk) has a reference value of 1 μPa, and cumulative sound exposure level (LE) has a reference value of 1μPa2s. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (*i.e.*, varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Ensonified Area

Here, we describe operational and environmental parameters of the activity that will feed into estimating the area ensonified above the relevant acoustic thresholds.

The surveys will acquire data with the 36-airgun array with a total discharge of 6,600 in^3 at a maximum tow depth of 12 m. L-DEO model results are used to determine the 160-dBrms radius for the 36-airgun array and 40-in^3 airgun at a 12-m tow depth in deep water (>1000 m) down to a maximum water depth of 2,000 m. Received sound levels were predicted by L-DEO's model (Diebold *et al.,* 2010) which uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (approximately 1,600 m), intermediate water depth on the slope (approximately 600–1,100 m), and shallow water (approximately 50 m) in the Gulf of Mexico in 2007–2008 (Tolstoy *et al.* 2009; Diebold *et al.* 2010).

For deep and intermediate-water cases, the field measurements cannot be used readily to derive Level A and Level B isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2,000 m. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant.

In deep and intermediate-water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of NSF-USGS, 2011).. Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating isopleths.

For deep water (>1,000 m), L-DEO used the deep-water radii obtained from model results down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1,000 m) were derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (See Fig. 16 in Appendix H of NSF-USGS, 2011).

Measurements have not been reported for the single 40-in^3 airgun. L-DEO model results are used to determine the 160-dB (rms) radius for the 40-in^3 airgun at a 12 m tow depth in deep water (See LGL 2018, Figure A-2). For intermediate-water depths, a correction factor of 1.5 was applied to the deep-water model results.

L-DEO's modeling methodology is described in greater detail in the IHA application (LGL 2018). The estimated distances to the Level B harassment isopleth for the *Langseth's* 36-airgun array and single 40-in^3 airgun are shown in Table 3.

Table 3: Predicted Radial Distances from R/V *Langseth* Seismic Source to Isopleths Corresponding to Level B Harassment Threshold

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted Distances (in m) to the 160-dB Received Sound Level
Single Bolt airgun, 40 in^3	12	>1000 m	431[1]
		100–1000 m	647[2]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]
		100–1000 m	10,100[2]

[1] Distance is based on L-DEO model results.

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

Predicted distances to Level A harassment isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L-DEO using the NUCLEUS software program and the NMFS User Spreadsheet, described below. The updated acoustic thresholds for impulsive sounds (*e.g.*, airguns) contained in the Technical Guidance were presented as dual metric acoustic thresholds using both $\mathrm{SEL}_{\mathrm{cum}}$ and peak sound pressure metrics (NMFS 2016). As dual metrics, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the two metrics is exceeded (i.e., metric resulting in the largest isopleth). The $\mathrm{SEL}_{\mathrm{cum}}$ metric considers both level and duration of exposure, as well as auditory weighting functions by marine mammal hearing group. In recognition of the fact that the requirement to calculate Level A harassment ensonified areas could be more technically challenging to predict due to the duration component and the use of weighting functions in the new $\mathrm{SEL}_{\mathrm{cum}}$ thresholds, NMFS developed an optional User Spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of take numbers.

The values for $\mathrm{SEL}_{\mathrm{cum}}$ and peak SPL for the *Langseth* airgun array were derived from calculating the modified farfield signature (Table 4). The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the array (*e.g.*, 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, when the source is an array of multiple airguns separated in space, the source level from the theoretical farfield signature is not necessarily the best measurement of the source level that is physically achieved at the source (Tolstoy *et al.* 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively, as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy *et al.* 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the large array effect near the source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for distributed sound sources, such as airgun arrays. L-DEO used the acoustic modeling methodology as used for Level B harassment with a small grid step of 1 m in both the inline and depth directions. The propagation modeling takes into account all airgun interactions at short distances from the source, including interactions between subarrays which are modeled using the NUCLEUS software to estimate the notional signature and MATLAB software to calculate the pressure signal at each mesh point of a grid.

Table 4. Modeled Source Levels Based on Modified Farfield Signature for the R/V Langseth 6,600 in^3 Airgun Array, and single 40 in^3 Airgun

	Low Frequency Cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	**Mid Frequency Cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB**	**High Frequency Cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)**	**Phocid Pinnipeds (Underwater) ($L_{pk,flat}$: 218 dB; $L_{E,HF,24h}$: 185 dB)**	**Otariid Pinnipeds (Underwater) ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)**
6,600 in^3 airgun array (Peak SPL$_{flat}$)	252.06	252.65	253.24	252.25	252.52
6,600 in^3 airgun array (SEL$_{cum}$)	232.98	232.83	233.08	232.83	232.07
40 in^3 airgun (Peak SPL$_{flat}$)	223.93	N.A.	223.92	223.95	N.A.
40 in^3 airgun (SEL$_{cum}$)	202.99	202.89	204.37	202.89	202.35

In order to more realistically incorporate the Technical Guidance's weighting functions over the seismic array's full acoustic band, unweighted spectrum data for the *Langseth's* airgun array (modeled in 1 hertz (Hz) bands) was used to make adjustments (dB) to the unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted/weighted spectrum levels were then converted to pressures (μPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted source levels by hearing group that could be directly incorporated within the User Spreadsheet (*i.e.*, to override the Spreadsheet's more simple weighting factor adjustment). Using the User Spreadsheet's "safe distance" methodology for mobile sources (described by Sivle *et al.*, 2014) with the hearing group-specific weighted source levels, and inputs assuming spherical spreading propagation and source velocities and shot intervals specific to each of the three planned surveys (Table 1), potential radial distances to auditory injury zones were then calculated for SEL$_{cum}$ thresholds.

Inputs to the User Spreadsheets in the form of estimated SLs are shown in Table 5. User Spreadsheets used by L-DEO to estimate distances to Level A harassment isopleths for the 36-airgun array and single 40 in^3 airgun for the surveys are shown is Tables A-2, A-3, A-5, and A-8 in Appendix A of the IHA application (LGL 2018). Outputs from the User Spreadsheets in the form of estimated distances to Level A harassment isopleths for the surveys are shown in Table 5. As described above, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the dual metrics ($\mathrm{SEL}_{\mathrm{cum}}$ and Peak $\mathrm{SPL}_{\mathrm{flat}}$) is exceeded (i.e., metric resulting in the largest isopleth).

