National Science Foundation
Geosciences Directorate
Division of Ocean Sciences
Alexandria, Virginia

FINDING OF NO SIGNIFICANT IMPACT (FONSI) PURSUANT TO THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) AND DECISION DOCUMENT (DD)

Marine Geophysical Survey in the Gulf of Alaska, 2019

Award: OCE 1928863
Principal Investigator/Institution: Geoffrey Abers, Cornell University
Project Title: Alaska Amphibious Community Seismic Experiment

A Final Environmental Assessment (Final EA) was prepared for the proposed research project funded by the National Science Foundation (NSF) entitled, "Alaska Amphibious Community Seismic Experiment" (AACSE) (Proposed Action). The Proposed Action would involve a marine geophysical survey (or "seismic survey") to be conducted on board Research Vessel *Marcus G. Langseth* (R/V *Langseth*) in the Gulf of Alaska (GOA). R/V *Langseth* is owned by NSF and operated on its behalf through a Cooperative Agreement entered in 2018 by L-DEO. The Proposed Action would involve the Principal Investigator (PI), Geoffrey Abers, Cornell University, and other collaborators identified in the award OCE 1928863 (referred to herein as the "Proposing Institutions"). Dr. Anne Becel, Columbia University Lamont-Doherty Earth Observatory (L-DEO), would be Chief Scientist of the survey.

The Final EA entitled, "Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Gulf of Alaska, 2019" (Report #FA0168-01) (Attachment 1), was prepared by LGL Limited environmental research associates (LGL) on behalf of NSF and analyzed the potential impacts on the human and natural environment associated with the Proposed Action pursuant to the National Environmental Policy Act (NEPA). The Final EA tiers to the *Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (June 2011) and the *Record of Decision* (June 2012) (jointly referred to herein as the PEIS). This Finding of No Significant Impact/Decision Document (FONSI/DD) also incorporates by reference the analyses and conclusions set forth in the Incidental Harassment Authorization (IHA) and the Biological Opinion (BiOp)/Incidental Take Statement (ITS) issued by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) for this Proposed Action. The conclusions from the Final EA, and other federal regulatory processes, were consistent with the conclusions of the PEIS and were used to inform the Division of Ocean Sciences (OCE) management of potential environmental impacts of the survey. OCE has reviewed and concurs with the Final EA findings. The Final EA is incorporated into this FONSI/DD by reference as if fully set forth herein.

Project Objectives and Context

The primary goal of this survey is to better constrain the geometry and properties of this active plate tectonic boundary, which has produced large earthquakes and tsunamis that are damaging to the Alaska region and to the west coast of the U.S. and Hawaii. Data collected through the survey would supplement data collected through the AACSE currently deployed in the survey area. Although the proposed activity has independent utility, the addition of data collected through active sources (airguns) would contribute to the project goals of the AACSE, which involve imaging the architecture for the Alaska Peninsula subduction zone and understanding the structures controlling how and where the planet's largest earthquakes occur. However, the information gained by the proposed activity would provide unique higher resolution constraints on the structure of the subduction zone that cannot be obtained by the AACSE data alone.

To achieve the project goal, the researchers propose to conduct a 2D seismic survey using the R/V *Langseth* in the western GOA to collect a wide-angle reflection/refraction dataset. The survey is illustrated with representative tracklines in the Final EA (Attachment 1, Figure 1).

Early career scientists would participate in the cruise and receive training in marine geophysics and subduction zone processes. The open access data obtained by this project would also be very useful for educational purposes after the cruise, since this cutting-edge data would be openly available.

Summary of Proposed Action and Alternatives

The procedures of the Proposed Action would be similar to those used during previous 2-D seismic surveys and would use conventional seismic methodology. The survey would involve one source vessel, the *Langseth*. The *Langseth* would tow an array of 36 airguns at a depth of 12 meters (m) as an energy source with a total volume of approximately (~) 6600 inches cubed (in^3). The receiving system would consist of previously deployed ocean bottom seismometers (OBSs) and onshore seismometers (Attachment 1, Figure 2). As the airgun arrays are towed along the survey lines, a hydrophone streamer and/or the OBSs and seismometers would receive the returning acoustic signals; OBSs would store the data internally for later analysis. In addition to the operations of the airgun array, a multibeam echosounder (MBES) and sub-bottom profiler (SBP) would be operated from R/V *Langseth* continuously throughout the cruise, but not during transit to the site.

The project consists of a number of tracklines that cross the trench onto the Pacific plate and shorter connecting tracklines. The representative tracklines shown in the Final EA (Attachment 1, Figure 1) have a total length of 4400 kilometers (km). There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. The majority of the survey effort would occur in deep water (greater than 1000 m) however, some would take place in shallow water (less than100 m) and intermediate water depths (100–1000 m).

The survey is expected to consist of up to 18 days of seismic operations and ~1 day of transit. The *Langseth* would leave from and return to port in Kodiak, likely in early June 2019. Some deviation in the length of the survey, and ports of call, may be required, depending on logistics and weather; however, seismic operations would only occur during the timeframe allowable under the IHA. 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.

Another alternative to conducting the Proposed Action would be the "No Action" alternative (i.e. the proposed research operations would not be conducted). The "No Action" alternative would result in no disturbance to marine species attributable to the Proposed Action, but geological data of considerable scientific value and relevance to increasing our understanding of the architecture for the subduction zone and understanding variability in slip behavior of the Alaska Peninsula subduction zone, and adding to the comprehensive assessment of geohazards for the Alaska region, such as earthquake and tsunami hazards, would not be collected. The purpose and need for the proposed activity would not be met through the "No Action" alternative.

Summary of environmental consequences

The Final EA includes analysis on the affected environment (Chapter III) and the potential effects of the Proposed Action on the environment (Chapter IV). Potential impacts of the Proposed Action on the environment would be primarily a result of the operation of the airgun array. The potential effects of sounds from airguns on marine species, mammals, and sea turtles of particular concern, are described in detail in Attachment 1 (Chapter IV and PEIS Chapters 3 & 4) and might 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. It is unlikely that the Proposed Action would result in any cases of temporary or especially permanent hearing impairment, or any significant non-auditory physical or physiological effects. Some behavioral disturbance is expected, if animals are in the general area during seismic operations, but this would be localized, short-term, and involve limited numbers of animals. The potential effects from the other proposed acoustic sources were also considered, however, they would not be likely to have a significant effect on the environment (Attachment 1, Chapter IV; and PEIS Chapter III).

The Proposed Action includes an extensive monitoring and mitigation program to further minimize potential impacts on the environment. Mitigation efforts include pre-cruise planning activities and operational activities (Attachment 1, Chapters II and IV; and PEIS 2.4.1.1). Pre-cruise planning mitigation activities included consideration of energy source optimization/minimization; survey timing (i.e., environmental conditions: seasonal presence of animals and weather); and calculation of mitigation zones. The operational mitigation program would further minimize potential impacts to marine species that may be present during the conduct of the proposed research to a level of insignificance.

As detailed in Attachment 1 (Chapters II and IV), the IHA and ITS issued by NMFS, and Letter of Concurrence (LOC) issued by USFWS, operational monitoring and mitigation measures would include: visual observations, acoustic monitoring, exclusion and buffer zones, pre-clearance and ramp ups, shutdowns and powerdowns, monitoring and reporting. The fact that the airgun array, as a result of its design, directs the majority of the energy downward, and less energy laterally, would also be an inherent mitigation measure. The acoustic source would be shut down for North Pacific right whales observed at any distance from the vessel. In addition, the R/V *Langseth* would only operate in North Pacific right whale critical habitat during daylight hours to facilitate the ability of PSOs to observe any right whales that may be present; vessel speed would be reduced to 5 knots to avoid the possibility of ship strike when transiting through North Pacific right whale critical habitat during darkness or conditions of similarly limiting visibility. Per the IHA, if a fin whale or group of fin whales is observed with 1,500 m of the acoustic source within the designated fin whale Biologically Important Area, LDEO must implement a shutdown. L-DEO would shutdown for a calf or aggregation of large whales (defined as 6 or more mysticetes or sperm whales) observed at any distance during operations. Operations would also avoid exposing sea otters and their critical habitat from ensonification levels of 160 dB re 1 µPa SPL or greater (Level B zone) to avoid take. The acoustic source would be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated exclusion zones. 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. PSOs would also watch for any impacts the acoustic sources may have on marine species, including seabirds and fish. The shutdown requirement would be waived for small dolphins of the following genera: *Lagenorhynchus* and *Grampus*. NMFS included vessel strike avoidance measures in the IHA; however, as noted in the Final EA, R/V *Langseth* (and other vessels in the U.S. Academic Research Fleet) have no history of marine mammal strikes. Although NSF calculated predicted distances to the Level A thresholds based on current NMFS Technical Acoustic Guidance[1], per the IHA, NMFS established a fixed 500 m exclusion zone and 1,000 m buffer zone for the survey. The predicted distances for the Level B zones are based on the 160 dB re 1 µPa SPL isopleth, per current NMFS policy for Level B harassment.

With the planned monitoring and mitigation measures, unavoidable impacts to marine species that could be encountered would be expected to be minimal, and limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals may be interpreted as falling within the federal Marine Mammal Protection Act (MMPA) definition of Level B Harassment for those species managed by NMFS, however, NMFS also issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects from the Proposed Action. Although considered unlikely, any Level A harassment potentially incurred would be expected to be in the form of some smaller degree of permanent hearing loss due in part to the required monitoring measures for detecting marine mammals and required mitigation measures for power downs or shut downs of the airgun array if any animal is likely to enter the exclusion zones. Neither mortality nor complete deafness of marine mammals is expected to result from the survey. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish or the populations to which they belong or on their habitats.

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, MBES, SBP, and acoustic pingers. However, the PEIS also stated that, cruise-specific cumulative effects analysis would be conducted, "allowing for the identification of other potential activities in the area of the proposed seismic survey that may result in cumulative impacts to environmental resources." The potential cumulative effects of the Proposed Action were evaluated in Section 4.1.8 of the Final EA. Due to the location of the Proposed Action and distance from shore, human activities in the area around the survey vessel would be anticipated to be limited to fishing, military (Navy) activities, and vessel traffic. Whale watching/tour boat operations could also occur in the survey area. Due to the proposed

[1] 2018 Revision to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0). Underwater thresholds for onset of permanent and temporary threshold shifts. Office of Protected Resources, NMFS, Silver Spring, MD.

timing, primarily offshore location, and brief period of operation near areas of potential whale watching and tour boat operations, however, no significant impacts would be anticipated from the proposed activity to these industries. Recreational SCUBA diving is a small industry in Alaska, and because the proposed survey would occur prior to the peak tourist season, recreational diving is unlikely to be impacted. Sportfishing is an economically important industry in Alaska; however, sport fishing generally occurs relatively close to shore and is thus unlikely to be impacted by the majority of the proposed survey activity. Fisheries activities and vessel traffic within the region and potential impacts are described in further detail in the Final EA, Chapters III and IV. Fisheries activities would not be precluded in the survey area; however, a safe distance would need to be kept to avoid possible entanglement with the towed airgun array. No fish kills or injuries were observed during any previous NSF-funded seismic survey activities. Given the brief duration of the proposed survey and the temporary nature of potential environmental impacts, no cumulative effects, or economic impacts to fisheries, would be anticipated.

Subsistence is an important component of Alaska Native culture and community. The proposed project could potentially impact the availability of marine mammals for harvest in a small area immediately around the *Langseth*, and for a very short time period during seismic operations. Considering the limited time that the planned seismic survey would take place close to shore, where most subsistence harvest of marine mammals occurs, and brief period of operations, the proposed project is not expected to have any significant impacts to the availability of Steller sea lions, harbor seals, or sea otters for subsistence harvest. The potential to negatively impact subsistence hunting would be minimized through outreach and avoidance during the survey.

The "No Action" alternative would remove the potential of the limited direct and indirect environmental consequences as described. However, it would preclude important scientific research from going forward that would contribute to our understanding of subduction zone architecture and variability in slip behavior of the Alaska Peninsula and the comprehensive assessment of geohazards for the GOA region, such as earthquake and tsunami hazards. The "No Action" alternative would result in a lost opportunity to obtain important scientific data and knowledge relevant to the geosciences and to society in general. The collaboration, involving PIs and students, would be lost along with the collection of new data, interpretation of these data, and introduction of new results into the greater scientific community. Loss of NSF support often represents a significant negative impact to the academic infrastructure, including the professional and academic careers of the researchers, students, ship technicians and crew who are part of the U.S. Academic Research Fleet. The "No Action" alternative would not meet the purpose and need of the Proposed Action.

NSF posted a Draft Environmental Assessment (Draft EA) on the NSF website for a 30-day public comment period from 1 April thru 1 May 2019. NSF contacted several organizations to help identify potential interested parties in the survey area (e.g., Marine Mammal Commission, Kodiak Agent Alaska Sea Grant Marine Advisory Program College of Fisheries and Ocean Sciences University of Alaska Fairbanks). Based on some recommendations from this outreach, web searches, and past contacts for similar work in the area, NSF sent notices about the availability of the Draft EA to potential interested parties (e.g., regional commissions, fisheries organizations). No comments were received during the public comment period or after.

As the Draft EA included information regarding marine mammals and threatened and endangered species in the proposed survey area, it was used for consultations with other regulatory agencies. As part of the

IHA process, NMFS posted a Notice of Intent to issue an IHA in the Federal Register with a 30-day public comment period. Public comments from two entities were received through this process. After discussions with federal regulators during MMPA and Endangered Species Act (ESA) processes, minor refinements to the information in the Draft EA were made, including special mitigation measures for North Pacific right whale critical habitat, as previously noted. The new information included in the Final EA, however, did not alter the overall conclusions of the Draft EA and remained consistent with the PEIS.

Coordination with Other Agencies and Processes

Endangered Species Act (ESA)

NSF engaged in formal consultation with NMFS and informal consultation with U.S. Fish and Wildlife Service (USFWS), pursuant to Section 7 of the ESA.

On 1 February 2019, NSF requested formal consultation under ESA Section 7 for the Proposed Action with USFWS as endangered and threatened species and critical habitat under USFWS jurisdiction could occur within the survey area, including northern sea otter critical habitat (Attachment 1, Section 3.2.1.2); northern sea otter (Enhydra lutris; Attachment 1, Section 3.3.4.1); and seabirds (Attachment 1, Section 3.5), both the short-tailed Albatross (*Phoebastria albatrus*; Attachment 1, Section 3.5.1) and Steller's eider (*Polysticta stelleri*; Attachment 1, Section 3.5.2). As originally designed, the Proposed Action had the potential for sea otter take and overlap with sea otter critical habitat. After initial consultation discussions with USFWS, however, the Proposed Action was modified to avoid sea otter critical habitat and sea otter take. On 7 April 2019, NSF revised its ESA Section 7 request for the Proposed Action from formal to informal consultation, concluding the proposed activities may affect but were not likely to adversely affect marine species or critical habitat under USFWS jurisdiction pursuant to Section 7 of the ESA of 1973 (16 U.S.C. 1531- 1544), as amended, and that no further consultation with USFWS was required. NSF received confirmation from USFWS on 7 May 2019 that the proposed activity may affect but was not likely to adversely affect endangered species or their designated critical habitats under their jurisdiction (Attachment 1, Appendix E).

On 16 November 2019, NSF submitted a formal consultation request to NMFS under Section 7 of the ESA. NSF and NMFS staff held biweekly meetings to discuss the Proposed Action and matters related to the consultation. NMFS issued a Biological Opinion and an Incidental Take Statement for the Proposed Action on 31 May 2019, and consultation was concluded (Attachment 2).

Marine Mammal Protection Act (MMPA)

On 19 November 2018, L-DEO submitted on behalf of NSF, L-DEO, and the Proposing Institutions to NMFS an IHA application pursuant to the MMPA. NSF and NMFS staff held biweekly meetings to discuss the Proposed Action and matters related to the IHA application. Following a 30-day public comment period, NMFS considered public comments received and issued an IHA on 31 May 2019 (Attachment 3).

NSF also contacted USFWS pursuant to the MMPA regarding potential for sea otter take and overlap with sea otter critical habitat. After initial discussions with USFWS, however, the Proposed Action was modified to avoid sea otter critical habitat and sea otter take. Specifically, operations would avoid exposing sea otters and their critical habitat from ensonification levels of 160 dB re 1 µPa SPL or greater (Level B zone) to avoid take. As no take was anticipated, an IHA for sea otter take was determined unnecessary.

Essential Fish Habitat (EFH)
Although NSF anticipated no significant impacts to EFH, as the proposed activities may affect EFH found in the water column, in accordance with the Magnuson-Stevens Fishery Conservation and Management Act NSF requested consultation with NMFS on 1 March 2019. In an email dated 20 March 2019, NMFS concluded the Proposed Action would not adversely effect EFH and no further consultation per section 305 of the Magnuson-Stevens Act was necessary (Attachment 1, Appendix F).

Conclusion and Decision
NSF has reviewed and concurs with the conclusions of the Final EA (Attachment 1) that implementation of the Proposed Action will not have a significant impact on the environment. Consequently, implementation of the Proposed Action will not have a significant direct, indirect or cumulative impact on the environment within the meaning of NEPA. Because no significant environmental impacts will result from implementing the Proposed Action, an environmental impact statement is not required and will not be prepared. Therefore, no further study under NEPA is required.

As described above, NSF's compliance with the MMPA, ESA, and EFH is completed.

In sum, after full consideration of the Final EA, the PEIS, the IHA and ITS issued by NMFS, the letter of concurrence from USFWS, the EFH conclusion, and the entire environmental compliance record, NSF concludes that implementation of the Proposed Action will not result in significant impacts. Accordingly, on behalf of NSF, I authorize the issuance of a Finding of No Significant Impact for the Proposed Action, the marine seismic survey proposed to be conducted on board the Research Vessel *Marcus G. Langseth* in the Gulf of Alaska during the effective time period of the IHA, and hereby approve the Proposed Action to commence.

4 June 2019

Bauke (Bob) Houtman — Date
Integrative Programs Section Head
Division of Ocean Sciences

Attachment 1: Final Environmental Analysis of Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Gulf of Alaska, 2019
Attachment 2: Biological Opinion/Incidental Take Statement
Attachment 3: Incidental Harassment Authorization

Draft Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Gulf of Alaska, 2019

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ABSTRACT

Researchers from Lamont-Doherty Earth Observatory (L-DEO), Cornell University, Colgate University, University of Washington, University of California Santa Cruz, University of Colorado Boulder, University of New Mexico, Washington University in St. Louis, and the United States Geological Survey (USGS) (herein collectively referred to as the Proposing Institutions), with funding from the U.S. National Science Foundation (NSF), propose to conduct a high-energy seismic survey from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) in the Gulf of Alaska (GOA) during 2019. The NSF-owned *Langseth* is operated by Columbia University's L-DEO under an existing Cooperative Agreement. The proposed seismic survey would likely occur off the Alaska Peninsula and the eastern Aleutian islands during late spring 2019 and would use a 36-airgun towed array with a total discharge volume of ~6600 in^3. The survey would take place within the U.S. Exclusive Economic Zone (EEZ), in water ~15 to ~6184 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 survey would collect data in support of research that would satisfy NSF program priorities. The primary goal of this survey is to better constrain the geometry and properties of this active plate tectonic boundary, which has produced large earthquakes and tsunamis that are damaging to the Alaska region and to the west coast of the US and Hawaii. Data collected through the survey would supplement data collected through the Alaska Amphibious Community Seismic Experiment (AACSE) currently deployed in the survey area. Although the proposed activity has independent utility, the addition of data collected through active sources (airguns) would contribute to the project goals of AACSE, which involve imaging the architecture for the Alaska Peninsula subduction zone and understanding the structures controlling how and where the planet's largest earthquakes occur. However, the information gained by the proposed activity would provide unique higher resolution constraints on the structure of the subduction zone that cannot be obtained by the AACSE data alone.

This Draft Environmental Assessment (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) for the proposed NSF federal action within the Alaskan EEZ. As operator of the *Langseth*, L-DEO, on behalf of itself, the Proposing Institutions, and NSF is requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental (i.e., not intentional) harassment of small numbers of marine mammals should this occur during the seismic survey. The analysis in this document 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 the PEIS. This document also tiers to an EA prepared for a similar seismic survey conducted by R/V *Langseth* in 2011 titled, "Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the western Gulf of Alaska, July–August 2011" (referred to herein as the 2011 GOA EA).

Numerous species of marine mammals inhabit the GOA. Several of these are listed as ***endangered*** under the ESA, including North Pacific right, sperm, sei, fin, and blue whales, the Cook Inlet Distinct

Population Segment (DPS) of beluga whales, the Western North Pacific DPSs of humpback and gray whales, and the Western DPS of Steller sea lions. The Southwest Alaska DPS of northern sea otters and the Mexico DPS of humpback whales, which is known to feed in Alaska, are listed as ***threatened***. Critical habitat for the North Pacific right whale, sea otter, and Steller sea lion is also found within the survey area. Other ESA-listed species that could occur in the area are the ***endangered*** short-tailed albatross, the ***threatened*** Steller's eider, the ***endangered*** leatherback turtle, and the ***threatened*** Central North Pacific DPS and East Pacific DPS of green turtle.