Table 5. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds

	Low Frequency Cetaceans ($L_{\mathrm{pk,flat}}$: 219 dB; $L_{\mathrm{E,LF,24h}}$: 183 dB)	**Mid Frequency Cetaceans ($L_{\mathrm{pk,flat}}$: 230 dB; $L_{\mathrm{E,MF,24h}}$: 185 dB**	**High Frequency Cetaceans ($L_{\mathrm{pk,flat}}$: 202 dB; $L_{\mathrm{E,HF,24h}}$: 155 dB)**	**Phocid Pinnipeds (Underwater) ($L_{\mathrm{pk,flat}}$: 218 dB; $L_{\mathrm{E,HF,24h}}$: 185 dB)**	**Otariid Pinnipeds (Underwater) ($L_{\mathrm{pk,flat}}$: 232 dB; $L_{\mathrm{E,HF,24h}}$: 203 dB)**
6,600 in^3 airgun array (Peak $\mathrm{SPL}_{\mathrm{flat}}$)	45.0	13.6	364.75	51.6	10.6
6,600 in^3 airgun array ($\mathrm{SEL}_{\mathrm{cum}}$)	320.2	N.A.	1	10.4	N.A.
40 in^3 airgun (Peak $\mathrm{SPL}_{\mathrm{flat}}$)	1.76	N.A.	12.5	1.98	N.A.
40 in^3 airgun ($\mathrm{SEL}_{\mathrm{cum}}$)	0.5	N.A.	N.A.	N.A.	N.A.

Note that because of some of the assumptions included in the methods used, isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimate of Level A harassment. However, these tools offer the best way to predict appropriate isopleths when more sophisticated modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the planned seismic survey, the User Spreadsheet predicts the closest distance at which a stationary animal would not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

Marine Mammal Occurrence

In this section we provide the information about the presence, density, or group dynamics of marine mammals that will inform the take calculations. The best available scientific information was considered in conducting marine mammal exposure estimates (the basis for estimating take).

In the planned survey area in the Hawaiian EEZ, densities from Bradford *et al.* (2017) were used, when available. For the pygmy sperm whale, dwarf sperm whale, and spinner dolphin, densities from Barlow *et al.* (2009) were used because densities were not provided by Bradford *et al.* (2017). For the humpback, sei, minke, and killer whales, the calculated take was increased to mean group size

For Hawaiian monk seals, NMFS followed the methods used by the U.S. Navy (Navy 2017a) to determine densities. The U.S. Navy calculated density of Hawaiian monk seal for three areas: the Main Hawaiian Islands in waters less than 200 meters, the Northwest Hawaiian Islands in waters less than 200 meters, and waters 200 meters deep to the Hawaiian EEZ boundary.

The 200 meter isobath was selected as a boundary because of information related to Hawaiian monk seal foraging behavior that came out of the final rule for designated critical habitat. Ninety-eight percent of recorded dives were within the 200-meter isobath in the Main Hawaiian Islands this depth boundary was considered sufficient for foraging habitat for adults and juveniles. The area around the Main Hawaiian Islands to the 200-meter isobath was estimated to be 6,630 km^2 (6,142 km^2 in the Northwest Hawaiian Islands). The area from the 200-meter isobath to the Hawaiian EEZ is estimated to be 2,461,994 km^2. The U.S. Navy also assumed that 90 percent of the population would occur inside the 200-meter isobath.

The U.S. Navy used the following calculation to estimate density:

[(number of seals*percent of the population in or out of the 200-m)/200-m area]*In-water factor

By applying the U.S. Navy’s methodology using updated population estimates for the 2017 stock assessment report for the U.S. Pacific (Carretta *et al.* 2018) and haul-out factors, we can estimate Hawaiian monk seal density.

Main Hawaiian Islands inside 200 m isobath

[(145 seals *0.90)/6,630 km^2]*0.68 = 0.0134 seals/km^2

Northwest Hawaiian Islands inside 200 m isobath

[(1,179 seals *0.90)/6,142 km^2]*0.68 = 0. 1175 seals/km^2

Hawaiian EEZ

[(1,324 *0.10)/ 2,461,994 km2]*0.68 = 0.000037 seals/km^2

Based on where the action will occur, it NMFS utilized the density estimate for the Hawaiian EEZ.

There are very few published data on the densities of cetaceans or pinnipeds in the Emperor Seamounts area, so NMFS relied on a range of sources to establish marine mammal densities. As part of the Navy’s Final Supplemental Environmental Impact Statement//Supplemental Overseas Environmental Impact Statement for SURTASS LFA Sonar Routine Training, Testing, and Military Operations, the Navy modelled densities for a designated mission area northeast of Japan during the summer season. These values were used for the North Pacific right whale, sei whale, fin whale, sperm whale, Cuvier's beaked whale, Stejneger's beaked whale, and Baird's beaked whale.

For northern right whale dolphin, Dall’s porpoise, and northern fur seal, L-DEO used densities from Buckland *et al.* (1993). Forney and Wade (2006) reported a density of 0.3/100 km^2 for killer whales at latitudes 43–48°N where the planned survey would be conducted. Although Miyashita (1993) published data on the abundance of striped, Pantropical spotted, bottlenose, and Risso’s dolphins, and false killer and short-finned pilot whales in the Northwest Pacific Ocean as far north as 41°N, the distributional range of the Pantropical spotted and bottlenose dolphins does not extend as far north as the planned survey area. For the other species, we used data from 40–41°N, 160–180°E to calculate densities and estimate the numbers of individuals that could be exposed to seismic sounds during the survey. Risso’s dolphin, false killer whale, and short-finned pilot whale are expected to be rare in the survey area, and the calculated densities were zero. Thus, we used the mean group size from Bradford *et al.* (2017) for Risso’s dolphin and short-finned pilot whale, and the mean group size of false killer whales from Barlow (2006).

The short-beaked common dolphin is expected to be rare in the Emperor Seamounts survey area; thus, there are no density estimates available. L-DEO used the mean group size (rounded up) for the California Current from Barlow (2016). The density of Bryde’s whale in the planned survey area was assumed to be zero, based on information from Hakamada *et al.* (2009, 2017) and Forney *et al.* (2015); its known distribution range does not appear to extend that far north. For this species, L-DEO rounded up the mean group size from Bradford *et al.* (2017). For pygmy and dwarf sperm whales, NMFS assumed densities in the Emperor Seamounts would be equivalent to those in the Hawaii survey are and used densities from Bradford *et al.* 2017.

The densities for the remaining species were obtained from calculations using data from the papers presented to the IWC. For blue and humpback whales, L-DEO used a weighted mean density from Matsuoka *et al.* (2009) for the years 1994–2007 and Hakamada and Matsuoka (2015) for the years 2008–2014. L-DEO used Matsuoka *et al.* (2009) instead of Matsuoka *et al.* (2015), as the later document did not contain all of the necessary information to calculate densities. L-DEO used densities for their Block 9N which coincides with the planned Emperor Seamounts survey area. The density for each survey period was weighted by the number of years in the survey period; that is, 14 years for Matsuoka *et al.* (2009) and 7 years for Hakamada and Matsuoka (2015), to obtain a final density for the 21-year period. For minke whales L-DEO used the estimates of numbers of whales in survey blocks overlapping the Emperor Seamounts survey area from Hakamada *et al.* (2009); densities were estimated by dividing the number of whales in Block 9N by the area of Block 9N. For gray whales, NMFS used a paper by Rugh *et al.* (2005) that looked at abundance of eastern DPS gray whales. The paper provides mean group sizes for their surveys, which ranged from 1 to 2 individuals. For purposes of estimating exposures we will assume that the western DPS group sizes would not vary greatly from the eastern DPS. As such, NMFS assumes that there will be two western DPS gray whales Level B takes, based on mean group size.

Finally, no northern elephant seals have been reported during any of the above surveys although Buckland *et al.* (1993) estimated fur seal abundance during their surveys. Telemetry studies, however, indicate that elephant seals do forage as far west as the Emperor Seamounts survey area. Here, L-DEO assumed a density of 0.00831/1000 km^2, which is 10% of that used by LGL Limited (2017) for an area off the west coast of the U.S. However, densities of northern elephant seals in the region are expected to be much less than densities of northern fur seals. For species that are unlikely to occur in the survey area, such as ribbon seals, exposures are set at 5 individuals. Densities for animals in Emperor Seamounts are shown in Table 8.

Take Calculation and Estimation

Here we describe how the information provided above is brought together to produce a quantitative take estimate. In order to estimate the number of marine mammals predicted to be exposed to sound levels that would result in Level A harassment or Level B harassment, radial distances from the airgun array to predicted isopleths corresponding to the Level A harassment and Level B harassment thresholds are calculated, as described above. Those radial distances are then used to calculate the area(s) around the airgun array predicted to be ensonified to sound levels that exceed the Level A harassment and Level B harassment thresholds. The area estimated to be ensonified in a single day of active seismic operations is then calculated (Table 6) based on the areas predicted to be ensonified around the array and the estimated trackline distance traveled per day. For purposes of Level B take calculations, areas estimated to be ensonified to Level A harassment thresholds are subtracted from areas estimated to be ensonified to Level B harassment thresholds in order to avoid double counting the animals taken (i.e., if an animal is taken by Level A harassment, it is not also counted as taken by Level B harassment). The daily ensonified areas are multiplied by density estimates for each species to arrive at a daily exposure rate. The daily exposure rate is subsequently multiplied by the number of planned survey days plus a 25 percent contingency factor. Active seismic operations are planned for 13 days at Emperor Seamounts and 19 days at Hawaii. Therefore, the number of survey days is increased to 16 in the Emperor Seamounts and 24 in

Hawaii area. Estimated exposures for the Hawaii survey and the Emperor Seamounts survey are shown respectively in Table 7 and Table 8.

Table 6. Areas (km^2) Estimated to be Ensonified to Level A and Level B Harassment Thresholds, Per Day for Hawaii and Emperor Seamounts Surveys

Survey	**Criteria**	**Daily Ensonified Area (km^2)**	**Planned Survey Days**	**Total Survey Days (25% Increase)**	**Relevant Isopleth (m)**
Hawaii Level B					
Multi-depth Line (intermediate water)	160 dB	538.5	12	15	10,100
Multi-depth Line (deep water)	160 dB	2349.8	12	15	6,733
Multi-depth Line (total)	160 dB	2888.2	12	15	6,733
Deep-water Line	160 dB	2566.3	7	9	6,733
Hawaii Level A[1]					
Hawaii	LF Cetacean	115.6	19	24	320.2
	MF Cetacean	4.9	19	24	13.6
	HF Cetacean	96.8	19	24	268.3
	Phocid	15.7	19	24	43.7
Emperor Seamounts Level B					
Emperor Seamounts	160 dB	2566.3	13	16	6,733
Emperor Seamounts Level A[1]					
Emperor Seamounts	LF Cetacean	115.6	13	16	320.2
	MF Cetacean	4.9	13	16	13.6
	HF Cetacean	96.8	13	16	268.3
	Phocid	15.7	13	16	43.7
	Otariid	3.8	13	16	10.6

[1] Level A ensonified areas are estimated based on the greater of the distances calculated to Level A isopleths using dual criteria (SEL_{cum} and $_{peak}\mathrm{SPL}$).

Table 7. Densities, Percentage of Stock or Population Exposed, and Number of Authorized Takes During Hawaii Survey.

Species	Stock	Density (#/1000 km^2)	Total Exposures	Percentage of stock/population	Authorized Takes	
					Level A	Level B
Humpback Whale	Central North Pacific	--	2[4]	<0.01	0	2
	Western North Pacific	--		0.2		
Minke whale,	Hawaii	0[3]	1[4]	<0.01	0	1
Bryde's whale	Hawaii	0.72[1]	47	2.8	2	45
Sei whale	Hawaii	0.16[1]	11	6.2	0	11
Fin whale	Hawaii	0.06[1]	4	2.7	0	4
Blue whale	Central north Pacific	0.05[1]	5	3.9	0	5
Odontocetes						
Sperm whale	Hawaii	1.86[1]	123	2.7	0	123
Pygmy sperm whale	Hawaii	2.91[2]	191	2.8	7	184
Dwarf sperm whale	Hawaii	7.14[2]	470	2.8	16	454
Cuvier's beaked whale	Hawaii pelagic	0.30[1]	20	2.8	0	20
Longman's beaked whale	Hawaii	3.11[1]	205	2.7	0	205
Blainville's beaked whale	Hawaii pelagic	0.86[1]	57	2.7	0	57
Ginkgo-toothed beaked whale	N/A	1.89[6]	124	0.5	0	124
Deraniygala's beaked whale	N/A	1.89[6]	124	0.5	0	124
Hubb's beaked whale	N/A	1.89[6]	124	0.5	0	124
Rough-toothed dolphin	Hawaii	29.63[1]	1,949	2.7	0	1,949
Common bottlenose dolphin	HI Pelagic	8.99[1]	592	2.7[7]	0	592
	Oahu			1.2		
	HI Islands			7.0		
Pantropical spotted dolphin	HI Pelagic	23.32[1]	1,534	2.6[8]	0	1,534
	Oahu			N.A.		
	HI Islands			N.A.		
Spinner dolphin	HI Pelagic	6.99[2]	460	N.A.	0	460
	HI Island			3.8[9]		