Potential impacts of the proposed seismic survey 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 survey. 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 survey is a monitoring and mitigation program designed to minimize potential impacts of the proposed activities on marine animals present during the proposed survey, 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; no start ups during poor visibility or at night unless the exclusion zone and passive acoustic monitoring (PAM) system 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 be shut down for North Pacific Right whales observed at any distance from the vessel. The acoustic source would also be powered or shut down in the event an ESA-listed seabird were to 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 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 are expected on individual marine mammals, sea turtles, seabirds, or 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 even though Level A takes are very unlikely. No significant impacts are 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
AACSE	Alaska Amphibious Community Seismic Experiment
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
DoN	US Department of the Navy
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
ESU	Evolutionarily significant unit
ETP	Eastern Tropical Pacific
EZ	Exclusion Zone
FM	Frequency Modulated
FMP	Fishery management plan
FONSI	Finding of no significant impact
GIS	Geographic Information System
GOA	Gulf of Alaska
GoM	Gulf of Mexico
h	hour
HAPC	Habitat Areas of Particular Concern
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
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
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
rms	root-mean-square
R/V	research vessel
s	second
SBP	Sub-bottom Profiler
SEL	Sound Exposure Level (a measure of acoustic energy)
SPL	Sound Pressure Level
SOSUS	(U.S. Navy) Sound Surveillance System
t	tonnes
TTS	Temporary Threshold Shift
U.K.	United Kingdom
UNEP	United Nations Environment Programme
U.S.	United States of America
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
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 Draft environmental assessment (EA) was prepared under the National Environmental Policy Act (NEPA). The Draft 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 Draft EA also tiers to an EA prepared for a similar seismic survey conducted by R/V *Langseth* in 2011 titled, "Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the western Gulf of Alaska, July–August 2011" (referred to herein as the 2011 GOA EA). This Draft EA evaluates the specific geographic location and different energy source level and configuration associated with this proposed survey, and includes relevant research and publications since the 2011 GOA EA. The purpose of this Draft 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 survey.

The Draft EA provides details of the Proposed Action at the site-specific level and addresses potential impacts of the proposed seismic survey on marine mammals, sea turtles, seabirds, fish, and invertebrates. The Draft EA will also be used in support of an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) and Section 7 consultations under the Endangered Species Act (ESA). The IHA would allow the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals[1] during the proposed seismic survey by Columbia University's Lamont-Doherty Earth Observatory (L-DEO) in the Gulf of Alaska (GOA) during 2019. Per NMFS requirement, small numbers of Level A takes will be 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 study area is a seismically active plate tectonic boundary that has produced large earthquakes and tsunamis in the past. However, many questions remain about the 3D geometry and properties of the subduction zone that creates these earthquakes; the proposed activity would provide unique new constraints that can be used to address those questions. The proposed survey would take advantage of passive seismic equipment already deployed in support of the Alaska Amphibious Community Seismic Experiment (AACSE). The survey

[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.

would employ active sources (airguns), and data collected would supplement the overall project goals of AACSE, which involve imaging the architecture of the subduction zone and understanding variability in slip behavior of the Alaska Peninsula subduction zone. The proposed activity, however, has independent utility from the AACSE and would provide unique higher resolution imaging of the subduction zone that is not possible with the AACSE data alone. Data collected would be in support of research that meets NSF program priorities and 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

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

II ALTERNATIVES INCLUDING PROPOSED ACTION

In this Draft EA, two alternatives are evaluated: (1) the proposed seismic survey 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 survey, is described in the following subsections.

2.1.1 Project Objectives and Context

Researchers from L-DEO, Cornell University, Colgate University, University of Washington, University of California Santa Cruz, University of Colorado Boulder, University of New Mexico, Washington University in St. Louis, and USGS (herein collectively referred to as the Proposing Institutions), have proposed to conduct a seismic survey using the Research Vessel (R/V) Marcus G. Langseth (Langseth) in the western GOA in the Northeast Pacific Ocean (Fig. 1).

AACSE deployed 75 ocean bottom seismometers (OBSs) offshore of the Alaska Peninsula in spring 2017, and this array will remain on the seafloor for 15 months until the end of summer 2019. The proposed study consists of a 19-day cruise to collect a wide-angle reflection/refraction dataset using a subset of the AACSE array. This project focuses on two subduction zone segments — the Semidi segment and the SW Kodiak Aperity. The addition of active sources (airguns) to the AACSE would directly contribute to the overall project goals of imaging the architecture for the subduction zone and understanding the structures controlling how and where the planet's largest earthquakes occur. In particular, the 3D P-wave velocity model derived from this seismic experiment would be beneficial for future AACSE passive array studies by providing the structure underneath a subset of the AACSE ocean bottom seismometer array. Data from this project would be made available for general scientific community use, referred to as "open access". The seismic data could be used to evaluate earthquake and tsunami hazards.

Another major objective of the cruise is educational. Early career scientists would participate in the cruise and receive training in marine geophysics and subduction zone processes. The open access data obtained by this project would also be very useful for educational purposes after the cruise, since this cutting edge data would be openly available.

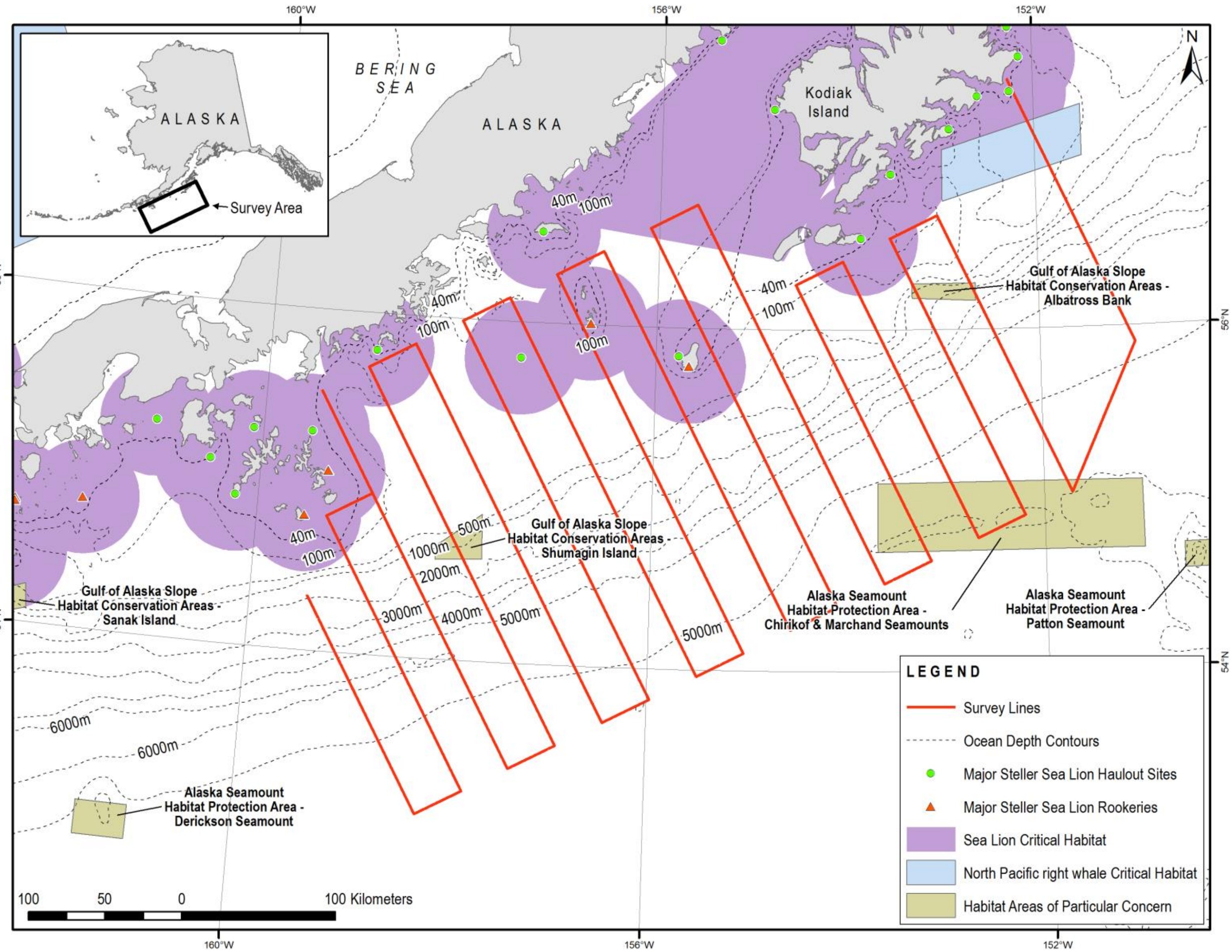

FIGURE 1. Map of the proposed 2019 seismic survey off the Alaskan Peninsula showing representative survey lines.

The main goal of the seismic program is to conduct a 2D survey along the Alaska Peninsula subduction zone using airguns. To achieve the project goals, the Principal Investigator (PI) Dr. G. Abers (Cornell University) and co-PIs Drs. A. Adams (Colgate University), E. Roland (University of Washington), S. Schwartz (University of California Santa Cruz), A. Sheehan (University of Colorado Boulder), D. Shillington (L-DEO), S. Webb (L-DEO), L. Worthington (University of New Mexico), D. Wiens (Washington University in St. Louis), and P. Haeussler (USGS) propose to collect 2D wide-angle seismic reflection/refraction data off the Alaska Peninsula. Dr. A. Bécel would be Chief Scientist.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed survey would occur within the area of ~52–58°N, ~150–162°W, within the EEZ of Alaska in water depths ranging from ~15 to ~6184 m. Representative survey tracklines are shown in Figure 1. As described further in this document, however, deviation in actual track lines, including 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, within the constraints of any federal authorizations issued for the activity, tracklines may shift from those shown in Figure 1 and could occur anywhere within the coordinates noted above and illustrated by the box in the inset map on Figure 1.

2.1.2.2 Description of Activities

The procedures to be used for the proposed marine geophysical survey would be similar to those used during previous surveys by L-DEO and would use conventional seismic methodology. The survey 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 previously deployed OBSs and onshore seismometers (Figure 2); no hydrophone streamer would be towed during the survey. As the airgun arrays are towed along the survey lines, the seismometers would receive and store the returning acoustic signals internally for later analysis. The shot interval would be 399.3 m (~155 s) at a speed of 5 kts.

The project consists of a number of tracklines that cross the trench onto the Pacific plate and shorter connecting tracklines. The representative tracklines shown in Figure 1 have a total length of 4400 km. 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. During the survey, approximately 13% of the line km would take place in shallow water (<100 m), 27% would occur in intermediate water depths (100–1000 m), and the rest (60%) would occur in deep water (>1000 m). For the purposes of calculating potential takes, however, habitat-based stratified marine mammal density areas developed by the U.S. Navy for assessing potential impacts of training activities in the GOA (DoN 2014) were used. Consistent with Rone et al. (2014), four strata were defined: Inshore: all waters <1000 m deep; Slope: from 1000 m water depth to the Aleutian trench/subduction zone; Offshore: waters offshore of the Aleutian trench/subduction zone; Seamount: waters within defined seamount areas (see § IV). Approximatley 40% of the line km would take place in the Inshore zone, 21% in the Slope zone, 35% in the Offshore zone, and 4% in the Seamount zone.

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. Adjustments to the survey procedures and plans described in this and other sections may be determined necessary during operations for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment.

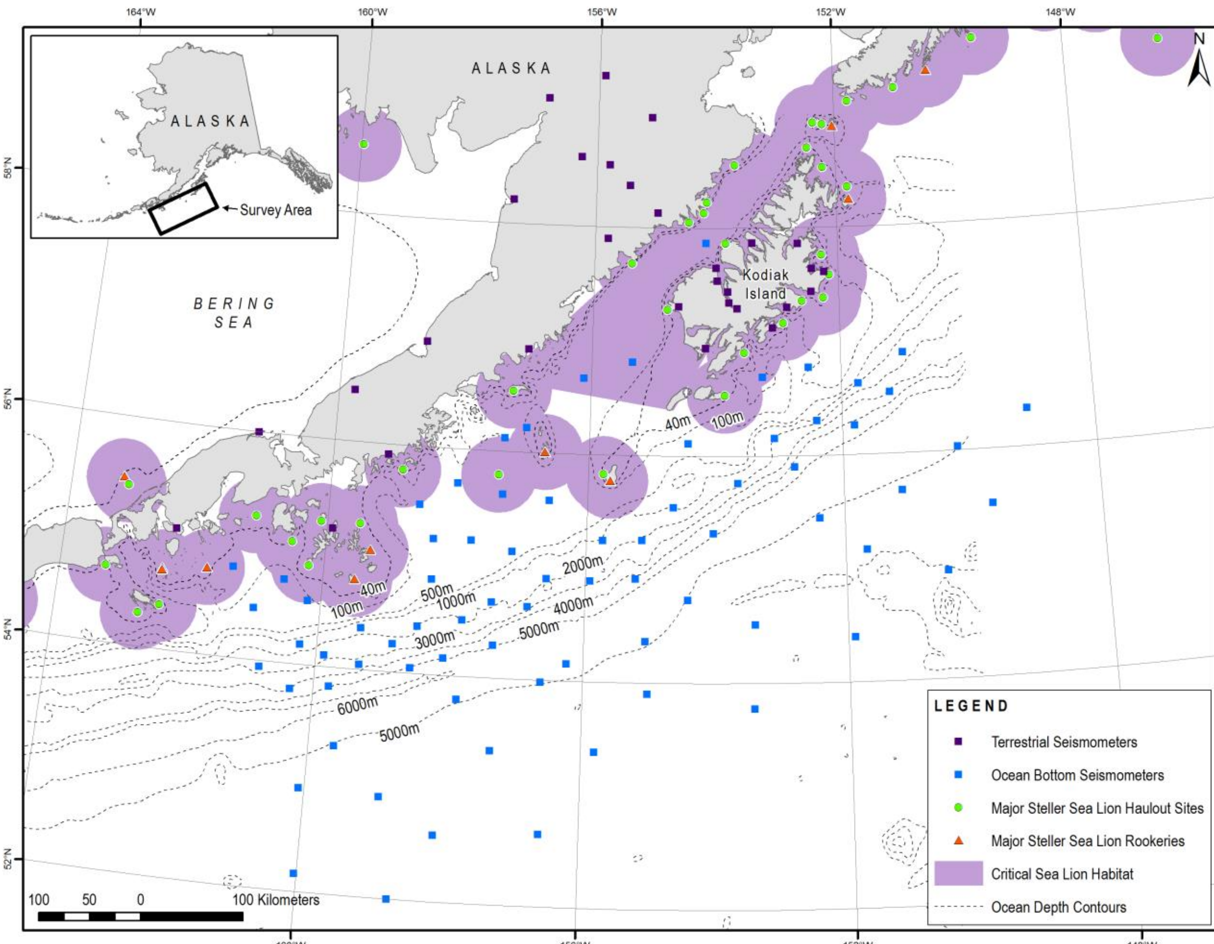

FIGURE 2. Map of previously deployed seismic receiver locations along the Alaskan Peninsula, including both terrestrial and ocean bottom seismometers.

2.1.2.3 Schedule

The survey is expected to consist of up to 18 days of seismic operations and ~1 day of transit. The *Langseth* would leave from and return to port in Kodiak, likely during late spring (end of May/early June) 2019. Tentative sail dates are 1–19 June 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 timelines associated with the ESA Section 7 consultation and IHA processes, not all research projects or vessel logistics will have been 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.

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 ~5 kts (~9.3 km/h).

2.1.2.5 Airgun Description

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 interval would be 399.3 m.

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 survey, but not during transits to/from the survey site and port. The ocean floor would be mapped with a 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 survey was to evaluate whether the research objectives could be met with a smaller energy source. The scientific objectives for the proposed survey could not be met using smaller sources, as the primary aim of the project is deep imaging of the megathrust from 0–40 km depth, the crust-mantle boundary (Moho) of the overriding continental plate (~35 km depth), and downgoing oceanic plate (~12 km depth, including water column), and to explore the upper-most mantle anisotropy of the oceanic plate, for which a large, low-frequency airgun array is required.

***Survey Location and Timing*.—**The survey needs to be conducted while the AACSE OBSs are on the sea floor (before 6 August 2019). The most value-added time window is mid-May through mid-June, when an on-shore, 400–450 element nodal seismic array will also be deployed on Kodiak Island and which could record an unprecedented ship-to-shore dataset.

When considering potential times to carry out the proposed survey, 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*. Many marine mammal species occur in the area year-round. However, baleen whale presence in the area is highest on a seasonal basis (summer and fall, beginning in June). Thus, the likely timing (i.e., late spring) for the proposed survey in late May or early June is advantageous for reducing potential impacts on baleen whales. In addition, subsistence hunting of marine mammals off

Kodiak Island is generally low during June and July, thus minimizing the impact of the survey on subsistence hunting.

Mitigation Zones.—During the planning phase, mitigation zones for the proposed marine seismic survey 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 survey 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 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. For shallow water (<100 m), radii are based on empirically derived measurements in the Gulf of Mexico (GoM) with scaling applied to account for differences in tow depth (see Appendix A). 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 survey in the GOA. 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]
		<100 m	1,041[3]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]
		100–1000 m	10,100[2]
		<100 m	25,494[3]

[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] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

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., harbor 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, 2018a), 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.

	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}	**40.1**	0	0.1	1.3	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 survey in the GOA.

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]
		<100 m	14[4](100[3])	170[4]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	181[1]	1,864[1]
		100–1000 m	272[1]	2,796[2]
		<100 m	344[4]	4,123[4]

[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, consistent with PEIS low-energy source requirements.
[4] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

This document has been prepared in accordance with the current National Oceanic and Atmospheric Administration (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). At the time of preparation of this document, how the technical guidance would be implemented operationally, along with other potential monitoring and mitigation measures, remains somewhat uncertain. For other recent high-energy seismic surveys conducted by L-DEO, NMFS required protected species observers (PSOs) to establish and monitor a 500-m EZ for power downs and to monitor an additional 500-m buffer zone beyond the EZ. A power down required the reduction of the full array to a single 40-in^3 airgun; a 100-m EZ was established and monitored for shut downs of the single airgun. 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 area. However, the number of individual animals expected to be approached closely during the proposed activities is 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 for use 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 collection 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 would be aboard 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 this cruise. Concentrations of large whales may be encountered within the 160-dB isopleth if migrating whales arrive in the region earlier than usual and aggregations of food are present. If aggregations of feeding whales are encountered, they would be avoided.

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, sea turtles, and seabirds, 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, i.e., do not issue an IHA and do not conduct the research operations (Table 4). Under the "No Action" alternative, NSF would not support L-DEO to conduct the proposed research operations. From NMFS' perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the "No Action" alternative entails NMFS denying the application for an IHA. If NMFS were to deny the application, L-DEO would not be authorized to incidentally take marine mammals. If the research was 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 survey location was chosen to supplement research activities already being conducted and equipment previously deployed as part of the AACSE array. This region was identified as highly suitable for studies on seismogenic zones and contrasts in subduction processes because dramatic variations in the seismic behavior, earthquake history, and geodetic seismic coupling occur within a compact area. Conducting a survey to achieve the same scientific goals in a different location would require substantially more resources and have a lower likelihood of a successful outcome.

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	Description
Proposed Action: Conduct marine geophysical survey and associated activities in the Gulf of Alaska	Under this action, research activities are proposed to study Earth processes and would involve a 2D seismic survey. Active seismic portions of the survey would be expected to take up to 18 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.
Alternatives	Description
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 architecture for the subduction zone and understanding variability in slip behavior of the Alaska Peninsula subduction zone, and adding to the comprehensive assessment of geohazards for the Alaska region, such as earthquake and tsunami hazards, would not be collected. An improved understanding of subduction zone processes associated with large earthquakes is important for assessing earthquakes and tsunami hazards at the Alaska Peninsula subduction zone and at other convergent margins worldwide. Earthquakes and associated near field tsunamis in the proposed survey area are a threat to local Alaskan populations and infrastructure. A recent USGS report shows that a tsunami generated at this subduction zone could also impact the heavily populated U.S. west coast and Hawaii. The collection of new data, interpretation of these data, introduction of new results into the greater scientific community, and application 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.
Alternatives Eliminated from Further Analysis	Description
Alternative E1: Alternative Location	The survey location was chosen by the scientific community to deploy the AACSE array. This region was identified as highly suitable for studies on seismogenic zones and contrasts in subduction processes because dramatic variations in the seismic behavior, earthquake history, and geodetic seismic coupling occur within a compact area. The data that would be collected would add to the comprehensive assessment of geohazards for this region, such as earthquake and tsunami hazards, and could not reasonably be

	collected elsewhere. The proposed science would meet NSF program priorities.
Alternative E2: 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 area. 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 area;
- *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 area 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 U.S. state and federal requirements;
- *Geological Resources (Topography, Geology and Soil)*—The proposed Project would make use of previously deployed OBSs and land-based seismometers and therefore would not result in disturbance to geologic resources;
- *Water Resources*—No discharges to the marine environment that would adversely affect marine water quality are expected in the Project area. Therefore, there would be no impacts to water resources resulting from the proposed Project activity;
- *Terrestrial Biological Resources*—The proposed Project activity 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 activity would involve a continually moving vessel, would be short-term, and would mainly occur outside of the viewshed from the coast;
- *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. Activities in the survey area could include commercial and recreational fishing, subsistence fishing and hunting, limited recreational diving, and other vessel traffic. These activities and potential impacts on them from the proposed survey 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 cultural resources in the proposed Alaskan survey area. Traditional fisheries occur within the Alaskan EEZ and are described in further detail in § III and § IV. The proposed survey would limit impacts to these resources by avoiding areas where subsistence fishers are fishing (see § IV). There are also numerous shipwrecks in the vicinity of the proposed survey area (see § 3.9). However, airgun sounds would have no effects on solid structures; therefore, no significant impacts on shipwrecks would be expected.