	Oahu/4 island			6.7		
Striped dolphin	HI Pelagic	25[1]	1,644	0.6	0	1,644
Fraser's dolphin	Hawaii	21.0[1]	1,381	2.7	0	1,381
Risso's dolphin	Hawaii	4.74[1]	312	2.7	0	312
Melon-headed whale	HI Islands	3.54[1]	810	8.6	0	810[10]
	Kohala resident			13.4		
Pygmy killer whale	Hawaii	4.35[1]	286	2.7	0	286
False killer whale	MHI Insular	0.09[5]	5	11.9	0	20[11]
	HI Pelagic	0.06[5]	40	2.6	0	40
Killer whale	Hawaiian Islands	0.06[1]	5[4]	2.42	0	5
Short-finned pilot whale	Hawaii	7.97[1]	524	2.7	0	524
Pinnipeds						
Hawaiian monk seal	Hawaii	0.000037[3]	3	0.22	0	3

1 – Bradford *et al.* (2017).
2 – Barlow *et al.* (2009).
3 – Baker *et a*l. (2016).
4 - Requested take authorization (Level B only) increased to mean group size from Mobley *et al.* (2001).
5 – Bradford *et al.* (2015).
6 – From Bradford *et al.* (2017) for 'Unidentified *Mesoplodon*'.
7 – Assumes 98.5 percent of takes are from Hawaii pelagic stock (588) with remaining 1 percent from Oahu stock (6) and 0.5 percent from Hawaiian Islands (3) stock. Assumed average group size of 9 for Oahu and Hawaii Island stocks.
8 – Assumes 94.16 percent of takes are from Hawaii pelagic stock (1,461), 5.25 percent are from Hawaiia Island stock (82), and 0.59 are from Oahu stock. Populations of insular stocks are unknown.
9 – Assumes 0.36 percent for Oahu/4-Islands stock (1), 0.95 percent for Hawaii Island stock (4) and remaining from Pelagic stock (459) stocks. NMFS will assume average group size of 24 for the Oahu/4-Island and Hawaii Island stock exposures (NMFS 2016).
10 – Assumes Level B harassment of 3 groups of 20 Kohala resident stock whales and 3 groups of 250 Hawaiian Island stock animals.
11 – Increased to average group size of 20 (Oleson *et al.* 2010).

NMFS has recalculated exposures of Main Hawaiian Islands insular false killer whale DPS due to recently designated critical habitat for this species (83 FR 35062; July 24, 2018). A total of 3,455-kilometers of tracklines will be surveyed around the Main Hawaiian Islands where insular false killer whales show a preference for deeper waters just offshore (45-meters) to the 3,200-meter depth boundary. The majority of the planned tracklines are outside this area in waters deeper than 3,200-meters. NMFS used critical habitat to serve as the range boundary for this DPS. In order to calculate the amount of exposure for Main Hawaiian Islands Insular false killer whales during the planned action, NMFS determined the amount of tracklines within the DPS's range. There are 236.6 km of planned tracklines in Main Hawaiian Islands insular false killer whale range (or about 6.8 percent of the tracklines for the entire Hawaii seismic survey). Only portions of Tracklines 1 and 2 are within the DPS's range. Because the size of the ensonified areas changes with water depth, NMFS determined the amount of tracklines in each depth range. All of Trackline 1 takes place in deep water (>1,000 meters/141.6 km), and most of Trackline 2 takes place in deep water (76.6 km) with 18.4 km in intermediate depth water (100 to 1,000 m). Tracklines 1 and 2 would be surveyed twice, once for reflection data, and once for refraction data. At a speed of 7.6 km/hr, it would take the *Langseth* about 37.3 hours to survey Trackline 1, and 25 hours to survey Trackline 2 (both passes), for about 2.6 days in total.

NMFS calculated ensonified area along the tracklines to arrive at a total of 3,940-km^2 within the species' range. As noted previously, a contingency of 25 percent was added to the number of survey days, which is the equivalent of adding 25 percent to the planned line tracklines. The total amount of ensonified area with the 25 percent contingency is 4,92 5km^2. Bradford *et al.* (2015) calculated the density of Main Hawaiian Islands Insular false killer whales at 0.09 individuals per 100 km^2, which was multiplied by the total ensonified area plus contingency, resulting in five Main Hawaiian Island insular false killer whale exposures. False killer whales are commonly sighted in groups of 10 to 20 (Baird 2009; Baird *et al.* 2010; Wade and Gerrodette 1993) with 20 individuals being regarded as about the average group size (Oleson *et al.* 2010). Therefore, authorized Level B harassment takes was increased from 5 individuals to 20.

NMFS estimated that there would be 235 Level B harassment takes of melon-headed whales from the combined Kohala resident stock and the Hawaiian Islands stock. Kohala resident stock members could only be affected during Trackline 1 operations off of the Kohala Peninsula and the west coast of Hawaii Island in waters of less than 2,500 m of water. This segment of the survey represents a small portion of the total Hawaiian Island tracklines. The Hawaiian Islands stock of melon-headed whales may be found along any of the planned tracklines, including within the range of the Kohala resident stock. Kohala resident whales can be found in large groups of up to several hundred with a median group size of 210 (Forney *et al.* 2017). However, they have also been observed in smaller groups of 4 and 17 individuals (Aschettino *et al.* 2011). However, these smaller groups were often followed by much larger groups, which suggests that the small groups may have branched off from larger groups.

L-DEO is required to shutdown whenever a melon-headed whale is detected while passing through the Kohala resident stock's range. L-DEO also intends to pass through this range during daylight hours to maximize the potential for detection. PSOs should be able to observe the larger groups containing hundreds of animals at a significant distance and implement shutdown accordingly. When a small group of whales is observed, shutdown will also be implemented and PSOs will shift to state of heightened alert since a larger main group may be in close proximity. Given this information, NMFS will assume that up to 3 groups of 20 Kohala resident whales may be taken by Level B harassment if they enter the zone undetected by PSOs. This would result in up to 60 Level B harassment takes. Given the species' large group sizes, NMFS will also assume that up to 3 groups of 250 Hawaiian Island animals may be taken during the remainder of the cruise outside of the range of Kohala resident stock. Therefore, NMFS authorizes the take of up to 810 melon headed whales.