3.1 Oceanography

The GOA includes all waters bordered by the southeastern, southcentral, and southwestern coasts of Alaska from Dixon Entrance to Unimak Pass. The GOA includes >2500 km of coastline. Greatest water depths within the GOA range from 3000 m off southeast Alaska to 4000 m off south-central Alaska, and over 7000 m at the Aleutian Trench. The Aleutian Trench extends from the northern-most point in the GOA west to the Kamchatka Peninsula, south of the Aleutian Islands. The continental shelf is narrowest in southeast Alaska, ranging in width from 50 km between Dixon Entrance and Cape Spencer, to 100 km or more along the southcentral coast to Seward, and 200 km west of Kodiak Island.

Water movements within the GOA are dominated by the Alaska Coastal Current (ACC). The ACC, which flows northward along the Alaskan coast, changes character and direction three times and is joined by other, narrower currents as it is forced by the coastline to change direction as it flows through the GOA. Coastal circulation is driven in winter by the persistent anti-clockwise wind stress over the GOA and in summer by the density gradient caused by immense freshwater input from coastal sources in British Columbia (B.C.) and southeast Alaska.

The Aleutian Low is a low-pressure system along the Aleutian Island chain (Stabeno et al. 1999). During the summer, with long daylight periods and high insolation, the Aleutian Low is weak (Stabeno et al. 1999). During winter, the Aleutian Low intensifies and dominates weather over the North Pacific and Bering Sea (Stabeno et al. 1999). During the winter, an average of 3–5 storms per month move eastward along the Aleutian Islands (Stabeno et al. 1999). The general climate is characterized by high winds, overcast skies, and frequent cyclonic storms (Armstrong 1971). Warm water from the Japanese current moderates the temperature.

The Alaska Stream flows west along the southern side of the Alaska Peninsula and Aleutian Islands. The Alaska Stream brings fresh surface waters and warm sub-surface water into the Bering Sea (Stabeno et al. 1999). The Alaska Stream enters the sea through the passes in the Aleutian Arc (Stabeno et al. 1999). Water flowing through the Amchitka and Amukta passes is the source of the Aleutian North Slope Current (Reed and Stabeno 1999), which flows eastward along the arc (Stabeno et al. 1999). There is extensive flow from the North Pacific through the 14 main passes in the Aleutian Arc into the Bering Sea; Unimak Pass is <80 m deep and ~30 km wide; it allows water from the ACC to flow into the Bering Sea (Stabeno et al. 1999). Samalga Pass appears to be a division between shallow shelf passes in the east and deeper passes to the west (Ladd et al. 2004, 2005). Surface waters were warmer and fresher, and nutrient concentrations were lower, to the east of Samalga Pass than those to the west of the pass (Ladd et al. 2004, 2005). Zeeman (2004) showed that there was a decline in productivity from the east to the west in the Aleutian Islands.

The GOA Large Marine Ecosystem (LME) is classified as a Class II, moderately productive (150–300 $gC/m^2/y$) ecosystem (Aquarone and Adams 2009). Productivity in the GOA appears to be related to upwelling associated with the counterclockwise gyre of the ACC. The GOA's cold, nutrient-rich waters support a diverse ecosystem. Evidence from observations during the past two decades, and the results of modeling studies using historical and recent data, suggest that physical oceanographic processes, particularly climatic regime shifts, might be driving ecosystem-level changes that have been observed in the GOA. Numerous publications have examined the role of climate shifts as a forcing agent on species and community structure of the North Pacific Ocean (e.g., Francis and Hare 1994; Klyashtorin 1998; McGowan et al. 1998; Hollowed et al. 1998; Hare and Mantua 2000). Regime shifts that might impact productivity in the GOA include the Pacific Decadal Oscillation, changes in the intensity of the Aleutian low-pressure system, and the El Niño Southern Oscillation.

3.2 Protected Areas

3.2.1 Critical Habitat for ESA-listed Species

Several areas near the proposed survey area have been specifically identified as important to ESA-listed species, including critical habitat for three species of marine mammals (Fig. 1).

3.2.1.1 North Pacific Right Whale Critical Habitat

Critical feeding-season habitat has been designated by NMFS for the North Pacific right whale in the western GOA and in the southeast Bering Sea (71 FR 38277, 73 FR 2008). The bulk of the critical habitat lies in the Bering Sea with a small portion in the GOA located southeast of Kodiak Island (Fig. 1). A single proposed survey line running south from Kodiak Island crosses this critical habitat.

3.2.1.2 Steller Sea Lion Critical Habitat

Critical habitat for Steller sea lions is defined in detail in the Code of Federal Regulations (50 CFR 226.202). This species is divided into Western and Eastern DPSs with a boundary at 144°W. The survey area lies within the range of the endangered Western DPS. The Eastern DPS was formerly listed as threatened but was delisted in 2013 (78 FR 66139, 4 November 2013). Since this delisting, NMFS has begun reviewing the critical habitat for the Western DPS (Muto et al. 2018). In brief, designated critical habitat currently includes terrestrial, aquatic, and air zones that extend 3000 ft (0.9 km) landward, seaward, and above each major rookery and major haulout in Alaska. For the Western DPS, the aquatic zone extends further, out 20 n.mi. (37 km) seaward of major rookeries and haulouts west of 144ºW (50 CFR 226.202). In addition, "no approach" buffer areas around rookery sites of the Western DPS of Steller sea lions are identified in the Code of Federal Regulations (50 CFR 223.202). "No approach" zones are restricted areas wherein no vessel may approach within 3 n.mi. (5.6 km) of listed rookeries. Critical habitat as well as "no approach" zones occur within the proposed survey area. In addition to the rookeries and haulouts in the area, the Shelikof Strait foraging area between the Alaska Peninsula and Kodiak Archipelago is also considered critical habitat. Sea Lion critical habitat in and near the proposed survey area is shown in Figure 1.

3.2.1.2 Northern Sea Otter Critical Habitat

Critical habitat for the Southwest Alaska DPS of the northern sea otter was designated in November 2009 (USFWS 2009a). The critical habitat primarily consists of shallow-water areas <20 m deep and nearshore water within 100 m of the mean tide line. Representative proposed survey lines occur near, and in some cases cross, sea otter critical habitat near the southern Shumagin Islands, Semidi Islands, and Chirikof Island (Fig. 2).

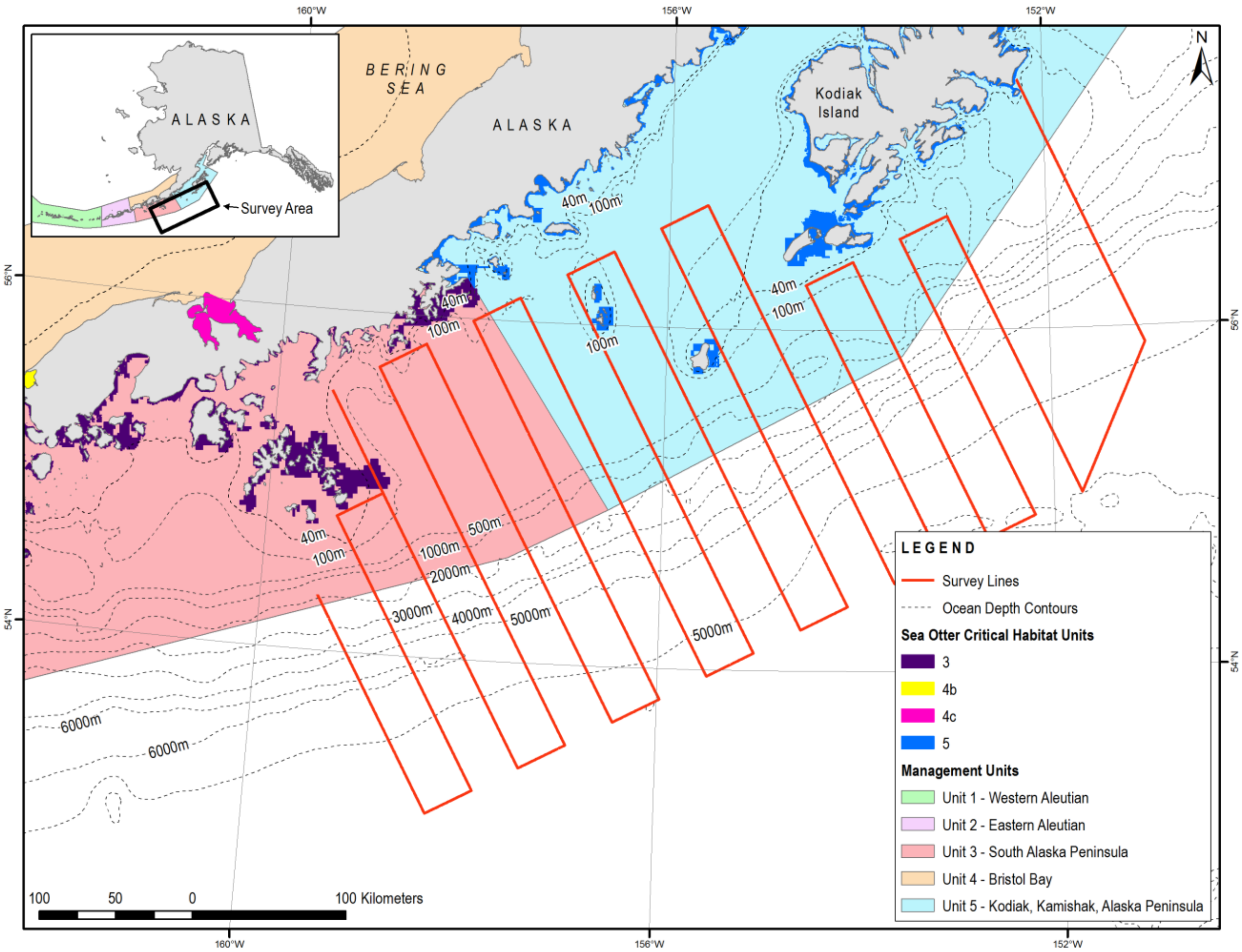

FIGURE 3. Sea otter critical habitat near the proposed survey lines.

3.2.2 Other Protected Areas

Several areas in and near the proposed survey area have been designated as Habitat Areas of Particular Concern (HAPCs) within Alaska's essential fish habitat (EFH). HAPCs are considered high - priority areas for conservation because they are rare, sensitive, or provide important ecosystem functions. HAPCs in and near the proposed survey area include the waters around Shumagin Island and Albatross Bank, which have been designated as Slope Habitat Conservation Areas, and several seamounts, which have been designated as Seamount Habitat Protection Areas (50 CFR 679). These include the Chirikof and Marchand seamounts, which overlap with the proposed survey area, and the Derickson and Patton seamounts, which are near the proposed survey area. HAPCs are shown on Figure 1 and discussed further below in section 3.7.

3.3 Marine Mammals

The marine mammals that occur in the proposed survey area belong to four taxonomic groups: odontocetes (toothed cetaceans, such as dolphins), mysticetes (baleen whales), pinnipeds (seals, sea lions, and walrus), and fissipeds (sea otter). Eighteen cetacean species, six pinniped species, and the northern sea otter are known to or could occur in the western GOA study area (Table 5). Several of these species/ populations are listed under the ESA as ***endangered***, including the North Pacific right, sperm, Western North Pacific DPSs of humpback and gray whales, fin, sei, and blue whales and the Western DPS of Steller sea lions. Individuals from the Cook Inlet DPS of beluga whales are not expected to occur in the survey area. The southwest Alaska DPS of the northern sea otter and the Mexico DPS of the humpback whale are listed as ***threatened***.

Several other North Pacific cetacean species are not included here because they do not typically occur in this part of the GOA. These are: the Bryde's whale; pygmy and dwarf sperm whales; Blainville's, gingko-toothed, and Longman's beaked whales; pygmy and false killer whales; beluga whale; short-finned pilot whale; melon-headed whale; northern right whale dolphin, long- and short-beaked common dolphins, Fraser's dolphin; pantropical spotted dolphin; striped and spinner dolphins; rough-toothed dolphin; and common bottlenose dolphin. Additionally, three pinniped species are not included. The Guadalupe fur seal, which only ranges as far north as California, and spotted and ribbon seals. Although the range of the two latter can extend into the Gulf of Alaska, they are strongly associated with sea ice and likely to be much further north as the ice recedes in the spring when the proposed survey is planned to occur.

Cetaceans and pinnipeds are the subject of the IHA application to NMFS. The northern sea otter and Pacific walrus are the two marine mammal species mentioned in this document that are managed by the U.S. Fish and Wildlife Service (USFWS); all others are managed by NMFS. Walrus sightings are rare in the GOA. Sea otters generally inhabit nearshore areas inside the 40-m depth contour (Riedman and Estes 1990) and could be encountered in coastal waters of the study area. However, few seismic operations (<2% or 100 km of the representative survey lines) are expected to occur in water <40 m deep, and only approximately 590 km of seismic surveys are expected to occur in water 40–100 m deep.

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 NSF/USGS PEIS. The general distributions of marine mammals in the western North Pacific Ocean is discussed in § 3.6.2.4, § 3.7.2.4, § 3.8.2.4, and § 3.9.2.3 of the PEIS for the western GOA. The rest of this section deals specifically with marine mammal distribution within the proposed survey area. Information on the occurrence near the proposed survey area, habitat, population size, and conservation status for each of the marine mammal species that could occur in the area is presented in Table 5.

3.3.1 Mysticetes

3.3.1.1 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). This species is divided into western and eastern North Pacific stocks. 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 GOA, 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).

Since the 1960s, North Pacific right whale sightings have been relatively rare (e.g., Clapham et al. 2004; Shelden et al. 2005). In the eastern North Pacific, south of 50ºN, only 29 reliable sightings were recorded from 1900 to 1994 (Scarff 1986, 1991; Carretta et al. 1994). Starting in 1996, right whales have been sighted regularly in the southeast Bering Sea, including calves in some years (Goddard and Rugh 1998; LeDuc et al. 2001; Moore et al. 2000, 2002b; Wade et al. 2006; Zerbini et al. 2009); they have also been detected acoustically when sonobuoys were deployed (McDonald and Moore 2002; Munger et al.

2003; 2005, 2008; Berchok et al. 2009). Right whales are known to occur in the southeast Bering Sea from May to December (e.g., Tynan et al. 2001; Hildebrand and Munger 2005; Munger et al. 2005, 2008). Call frequencies tended to be higher in July–October than from May–June or November–December (Munger et al. 2008). Right whales seem to pass through the middle-shelf areas, without remaining there longer than a few days (Munger et al. 2008).

Shelden et al. (2005) reported that the slope and abyssal plain in the western GOA were important areas for right whales until the late 1960s, but sightings and acoustic detections in this region in recent decades are rare. In March 1979, a group of four right whales was seen in Yakutat Bay (Waite et al. 2003), but there were no further reports of right whale sightings in the GOA until July 1998, when a single whale was seen southeast of Kodiak Island (Waite et al. 2003). Three sightings and one acoustic detection of right whales were made in Barnabas Trough south of Kodiak Island during NOAA surveys in 2004 to 2006 in areas with high densities of zooplankton (Wade et al. 2011a). Those authors also report a fourth opportunistic sighting by a commercial fisher during that time in the same area. One right whale was sighted in the Aleutian Islands south of Unimak Pass in September 2004 (Wade et al. 2011b). A BIA for feeding for North Pacific right whales was designated east of the Kodiak Archipelago, encompassing the GOA critical habitat and extending south of 56° N and north of 58° N and beyond the shelf edge (Ferguson et al. 2015).

Right whale acoustic detections were made south of the Alaska Peninsula and to the east of Kodiak Island in 2000 during August and September (see Waite et al. 2003; Mellinger et al. 2004b), but no acoustic detections were made from April to August 2003 (Munger et al. 2008) or in April 2009 (Rone et al. 2010). Three right whales were acoustically detected in the Barnabas Trench area during a towed-PAM survey of the U.S. Navy training area east of Kodiak in the summer of 2013 but none were observed visually (Rone et al. 2014). Right whales were not detected acoustically in any year (2011-2015) of the fixed PAM monitoring in this region (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). No right whales were visually observed during the three years of surveys (2009, 2013, and 2015) in this military area east of Kodiak (Rone et al. 2017). The DoN assigned a year-round density of 0.00001/km^2 for right whales in this region (DoN 2014). There was one sighting of a single North Pacific right whale during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). Thus, it is possible that a right whale could be seen during the proposed survey.

3.3.1.2 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 eastern North Pacific.

Gray whale populations were severely reduced by whaling, but the eastern North Pacific population is considered to have recovered. Punt and Wade (2012) estimated the eastern North Pacific population to be at 85% of its carrying capacity in 2009. The eastern North Pacific gray whale breeds and winters in Baja, California, and migrates north to summer feeding grounds in the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1971; Rice 1998; Jefferson et al. 2015). Most of the eastern Pacific population makes a round-trip annual migration of more than 18,000 km. From late May to early October, the majority of the population concentrates in the northern and western Bering Sea and in the Chukchi Sea. However, some individuals spend the summer months scattered along the coasts of southeast Alaska, B.C., Washington, Oregon, and northern California (Rice and Wolman 1971; Nerini 1984; Darling et al. 1998; Dunham and Duffus 2001, 2002; Calambokidis et al. 2002). Gray whales are found primarily in shallow water; most follow the coast during migration, staying close to the shoreline except when crossing major bays, straits, and inlets (Braham 1984).

It is difficult to determine precisely when the southbound migration begins; whales near Barrow were moving predominantly south in August (Maher 1960; Braham 1984). Gray whales leave the Bering Sea through Unimak Pass from late October through January (Braham 1984). From October to January, the main part of the population moves down the west coast of North America. Rugh et al. (2001) analyzed data collected from two sites in California to estimate the timing of the gray whale southward migration. They estimated that the median date for the migration past various sites was 1 December in the central Bering Sea (a nominal starting point), 12 December at Unimak Pass, 18 December at Kodiak Island, and 5 January for Washington.

By January and February, most of the whales are concentrated in the lagoons along the Pacific coast of the Baja Peninsula, Mexico. From late February to June, the population migrates northward to arctic and subarctic seas (Rice and Wolman 1971). The peak of northward migration in the GOA occurs in mid-April (Braham 1984). Most gray whales follow the coast during migration and stay within 2 km of the shoreline, except when crossing major bays, straits, and inlets from southeast Alaska to the eastern Bering Sea (Braham 1984). Gray whales use the nearshore areas of the Alaska Peninsula during the spring and fall migrations, and are often found within the bays and lagoons, primarily north of the peninsula, during the summer (Brueggeman et al. 1989 *in* Waite et al. 1999). However, gray whales are known to move further offshore between the entrance to Prince William Sound (PWS) and Kodiak Island and between Kodiak Island and the southern part of the Alaska Peninsula (Consiglieri et al. 1982). During May–October, primary occurrence extends seaward 28 km from the shoreline. This is the main migratory corridor for gray whales.

In the summer, gray whales are seen in the southeast Bering Sea (Moore et al. 2002b) and in the GOA, including around Kodiak Island (e.g., Wade et al. 2003; Calambokidis et al. 2004; Calambokidis 2007; Moore et al. 2007). In fact, gray whales have been seen feeding off southeast Kodiak Island, in particular near Ugak Bay, year-round (Moore et al. 2007). Moore et al. (2007) noted monthly sighting rates that exceeded 100 sightings/h in January, June, September, and November, and >20 sightings/h in most other months. One feeding aggregation in July consisted of 350-400 animals, clustered in groups of 10–20 animals, from the mouth of Ugak Bay to 100 km ESE of Ugak Island (Moore et al. 2007). Wade et al. (2003) reported a group size of 5.6 in the western GOA. A biologically important area (BIA) for feeding for gray whales has been identified in the waters east of the Kodiak Archipelago, with the greatest densities of gray whales occurring from June through August (Ferguson et al. 2015). Additionally, a gray whale migratory corridor BIA has been established extending from Unimak Pass in the western GOA to the Canadian border in the eastern GOA (Ferguson et al. 2015), including much of the landward side of the survey area. Gray whales occur in this area in high densities during November through January (southbound) and March through May (northbound).

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	Habitat	Occurrence in/near Study Area	Abundance (Alaska)	Regional Abundance	ESA[1]	IUCN[2]	CITES[3]	Notes on Abundance Estimates
Mysticetes North Pacific right whale	Coastal, shelf	Rare	28–31[4]	400-500[5]	EN	EN	I	[4] Bering Sea/Aleutian Islands (Wade et al. 2011b). [5] North Pacific (Jefferson et al. 2015).
Gray whale	Coastal	Uncommon	N.A.	20,990[6]	DL	LC	I	[6] Eastern North Pacific (Carretta et al. 2016).
Humpback whale	Coastal, banks	Common	2215[7]	21,063[8]	EN/T/DL*	LC	I	[7] NW GOA, Kodiak to ~142°W (Rone et al. (2017). [8] North Pacific, 2004–2006 (Barlow et al. 2011).
Common minke whale	Coastal, shelf	Uncommon	1233[9]	25,000[10]	NL	LC	I	[9] W. GOA and E. Aleutians (Zerbini et al. 2006). [10] NW Pacific and Okhotsk Sea (IWC 2018a).
Sei whale	Pelagic	Rare	N.A.	27,197[11]	EN	EN	I	[11] Central and Eastern North Pacific (Hakamada and Matsuoka 2015a).
Fin whale	Pelagic	Common	3168[7]	13,620-18,680[12]	EN	EN	I	[7] NW GOA, Kodiak to ~142°W (Rone et al. (2017). [12] North Pacific (Ohsumi and Wada 1974).
Blue whale	Pelagic, shelf, coastal	Rare	63[7]	1647[13]	EN	EN	I	[7] NW GOA, Kodiak to ~142°W (Rone et al. (2017). [13] Eastern North Pacific Stock (Calambokidis and Barlow 2013).
Odontocetes Sperm whale	Pelagic	Uncommon	129[7]	26,300[14]	EN	VU	I	[7] NW GOA, Kodiak to ~142°W (Rone et al. (2017). [14] NW Temperate Pacific; estimate based on visual sightings (Barlow and Taylor 2005).
Cuvier's beaked whale	Pelagic	Common	N.A.	20,000[15]	NL	LC	II	[15] ETP (Wade and Gerrodette 1993).
Baird's beaked whale	Pelagic	Rare	N.A.	25,300[16] 5029[17] 10,190[18]	NL	DD	I	[16] Includes all species of the genus *Mesoplodon* in the ETP (Wade and Gerrodette 1993). [17] Pacific coast of Japan (Kasuya 2009a). [18] Western Pacific Ocean (Okamura et al. 2012).
Stejneger's beaked whale	Likely pelagic	Common	N.A	N.A	NL	DD	II	
Pacific white-sided dolphin	Pelagic, shelf, coastal	Common	26,880[19]	988,333[20]	NL	LC	II	[19] North Pacific Stock (Muto et al. 2016). [20] North Pacific Ocean (Miyashita 1993b).
Risso's dolphin	Pelagic, shelf, coastal	Extralimital	N.A.	838,000[21]	NL	LC	II	[21] Western North Pacific Ocean (Miyashita 1993a).
Killer whale	Pelagic, shelf, coastal	Common	2934[22]	8500[23]	NL‡	DD	II	[22] Minimum abundance in Alaska, includes 2347 residents and 587 transients (Muto et al. 2017). [23] ETP (Ford 2009).
Harbor porpoise	Coastal	Uncommon	31,046[24]	79,261[25]	NL	LC	II	[24] GOA stock (Muto et al. 2018). [25] GOA plus Bering Sea stocks (Muto et al. 2018).

Species	Habitat	Occurrence in/near Study Area	Abundance (Alaska)	Regional Abundance	ESA[1]	IUCN[2]	CITES[3]	Notes on Abundance Estimates
Dall's porpoise	Pelagic, shelf	Common	83,400[26]	1,186,000[27]	NL	LC	II	[26] Alaska stock (Muto et al. 2016). [27] North Pacific Ocean and Bering Sea (Houck and Jefferson 1999).
Pinnipeds Northern fur seal	Pelagic, breeds coastally	Uncommon	626,734[28]	1.1 million[29]	NL	VU	NL	[28] Eastern Pacific Stock (Muto et al. 2017). [29] North Pacific (Gelatt and Lowry 2008).
Steller sea lion	Coastal, offshore	Common	41,638[30] 53,303[31]	N.A.	EN/DL[†]	NT	NL	[30] Eastern U.S. Stock (Muto et al. 2017). [31] Western U.S. Stock (Muto et al. 2018).
California sea lion	Coastal	Uncommon	N.A.	296,750[32]	NL	LC	NL	[32] Carretta et al. (2015).
Harbor seal	Coastal	Uncommon	54,906[33]	205,090[34]	NL	LC	NL	[33] Total of North Kodiak, South Kodiak, and Cook Inlet/Shelikof Strait Stocks (Muto et al. 2016). [34] Alaska statewide (Muto et al. 2016).
Northern elephant seal	Coastal, offshore	Uncommon	N.A.	210,000-239,000[35]	NL	LC	NL	[35] U.S. and Mexico (Lowry et al. 2014).
Pacific walrus	Ice	Extralimital	129,000[36]	N.A.	NL	DD	III	[36] Speckman et al. (2011).
Mustelids Northern sea otter	Coastal	Very rare	25,712[37] 18,297[38] 54,771[39]	N.A.	T[¶]	EN	II	[37] SE Alaska Stock (Muto et al. 2018). [38] Southcentral Alaska Stock (Muto et al. 2018). [39] SW Alaska Stock (Muto et al. 2018).

N.A. = data not available.
[1] U.S. Endangered Species Act. EN = Endangered; T = Threatened; DL = Delisted; NL = Not listed.
[2] Codes for IUCN (2010) classifications: EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient.
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES-UNEP 2010): Appendix I = threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled; Appendix III = trade of species regulated but cooperation from other countries needed to prevent unsustainable or illegal exploitation.
* The Western North Pacific DPS is listed as endangered and the Mexico DPS is listed as threatened; the Hawaii DPS was delisted in 2016 (81 FR 62260, 8 September 2016). Both the Central and Western North Pacific stock are considered depleted under the MMPA (Muto et al. 2018).
[†] Stocks in Alaska are not listed, but the southern resident DPS is listed as endangered. AT1 transient in Alaska is considered depleted and a strategic stock (NOAA 2004a).
[‡] The Western DPS is listed as endangered; the Eastern DPS was delisted in 2013 (78 FR 66139, 4 November 2013).
[¶] Southwest Alaska DPS.

Rone et al. (2017) sighted gray whales off Ugak Island, Kodiak, in all three years (2009, 2013, and 2015) of surveys in the military training area east of Kodiak. The US Department of the Navy (DoN 2014) estimated gray whale densities of 0.0485724/km^2 within 2.25 nmi of the coast and 0.0024276/km^2 for waters 2.25 to 20 nmi from shore for this area. Gray whales were detected acoustically throughout the summer and fall at fixed hydrophones on the shelf off Kenai Peninsula and near Kodiak Island in this military training area in a 2014-2015 study (Rice et al. 2015), but they were not detected at deeper slope or seamount sites and they were detected only once in prior years of study from 2011 to 2013 (Baumann-Pickering et al. 2012; Debich et al. 2013). Gray whales were neither observed visually nor detected acoustically during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). Gray whales could be encountered during the proposed seismic survey in the GOA.

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 Mexico, Central America, Hawaii, and Western Pacific DPSs (NMFS 2016b). Hawaii is the primary wintering area for whales from summer feeding areas in the Gulf of Alaska (Calambokidis et al. 2008). Individuals from the Hawaii, Western Pacific, and Mexico DPSs could occur in the proposed survey area to feed.

There is potential for mixing of the western and eastern North Pacific humpback populations on their summer feeding grounds, and several sources suggest that this occurs to a limited extent (Muto et al. 2018). NMFS is currently reviewing the global humpback whale stock structure in light of the recent revision to their ESA listing and identification of 14 DPSs (81 FR 62259, 8 September 2016). Currently, two stocks of humpback whales are recognized as occurring in Alaskan waters. The Central North Pacific Stock occurs from southeast Alaska to the Alaska Peninsula and the Western North Pacific Stock occurs from the Aleutians to the Bering Sea and Russia. These two stocks overlap on feeding grounds in the eastern Bering Sea and the western Gulf of Alaska (Muto et al. 2018), encompassing the entire proposed survey area. BIAs for humpback whale feeding have been designated surrounding Kodiak Island and the Shumagin Islands (Ferguson et al. 2015). The highest densities of humpback whales occur during July through September around Kodiak Island and during July through August in the Shumagin Islands.

Humpback whales are commonly sighted within the proposed survey area. Waite (2003) reported that 117 humpbacks were seen in 41 groups during their surveys in the western GOA in 2003, with aggregations seen off northeast Kodiak Island. During summer surveys from the Kenai Fjords to the central Aleutian Islands in 2001–2003, humpbacks were most abundant near Kodiak Island, the Shumagin Islands, and north of Unimak Pass (Zerbini et al. 2006). Sightings of humpbacks around the Kodiak Islands were made most frequently in the fall, and aggregations were seen off Shuyak and Sitkalidak islands (Wynne and Witteveen 2005), as well as in Marmot and Chiniak bays (Baraff et al. 2005). Waite et al. (1999) noted another aggregation area north of Unalaska Island. Offshore sightings of humpbacks have also been made south of the Alaska Peninsula, including ~280 km south of the Shumagin Islands (e.g., Forney and Brownell 1996; Waite et al. 1999). Humpback whales were sighted a total of 220 times (637 animals) during the three years of surveys (2009, 2013, and 2015) in and near the U.S. Navy training area east of Kodiak (Rone et al. 2017). Humpback whales were also frequently detected acoustically during all years (2011-2015) of fixed-PAM studies in this area, with peak detections during late fall through early winter and detections at all shelf, slope, and seamount sites (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). Using sightings data from the June–July 2013 survey, density estimates for humpback whales were calculated for four different habitat strata: 0.093/km^2 for the inshore stratum (shelf waters), 0.001/km^2 for the offshore stratum (pelagic waters), 0.001/km^2 for the seamount stratum, and 0.0000/km^2 for the slope stratum (Rone et al. 2017). Humpback whales were the most frequently sighted cetacean during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey, comprising 50% of all cetacean sightings (RPS 2011). There were 92 sightings of this species, representing 288 animals during the 37 days of monitoring. The average group size was three and the maximum group size was 37. This species is likely to be common in the proposed survey area.

Calambokidis et al. (2008) reported an abundance estimate of 3000–5000 for the GOA. Rone et al. (2017) calculated an abundance estimate of 2,215 (uncorrected for missed animals) from a June–July 2013 survey in the U.S. Navy training area east of Kodiak Island, with the bulk of this estimate (2,927) found in the inshore stratum. NMFS provides best estimates of 1,107 for the Western North Pacific Stock and 10,103 for the Eastern North Pacific Stock (Muto et al. 2018). The entire North Pacific population has been estimated to number 21,063 individuals (Barlow et al. 2011).

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). NMFS recognizes a single stock in Alaskan waters and a second California/Oregon/Washington Stock (Muto et al. 2010).

The minke whale tends to be solitary or in groups of 2–3 but can occur in much larger aggregations around prey resources (Jefferson et al. 2008). Predominantly solitary animals were seen during surveys in Alaska (Wade et al. 2003; Waite 2003; Zerbini et al. 2006). The small size, inconspicuous blows, and brief surfacing times of minke whales mean that they are easily overlooked in heavy sea states, although they are known to approach vessels in some circumstances (Stewart and Leatherwood 1985). Little is known about the diving behavior of minke whales, but they are not known to make prolonged deep dives (Leatherwood and Reeves 1983).

Minke whales are relatively common in the Bering and Chukchi seas and in the inshore waters of the GOA (Mizroch 1992), but they are not considered abundant in any other part of the eastern Pacific (Brueggeman et al. 1990). Waite (2003) sighted four minke whales in three groups during surveys in the western GOA in 2003, south of the Kenai Peninsula and south of PWS. Moore et al. (2002b) reported a minke whale sighting south of the Sanak Islands. Baraff et al. (2005) reported a single sighting near Kodiak

Island in July 2002. During surveys in the western GOA and eastern Aleutians, minke whales occurred primarily in the Aleutians; a few sightings were made south of the Alaska Peninsula and near Kodiak Island (Zerbini et al. 2006). Rone et al. (2017) reported two sightings totaling three minke whales in 2009, three sightings totaling six minke whales in 2013, and no sightings of minke whales in 2015 in the U.S. Navy training area east of Kodiak. In 2009 the DoN derived a year-round density of 0.0006/km^2 for minke whales for this area, which they consider the best available estimate given the scarce sightings of this species in this area. Minke whales were not detected acoustically during any year (2011-2015) of the fixed-PAM studies in the DoN area east of Kodiak (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). There was one sighting of a single common minke whale during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.1.5 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). On feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987) such as the cold eastern currents in the North Pacific (Perry et al. 1999a). Sei whales are frequently seen in groups of 2–5 (Jefferson et al. 2008), although larger groups sometimes form on feeding grounds (Gambell 1985a).

In the U.S. Pacific, an Eastern North Pacific and a Hawaii stock are recognized (Carretta et al. 2017). During summer in the North Pacific, the sei whale can be found from the Bering Sea to the northern GOA and south to California, and in the western Pacific from Japan to Korea. Its winter distribution is concentrated at about 20°N, and sightings have been made between southern Baja California and the Islas Revilla Gigedo (Rice 1998). No breeding grounds have been identified for sei whales; however, calving is thought to occur from September to March.

Moore et al. (2002b) made four sightings of six sei whales during summer surveys in the eastern Bering Sea, and one sighting south of the Alaska Peninsula between Kodiak and the Shumagin Islands. No sei whales were seen during surveys of the GOA by Wade et al. (2003), Waite (2003), or Zerbini et al. (2006). Rone et al. (2017) reported no sei whale sightings in 2009 or 2013 and a single sei whale sighting of one animal in 2015 in the U.S. Navy training area east of Kodiak. DoN (2014; see Figs. 5-24 and 5.25) estimated densities in the range of 0.000000-0.000102/km^2 for this area during the spring, summer, and fall. There was one sighting of two sei whales during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). Sei whale sightings are likely to be uncommon in the proposed survey area.

3.3.1.6 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 the GOA (e.g., Moore et al. 2006; Stafford et al. 2007, 2009; Edwards et al. 2015). Near the Alaska Peninsula in the western GOA, the number of calls received peaked in May–August, with few calls during the rest of the year (Moore et al. 1998). In the central North Pacific, the GOA, and the Aleutian Islands, call rates peak during fall and winter (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2009).

Rice and Wolman (1982) encountered 19 fin whales during surveys in the GOA, including 10 aggregated near Middleton Island on 1 July 1980. During surveys from the Kenai Peninsula to the central Aleutian Islands, fin whales were most abundant near the Semidi Islands and Kodiak Island (Zerbini et al. 2006). Numerous sightings of fin whales were also seen between the Semidi Islands and Kodiak Island during surveys by Waite (2003). Fin whale sightings around Kodiak Island were most numerous along the western part of the island in Uyak Bay and Kupreanof Straits, and in Marmot Bay (Wynne and Witteveen 2005; Baraff et al. 2005). Fin whales were sighted around Kodiak Island year-round, but most sightings were made in the spring and summer (Wynne and Witteveeen 2005). A BIA for fin whale feeding has been designated southward from the Kenai Peninsula inshore of the Kodiak Archipelago and along the Alaska Peninsula to include the Semidi Islands (Ferguson et al. 2015), overlapping with a proportion of the proposed survey area. Densities of fin whales are highest in this area during June through August.

Rone et al. (2017) reported 24 fin whale sightings (64 animals) in 2009, two hundred fin whale sightings (392 animals) in 2013, and 48 fin whale sightings (69 animals) in 2015 in the U.S. Navy training area east of Kodiak. They used the 2013 data to calculate densities of fin whales for four habitat areas: 0.068/km^2 for the inshore stratum, 0.016/km^2 for the offshore stratum, 0.003/km^2 for the seamount stratum, and 0.013/km^2 for the slope stratum. That study also provided an abundance estimate of 3168 for this area. The density and abundance estimates were not corrected for missed animals. Fin whales were also frequently detected acoustically throughout the year during all years (2011-2015) of fixed-PAM studies in this area and detections occurred at all shelf, slope, and seamount sites (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). Fin whales were the second most freqently sighted cetacean during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey, comprising 15.2% of all cetacean sightings (RPS 2011). There were 28 sightings of this species, representing 79 animals during the 37 days of monitoring. The average group size was three and the maximum group size was 10. Fin whales are likely to be common in the proposed survey area.

3.3.1.7 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).

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).

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. In the GOA, no detections of blue whales had been made since the late 1960s (NOAA 2004b; Calambokidis et al. 2009) until blue whale calls were recorded in the area during 1999–2002 (Stafford 2003; Stafford and Moore 2005; Moore et al. 2006; Stafford et al. 2007). Call types from both northeastern and northwestern Pacific blue whales were recorded from July through December in the GOA, suggesting that two stocks used the area at that time (Stafford 2003; Stafford et al. 2007). Call rates peaked from August through November (Moore et al. 2006). More recent acoustic studies using fixed PAM have confirmed the presence of blue whales from both the Central and Northeast Pacific stocks in the Gulf of Alaska concurrently (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). Blue whale calls were recorded in all months; at all shelf, slope, and seamount sites; and during all years (2011-2015) of those studies.

In July 2004, three blue whales were sighted in the GOA. The first blue whale was seen on 14 July ~185 km southeast of PWS. Two more blue whales were seen ~275 km southeast of PWS (NOAA 2004b; Calambokidis et al. 2009). These whales were thought to be part of the California feeding population (Calambokidis et al. 2009). Western blue whales are more likely to occur in the western portion of the GOA, southwest of Kodiak, where their calls have been detected (see Stafford 2003). Two blue whale sightings were also made in the Aleutians in August 2004 (Calambokidis et al. 2009). No blue whales were seen during surveys of the western GOA by Zerbini et al. (2006).

Rone et al. (2017) reported no blue whale sightings in 2009, five blue whale sightings (seven animals) in 2013, and 13 blue whale sightings (13 animals) in 2015 in the U.S. Navy training area east of Kodiak. Rone et al. (2017) used the June–July 2013 sightings data to calculate a blue whale density of 0.0014/km^2 for the seamount stratum and an abundance estimate of 63 for that area. These density and abundance estimates were not corrected for missed animals. The DoN considers blue whale densities to be in the range of 0.001651–0.002644/km^2 for the seamount stratum and 0.000010–0.000826/km^2 for the other areas in the region year-round (see Fig. 5-36 of DoN 2014). Blue whales were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

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).

Most of the information regarding sperm whale distribution in the GOA (especially the eastern GOA) and southeast Alaska has come from anecdotal observations from fishermen and reports from fisheries observers aboard commercial fishing vessels (e.g., Dahlheim 1988). Fishery observers have identified interactions (e.g., depredation) between longline vessels and sperm whales in the GOA and southeast Alaska since at least the mid-1970s (e.g., Hill et al. 1999; Straley et al. 2005; Sigler et al. 2008), with most interactions occurring in the West Yakutat and East Yakutat/Southeast regions (Perez 2006; Hanselman et al. 2008). Sigler et al. (2008) noted high depredation rates in West Yakutat, East Yakutat/Southeast region, as well as the central GOA. Hill et al. (1999) found that most interactions in the GOA occurred to the east of Kodiak Island, even though there was substantial longline effort in waters to the west of Kodiak. Mellinger et al. (2004a) also noted that sperm whales occurred less often west of Kodiak Island.

Sperm whales are commonly sighted during surveys in the Aleutians and the central and western GOA (e.g., Forney and Brownell 1996; Moore 2001; Waite 2003; Wade et al. 2003; Zerbini et al. 2004; Barlow and Henry 2005; Ireland et al. 2005; Straley et al. 2005). Waite (2003) and Wade et al. (2003) noted an average group size of 1.2 in the western GOA. In contrast, there are fewer reports on the occurrence of sperm whales in the eastern GOA (e.g., Rice and Wolman 1982; Mellinger et al. 2004a; MacLean and Koski 2005; Rone et al. 2010). Rone et al. (2017) reported no sperm whale sightings in 2009, 19 sperm whale sightings (22 animals) in 2013, and 27 sperm whale sightings (45 animals) in 2015 in the U.S. Navy training area east of Kodiak. Additionally, there were 241 acoustic encounters with sperm whales during the 2013 towed-hydrophone survey in that study (Rone et al. 2014). Sperm whales were also frequently detected acoustically throughout the year during all years (2011-2015) of fixed-PAM studies in this area and detections occurred at all shelf, slope, and seamount sites, but they were less common at the shelf site near Kenai Peninsula and most common on the slope (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015).

Rone et al. (2017) used the June–July 2013 sightings data to calculate sperm whale densities of 0.0000/km^2 for the seamount stratum and 0.003/km^2 for the slope stratum, with an overall density of 0.0003/km^2 for the area. They also provided an abundance estimate (uncorrected for missed animals) for the area of 129 sperm whales, most of which were found in slope waters. Sperm whales were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.2.2 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 ranges north to the GOA, including southeast Alaska, the Aleutian Islands, and the Commander Islands (Rice 1986, 1998). Most reported sightings have been in the Aleutian Islands (e.g., Leatherwood et al. 1983; Forney and Brownell 1996; Brueggeman et al. 1987). Waite (2003) reported a single sighting of four Cuvier's beaked whales at the shelf break east of Kodiak Island during the summer of 2003 and one stranded on Kodiak Island in January 1987 (Foster and Hare 1990). There was one sighting of a single Cuvier's beaked whale during a 2013 survey in the U.S. Navy training area east of Kodiak, but none during the 2009 and 2015 surveys in that region (Rone et al. 2017). There were also five sightings (eight animals) of unidentified beaked whales during the 2013 survey and none during the other years. Additionally, there were 34 acoustic encounters with Cuvier's beaked whales during the 2013 towed-hydrophone survey in that study (Rone et al. 2014). Cuvier's beaked whales were detected occasionally at deep-water sites (900-1000 m) during the 2011-2015 fixed-PAM studies in the U.S. Navy training area. They were infrequently detected on the slope site but more commonly detected at Pratt and Quinn seamounts. Detections occurred May to July 2014 at Pratt Seamount and October 2014 to March 2015 at Quinn Seamount in one of those studies (Rice et al. 2015). The U.S. DoN (2014) used Waite (2003) sightings data for this species to calculate a density estimate of 0.0022/km^2 for their GOA training area east of Kodiak year-round. Beaked whales were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.2.3 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; Wade et al. 2003). There have been no confirmed sightings of Stejneger's beaked whale in the GOA since 1986 (Wade et al. 2003). However, they have been detected acoustically in the Aleutian Islands during summer, fall, and winter (Baumann-Pickering et al. 2014) and were detected year-round at deep-water sites during the 2011-2015 fixed-PAM studies in the U.S. Navy training area east of Kodiak (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). In contrast to Cuvier's beaked whales, which were more prevalent at seamounts, Stejneger's beaked whales were detected most frequently at the slope site, with peak detections in September and October (Debich et al. 2013; Rice et al. 2015). There were no sightings of Stejneger's beaked whales during three years of surveys (2009, 2013, 2015) in this area (Rone et al. 2017). However, there were five sightings (eight animals) of unidentified beaked whales during the 2013 survey. Additionally, there were six acoustic encounters with Stejneger's beaked whales during the 2013 towed-hydrophone survey in that study (Rone et al. 2014). Beaked whales were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.2.4 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). 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).