There are four individual common bottlenose dolphin stocks within the Hawaiian Islands complex. None of the planned survey tracklines will traverse the ranges of the Kauai/Niihau or 4-Islands stocks so animals from these stocks will not be impacted by seismic activities. Survey Trackline 1 will spend a short time traversing the northern boundary of the Hawaiian Island stock while Trackline 2 briefly runs through the northwest boundary of the Oahu stock. The vast majority of planned survey tracklines occur in waters that are greater than 1,000 m which marks the boundary between the Hawaiian pelagic and Hawaiian insular stocks. According to a GIS analysis, an estimated 0.47 percent of all Hawaii tracklines will take place in waters less than 1,000 m deep northwest of Oahu along Trackline 2 and 1.00 percent will occur in depths less than 1,000 m north of Hawaii along Trackline 1. Therefore, NMFS will assume that the remaining 98.5% percent (588) of total takes will be accrued by the pelagic stock, 0.5 percent (3) will accrue to the Oahu stock and 1 percent (6) will accrue to the Hawaiian Island stock. Insular stocks have an average group size of group size of 8.5 rounded up to 9, so 9 takes will accrue to the Oahu stock and 9 takes to the Hawaiian Island stock (Baird et al. 2002). Note that the ranges of these two insular stocks completely encompass the islands for which they are named out to the 1,000 m bathymetric contour line. Given such expansive ranges, it is unlikely that large numbers of either stock would be concentrated near a trackline during the short time the vessel is within the delineated stock boundaries.

There are four stocks of spinner dolphins within the U.S. EEZ of the Hawaiian Islands. Planned seismic survey tracklines would traverse the ranges of the Hawaii Island, Oahu/4-Islands, and Hawaii Pelagic stocks. Stock boundaries for the Hawaii Island and Oahu/4-Islands stocks extend out 10 nautical miles (nmi) from the coasts of these islands. An estimated 0.36 percent of all tracklines will take place in the range of the Oahu/4-Island stock northwest of Oahu along Trackline 2, and 0.95 percent will occur in the range of the Hawaii Island stock north of Hawaii along Trackline 1, with remaining takes being accrued by the Hawaii Pelagic stock. This results in 1 estimated Oahu/4-Island stock exposure, 4 Hawaii Island stock exposures, and 459 Pelagic stock exposures. NMFS will assume average group size of 24 individuals for the Oahu/4-Island and Hawaii Island stock exposures (NMFS 2016).

There are four management stocks of pantropical spotted dolphins within the Hawaiian Islands EEZ (Oleson *et al.* 2013) including: 1) the Oahu stock, which includes spotted dolphins within 20 km of Oahu, 2) the 4-Island stock, which includes spotted dolphins within 20 km of Maui, Molokai, Lanai, and Kahoolawe collectively, 3) the Hawaii Island stock, which includes spotted dolphins found within 65 km of Hawaii Island, and 4) the Hawaii pelagic stock, which includes spotted dolphins inhabiting the waters throughout the Hawaiian Islands EEZ,outside of the insular stock areas, but including adjacent high seas. Planned seismic survey lines would traverse the Hawaii Island, Oahu, and Hawaii Pelagic stocks. An estimated 0.59 percent of all tracklines will take place in the range of the Oahu stock northwest of Oahu along Trackline 2, and 5.25 percent will occur in the range of the Hawaii Island stock north and west of Hawaii along Trackline 1 with the remaining accrued by the Hawaii Pelagic stock. This results in an estimated 9 Oahu stock exposures, 82 Hawaii Island stock exposures, and 1,461 Pelagic stock exposures.

For Hawaiian monk seals, NMFS multiplied the estimated density as describe above by the daily ensonified area (160 dB zone) on one day, times the 1.25 percent operational contingency. Since the planned action will take place in different water depths, there are two different daily ensonified areas. For deep water (>1,000 meters), the daily ensonified area is 2,349.8 km^2. For intermediate depths (100-1,000 meters), the daily ensonified area is 538.5 km^2. The vast majority of the survey (3,403 kilometers) will take place in deep water. Only 52 km will take place in intermediate depths. This results in an authorized Level B harassment take of 3 monk seals.

Table 8. Densities, Percentage of Stock or Population Exposed, and Number of Authorized Takes During Emperor Seamounts Survey.

Species	Stock	Estimated Density (#/1000 km^2)	Total Exposures	% of Population	Authorized Takes	
					Level A	Level B
Gray whale	N/A	N.A.	2[2]	1.43	0	2
North Pacific right whale	N/A/	0.01[1]	2[10]	0.45	0	2
Humpback whale	Central North Pacific	0.41[1]	18	0.19[11]	2[13]	16[11]
	Western North Pacific DPS			0.18[11]		
Minke whale	N/A	2.48	103	0.47	5	98
Bryde's whale	N/A	N.A.	2[3]	<0.01	0	2
Sei whale	N/A	0.29[1]	14	0.05	3[3]	11
Fin whale	N/A	0.20[1]	8	0.06	0	8
Blue whale	Central North Pacific	0.13	5	3.7	0	5
Odontocetes						
Sperm whale	N/A	2.20[1]	90	0.30	0	90
Pygmy sperm whale	N/A	2.91[4]	121	1.7	0	121
Dwarf sperm whale	N/A	7.14[4]	298	1.7	0	298
Cuvier's beaked whale	N/A	5.40[1]	225	1.11	0	225
Stejner's beaked whale	Alaska	0.5[1]	21	0.08	0	21
Baird's beaked whale	N/A	2.9[1]	121	1.19	0	121
Short-beaked common dolphin	N/A	180[5]	N.A.	<0.01	0	180
Striped dolphin	N/A	9.21[6]	384	0.04	0	384
Pacific white-sided dolphin	N/A	68.81[7]	2,870	0.29	0	2,870
Northern	N/A	3.37[7]	141	0.04	0	141

right whale dolphin						
Risso's dolphin	N/A	27[3]	1,126	1.02	0	1,126
False killer whale	N/A	10[5]	417	2.5	0	417
Killer whale	N/A	3.00[8, 12]	1,253	14.7	0	1,253
Short-finned pilot whale	N/A	41[3]	1,713	3.2	0	1,713
Dall's porpoise	N/A	35.46	1,479	0.13	56	1,423
Pinnipeds						
Northern fur seal	N/A	3.56[7]	149	0.01	0	149
Northern elephant seal	N/A	8.31	343	0.15	0	343
Ribbon seal	Alaska	N.A.	5[9]	<0.01	0	5

1 – Navy 2017b. Final Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement. SURTASS.
2 – Mean group size based on Rugh *et al.* (2005).
3 – Mean group size from Bradford *et al.* (2017).
4 – Bradford *et al.* (2017).
5 – Mean group size from Barlow (2016).
6 – Miyashita (1993).
7 –Buckland *et al.* (1993).
8 –Forney and Wade (2006).
9 – Estimated exposures increased to 5 for pinnipeds.
10 – Mean group size from Matsuoka *et al.* (2009).
11 – Based on population size, take is split proportionally between central north Pacific (91.2 percent of total take) and western north Pacific DPS stocks (9.8 percent of total take).
12 – Density is based on number of animals/100 km^2.
13 – Mean group size from Mobley *et al.* (2001).

It should be noted that authorized take numbers shown in Tables 7 and 8 are expected to be conservative for several reasons. First, in the calculations of estimated take, 25 percent has been added in the form of operational survey days to account for the possibility of additional seismic operations associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate take as described above. Additionally, marine mammals would be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of Level A takes. However, the extent to which marine mammals would move away from the sound source is difficult to quantify and is, therefore, not accounted for in the take estimates.

APPENDIX F: EFH LETTER OF CONCURRENCE

From: Stuart Goldberg - NOAA Federal <stuart.goldberg@noaa.gov>**Sent:** Thursday, May 03, 2018 10:14 PM; **To:** Smith, Holly E. <hesmith@nsf.gov>**Cc:** Ian Lundgren - NOAA Affiliate <ian.lundgren@noaa.gov>; Malia Chow - NOAA Federal <malia.chow@noaa.gov>; Gerry Davis - NOAA Federal <gerry.davis@noaa.gov>**Subject:** Re: EFH Consultation Request

Aloha Holly,

We appreciate you coordinating on this proposed marine geophysical survey project under the essential fish habitat (EFH) provision of the Magnuson-Stevens Fishery Conservation and Management Act (MSA; section 305(b)(2)). Since EFH may only be described and identified within the U.S. Exclusive Economic Zone (EEZ; see § 600.805), NMFS has reviewed this EFH consultation request for only the Main Hawaiian Islands survey within the Hawaiian EEZ. This response does not consider or apply to the proposed Emperor Seamount survey in international waters.

The National Science Foundation (NSF; the applicant) proposes to fund research that conducts high-energy marine geophysical surveys in the North Pacific Ocean in the Main Hawaiian Islands EEZ. The purpose of the surveys is to gain fundamental insight into the formation and evolution of the Hawaiian-Emperor Seamount chain. Surveys would be funded by NSF and led by researchers from multiple academic institutions with international collaboration aboard the research vessel (R/V) *Marcus G. Langseth* (*Langseth*). The survey will be conducted in water depths ranging from greater than 700 meters to greater than 5000 m.

Surveys would collect two-dimensional marine seismic data using a 36 airgun array. Returning acoustic signals would be received using a towed hydrophone streamer and ocean bottom seismometers (OBS). The R/V *Langseth* would deploy all 70 OBS approximately 15 kilometers apart. Deployment of the OBS will require small anchors on the seabed consisting either of hot-rolled steel (weight: 23 kilograms; dimensions: two and one half by 30.5 by 38.1 centimeters) or iron grates (weight: 36 kg; dimensions: seven by 91 by 91.5 cm). While OBS will be recovered, anchors will be left behind.

EFH along the proposed survey includes only the water column. Potential adverse effects to various life stages of invertebrate and fish management unit species (MUS) may occur due to noise from the airgun array, other acoustic research devices, and the ship. While the project footprint is not within any habitat areas of particular concern (HAPC), noise from the deployment of the airgun array may reach nearby HAPCs. The applicant’s draft Environmental Assessment (EA) provides a thorough literature review of potential adverse effects from noise on marine invertebrates and fish, and concludes that there will be no significant impacts on marine invertebrates, marine fish, and their fisheries. To further ensure that adverse effects to EFH from the proposed activities are avoided and minimized, the applicant has proposed monitoring and mitigation measures, including directing airgun energy downward rather than laterally, to ensure that there will be no long-term or significant effects on invertebrate and fish MUS.

NMFS agrees with the NSF’s determination that the proposed project may effect EFH and HAPC, but that any adverse effects would be localized and transitory and therefore would not be significant. As such, NMFS will not provide additional conservation recommendations for this project, thus satisfying the requirements of both sections 305(b)(2)(A) and sections 305(b)(2)(B) of the Magnuson-Stevens Act.

NMFS appreciates the opportunity to comment. Please don’t hesitate to contact me with any questions or concerns.

Best,
Stu

APPENDIX G: USFWS LETTER OF CONCURRENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai'i 96850

In Reply Refer To:
01EPIF00-2018-I-0402

Ms. Holly E. Smith
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

Subject: Informal Consultation on the National Science Foundation Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the North Pacific Ocean

Dear Ms. Smith:

Thank you for your April 20, 2018, letter requesting informal consultation from the U.S. Fish and Wildlife Service (Service) on the proposed high-energy marine geophysical surveys to be undertaken in 2018-2019 in waters surrounding the Main Hawaiian Islands and the Emperor Seamounts, North Pacific Ocean, pursuant to the Endangered Species Act (ESA), as amended. The proposed seismic surveys are funded by the National Science Foundation (NSF) and led by Principal Investigators from multiple academic institutions. The proposed seismic surveys will be conducted on the research vessel (R/V) *Marcus G. Langseth* (*Langseth*), which is owned by NSF and operated by Columbia University's Lamont-Doherty Earth Observatory (LDEO). The proposed surveys would collect seismic data using an array of 36 airguns deployed as an energy source, and ocean bottom seismometers (OBSs) and a towed hydrophone streamer, as the receiving systems for the returning acoustic signals.

You requested Service concurrence with your determination that the proposed action may affect, but is not likely to adversely affect the federally endangered short-tailed albatross (*Phoebastria albatrus*), Hawaiian petrel (*Pterodroma sandwichensis*), band-rumped storm petrel – Hawaii Distinct Population Segment (DPS) (*Oceanodroma castro*), and the threatened Newell's shearwater (*Puffinus auricularis newelli*). NSF is also seeking an Incidental Harassment Authorization and are consulting with the National Marine Fisheries Service pursuant to Section 7 of the ESA to address impacts to protected species within their jurisdiction.

The proposed surveys would be implemented as described in the: 1) Proposed Action Alternative of the 2018 Draft Environmental Assessment/Analysis of Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the North Pacific Ocean, 2018/2019 (NSF 2018); 2) NSF Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement (NSF 2011); and 3) other information provided in your request. The action area includes the Hawaii and Emperor Seamounts survey areas and transit routes to and from ports. The survey at the Emperor Seamounts will occur in International Waters (approximately between 43–48°N and 166–173°E) where water depths are 1500–6000 m. The Hawaii survey will occur within the U.S. Exclusive Economic Zone (approximately between 18–24°N and 153–160°W), in water approximately 700 to >5000 m deep. The two survey areas and representative tracklines are shown in Figures 1 and 2 below. A total of approximately 5,567 km of tracklines will be surveyed. No activities or transit will occur within the Papahānaumokuākea Marine National Monument.