Baird's beaked whale is migratory, arriving in the Bering Sea in the spring, and remaining there throughout the summer; the winter distribution is unknown (Kasuya 2002). There are numerous sighting records from the central GOA to the Aleutian Islands and the southern Bering Sea (Leatherwood et al. 1983; Kasuya and Ohsumi 1984; Forney and Brownell 1996; Brueggeman et al. 1987; Moore et al. 2002b; Waite

2003; Wade et al. 2003). There were seven sightings of Baird's beaked whales (58 animals) during a 2013 survey in the U.S. Navy training area east of Kodiak (Rone et al. 2017). Additionally, there were nine acoustic encounters with Baird's beaked whales during the 2013 towed-hydrophone survey in that study (Rone et al. 2014). There were also five sightings (eight animals) of unidentified beaked whales during that survey. No beaked whales were observed in 2009 or 2015 surveys in the same area (Rone et al. 2017). Baird's beaked whales were detected acoustically during fixed-PAM studies in this area during the 2011-2012 and 2012-2013 studies but not in 2014-2015 (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). They were detected regularly at the slope site from November through and January and at the Pratt Seamount site during most months. The U.S. DoN (2014) used Waite (2003) sightings data for this species to calculate a density estimate of 0.0005/km^2 for their GOA training area east of Kodiak year round. Beaked whales were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.2.5 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). During winter, this species is most abundant in California slope and offshore areas; as northern marine waters begin to warm in the spring, it appears to move north to slope and offshore waters off Oregon/Washington (Green et al. 1992, 1993; Forney 1994; Forney et al. 1995; Buchanan et al. 2001; Barlow 2003). During the summer, Pacific white-sided dolphins occur north into the GOA and west to Amchitka in the Aleutian Islands, but rarely in the southern Bering Sea (Allen and Angliss 2010). Moore et al. (2002b) documented a single sighting of eight Pacific white-sided dolphins in the southeast Bering Sea along the Alaska Peninsula. Sightings in the GOA and Aleutian Islands have been documented in the summer by Waite (2003) and Wade et al. (2003), and in the spring to the southeast of Kodiak Island by Rone et al. (2010). Dahlheim and Towell (1994) reported sightings for southeast Alaska. There was one sighting of 60 Pacific white-sided dolphins in 2009, no sightings in 2013, and 10 sightings of Pacific white-sided dolphins (986 animals) in 2015 during surveys in the U.S. Navy training area east of Kodiak (Rone et al. 2017). The DoN (2014) has assigned this species a year-round density estimate of 0.0208/km^2 in this region. Pacific white-sided dolphins were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011), but there was one sighting of two unidentified small odontocetes.

3.3.2.6 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).

Throughout the region from California to Washington, the distribution and abundance of Risso's dolphins are highly variable, presumably in response to changing oceanographic conditions on both annual and seasonal time scales (Forney and Barlow 1998; Buchanan et al. 2001; Becker 2007). Water temperature appears to be an important factor affecting their distribution (Kruse et al. 1999; see also Becker 2007). Like the Pacific white-sided dolphin, Risso's dolphin is believed to make seasonal north-south movements related to water temperature, spending colder winter months off California and moving north to waters off Oregon/Washington during the spring and summer as northern waters begin to warm (Green et al. 1992, 1993; Buchanan et al. 2001; Barlow 2003; Becker 2007). Risso's dolphins are uncommon to rare in the GOA. Risso's dolphins have been sighted near Chirikof Island (southwest of Kodiak Island) and offshore in the GOA (Consiglieri et al. 1980; Braham 1983). They were detected acoustically once, in January 2013, near Pratt Seamount during fixed-PAM studies from 2011-2015 in the U.S. Navy training area (Debich et al. 2013). The DoN (2014) considers this species to be only an occasional visitor to their GOA training area and has assigned them a year-round density of 0.00001/km^2 in this region. Risso's dolphins were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). There was one sighting of two unidentified small odontocetes.

3.3.2.7 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.

Of eight killer whale stocks currently recognized in the Pacific U.S., six occur in Alaskan waters: (1) the Eastern North Pacific Alaska Resident Stock, from southeast Alaska to the Aleutians and Bering Sea, (2) the Eastern North Pacific Northern Resident Stock, from B.C. through parts of southeast Alaska, (3) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock, from PWS through to the Aleutians and Bering Sea, (4) the AT1 Transient Stock, from PWS through the Kenai Fjords, (5) the West Coast Transient Stock, from California through southeast Alaska, and (6) the Offshore Stock, from California through Alaska. The AT1 Transient Stock is considered depleted under the MMPA and therefore a strategic stock. Movements of resident groups between different geographic areas have also been documented (Leatherwood et al. 1990; Dahlheim et al. 1997; Matkin et al. 1997, 1999 *in* Allen and Angliss 2010). In the proposed study area, individuals from one resident stock, the offshore stock, and two transient stocks (including the depleted AT1 transient stock), could be encountered during the survey.

During surveys of the western GOA and Aleutian Islands, transient killer whale densities were higher south of the Alaska Peninsula between the Shumagin Islands and the eastern Aleutians than in other areas (Wade et al. 2003; Zerbini et al. 2007). They were not seen between the Shumagin Islands and the eastern side of Kodiak Island during surveys in 2001–2003, but they were sighted there during earlier surveys (e.g., Dahlheim 1997 *in* Zerbini et al. 2007). Resident killer whales were most abundant near Kodiak Island, around Umnak and Unalaska Islands in the eastern Aleutians, and in Seguam Pass in the central Aleutians (Wade et al. 2003; Zerbini et al. 2007). No residents were seen between 156ºW and 164ºW, south of the Alaska Peninsula (Zerbini et al. 2007).

Little is known about offshore killer whales in the GOA, but they could be encountered during the proposed survey. During summer surveys of the western GOA and Aleutian Islands in 2001–2003, two sightings of offshore killer whales were made, one northeast of Unalaska Island and another one south of Kodiak Island near the Trinity Islands (Wade et al. 2003; Zerbini et al. 2007). As the groups sighted were large, it suggests the number of offshore killer whales in the area is relatively high (Zerbini et al. 2007). Dahlheim et al. (2008b) encountered groups of 20–60 killer whales in western Alaska; offshore killer whales encountered near Kodiak Island and the eastern Aleutians were also sighted in southeast Alaska and California. A group of at least 54 offshore killer whales was sighted in July 2003 during a survey in the eastern Aleutian Islands (Matkin et al. 2007).

Rone et al. (2017) reported six killer whale sightings (119 animals) in 2009, 21 killer whale sightings

(138 animals) in 2013, and 10 killer whale sightings (73 animals) in 2015 in the U.S. Navy training area east of Kodiak. Additionally, there were 32 acoustic encounters with killer whales and three acoustic encounters with offshore killer whales (based on known differences in their acoustic signals) during the 2013 towed-hydrophone survey in that study (Rone et al. 2014). Killer whales were detected acoustically sporadiacally throughout the year at shelf, slope, and seamount sites in the U.S. Navy training area (Baumann-Pickering et al. 2012; Debich et al. 2013). Rone et al. (2017) used the June–July 2013 sightings data to calculate killer whale densities of $0.005/km^2$ for the inshore stratum, $0.002/km^2$ for the seamount stratum, and $0.019/km^2$ for the slope stratum, with an overall density of $0.0023/km^2$ for the area. They also provided an abundance estimate (uncorrected for missed animals) for the area of 899 killer whales, most of which were found in slope waters. There was one sighting of a single killer whale during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.2.8 Dall's Porpoise (*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).

Dall's porpoise occurs throughout Alaska; the only apparent gaps in distribution in Alaskan waters south of the Bering Strait are for upper Cook Inlet and the Bering Sea shelf. Using a population estimate based on vessel surveys during 1987–1991, and correcting for the tendency of this species to approach vessels, which Turnock and Quinn (1991) suggested resulted in inflated abundance estimates perhaps by as much as five times, a population estimate of 83,400 was calculated for the Alaska stock of Dall's porpoise. Because this estimate is more than eight years old, NMFS considers it to be unreliable and reported that there are no reliable abundance estimates available for the Alaska Stock of this species when it was last reviewed (Muto et al. 2016).

Numerous studies have documented the occurrence of Dall's porpoise in the Aleutian Islands and western GOA (Forney and Brownell 1996; Moore 2001; Wade et al. 2003; Waite 2003; Baraff et al. 2005; Ireland et al. 2005) as well as in the Bering Sea (Moore et al. 2002b). Dall's porpoise was one of the most frequently sighted species during summer seismic surveys in the central and eastern GOA and southeast Alaska (MacLean and Koski 2005; Hauser and Holst 2009). Rone et al. (2017) reported 10 Dall's porpoise sightings (59 animals) in 2009, 337 Dall's porpoise sightings (907 animals) in 2013, and 98 Dall's porpoise sightings (391 animals) in 2015 in the U.S. Navy training area east of Kodiak. Additionally, there were three acoustic encounters with Dall's porpoise during the 2013 towed-hydrophone survey in that study (Rone et al. 2014). Rone et al. (2017) used the June–July 2013 sightings data to calculate Dall's porpoise densities for four habitat strata – $0.218/km^2$ for the inshore stratum, $0.037/km^2$ for the offshore stratum, $0.024/km^2$ for the seamount stratum, and $0.196/km^2$ for the slope stratum, with an overall density of $0.0398/km^2$ for this area. They also provided an abundance estimate for the area of 15,423 Dall's porpoises. This estimate was uncorrected for missed animals and did not account for their propensity to approach vessels. Dall's porpoise was the second most freqently sighted cetacean during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey, comprising 14.1% of all cetacean sightings (RPS 2011). There were 26 sightings of this species, representing 227 animals during the 37 days of monitoring. The average group size was nine and the largest group size was 35.

3.3.2.9 Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore but is occasionally sighted in deeper offshore water (Jefferson et al. 2015); abundance declines linearly as depth increases (Barlow 1988). In the eastern North Pacific, its range extends from Point Barrow, Alaska, to Point Conception, California.

In Alaska, there are three separate stocks of harbor porpoise: Southeast Alaska, GOA, and Bering Sea. The Southeast Alaska Stock occurs from northern B.C. to Cape Suckling, and the GOA Stock ranges from Cape Suckling to Unimak Pass. The population estimates for the Southeast Alaska, GOA, and Bering Sea stocks are 11,146, 31,046, and 48,215, respectively (Muto et al. 2016).

Harbor porpoise are seen regularly in the western GOA and Aleutian Islands (e.g., Wade et al. 2003; Waite 2003; Baraff et al. 2005; Ireland et al. 2005) and Bering Sea (Moore et al. 2002b). Harbor porpoises are also sighted in the eastern and central GOA and southeast Alaska (Dahlheim et al. 2000, 2008a; MacLean and Koski 2005; Rone et al. 2010). There were 30 sightings (89 animals) of harbor porpoise in 2009, eight sightings (11 animals) of harbor porposie in 2013, and a single sighting of one harbor porpoise in 2015 during surveys in the U.S. Navy training area east of Kodiak (Rone et al. 2017). Harbor porpoise were not observed during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011), but there was one sighting of two unidentified small odontocetes.

3.3.3 Pinnipeds

3.3.3.1 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. 2018). 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. 2018). 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. 2018). In the U.S., two stocks are recognized—the Eastern Pacific and the California stocks (Muto et al. 2018). 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. 2018).

When not on rookery islands, northern fur seals are primarily pelagic but occasionally haul out on rocky shorelines (Muto et al. 2018). 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. 2018). 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 GOA, off Japan, and the west coast of the U.S. (Muto et al. 2018). Pups travel through Aleutian passes and spend the first two years at sea before returning to their islands of origin.

In November, adult females and pups leave the Pribilof Islands and migrate into the North Pacific Ocean to areas including offshore Oregon and Washington (Ream et al. 2005). Males usually migrate only as far south as the GOA (Kajimura 1984). Ream et al. (2005) showed that migrating females moved over the continental shelf as they migrated southeasterly. Instead of following depth contours, their travel corresponded with movements of the Alaska Gyre and the North Pacific Current (Ream et al. 2005). Their foraging areas were associated with eddies, the subarctic-subtropical transition region, and coastal mixing (Ream et al. 2005; Alford et al. 2005). Some juveniles and non-pregnant females may remain in the GOA throughout the summer (Calkins 1986).

Robson et al. (2004) reported that female fur seals from St. Paul and St. George islands traveled in different directions. They also observed habitat separation among breeding sites on the same island (Robson et al. 2004). Lactating females from the same breeding site share a foraging area, whereas females from different sites tend to forage in different areas (Robson et al. 2004). Females from both islands traveled for similar durations and maximum distances (Robson et al. 2004).

Northern fur seals were seen throughout the North Pacific during surveys conducted during 1987–1990 (Buckland 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; females migrated to the GOA and the California Current (Sterling et al. 2014).

A total of 42 northern fur seals was seen during 3767 km of shipboard surveys in the northwestern GOA during June–July 1987 (Brueggeman et al. 1988). Leatherwood et al. (1983) reported 14 sightings of 34 northern fur seals away from the breeding islands in the southeast Bering Sea during aerial surveys in 1982, mostly during July and August. No fur seals were seen during summer surveys in the GOA in 2004 and 2008 (MacLean and Koski 2005; Hauser and Holst 2009) or during spring surveys in 2009 (Rone et al. 2010). None of the 42 female northern fur seals tagged on St Paul Island between August–October 2007 and 2008 traveled south of the Aleutian Islands (Kuhn et al. 2010). Rone et al. (2014) reported 78 northern fur seal sightings (83 animals) in 2013 in the U.S. Navy training area east of Kodiak and calculated densities for four habitat strata: 0.015/km^2 for the inshore stratum, 0.017/km^2 for the offshore stratum, 0.006/km^2 for the seamount stratum, and 0.004/km^2 for the slope stratum, with an overall density of 0.011/km^2 for the area. They also provided an abundance estimate (uncorrected for missed animals) for the area of 1770 northern fur seals. There were seven sightings, representing 7 northern fur seals, during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.3.2 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 Eastern DPSs, which are divided at 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 haulouts and rookeries, as well as three large foraging areas (NMFS 2017b). The critical habitat of both stocks is currently under review in light of the delisting of the Eastern DPS (Muto et al. 2018). Critical habitat as well as “no approach” zones occur within the proposed study area. “No approach” zones are restricted areas wherein no vessel may approach within 3 n.mi. (5.6 km) of listed rookeries (50 CFR 223.202). Only individuals from the Western DPS are expected to occur in the proposed survey area. The Eastern DPS is estimated at 41,638 (Muto et al. 2017) and appears to have increased at an annual rate of 4.76% between 1989 and 2015 (Muto et al. 2018).

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).

Steller sea lions are present in Alaska year-round, with centers of abundance in the GOA and Aleutian Islands. There are five major rookery sites within the study area in the northern GOA: Chirikof, Chowiet, Atkins, Chernabura islands, and Pinnacle Rock. There are also numerous haulout sites located within the study area (see Fig. 1); most haulout sites on Kodiak Island (and within the study area) are used year-round (e.g., Wynne 2005). Counts are highest in late summer (Wynne 2005). Sea lion counts in the central GOA, including Kodiak Island, were reported to be declining between 1999 and 2003 (Sease and Gudmundson 2002; Wynne 2005). Evidence suggests that counts in Alaska were lowest in 2002 and 2003, but between 2003 and 2016 pup and non-pup counts have increased by 2.19%/year and 2.24%/year, respectively (Muto et al. 2018). These rates vary regionally, with the highest rates of increase in the eastern Gulf of Alaska and a steadily decreasing rate of increase heading west to the Aleutian Islands.

Steller sea lions are an important subsistence resource for Alaska Natives from southeast Alaska to the Aleutian Islands. There are numerous communities along the shores of the GOA that participate in subsistence hunting. In 2008, 19 sea lions were taken in the Kodiak Island region and 9 were taken along the South Alaska Peninsula (Wolfe et al. 2009). As of 2009, data on community subsistence harvests are no longer being collected consistently so no data are available. The most recent 5 years of data available (2004–2008) show an annual average catch of 172 steller sea lions for all areas in Alaska combined except the Pribilof Islands in the Bering Sea (Muto et al. 2018).

The U.S. DoN (2014) estimates a density of 0.0098/km^2 for this species year-round in its training area east of Kodiak. There was one sighting of 18 Steller sea lions during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.3.3.3 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 GOA 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 (Le Boeuf et al. 2000; Robinson et al. 2012; Robinson 2016 *in* OBIS 2018; Costa 2017 *in* OBIS 2018). Post-molting seals traveled longer and farther than post-breeding seals (Robinson et al. 2012). Rone et al. (2014) reported 16 northern fur seal sightings (16 animals) in a June–July 2013 survey in the U.S. Navy training area east of Kodiak. The U.S. DoN (2014) estimates a cold water (winter/spring) density of 0.0024/km^2 and warm water (summer/fall) density of 0.0022/km^2 for this species in its GOA training area east of Kodiak. Northern elephant seal males could occur in the GOA throughout the year (Calkins 1986).

3.3.3.4 California Sea Lion (*Zalophus californianus*)

The primary range of the California sea lion includes the coastal areas and offshore islands of the eastern North Pacific Ocean from BC, Canada, to central Mexico, including the Gulf of California (Jefferson et al. 2015). However, its distribution is expanding (Jefferson et al. 2015), and its secondary range extends into the GOA where it is occasionally recorded (Maniscalco et al. 2004) and southern Mexico (Gallo-Reynoso and Solórzano-Velasco 1991). California sea lions are coastal animals that often haul out on shore throughout the year. King (1983) noted that sea lions are rarely found more than 16 km offshore. During fall and winter surveys off Oregon/Washington, mean distance from shore was ~13 km (Bonnell et al. 1992).

California sea lion rookeries are on islands located in southern California, western Baja California, and the Gulf of California (Carretta et al. 2016a). A single stock is recognized in U.S. waters: the U.S. Stock. Five genetically distinct geographic populations have been identified: (1) Pacific Temperate (includes rookeries in U.S. waters and the Coronados Islands to the south), (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California (Schramm et al. 2009). Animals from the Pacific Temperate population occur in the proposed project area. California sea lions that are sighted in Alaska are typically seen at Steller sea lion rookeries or haulouts, with most sightings occurring between March and May, although they can be found in the GOA year-round (Maniscalco et al. 2004). The U.S. DoN (2014) estimates a density of 0.00001/km^2 for this species year-round in its training area east of Kodiak

3.3.3.5 Harbor Seal (*Phoca vitulina*)

The harbor seal is distributed in the North Atlantic and North Pacific. Two subspecies occur in the Pacific: *P.v. stejnegeri* in the northwest Pacific Ocean and *P.v. richardii* in the eastern Pacific Ocean. Eastern Pacific harbor seals occur in nearshore, coastal, and estuarine areas ranging from Baja California, Mexico, north to the Pribilof Islands in Alaska (Muto et al. 2016). Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows. They are generally non-migratory, but move locally with the tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Twelve stocks of harbor seals are recognized in Alaska (Muto et al. 2016). The proposed survey would take place within the range of three of these stocks: North Kodiak, South Kodiak, and Cook Inlet/Shelikof Strait stocks. Nearby stocks are the Aleutian Islands, Prince William Sound, and Glacier Bay/Icy Strait stocks. There are two stocks in the Bering Sea (Bristol Bay and Pribilof Islands) and four stocks in southeast Alaska.

Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows; pups are born from May to mid-July. The mother and pup remain together until weaning occurs at 3–6 weeks (Bishop 1967; Bigg 1969). When molting, which occurs primarily in late August, seals spend the majority of the time hauled out on shore, glacial ice, or other substrates. Juvenile harbor seals can travel significant distances (525 km) to forage or disperse, whereas adults were generally found within 190 km of their tagging location in Prince William Sound, Alaska (Lowry et al. 2001). The smaller home range used by adults is suggestive of a strong site fidelity (Pitcher and Calkins 1979; Pitcher and McAllister 1981; Lowry et al. 2001). Pups tagged in the GOA most commonly undertook multiple return trips of more than 75 km from natal areas, followed by movements of <25 km from the natal area (Small et al. 2005). Pups tagged in Prince William Sound traveled a mean maximum distance of 43.2 km from their tagging location, whereas those tagged in the GOA moved a mean maximum distance of 86.6 km (Small et al. 2005).

Harbor seals are an important subsistence resource for Alaska Natives in the northern GOA. In 2011–2012, 37 harbor seals were taken from the North Kodiak Stock and 126 harbor seals were taken from the South Kodiak Stock by communities on Kodiak Island (Muto et al. 2016). The number taken from the Cook Inlet/Shelikof Strait Stock for 2011–2012 is unknown, but an average of 233 were taken from this stock annually during 2004-2008 (Muto et al. 2016).

The U.S. DoN (2014) estimates a density of 0.00001/km^2 for this species year-round in its training area east of Kodiak. There was one sighting of nine harbor seals during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). Harbor seals could be encountered in the proposed survey area.

3.3.3.6 Pacific Walrus (*Odobenus rosmarus divergens*)

The walrus occurs in moving pack ice over shallow waters of the circumpolar arctic coast (King 1983). There are two subspecies, the Atlantic walrus (*O. r. rosmarus*) and the Pacific walrus (*O. r. divergens*). The Pacific walrus ranges from the Bering Sea to the Chukchi Sea, occasionally moving to the East Siberian and Beaufort seas. Walruses are migratory, moving south with the advancing ice in autumn and north as the ice recedes in spring (Fay 1981). In summer, most of the population of the Pacific walrus moves to the Chukchi Sea, but several thousand aggregate in the Gulf of Anadyr and in Bristol Bay (Allen and Angliss 2010). During the late winter breeding season, walrus concentrations occur from the Gulf of Anadyr to southwest of St. Lawrence Island, and in the southeast Bering Sea, from south of Nunivak Island to northwestern Bristol Bay.