The *Langseth* would tow an array of 36 airguns at a depth of 12 m as an energy source with a total discharge volume of approximately 6600 cubic inches. The receiving system would consist of OBSs and a single hydrophone streamer 15 km in length. The shot interval would be 50 m for multi-channel seismic (MCS) reflection lines and 150 m for OBS refraction lines. The Hawaii survey will occur during summer/early fall 2018 and the Emperor Seamounts survey is planned for spring/early summer 2019.

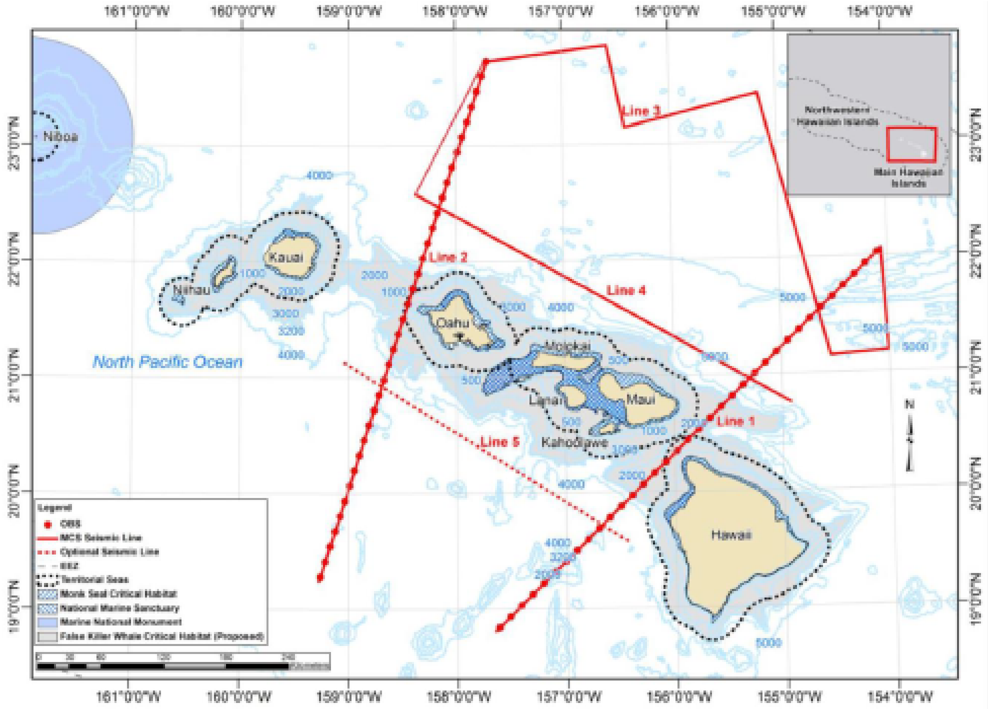

FIGURE 1. Location of the proposed 2018 seismic survey at the Main Hawaiian Islands, and proposed locations of ocean bottom seismometers (OBSs). The National Marine Sanctuary is the Hawaii Islands Humpback Whale National Marine Sanctuary. Marine National Monument is the Papahānaumokuākea Marine National Monument (NSF 2018).

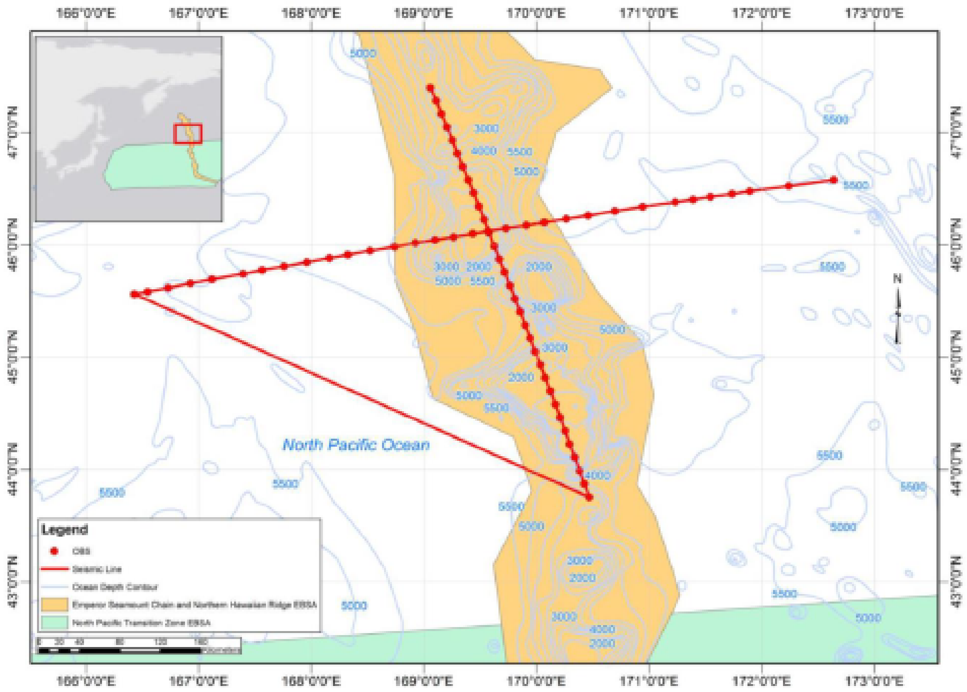

FIGURE 2. Location of the proposed 2019 seismic survey at the Emperor Seamounts in the western North Pacific Ocean, and the proposed locations of ocean bottom seismometers (OBSs) (NSF 2018). OBSs would be deployed and recovered along one line at a time.

It is not likely that seabirds would be affected by the deployment and use of seismic air guns because the energy source is deployed at a depth of 12 m below the surface and directed downward, most seabirds spend little time submerged, and therefore, exposure sufficiently intense (i.e., of a certain duration or within close proximity) to cause physiological impacts are unlikely. Hawaiian petrels, short-tailed albatrosses, and band-rumped storm petrels do not submerge while foraging; therefore, they would not be exposed to the energy discharged by seismic air guns. Newell's shearwater may briefly submerge up to depths of 10 m while foraging (e.g., pursuit diving), so there is a remote chance that these species could be exposed to energy discharges. However, the depth (12 m) of deployment and the downward direction of the energy discharged by the air guns, would make the likelihood of exposure insignificant or unlikely.