A single stock of Pacific walrus is recognized in the U.S. – the Alaska Stock (USFWS 2014a). The Pacific walrus is vagrant to the GOA (Fay 1982). Two walruses were seen during surveys of the southern Alaska Peninsula in July 1979 at Spitz and Mitrofania Islands (Bailey and Faust 1981). Walruses have also been reported that summer in Chignik Bay (Bailey and Faust 1981). No Pacific walruses were sighted during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). Walruses likely would not be encountered during the proposed survey.

3.3.4 Marine Fissiped

3.3.4.1 Northern Sea Otter (*Enhydra lutris*)

There are two subspecies of sea otters in U.S. waters. The southern sea otter (*E. l. nereis*) is found in California and the northern sea otter (*E. l. kenyoni*) can be found in Washington and Alaska. Sea otters generally occur in shallow (<35 m), nearshore waters in areas with sandy or rocky bottoms, where they feed on a wide variety of sessile and slow-moving benthic invertebrates (Rotterman and Simon-Jackson 1988). Sea otters in Alaska are generally not migratory and do not disperse over long distances. However, individual sea otters are capable of long-distance movements of >100 km (Garshelis and Garshelis 1984), although movements are likely limited by geographic barriers, high energy requirements of animals, and social behavior. Before commercial exploitation, the worldwide population of sea otters was estimated to be between 150,000 (Kenyon 1969) and 300,000 (Johnson 1982). Sea otters occupied coastal areas from Hokkaido, Japan, around the North Pacific Rim to central Baja California (Rotterman and Simon-Jackson 1988). Commercial exploitation reduced the total sea otter population to as low as 2000 in 13 locations (Kenyon 1969). In 1911, sea otters received protection under the North Pacific Fur Seal Convention, and populations recovered quickly (Kenyon 1969).

Three stocks (DPSs) of sea otters are recognized in Alaska: the Southeast Alaska Stock, from Dixon Entrance to Cape Yakataga; the Southcentral Alaska Stock, from Cape Yakataga to Cook Inlet, including PWS, the Kenai Peninsula, and Kachemak Bay; and the Southwest Alaska Stock, from the Alaska Peninsula and Bristol Bay coasts, and the Aleutian, Barren, Kodiak, and Pribilof Islands (USFWS 2014b). The Southwest Alaska DPS of the sea otter occurs in the proposed study area; it is listed as ***Threatened*** under the ESA. This DPS had declined by more than 50% since the mid-1980s when it was listed as threatened in 2005 (USFWS 2013). However, the most recent estimate for the size of this stock is 54,772 (USFWS 2014b). The population declined substantially in the Aleutian Islands from 1993 to 2003 but now appears to be stable (i.e., growth rate ~0), and populations numbers in the Kodiak Archipelago, the Alaska Peninsula, and Kamishak Bay appear to be stable and perhaps increasing (USFWS 2014b). Critical habitat for the Southwest Alaska DPS of the northern sea otter was designated in November 2009 (USFWS 2009a). The critical habitat primarily consists of shallow-water areas <20 m deep and nearshore water within 100 m of the mean tide line. The proposed survey lines encroach on sea otter critical habitat near the southern Shumagin Islands, Semidi Islands, and Chirikof Island (Fig. 2).

Sea otters are an important subsistence resource for Alaska Natives from southeast Alaska to the Aleutian Islands. There are numerous communities along the shores of the GOA that participate in subsistence hunting. For 2006–2010, the average subsistence takes of northern sea otters were 293 animals for the Southcentral Alaska Stock, 447 animals for the Southeast Alaska Stock, and 76 for the Southwest Alaska Stock (USFWS 2014b,c,d).

During surveys between Mitrofania and Sutwik islands in July 1979, most otters were seen around Unavikshak Island; large numbers were also seen around Sutwik Island, and a few sea otters were seen between Kuiukta and Warner bays (Bailey and Faust 1981). Rone et al. (2010) sighted one sea otter off southern Kodiak Island during surveys in April 2009. During vessel-based sea otter surveys in the Aleutian Islands in 2000, sea otter encounter rates were 0.61–5.19/km (Doroff et al. 2003). There were three sightings representing 39 northern sea otters during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011).

3.4 Sea Turtles

Two species of sea turtles could occur in or near the proposed survey area, including the ***endangered*** leatherback turtle and the ***threatened*** Central North Pacific DPS and East Pacific DPS of the green turtle (Márquez 1990; ADF&G 2010a). Although far less common, the olive ridley turtle (*Lepidochelys olivacea*) and loggerhead turtle (*Caretta caretta*) have also been recorded in Alaska waters. The leatherback is the most likely turtle species to occur in the relatively cold water of the proposed project area. The other species are considered warm-water species and would be extralimital (ADF&G 2010a). There were no sightings of sea turtles during the NSF/L-DEO seismic survey conducted in the summer of 2011 in the same area as the currently proposed survey (RPS 2011). Any sea turtles occurring in the GOA would be non-nesting individuals. 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 GOA is discussed in § 3.4.2.4 of the PEIS. The rest of this section deals specifically with their distribution within the proposed survey area.

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). 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).

After analyzing some 363 records of sea turtles sighted along the Pacific coast of North America, Stinson (1984) concluded that the leatherback was the most common sea turtle in U.S. waters north of Mexico. Sightings and incidental capture data indicate that leatherbacks are found in Alaska as far north as 60°N, 145°W, and as far west as the Aleutian Islands, and documented encounters extend southward through the waters of B.C., Washington, Oregon, and California (NMFS and USFWS 1998a). Leatherbacks occur north of central California during the summer and fall, when sea surface temperatures are highest (Dohl et al. 1983; Brueggeman 1991). Some aerial surveys of California, Oregon, and Washington waters suggest that most leatherbacks occur in continental slope waters and fewer occur over the continental shelf.

3.4.2 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). In the central Pacific, green turtles are found around most tropical islands, including Hawaii (NMFS 2016e). Green turtles can undertake long migrations from foraging areas to nesting sites (NMFS 2016e).

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 the eastern Pacific, green turtles nest at several locations on the Mexican mainland, Central America, and off the coast of Colombia and Ecuador. The primary nesting grounds are located in Michoacán, Mexico, and the Galápagos Islands, Ecuador (NMFS and USFWS 2007). Nesting occurs in Michoacán from August to January, with a peak in October-November, and on the Galápagos Islands from December to May with a peak in February–March (Alvarado and Figueroa 1995). Stinson (1984) reviewed sea turtle sighting records from northern Baja California to Alaska, and determined that the East Pacific green turtle was the most commonly observed hard-shelled sea turtle on the U.S. Pacific coast. Most of the sightings (62%) were reported from northern Baja California and southern California. In the North Pacific, the species has been documented as far north as southern Alaska (ADF&G 2010a).

3.5 Seabirds

Two seabird species for which there is concern related to declining numbers in portions of their range could occur in the survey area. The Steller's eider (*Polysticta stelleri*), which is listed as ***Threatened***, is found in the area in low densities during the summer but is more common in the GOA during fall and winter. The ***Endangered*** short-tailed albatross (*Phoebastria albatrus*) may occur as a seasonal visitor to the project area. Both are considered ***Vulnerable*** by the IUCN (2018). The species is listed as ***Endangered*** on the IUCN Red List of Threatened Species (IUCN 2018).

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of seabird families is given in § 3.5.1 of the PEIS.

3.5.1 Short-tailed Albatross (*Phoebastria albatrus*)

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 2018a). However, this population is increasing, and the most recent population estimate is 4200 individuals (Birdlife International 2018a). 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 2018a). 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 2018a). 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. Short-trailed albatrosses, particularly juveniles, start appearing in the Aleutian Islands as early as June (USFWS 2008b), but most birds travel to the Aleutians in September (Suryan et al. 2006). This species can be found throughout the Aleutians and GOA during the summer and early fall (USWFS 2008b; Suryan et al. 2006, 2007).

3.5.2 Steller's Eider (*Polysticta stelleri*)

There are three breeding populations of Steller's eiders worldwide: two in Arctic Russia and one in Alaska. The largest population breeds across coastal eastern Siberia and may number >128,000 (Hodges and Eldridge 2001). Smaller numbers breed in western Russia and on the Arctic Coastal Plain of Alaska. Steller's eider was listed as ***Threatened*** under the ESA in July 1997 because of a reduction in the number of breeding birds and suspected reduction in the breeding range in Alaska (USFWS 1997).

Although Steller's eiders were formerly common breeders in the Yukon-Kuskokwim (Y-K) Delta, numbers there declined drastically, and only a small subpopulation breeds there now (Kertell 1991; Flint and Herzog 1999; Birdlife International 2018b). Flint and Herzog (1999) reported single Steller's eider nests in the Y-K Delta in 1994, 1996, and 1997, and three nests in 1998. Steller's eiders continue to nest in extremely low numbers in the Y-K Delta (MMS 2006). Steller's eider density on the Arctic Coastal Plain is low, with the highest densities reported near Barrow (Ritchie and King 2001, 2002 *in* USFWS 2002).

Mallek et al. (2006) reported lower than average population indices for Steller's eiders on the North Slope of Alaska for the period 2000–2005, when the indices ranged from 0 to 563 birds. The long-term average for the index had been 968 for the period 1986–2001 (Mallek et al. 2003). Larned et al. (2009) also reported a decreasing population growth rate for Steller's eiders during eider breeding pair surveys on the North Slope, but the numbers detected were so few that the survey was used primarily to document occurrence and long-term distribution rather than to detect a meaningful trend. Based on comparisons of historical and recent data, Quakenbush et al. (2002) suggested that a reduction in both occurrence and breeding frequency of Steller's eiders had occurred on the Arctic Coastal Plain with the exception of the Barrow area. Larned (2005a) also reported a declining trend during annual spring surveys for Steller's eiders in the Bristol Bay area during migration. Flint et al. (2000) noted a lower survival rate in males than in females.

In Alaska, Steller's eiders nest on tundra habitats often associated with polygonal ground both near the coast and at inland locations (e.g., Quakenbush et al. 2004); nests have been found as far inland as 90 km (USFWS 2002). Emergent *Carex* and *Arctophila* provide important areas for feeding and cover. At Barrow, Steller's eiders apparently nest during high lemming years when predators, such as snowy owl (*Nyctea scandiaca*) and pomarine jaeger (*Stercorarius pomarinus*), that feed on lemmings are also nesting (Quakenbush et al. 2004). Steller's eiders, as well as snowy owls and pomarine jaegers, may not nest at all during low lemming years. This cycle has been consistent since the initiation of intensive studies of Steller's eider nesting biology in the Barrow area in 1991 and has continued through 2006 (Quakenbush et al. 1995, 2004; Obritschkewitsch et al. 2001; Obritschkewitsch and Martin 2002a,b; Rojek and Martin 2003; Rojek 2007). Theoretically, an ample supply of lemmings may divert potential predators away from eider eggs and chicks, thus making it more advantageous for eiders to nest during years of high lemming populations (Quakenbush et al. 2004). Some evidence also suggests that Steller's eiders may benefit by nesting close to nests of avian predators such as jaegers and snowy owls; these aggressive birds defend their own nests against other predators, and eider nests located nearby may benefit when potential predators are driven from the area (Quakenbush et al. 2004).

Steller's eiders move to nearshore marine habitats after breeding (Fredrickson 2001). The young Steller's eiders hatch in late June. Male departure from the breeding grounds begins in late June or early July. Females that fail in breeding attempts may remain in the Barrow area into late summer. Females and fledged young depart the breeding grounds in early to mid-September.

The molting period occurs from late July to late October (USFWS 2002). Molting occurs throughout southwest Alaska, but is concentrated at four areas along the north side of the Alaska Peninsula; molting areas tend to be shallow areas with eelgrass beds and intertidal sand flats and mudflats (USFWS 2002). During the molt, winter, and spring migration, the Alaska breeding population mixes with the Russian-Pacific population in the waters of southwest Alaska (USFWS 2002).

During the non-breeding season, Steller's eiders that nested on the Arctic Coastal Plain may use lagoon systems and coastal bays from Barrow to Cape Lisburne, the northeast Chukotka coast, and numerous locations in southwest Alaska (USFWS 2002). Steller's eiders are known to occur in shallow marine habitats of Kodiak Island, the south side of the Alaska Peninsula, and the eastern Aleutian Islands to lower Cook Inlet, with stragglers occurring south to B.C. during the non-breeding season. There are four locations along the north coast of the Alaska Peninsula that are particularly important for molting and staging Steller's eiders: the Izembek Lagoon, Nelson Lagoon, Port Heiden, and Seal Islands. Photographic surveys during spring migration in late April of 2012 recorded 24,108 in the Izembek Lagoon, 5,767 in Nelson Lagoon, 5,960 in the Seal Islands Lagoon, and 6,127 in Port Heiden (Larned 2012). Surveys of molting Steller's eider from 26 August to 2 September 2016 recorded 6,457 at the Izmebek Lagoon, 24,716 at Nelson Lagoon, 8,484 at Seal Islands Lagoon, and 368 at Port Heiden (Williams et al 2016). Steller's eiders may begin to arrive in the proposed project area in late August or September. However, they are considered to be uncommon in the Kodiak Island Archipelago during the fall (MacIntosh 1998). During the winter and spring, they are more common in the Kodiak area. Larned (2005b) reported over 2000 Steller's eiders in Kamishak Bay in lower Cook Inlet during an aerial survey on 14 September 2005. During aerial surveys conducted in 2004 and 2005, the numbers of Steller's eiders in lower Cook Inlet, which is adjacent to the proposed project area, peaked in January (Larned 2006).

Causes for the decline of the Steller's eider population in Alaska are unknown but may include increased predation pressure on the North Slope and Y-K Delta breeding grounds, subsistence harvest, ingestion of lead shot, and contaminants (Quakenbush and Snyder-Conn 1993). Flint et al. (2000) suggested that a decrease in adult survival may have brought on the long-term decline in the population. Bustnes and Systad (2001) also suggested that Steller's eiders may have specialized feeding behavior that may limit the availability of winter foraging habitat. Steller's eiders could be affected by global climate regime shifts that cause changes in prey communities.

The USFWS has established Steller's eider critical habitat in the Y-K Delta nesting area, the Kuskokwim Shoals, and at the Seal Island, Nelson Lagoon, and Izembek Lagoon units on the Alaska Peninsula (USFWS 2004), but none of these areas occur within the proposed study area. Strategies for recovery of the Alaska breeding population of Steller's eiders are discussed in detail in the Steller's Eider Recovery Plan (USFWS 2002).

3.6 Corals

There are 137 distinct taxa of corals that occur throughout Alaskan waters, including octocorals (89 taxa), hydrocorals (24 taxa), antipatharians (12 taxa), and scleractinian corals (12 taxa) (Stone and Cairns 2017). The Aleutian Islands region supports the highest abundance and diversity of corals in Alaska with 96 taxa recorded (Heifetz 2000; Stone and Cairns 2017). The Western GOA, including the survey area, has 24 taxa of coral (Stone and Cairns 2017), which are patchily distributed across the continental shelf and slope, with some dense groves of gorgonians and sea pens (Stone and Shotwell 2007). Coral diversity is lower in deep water, although corals may be found at depths greater than 4700 m (Alaska Science Outreach 2004; Stone and Shotwell 2007). The most diverse communities occur at 300–350 m and continue to a lesser degree down to 800 m (Alaska Science Outreach 2004). These ecologically important coral communities provide structure and refuge for fish and invertebrates, especially juveniles (Stone and Shotwell 2007), and in the central Aleutian Islands, 84.7% of commercial fish and crab species were associated with corals and other epibenthic invertebrate structures (Stone 2006). Several areas in the GOA with coral communities have been designated as habitat areas of particular concern (HAPC) for fish (see Fig. 1).

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

3.7.1 ESA-Listed Fish Species

There are no ESA-listed fish species that have critical habitat in Alaska. However, there are several ESA-listed fish species that spawn on the West Coast of the Lower 48 United States and may occur in Alaskan waters during the marine phases of their life cycles. Species listed as ***Endangered*** include the sockeye salmon (*Oncorhynchus nerka*; Snake River Evolutionarily Significant Unit [ESU]) and chinook salmon (*Oncorhynchus tshawytscha*; Upper Columbia River spring-run ESU). Species listed as ***Threatened*** include the green sturgeon (*Acipenser medirostris*; Southern DPS), chum salmon (*Oncorhynchus keta*; Hood Canal summer-run ESU), coho salmon (*Oncorhynchus kisutch*; Lower Columbia River ESU), steelhead trout (*Oncorhynchus mykiss*; Snake River Basin DPS, Upper Willamette River DPS, and Lower, Middle, Upper Columbia River DPSs), and chinook salmon (*Oncorhynchus tshawytscha*; Lower Columbia River ESU, Upper Willamette River ESU, Puget Sound ESU, Snake River fall-run ESU, Snake River spring/summer-run ESU) (NOAA 2018a). The Alaskan populations of these species, which are more likely to be encountered near the survey area, are not listed under the ESA.

3.7.2 Important Fish Resources

The GOA supports substantial ESA non-listed finfish resources, including groundfish, forage fish, rockfish, and salmonids, that are important to the area both biologically and economically. Additionally, there are important shellfish and invertebrate resources.

3.7.2.1 Groundfish

Walleye pollock (*Theragra chalcogramma*) occupy demersal habitats along the outer continental shelf (OCS) and slope during winter. They migrate into shallower waters and aggregate for spawning in the Shumagin Islands between 15 February and 1 March, and in Shelikof Strait typically between 15 March 15 and 1 April. Walleye pollock in the GOA are managed as a single stock (Dorn et al. 2007).

Pacific cod (*Gadus macrocephalus*) has been an important commercial species in Alaska since 1882 (Rigby 1984). Pacific cod inhabit waters of the continental shelf and upper continental slope waters (100–250 m deep) in the winter (Hart 1973) and move to water <100 m deep in the summer (NOAA 2004c). They are moderately fast growing and short lived compared to many other Alaskan groundfish. Spawning generally occurs from January to April in waters 40–120 m deep (Klovach et al. 1995). Eggs and winter concentrations of adults have been found to be associated with coarse sand and cobble bottom types, and it has been inferred that this is optimal spawning habitat (Palsson 1990). Larvae and juveniles are pelagic, and there is some evidence that both larvae and juveniles are transported to nursery habitats by currents (Garrison and Miller 1982). Nursery habitats are associated with shallow water and intertidal areas with a sandy bottom and kelp or eel grass (Miller et. al. 1976). It has been suggested that, with increasing size and age, juveniles move into deeper water (Brodeur et al. 1995).

Sablefish (*Anoplopoma fimbria*) inhabit the northeastern Pacific Ocean from northern Mexico to the GOA, westward to the Aleutian Islands, and into the Bering Sea (Wolotira et al. 1993). Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords, generally at depths greater than 200 m. Sablefish observed from a manned submersible were found on or within 1 m of the bottom (Krieger 1997). In contrast to their adult distribution, juvenile sablefish (<40 cm long) spend their first two to three years on the continental shelf of the GOA. Sablefish are highly migratory for at least part of their life (Heifetz and Fujioka 1991; Maloney and Heifetz 1997; Kimura et al. 1998) and are assessed as a single population in Alaskan waters (Hanselman et al. 2007a).

The arrowtooth flounder (*Atheresthes stomias*) is the most abundant groundfish species in the GOA, and it ranges from central California to the eastern Bering Sea (Turnock and Wilderbuer 2007) in water depths 20–800 m. Although their stock structure and migratory patterns are poorly understood, they do appear to move to deeper water as they grow (Zimmerman and Goddard 1996), but recent research suggests juveniles may be more ubiquitous across depths than previously thought (Doyle et al. 2018).

Pacific halibut (*Hippoglossus stenolepis*) spawn during the winter, primarily from December through February, off the edge of the continental shelf in waters 350–550 m deep (IPHC 1998). Males reach maturity at ~7 years of age and females at ~8 years. Females are highly fecund, laying two to three million eggs annually. Younger halibut, <10 years of age, are highly migratory and range throughout the GOA. Older halibut tend to be much less migratory; they often use both shallow and deep waters over the annual cycle, but they do not travel as much as the younger fish (IPHC 1998).

3.7.2.3 Other Groundfish

Other groundfish that are found in the waters of the project area include Atka mackerel (*Pleurogrammus monopterygius*), black rockfish (*Sebastes melanops*), lingcod (*Ophiodon elongatus*), yellowfin sole (*Limanda aspera*), starry flounder (*Platichthys stellatus*), and other flatfish, greenlings, scuplins, poachers, and pricklebacks, which inhabit the Kodiak and southern Aleutian Peninsula region (NPFMC 2015; Mecklenburg et al., 2002). These species generally are in the same habitats as the previously discussed groundfish species and are often food sources for other fish, birds, and mammals.

3.7.2.4 Forage Fish

Pacific herring (*Clupea pallasi*) is an abundant and widespread forage fish of the Gulf of Alaska. They are critical prey for a variety of fishes, mammals, and birds. Herring migrate in large schools and generally spawn in the spring. Herring spawn extensively along much of the Shelilidof coast of Kodiak Island, and the southern Alaska Peninsula. After spawning, most adults leave inshore waters and move seaward to feed primarily on zooplankton such as copepods and other crustaceans. They are seasonal feeders and accumulate fat reserves for periods of relative inactivity. Herring schools often demonstrate a diel vertical migration, spending daylight hours near the seafloor and moving upward during the evening to feed (ADF&G 2015).