In the Hawaii survey area, the Hawaiian petrel, Newell's shearwater, and band-rumped storm petrel occur at low frequencies, and occurrence of the short-tailed albatross is rare. In the Emperor Seamounts survey area, the occurrence of the short-tailed albatross is rare, and the other three species are not likely to occur.

Seismic sound and other aspects of survey activities could result in adverse effects (collisions, injury, entanglement, ingestion, disturbance) to seabirds. Due to low levels of exposure and transitory nature of disturbance caused by survey activities, coupled with the low frequency of the four seabird species within the action area, we consider such effects to the short-tailed albatross, Hawaiian petrel, Newell's shearwater, and band-rumped storm petrel possible, but unlikely to occur, so the effects would be considered discountable. Therefore, we concur with the NSF's determination that implementation of the proposed survey activities may affect, but is not likely to adversely affect the four listed seabirds.

To avoid impacts to the listed seabirds during survey operations, the NSF will implement the following avoidance and minimization measures as described in the information provided:

- Monitoring by Protected Species Observers (PSOs) for ESA-listed seabirds diving near the vessel, and observing for potential impacts of acoustic sources on fish;
- Passive acoustic monitoring (PAM);
- PSO data and documentation; and
- The acoustic source would be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated Exclusion Zone.

Based on the above and implementation of mitigation and avoidance and minimization measures outlined in detail, we concur with the NSF's determination that implementation of the proposed seismic surveys may affect, but is not likely to adversely affect the four ESA-listed seabird species. This concludes informal consultation on the actions outlined in the request. However, as provided in 50 CFR §402.16, reinitiation of consultation is required if: (1) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (3) a new species is listed or critical habitat designated that may be affected by the action.

We appreciate your concern and efforts to address the conservation needs of fish and wildlife and plants. If you have questions regarding these comments, please contact James Kwon, Fish and Wildlife Biologist (phone: 808-792-9400, email: james_kwon@fws.gov).

Sincerely,

DARREN
LEBLANC
Digitally signed by
DARREN LEBLANC
Date: 2018.07.13
13:16:25 -10'00'

Mary M. Abrams, Ph.D.
Field Supervisor

APPENDIX H:
COASTAL ZONE MANAGEMENT PROGRAM LETTER OF CONCURRENCE

OFFICE OF PLANNING
STATE OF HAWAII

DAVID Y. IGE
GOVERNOR

LEO R. ASUNCION
DIRECTOR
OFFICE OF PLANNING

235 South Beretania Street, 6th Floor, Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Telephone: (808) 587-2846
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Web: http://planning.hawaii.gov/

DTS201805141028RI

May 14, 2018

Ms. Holly E. Smith
Environmental Compliance Officer
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

Dear Ms. Smith:

Subject: Hawaii Coastal Zone Management Program Federal Consistency Review of National Science Foundation Supported Marine Geophysical Surveys in the Main Hawaiian Islands

The Hawaii Coastal Zone Management (CZM) Program has completed the federal consistency review of the proposed National Science Foundation (NSF) supported marine geophysical survey in the Main Hawaiian Islands. According to the consistency determination, the proposed activity involves conducting a seismic survey in ocean waters within the Main Hawaiian Islands (within 18-24° N, 153-160° W) over a 36-day period in 2018 (proposed activity). The procedures to be used for the marine geophysical survey would use conventional seismic methodology, involving one source vessel, the NSF-owned *Marcus G. Langseth*, towing an array of 36 airguns at a depth of 12 meters as an energy source. The receiving system would consist of Ocean Bottom Seismometers and a single hydrophone streamer 15 km in length.

The Hawaii CZM Program conditionally concurs with the NSF determination that the proposed activity is consistent to the maximum extent practicable with the enforceable policies of the Hawaii CZM Program. The following conditions shall apply to all NSF supported marine geophysical survey activities associated with the proposed activity.

1. The proposed activity shall be conducted as represented in the consistency determination. Any changes to the proposal shall be submitted to the Hawaii CZM Program for review and approval. Changes to the proposal may require a full federal consistency review, including publication of a public notice and provision for public review and comment. This condition is necessary to ensure that the proposed activity is implemented as reviewed for consistency with the enforceable policies of the Hawaii CZM Program. Hawaii Revised Statutes (HRS) Chapter 205A, Coastal Zone Management, is the federally approved enforceable policy of the Hawaii CZM Program that applies to this condition.

2. The proposed monitoring and mitigation measures that are represented in section 2.1.3 Monitoring and Mitigation Measures, in the "Draft Environmental Assessment/Analysis of Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the North Pacific Ocean, 2018/1019" (March 23, 2018), which was submitted in support of the consistency determination, shall be fully implemented. This condition is necessary to ensure consistency with the Hawaii CZM Program coastal ecosystems policies established in HRS Chapter 205A, Coastal Zone Management, which is the federally approved enforceable policy that applies to this condition.

3. State of Hawaii listed endangered, threatened, and indigenous species shall be provided protections that are consistent with the provisions of Hawaii CZM Program enforceable policies HRS Chapter 195D, Conservation of Aquatic Life, Wildlife, and Land Plants, and Hawaii Administrative Rules (HAR) Chapter 13-124, Indigenous Wildlife, Endangered and Threatened Wildlife, and Introduced Wild Birds. The endangered, threatened, and indigenous species referred to in this condition are those listed in HAR Chapter 13-124. This condition shall not apply to marine mammals.[1]

If the requirements for conditional concurrences specified in 15 CFR § 930.4(a), (1) through (3), are not met, then all parties shall treat this conditional concurrence letter as an objection pursuant to 15 CFR Part 930, subpart C.

The Hawaii CZM Program solicited and received comments from the State Department of Land and Natural Resources, Division of Aquatic Resources (DAR), on the proposed activity. The DAR comments, which are enclosed, raise important concerns regarding marine mammals. Although the DAR concerns could not be factored into this conditional concurrence, the DAR comments are relevant and important to the Hawaii CZM Program, and therefore, are being provided for your consideration.

This conditional concurrence does not represent an endorsement of the proposed activity nor does it convey approval with any other regulations administered by any state or county agency. Thank you for your cooperation in complying with the Hawaii CZM Program. If you have any questions, please call John Nakagawa of our CZM Program at (808) 587-2878.

Sincerely,

Leo R. Asuncion
Director

Enclosure

c: Catherine Gewecke, DLNR, Division of Aquatic Resources (w/o enclosure)

---

[1] Letter from Jane C. Luxton, NOAA General Counsel, to Frank R. Jimenez, General Counsel of the Navy, June 20, 2008.