Other forage fish that are critical food sources to marine mammals, seabirds, and larger fish species and found near Kodiak and the Aleutian Peninsula region of the GOA include eulochon (*Thaleichthys pacificus*), capelin (*Mallotus villosus*), and Pacific sandlance (*Ammodytes hexapterus*) (Ormseth and Vollenweider 2018).

3.7.2.5 Salmonids

Pacific salmon (*Oncorhynchus* spp.) rear in the GOA and are managed in three regions based on freshwater drainage areas: southeast, central (Cook Inlet, PWS, and Bristol Bay), and westward (Alaska Peninsula, Chignik, and Kodiak). Although some Pacific salmon species are listed under the ESA in parts of their range, they are not listed in Alaska. Salmon distribution throughout the GOA varies by species and stock. All salmon except chinook generally spend the majority of their ocean life in offshore pelagic waters, bounded by brief periods of migration through coastal areas as juveniles and returning adults. Chinook salmon migrate through coastal areas as juveniles and returning adults, whereas adult chinook salmon undergo extensive migrations and can be found inshore and offshore throughout the North Pacific (Morrow 1980). Salmon are not targeted in high seas fisheries, but are targeted in nearshore waters with troll, gillnet, and seine gear.

3.7.2.6 Rockfish

Rockfishes (*Sebastes* spp.) range from southern California to the Bering Sea. At least 30 rockfish species inhabit Alaskan waters, with Pacific ocean perch (*S. alutus*) being the most common. Pacific ocean perch are slow growing, bear live young, and reach a maximum age of ~30 years (Hart 1973). Males grow more slowly and have shorter life spans than do females. Rockfishes are internal fertilizers, with females releasing larvae. Pacific ocean perch release their larvae in winter. Larvae and juveniles are pelagic until joining adults in demersal habitats after two or three years. Adults are found primarily on the OCS and the upper continental slope in depths 150–420 m. In the summer, adults inhabit shallower depths, especially 150–300 m; in the fall, they migrate farther offshore to depths of ~300–420 m. They stay at these deeper depths until about May, when they return to their shallower summer depths (Love et al. 2002; Hanselman et al. 2007b).

3.7.2.7 Shellfish

Crab, shrimp, other crustaceans, and mollusks are harvested from Alaskan waters. All these species, grouped in this document as shellfish, inhabit benthic regions as adults, but can occupy pelagic waters as larvae. Three species of king crab (red, *Paralithodes camtschaticus*; blue, *P. platypus*; golden, *Lithodes aequispinus*) and two species of Tanner crab (Tanner, *Chionoecetes bairdi*; snow, *C. opilio*) occur in the GOA. *Pandalus* shrimp, Geoduck clam (*Panopea generosa*), spot prawn (*Pandalus platyceros*), and Weathervane scallop (*Patinopecten caurinus*) are also important shellfish resources. These are discussed further below.

3.7.3 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).

EFH is identified for only those species managed under a federal Fishery Management Plan (FMP), which in the GOA includes groundfish, Pacific cod, sablefish, rockfish, scallops, and Pacific salmon. As the entire GOA has been designated as EFH, the proposed survey work would be conducted in areas designated as EFH. The *Magnuson-Stevens Fishery Conservation and Management Act* (16 U.S.C. §1801-1882) established Regional Fishery Management Councils and mandated that FMPs be developed to manage exploited fish and invertebrate species responsibly in federal waters of the U.S. When Congress reauthorized the act in 1996 as the Sustainable Fisheries Act, several reforms and changes were made. One change was to charge NMFS with designating and conserving EFH for species managed under existing FMPs; this mandate was intended to minimize, to the extent practicable, any adverse effects on habitat caused by fishing or non-fishing activities, and to identify other actions to encourage the conservation and enhancement of such habitat. EFH has been designated for groundfish species or species assemblages, salmonids, and invertebrates in different development stages in the GOA (Table 6). NSF will consult with NMFS on EFH .

TABLE 6. Species with Essential Fish Habitat (EFH) in the Gulf of Alaska.

Species	Eggs	Larvae	Early Juvenile	Late Juvenile	Adult
Walleye pollock	✓	✓	-	✓	✓
Pacific cod	✓	✓	-	✓	✓
Yellowfin sole	✓	✓	-	✓	✓
Arrowtooth flounder	-	✓	-	✓	✓
Northern rock sole	-	✓	-	✓	✓
Southern rock sole	-	✓	-	✓	✓
Alaska plaice	✓	✓	-	✓	✓
Rex sole	✓	✓	-	✓	✓
Dover sole	✓	✓	-	✓	✓
Flathead sole	✓	✓	-	✓	✓
Sablefish	✓	✓	-	✓	✓
Pacific ocean perch	-	✓	-	✓	✓
Shortraker rockfish	-	-	-	-	✓
Blackspotted/rougheye rockfish	-	-	-	-	✓
Northern rockfish	-	-	-	-	✓
Thornyhead rockfish	-	✓	✓	✓	✓
Yelloweye rockfish	-	✓	✓	✓	✓
Dusky rockfish	-	✓	-	-	✓
Atka mackerel	✓	✓	-	-	✓
Sculpins	-	-	-	✓	✓
Skates	-	-	-	-	✓
Sharks	-	-	-	-	-
Forage fish complex	-	-	-	-	-
Squid	-	-	-	✓	✓
Octopus	-	-	-	-	-
Chinook salmon*	-	-	✓	✓	✓
Chum salmon*	-	-	✓	✓	✓
Coho salmon*	-	-	✓	✓	✓
Pink salmon*	-	-	✓	✓	✓
Sockeye salmon*	-	-	✓	✓	✓
Weathervane scallop	-	-	-	✓	✓

–information currently unavailable.
* Salmon egg and larval life stages not included because they occur in freshwater.
Source: Most recent FMPs, available from North Pacific Fishery Management Council website, http://npfmc.org.

3.7.4 Habitat Areas of Particular Concern

A Habitat Area of Particular Concern (HAPC) is a subset of EFH that provides important ecological functions, is especially vulnerable to degradation, or includes habitat that is rare (NOAA 2018). In the GOA, 10 areas along the continental slope are designated as HAPCs; they are closed to bottom trawling to protect hard bottom that may be important to rockfish. These areas, which are thought to contain high relief bottom and coral communities, total 7155 km^2 (Witherell and Woodby 2005). Five small areas off southeast Alaska (a total of 46 km^2) are closed to all bottom-contact fishing to protect dense thickets of red tree corals.

Another 15 areas offshore are closed to all bottom fishing to protect seamounts (NOAA 2018b). Additionally, all trawling has been prohibited east of longitude 140°W since 1998. HAPCs within and near the proposed survey area are shown in Figure 1.

3.8 Fisheries

3.8.1 Commercial Fisheries

The GOA supports many active fisheries. Most fishing in the GOA occurs over the relatively narrow continental shelf and slope. Principal groundfish fisheries in the GOA are directed at pollock, Pacific cod, sablefish, flatfish, and rockfish. Halibut, not included in the groundfish group, is another targeted species that is managed independently. In addition, the nearshore salmon fishery contributes to the overall value of the GOA fisheries. The total ex-vessel value of all domestic fish and shellfish in Alaska during 2016 was $1.7 billion, with 51% of the value attributable to the groundfish fishery and 26% attributable to the salmon fishery (NOAA 2017). Catches of the main species or species groups for 2016 and 2017 are shown in Table 7.

Beginning in the early 1970s, foreign vessels were fishing walleye pollock in the GOA (Megrey 1989), but by 1988 the pollock fishery was operated by a wholly domestic fleet. The winter fishery targets pre-spawning fish for their valuable roe. All walleye pollock fishing in the GOA is shore based. Fishing in summer is generally around the east side of Kodiak Island and in nearshore waters of the Alaska Peninsula (Dorn et al. 2007). Foreign fleets trawled for rockfish in Alaskan waters in the early 1960s, which resulted in overfishing. The rockfish stocks have since rebounded to some extent, and currently most rockfish are caught with bottom or pelagic trawls. In 2017, none of the groundfish fishery stocks were overfished or undergoing overfishing (NOAA 2017).

Walleye pollock contributes a large percentage to the total groundfish harvest in the GOA. In 2018, acceptable biological catch (ABC) of walleye pollock in the GOA was projected at 170,265 metric tons (NOAA 2018d). Pacific cod has been an important commercial species in Alaska since 1882 (Rigby 1984) and was the second largest volume groundfish fishery in the GOA, after pollock, according to 2017 landings. However, the 2018 ABC of Pacific cod was reduced from 2017 by 80% in order to reduce fishing pressure on spawning biomass (NOAA 2017).

The Pacific halibut is a large flatfish harvested on the continental shelf throughout the North Pacific Ocean, primarily in the GOA. This species is managed internationally by the International Pacific Halibut Commission (IPHC) and the North Pacific Fishery Management Council (NPFMC). The largest fisheries occur in the GOA, with smaller fisheries in the Bering Sea. Halibut are harvested by longline gear only, and the fishery is conducted as an Individual Transferable Quota fishery in Alaska.

TABLE 7. Total commercial catches in metric tons from the Gulf of Alaska in 2016 and 2017. See footnotes for data sources.

	Commercial Catch (t)	
Species	**2016**	**2017**
Walleye pollock	173,226	184,243
Pacific cod	39,544	33,115
Arrowtooth flounder	19,830	26,007
Pacific ocean perch	23,127	22,919
Sablefish	9,354	10,386
Shallow water flatfish	3,808	2,481

Northern rockfish	3,437	1,779
Dusky rockfish	3,328	2,587
Flathead sole	2,420	1,875
Rex sole	1,748	1,410
Atka mackerel	1,092	1,048
Big skate	2,101	1,565
Longnose skate	1,396	1,119
Other skates	1,666	1,472
Thornyheads	1,119	1,012
Sculpins	1,332	1,284
Sharks	2,016	1,505
Pacific halibut	7,600	7,998
Chinook salmon	2,211	1,431
Sockeye salmon	130,419	131,953
Coho salmon	12,529	14,883
Pink salmon	68,075	233,709
Chum salmon	53,374	86,932
Other rockfish	1,283	1,059
Shortraker rockfish	777	547
Rougheye and blackspotted rockfish	641	536
Deep water flatfish	238	241
Demersal shelf rockfish	117	124
Squid	239	44
Octopus	383	180

	Commercial Catch (t)	
	2014	**2015**
Tanner/Snow crab	26,308	37,648
King crab	7,938	7,666

Groundfish (https://www.afsc.noaa.gov/REFM/Stocks/assessments.htm)
Shellfish (https://www.afsc.noaa.gov/News/pdfs/Wholesale_Market_Profiles_for_Alaskan_Groundfish_and_Crab_Fisheries.pdf)
Salmon (http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherysalmon.salmon_by_report_type)
Halibut (https://alaskafisheries.noaa.gov/fisheries-catch-landings)

Sablefish (*Anoplopoma fimbria*), or black cod, is managed as a directed fishery in the GOA. It is long lived and occurs along the OCS in water depths >900 m. It is harvested primarily by longline and is under an Individual Transferable Quota program in all federal waters. Some sablefish is harvested as trawl bycatch or by pot gear.

At least 30 rockfish species inhabit Alaskan waters, with Pacific Ocean perch being the most common. In 1998, a prohibition on rockfish trawling was imposed for the GOA east of 140ºW longitude; rockfish in the GOA are primarily caught in the western region and along the Aleutian Islands.

All five species of Pacific salmon occur in the GOA: chinook (*O. tshawytscha*), sockeye (*O. nerka*), chum (*O. keta*), coho (*O. kisutchv*), and pink (*O. gorbuscha*). Sockeye is the most valuable commercial salmon species in Alaska, and the pink salmon is the most numerous; the two comprise most of the salmon catch in the GOA.

Large quantities of crab, shrimp, other crustaceans, and mollusks are harvested from Alaskan waters.

The most lucrative of the Alaska shellfish fisheries is the crab fishery. Three species of king crab (red, *Paralithodes camtschaticus*; blue, *P. platypus*; golden, *Lithodes aequispinus*) and two species of Tanner crab (Tanner, *Chionoecetes bairdi*; snow, *C. opilio*) traditionally have been harvested in the GOA. Statewide the peak harvests were 81,647 t of king crab in 1980 and 166,922 t of Tanner crab in 1991 (NOAA 2016). Historically, large harvests originated from the Kodiak area, but that fishery has failed to recover since its closure in 1983, and several other once important king and Tanner crab fishing grounds have been closed because of conservation concerns (Woodby et al. 2005; NOAA 2016). The average annual harvests during the 2011–2014 seasons were 7620 t of king crabs, worth $122.5 million, and 30,708 t of snow crabs worth $246.3 million. The majority of both the Tanner and king crab harvests were obtained from the Bering Sea. The predominant king crab commercial harvests are of red king crab from Bristol Bay, followed by golden king crab from the Aleutian Islands, and blue king crab from St. Matthew (NOAA 2016).

Pandalus shrimp, once a major component of the commercial GOA fishery, with landings reaching over 54,431 t in the 1970s, declined drastically in the early 1980s to harvests of ~1000 t between 1998 and 2017 (Woodby et al. 2005; ADF&G 2018a). The 2017 harvest of 1,288,068 pounds was worth a wholesale value of $4.3 million (ADF&G 2018a). The primarily Kodiak-based fishery declined following a climate-induced regime shift concomitant with an increase in Pacific cod, a major shrimp predator. Small trawl fisheries continue in southeast Alaska, PWS, and the Kodiak area, as well as a pot fishery for spot prawns (*Pandalus platyceros*) in southeast Alaska (ADF&G 2018a).

The Weathervane scallop (*Patinopecten caurinus*) supports a sporadic commercial fishery in Alaska waters from Yakutat west to the eastern Aleutian Islands. Most dredging occurs at depth, between 70 and 110 m, where the scallops are aggregated in elongated beds parallel to the depth contours.

Geoduck clams (*Panopea generosa*), California sea cucumber (*Parastichopus californicus*), red sea urchin (*Mesocentrotus franciscanus*), and green sea urchin (*Strongylocentrotus droebachiensis*) are harvested in small hand-pick SCUBA diving fisheries in the GOA. Traditionally there is also a dive fishery for pinto abalone (*Haliotis kamschatkana*), which is now closed commercially (ADF&G 2018b).

3.8.2 Recreational and Subsistence Fisheries

Subsistence fisheries and subsistence hunting make up 0.9% of all harvest of fish and game statewide in Alaska, compared to 98.5% taken by commercial fisheries. Although a small sector overall, subsistence fishing provides crucial sustenance for local communities, on average providing ~275 pounds of food per person per year in rural Alaska (ADF&G 2014a). Of the estimated 34.3 million pounds of wild foods harvested in rural Alaska communities annually, subsistence fisheries contribute 53.2% from finfish and 3.2% from shellfish (ADF&G 2014a).

In the rural communities along the GOA, salmon species are the most targeted subsistence fish, making up 31.8% of total subsistence harvests (ADF&G 2014). In 2012, 935,470 salmon were harvested by subsistence fishers in Alaska (ADF&G 2012). Most of the salmon harvest consisted of chum salmon (39%), followed by sockeye (37%), coho (9%), chinook (8%), and pink (7%) (ADF&G 2012). The three management areas that fall within the study area (Kodiak, Alaska Peninsula, and Chignik) each contributed 5% or less to the total subsistence salmon harvest in 2015 (Fall et al. 2018). Set gillnets are the preferred subsistence harvest method for salmon, and there are no restrictions on specific streams, nor are there daily or annual limits to the number of fishes taken; there are restrictions to keep subsistence and commercial fisheries separate (ADF&G 2005). Bottomfish, Pacific herring, smelt, crustaceans, and mollusks are also caught by subsistence fishers in the northwestern GOA.

In 2014, the subsistence catch of halibut made up 2.3% of the total harvest, with 4506 subsistence fishers taking 40,698 halibut, totaling 760,469 pounds (ADF&G 2014b). The majority of the catch (71%) was taken by setline, and 29% was taken by hand-operated fishing gear (ADF&G 2014b). Regulatory area 2C (Southeast Alaska) took the greatest percentage of the harvest (56%), followed by 3A (Southcentral Alaska; 32%) and 4E (East Bering Sea; 9%) (ADF&G 2014b). Rockfish and lingcod are also taken by subsistence halibut fishers (Fall and Koster 2008).

Recreational fisheries in Alaska are a small but economically valuable sector, taking less than 0.4% of total fisheries harvests in 2014 (ADF&G 2014a). In 2007, recreational fisheries generated $1.4 billion in total expenditures of sport fishers (ADF&G 2007). In 2017 in the Southcentral Alaska Region, including the study area in the GOA, 320,086 anglers fished a total of 1,312,586 angler-days (ADF&G 2018c). The largest portions of recreational harvest by numbers of fish were the five species of salmon (263,876), halibut (237,193), and rockfish (128,708). Other fish species targeted were Pacific cod, lingcod, smelt, sablefish, Arctic char, shark, and steelhead trout. Tanner and Dungeness crabs and shellfish, including hard-shell clams and razor clams, were also taken in the recreational fishery (ADF&G 2018c).

3.8.3 Aquaculture

The *Aquatic Farming Act* was approved in Alaska in 1988, allowing for the culture of indigenous shellfish and aquatic plants in nearshore waters. The culture of finfish is prohibited. In 2015, there were 63 permitted operations, including 54 aquatic farms, seven hatcheries, and two nurseries. Four of these aquatic farms and one hatchery are located in the Kodiak region near the study area. The 2015 inventory of primary cultured species includes Pacific oyster (15.2 million oysters; 63% of total farm production), blue mussel (8 million), and geoduck clam (910,926). Littleneck clam and several species of urchin, scallop, cockle, and sea cucumber are also produced by permitted operations. Production of several species of kelp and seaweed is becoming a viable part of the aquaculture industry as well. Sales of shellfish and aquatic plants from all operations totaled $1.13 million in 2015 (ADF&G 2016).

3.9 Recreational SCUBA Diving

Recreational SCUBA diving occurs in the GOA and near Kodiak Island, but is not a high capacity operation. Popular dive sites are primarily located within reach of shore off Kodiak Island. Several shipwrecks exist in the GOA and near Kodiak Island, but are not frequented as dive sites.

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 survey. A description of the rationale for NSF's estimates of the numbers of individuals exposed to received sound levels ≥160 dB re 1 μPa_{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 survey 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 $\mu Pa^2 \cdot s$ (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 $\mu Pa^2 \cdot s$ (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 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 $\mu Pa^2 \cdot s$. 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 (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including LF cetaceans (e.g., baleen whales), MF cetaceans (e.g., most delphinids), HF cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

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

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

Since 1991, there have been 67 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2018b). 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 area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Sea Turtles

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

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 Draft 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 survey as an integral part of the planned activity. These measures include the following: ramp up of the airgun array; 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 (unless the system and back-up systems are damaged during operations); 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.

As a result of the very small population size of North Pacific right whales, a shutdown of all operating airguns would be implemented upon sighting of this species at any distance from the vessel. Additionally, concentrations of feeding whales would be avoided, to the extent possible, and the array would be powered-down if necessary.

Previous and subsequent analysis of the potential impacts take 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 the methods used to estimate the number of potential exposures to Level A and Level B threshold and present estimates of the numbers of marine mammals that could be affected during the proposed seismic survey. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the seismic survey in the GOA. 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 (individuals 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 survey, we consulted with NMFS regarding which marine mammal density sources to use for developing take estimates. In response, NMFS recommended the use of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the GOA (DoN 2014). Consistent with Rone et al. (2014), four strata were defined: Inshore: all waters <1000 m deep; Slope: from 1000 m water depth to the Aleutian trench/subduction zone; Offshore: waters offshore of the Aleutian trench/subduction zone; Seamount: waters within defined seamount areas. Densities corresponding to these strata were based on data from several different sources, including Navy funded line-transect surveys in the GOA as described below and in Appendix B.

To develop densities specific to the GOA, the Navy conducted two comprehensive marine mammal surveys in the Temporary Marine Activities Area (TMAA) in the GOA prior to 2014. The first survey was conducted from 10 to 20 April 2009 and the second was from 23 June to 18 July 2013. Both surveys used systematic line-transect survey protocols including visual and acoustic detection methods (Rone et al. 2010; Rone et al. 2014). The data were collected in four strata that were designed to encompass the four distinct habitats within the TMAA and greater GOA. Rone et al. (2014) provided stratified line-transect density estimates used in this analysis for fin, humpback, blue, sperm, and killer whales, as well as northern fur seals (Table 8). Data from a subsequent survey in 2015 were used to calculate alternative density estimates for several species (Rone et al. 2017) and the density estimates for Dall's porpoise used here were taken from that source. DoN (2014) derived gray whale densities in two zones, nearshore (0–2.25 n.mi from shore) and offshore (from 2.25–20 n.mi. from shore). In our calculations, the nearshore density was used to represent the inshore zone and the offshore density was used to represent the slope zone. Harbor porpoise densities in DoN (2014) were derived from Hobbs and Waite (2010) which included additional shallow water depth strata. The density estimate from the 100 m to 200 m depth strata was used to represent the entire inshore zone (<1000 m) in this analysis. Similarly, harbor seals typically remain close to shore so minimal estimates were used for the three deep water zones and a one thousand fold increase of the minimal density was used to represent the entire inshore zone (DoN 2014). Densities for Minke whale, Pacific white-sided dolpin, and Cuvier's and Baird's beaked whales were based on Waite (2003 *in* DoN 2009). Although sei whale sightings and Stejneger's beaked whale acoustic detections were recorded during the Navy funded GOA surveys, data were insufficient to calculate densities for these species, so predictions from a global model of marine mammals densities were used (Kaschner et al. 2012 *in* DoN 2014). Steller sea lion and northern elephant seal densities were calculated using shore-based population estimates divided by the area of the GOA Large Marine Ecosystem (DoN 2014). The North Pacific right whale, Risso's dolphin, and California sea lion are only rarely observed in or near the survey area, so minimal densities were used to represent their potential presence.

All densities were corrected for perception bias [$f(0)$] but only harbor porpoise densities were corrected for availability bias [$g(0)$], as described by the respective authors. 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 survey.

TABLE 8. Densities of marine mammals that could be exposed to Level B and Level A thresholds for NMFS defined hearing groups during the proposed GOA survey. Species in *italics* are listed under the ESA.

	Estimated Density (#/1000 km^2)			
Species	**Inshore** <1000 m	**Slope** (1000 m to Aleutian Trench)	**Offshore** (Offshore of Aleutian Trench)	**Seamount** (In Defined Seamount Areas)
LF Cetaceans				
North Pacific right whale	0.01	0.01	0.01	0.01
Humpback whale	129.00	0.20	1.00	1.00
Blue whale	0.50	0.50	0.50	2.00
Fin whale	71.00	14.00	21.00	5.00
Sei whale	0.10	0.10	0.10	0.10
Minke whale	0.60	0.60	0.60	0.60
Gray whale	48.57	2.43	0.00	0.00
MF Cetaceans				
Sperm whale	0.00	3.30	1.30	0.36
Killer whale	5.00	20.00	2.00	2.00
Pacific white-sided dolphin	20.80	20.80	20.80	20.80
Cuvier's beaked whale	2.20	2.20	2.20	2.20
Baird's beaked whale	0.50	0.50	0.50	0.50
Stejneger's beaked whale	0.01	1.42	1.42	1.42
Risso's dolphin	0.01	0.01	0.01	0.01
HF Cetaceans				
Harbor Porpoise	47.30	0.00	0.00	0.00
Dall's porpoise	218.00	196.00	37.00	24.00
Otariid Seals				
Steller sea lion	9.80	9.80	9.80	9.80
California sea lion	0.01	0.01	0.01	0.01
Northern fur seal	15.00	4.00	17.00	6.00
Phocid Seal				
Northern elephant seal	2.20	2.20	2.20	2.20
Harbor seal	10.00	0.01	0.01	0.01
Marine Fissiped				
Northern Sea Otter	727.03	0.00	0.00	0.00

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". Using the density estimates shown in Table 8, estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the proposed seismic survey in GOA if no animals moved away from the survey vessel are shown in Table 9. The *Requested Take Authorization* is given in the right-most column of Table 9.

TABLE 9. 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 GOA survey.

	Calculated Take NMFS Daily Method[1]				
Species	Level B[2]	Level A[3]	Regional Population Size	Level B + Level A as % of Pop.[4]	Requested Take Authorization[5]
LF Cetaceans					
North Pacific right whale[6]	1	1	400	0.5	0
Humpback whale	5,730	1	21,063	27.2	5,731
Blue whale	49	1	1,647	3.0	50
Fin whale	3,913	1	18,680	21.0	3,914
Sei whale	9	1	27,197	0.0	10
Minke whale	54	1	25,000	0.2	55
Gray whale	2,183	1	20,990	10.4	2,184
MF Cetaceans					
Sperm whale	86	1	26,300	0.3	87
Killer whale	587	1	8,500	6.9	588
Pacific white-sided dolphin	1,838	1	988,333	0.2	1,839
Cuvier's beaked whale	195	1	20,000	1.0	196
Baird's beaked whale	45	1	25,300	0.2	46
Stejneger's beaked whale[7]	64	1	25,300	0.3	65
Risso's dolphin[8]	1	1	838,000	0.0	16
HF Cetaceans					
Harbor Porpoise	2,090	3	79,261	2.6	2,093
Dall's porpoise	13,677	21	1,186,000	1.2	13,698
Otariid Seals					
Steller sea lion	866	1	53,303	1.6	867
California sea lion	1	1	296,750	0.0	2
Northern fur seal	1,184	1	1,100,000	0.1	1,185
Phocid Seal					
Northern elephant seal	195	1	239,000	0.1	196
Harbor seal	443	1	129,000	0.3	444
Marine Fissiped					
Northern Sea Otter[9]	7,768	2	54,771	14.2	7,770

[1]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 (222 km) multiplied by the number of survey days (18 days), times 1.25; daily ensonified area = full 160-dB area minus ensonified area for the appropriate PTS thresholds. See text for more details.
[2] Level A takes if there were no mitigation measures.
[3] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[4] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population in the North Pacific (see Table 5).
[5] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated.
[6] To avoid incidental take, a shutdown of operating airguns would occur upon sighting of a North Pacific right whale at any distance (see Mitigation), so no incidental take is requested.
[7] Abundance estimate not available, but acoustic monitoring suggests Stejneger's beaked whales are at least as abundant as Baird's beaked whale in the GOA (Baumann-Pickering et al. 2014), so use of Baird's beaked whale abundance estimate should result in a cautionary estimate of the percent of the population potentially taken.
[8] Requested take authorization (Level B only) increased to mean group size.
[9] Calculated using area ensonified to ≥160 dB re 1 µPa$_{rms}$ in waters <40 m deep.

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. Species (and relevant sources) for which the *Requested Take*

Authorization was increased to mean group size include the Risso's dolphin (Bradford et al. 2017). For the Stehneger's beaked whale, which may be present but unlikely to be observed and for which no reasonable estimates of group size are available from this region, the *Requested Take Authorization* was increased to 5 individuals.

It should be noted that the exposure estimates assume that the proposed survey would be fully completed; in fact, the calculated takes ***have been increased by 25%*** by assuming additional survey operations would take place (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).

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions have been estimated using a method required by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day (~222 km) with a proportion occurring in the marine mammal density zones (inshore, slope, offshore, and seamount) 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, increased by 25%, were then multiplied by the number of survey days (18 days). This is equivalent to adding an additional 25% to the proposed line km (Appendix D). 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 Table 9. 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. Dall's porpoise could be more susceptible to exposure to sound levels that exceed the PTS threshold than other marine mammals, as this species 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 area.

The estimate of the number of marine mammals that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the GOA survey area is 27,099 cetaceans and 2,037 pinnipeds (Table 9). That total includes 3,613 cetaceans listed as ***endangered*** under the ESA: 80 sperm whales, 9 sei whales, 3,480 fin whales, 44 blue whales, representing 0.3%, 0.03%, 18.6%, 2.7% of their regional populations, respectively. The total also includes 781 pinnipeds listed as endangered under the ESA, all of which are Stellar sea lions which represents 1.5% of the population. In addition, 277 beaked whales could be exposed. Most (52%) of the cetaceans potentially exposed would be porpoise; the Dalls' porpoise is expected to be the most common marine mammal species in the area, with up to 12,172 exposed to ≥160 dB re 1 μPa_{rms}, (1% of their regional populations).

4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

The proposed seismic survey 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, § 3.8.7, and § 3.9.7, 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, pinnipeds, and fissiped 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 recent 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, 2016f,g, 2017a,f).

In this analysis, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause Level A and/or B harassment are low percentages of the regional population sizes (Table 9). 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 activity, and it 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 seen no seismic sound-related marine mammal injuries or mortality. Also, the actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., what would be considered takes) have almost always been much lower than the 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 a 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). During an NSF-funded ~3455 km, 2-D seismic survey conducted by the *Langseth* off the coast of Hawaii in 2018, no marine mammals were observed within the predicted 160-dB zone and potentially taken, representing 0% of the 11,068 takes authorized by NMFS (RPS *in prep.*). 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, and 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. 2017), including how particle motion, rather than sound pressure level, affects 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 dB re 1 μPa^2. The study animals still incurred acoustic trauma and injury to statocysts, despite not being held in confined tanks with walls. A later study from this research group showed that statocyst damage was more severe in cephalopod hatchlings than in adults, suggesting a developmental period of greater sensitivity (Solé et al. 2018).

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, 2018), one study (Day et al. 2016a,b, 2017) did show adverse effects including an increase in mortality rates. Przeslawski et al. (2016, 2018) 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 $\mu Pa^2 \cdot s$ 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, 2018).

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 $\mu Pa^2 \cdot s$. 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 airgun 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 a 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-pk} were 204 dB re 1 $\mu Pa^2 \cdot s$ 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 $\mu Pa^2 \cdot s$ 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 μPa^2/Hz and the fish were exposed to 50 discharges per trial. The results provided evidence that fish exposed to seismic sound either increased or decreased their expressions of different genes, demonstrating that seismic sound can affect fish on a genetic level.

Sierra-Flores (2015) examined 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 μPa_{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-p} , 243 dB re 1μPa_{p-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 $\mu Pa^2 \cdot s$. 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, Fisheries, and EFH

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 recreation fisheries would not be significant.

Interactions between the proposed survey and fishing operations in the proposed survey area are expected to be limited. There could be a possible conflict with the *Langseth*'s towed equipment entangling with fishing gear. Since the *Langseth* would not be towing hydrophone streamers during this survey, the potential for entanglement is greatly reduced. Fishing activities could occur within the proposed survey area; however, vessels actively fishing would need to maintain a safe distance from the *Langseth* and the towed seismic equipment. Conflicts would be avoided through communication with the fishing community before and during the survey. 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, their fisheries, and EFH would be expected, and the survey 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.

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 survey is 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, including EFH, 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 survey, 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 survey 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 Possible Effects on Subsistence Hunting and Fishing

Subsistence hunting and fishing continue to feature prominently in the household economies and social welfare of some Alaskan residents, particularly among those living in small, rural villages (Wolfe and Walker 1987). Subsistence remains the basis for Alaska Native culture and community. In rural Alaska, subsistence activities are often central to many aspects of human existence from patterns of family life to artistic expression and community religious and celebratory activities.

Marine mammals are hunted legally in Alaskan waters by coastal Alaska Natives. In the GOA, the marine mammals that are hunted are Steller sea lions, harbor seals, and northern sea otters. In 2011–2012, 37 harbor seals were taken from the North Kodiak Stock and 126 harbor seals were taken from the South Kodiak Stock by communities on Kodiak Island (Muto et al. 2016). The number taken from the Cook Inlet/Shelikof Strait Stock for 2011–2012 is unknown, but an average of 233 were taken from this stock annually during 2004-2008 (Muto et al. 2016). The seasonal distribution of harbor seal takes by Alaska Natives typically shows two distinct hunting peaks — one during spring and one during fall and early winter; however, seals are taken in all months (Wolfe et al. 2012). In general, the months of highest harvest are September through December, with a smaller peak in February/March (Wolfe et al. 2012). Harvests are traditionally low from May through August, when harbor seals are raising pups and molting.

In 2008, 19 steller sea lions were taken in the Kodiak Island region and 9 were taken along the South Alaska Peninsula (Wolfe et al. 2009). As of 2009, data on community subsistence harvests are no longer being collected consistently so few data are available. Wolfe et al. (2012) reported an estimated 20 sea lions taken by hunters on Kodiak Island in 2011. The most recent 5-year period with data available (2004–2008) shows an annual average catch of 172 steller sea lions for all areas in Alaska combined except the Pribilof Islands in the Bering Sea (Muto et al. 2018). Sea lions are taken from Kodiak Island in low numbers year round (Wolfe et al. 2012).

Sea otters are harvested by Alaska Native hunters from southeast Alaska to the Aleutian Islands. The USFWS monitors the harvest of sea otters in Alaska. For 2006–2010, the average subsistence takes of northern sea otters were 293 animals for the Southcentral Alaska Stock, 447 animals for the Southeast Alaska Stock, and 76 for the Southwest Alaska Stock (USFWS 2014b,c,d). During 2010–2014, hunters from Kodiak took 236 sea otters (USFWS 2014e). The subsistence harvest of sea otters occurs year-round in coastal communities throughout the GOA. However, there is a general reduction in harvest during the summer months (D. Willoya, The Alaska Sea Otter and Steller Sea Lion Commission, pers. comm.). Hunters are required to obtain tags for sea otter pelts from designated USFWS taggers located in all harvesting villages. Harvests can take place from a large geographic area surrounding each sea otter harvesting village (D. Willoya, pers. comm.).

An endangered DPS of beluga whales occurs in Cook Inlet. Although these belugas have been hunted in the past, harvesting of this population is currently not permitted, because of the small population size (see § III). Gray whales are not hunted within the project area. Some of the gray whales that migrate through the GOA in spring and late autumn are hunted in Russian waters, and a very limited subsistence hunt has occurred in recent years off Washington. Any small-scale disturbance effects that might occur in the GOA as a result of the proposed activity would have no effect on the hunts for gray whales in those distant locations.

The proposed project could potentially impact the availability of marine mammals for harvest in a small area immediately around the *Langseth*, and for a very short time period during seismic operations. Considering the limited time that the planned seismic surveys would take place close to shore, where most subsistence harvest of marine mammals occurs, the proposed project is not expected to have any significant impacts to the availability of Steller sea lions, harbor seals, or sea otters for subsistence harvest.

Subsistence fisheries, on average, provide ~275 pounds of food per person per year in rural Alaska (ADF&G 2014a). Of the estimated 34.3 million pounds of wild foods harvested in rural Alaska communities annually, subsistence fisheries contribute 53.2% from finfish and 3.2% from shellfish (ADF&G 2014a). In the rural communities along the GOA, salmon species are the most targeted subsistence fish, making up 31.8% of total subsistence harvests (ADF&G 2014a). In 2012, 935,470 salmon were harvested by subsistence fishers in Alaska (ADF&G 2012). Most of the salmon harvest consisted of chum salmon (39%), followed by sockeye (37%), coho (9%), chinook (8%), and pink (7%) (ADF&G 2012). The three management areas that fall within the study area (Kodiak, Alaska Peninsula, and Chignik) each contributed 5% or less to the total subsistence salmon harvest in 2015 (Fall et al. 2018). Set gillnets are the preferred subsistence harvest method for salmon, and there are no restrictions on specific streams, nor are there daily or annual limits to the number of fish taken; there are restrictions to keep subsistence and commercial fisheries separate (ADF&G 2005). Bottomfish, Pacific herring, smelt, crustaceans, and mollusks are also caught by subsistence fishers in the northwestern GOA.

In 2014, the subsistence catch of halibut made up 2.3% of the total harvest, with 4506 subsistence fishers taking 40,698 halibut, totaling 760,469 pounds (ADF&G 2014b). The majority of the catch (71%) was taken by setline, and 29% was taken by hand-operated fishing gear (ADF&G 2014b). Regulatory area 2C (Southeast Alaska) took the greatest percentage of the harvest (56%), followed by 3A (Southcentral Alaska; 32%) and 4E (East Bering Sea; 9%) (ADF&G 2014b). Rockfish and lingcod are also taken by subsistence halibut fishers (Fall and Koster 2008).

Seismic surveys can, at times, cause changes in the catchability of fish (see subsection (4.1.5), above). L-DEO would minimize the potential to negatively impact the subsistence fish harvest by avoiding areas where subsistence fishers are fishing, if requested or viewed necessary. Additionally, the PIs will conduct outreach with communities near the planned project area to identify and avoid areas of potential conflict, including for marine subsistence activities (mammals and fisheries).

4.1.6 Direct Effects on Recreational Fisheries and Their Significance

Sportfishing is an ecomonically important industry in Alaska, with an average of 1.27 million fish caught annually during 2008–2017 in southcentral Alaska's saltwater regions, which include the Kodiak/Aleutians area where the seismic survey is proposed to take place (ADF&G 2018d). King, sockeye, and chum salmon availability begins in May with peaks in June and July. However, sport fishing generally occurs relatively close to shore and is thus unlikely to be impacted by the majority of the proposed survey activity.

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

Recreational diving is a small industry in Alaska, and because the proposed survey would occur prior to the peak tourist season, recreational diving is unlikely to be impacted.

4.1.8 Cumulative Effects

Cumulative effects refer to the impacts on the environment that result from a combination of past, existing, and reasonably foreseeable projects and human activities. Cumulative effects can result from multiple causes, multiple effects, effects of activities in more than one locale, and recurring events. Human activities, when conducted separately or in combination with other activities, could affect marine animals in the study area. However, understanding cumulative effects is complex because of the animals' extensive habitat ranges, and the difficulty in monitoring populations and determining the level of impacts that may result from certain activities. 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 survey 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 area.

4.1.8.1 Past and Future Research Activities

The 2011 Alaska *Langseth* Experiment to Understand the Megathrust (ALEUT) seismic survey acquired two refraction profiles separated by 250 km with a 6600 in^3 tuned airgun array. In total, the program acquired 3500 km of multichannel seismic (MCS) profiles and two ~300 km long OBS refraction profiles that were acquired coincident with two of the MCS profiles. The data were of good quality and provided a baseline for a much denser acquisition that would allow 3D regional seismic imaging. To date, no previous refraction data have been acquired across the SW Kodiak asperity; the depth velocity structure remains unknown in this area.

An Electro-magnetic(EM)/Magneto-telluric (MT) experiment (PI: Kerry Key, NSF funded project) is planned to be conducted in spring 2019 in this region. The main goal of this marine EM/MT project is to track fluids along the megathrust and within the incoming oceanic plate. Profiles are coincident with the two ALEUT refraction profiles.

4.1.8.2 Naval Activities

The U.S. Navy currently conducts training exercises in the GOA in its Temporary Maritime Activities Area (TMAA). The TMAA encompasses 145,482 km^2 of sea surface and subsurface areas as well as the overlying airspace (DoN 2011). The TMAA is located south of PWS and east of Kodiak Island, and 44 km south of the Kenai Peninsula (DoN 2011). Navy activities occur in the area during the April to October period and consist of one large-scale military exercise lasting up to 21 days (DoN 2016). The 2019 military exercise is currently scheduled to occur 13-24 May.

During Navy operations in 2019, marine mammals and sea turtles within the TMAA could be exposed to sounds from training exercises, including mid- and high-frequency sonars and impulsive detonations. The main impact associated with naval operations is the addition of underwater noise to oceanic ambient noise levels. The proposed seismic survey area is located to the southwest of the TMAA and the survey is proposed for early June. Thus there is no geographic or temporal overlap with the 2019 TMAA exercises. Marine animals could only be exposed to sounds from airguns and Navy training exercises if they were to travel from one area to the other, and exposure could not happen simultaneously.

The Navy uses both passive and active sonars during its operations. Passive sonars detect sound waves by using hydrophones and can indicate the presence and movement of submarines. Active sonars transmit sound that reflects off objects and returns to the receiving system. Mid-frequency sonars, as proposed for use in the GOA, operate at frequencies between 1 and 10 kHz; these are designed to detect submarines in tactical operation scenarios (DoN 2011). There are increasing indications that some beaked whales tend to strand when naval exercises involving mid-frequency sonar operation are ongoing nearby (e.g., Simmonds and Lopez-Jurado 1991; Frantzis 1998; NOAA and USN 2001; Jepson et al. 2003; Hildebrand 2005; Barlow and Gisiner 2006). These strandings may be in part a disturbance response, although auditory or other injuries or other physiological effects may also be involved (see §IV *Strandings and Mortality*). Seismic survey sounds, in contrast, are quite different from the naval sonars that are proposed for use in the GOA TMAA in 2019.

4.1.8.3 Vessel Traffic

Vessel traffic in the proposed study area would consist of fishing vessels, as well as other commercial (cargo), wildlife cruise, and pleasure vessels. The GOA is a very busy shipping route. A total of 41.2 million tons of waterborne cargo were handled at Alaskan ports in 2017, including domestic and foreign exports and imports, and intrastate shipments (WCSC 2018). Six Alaskan ports were ranked among the busiest U.S. ports by cargo tonnage in 2017 (AAPA 2018): Valdez, Nikishka, Kivilina, Anchorage, Ketchikan, and Unalaska Island.

The Alaska Marine Highway System (AMHS) provides year-round service to over 30 communities in Alaska, as well as Bellingham, WA, and Prince Rupert, B.C. Ports located within the proposed GOA study area include Chignik, Sand Point, and King Cove on the Alaska Peninsula, and Port Lions, Old Harbor, Ouzinkie, and Kodiak on Kodiak Island. The AMHS currently operates eleven vessels, and the busiest months in Southwest Alaska are June and July (AMHS 2015). In 2015, the AMHS carried a total of 288,133 passengers and 100,547 vehicles (AMHS 2015). The bulk of this is in Southeast Alaska, with 65,133 passengers and 26,148 vehicles carried in Southwest Alaska in 2015 (AMHS 2015). In 2015, AMHS vessels travelled >200,000 km in Southwest Alaska (AMHS 2015).

The total transit distance of ~4700 km (including ~300 km transit to and from port and ~4400 km of survey effort) by the *Langseth* would be small relative to total transit length for vessels operating in the general regions around the proposed survey area. 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.

4.1.8.4 Fisheries Interactions

The commercial fisheries in the general area of the proposed survey 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. Section 118 of the MMPA requires all commercial fisheries to be placed in one of three categories based on the level of incidental take of marine mammals relative to the Potential Biological Removal (PBR) for each marine mammal stock. Category I, II, and III fisheries are those for which the combined take is ≥50%, 1%–50%, and <1%, respectively, of PBR for a particular stock. In 2018, all groundfish fisheries in the GOA were listed as Category III fisheries, except for sablefish longline fishery, which is Category II because of sperm whale bycatch (83 FR 5349). Additionally, some salmon drift and set gillnet fisheries are listed in Category II.

The highest annual mortality rate of any cetacean in Alaska attributable to commercial fisheries is the harbor porpoise. In NOAA Fisheries most recent stock assessment harbor porpoises of the GOA stock had a minimum total annual mortality rate of 74 animals; incidental takes of Dall's porpoise are also high, with a minimum mean of 38 animals taken annually (Muto et al. 2018). The highest minimum mean annual mortality rate for baleen whales in Alaska fisheries was reported for the humpback whale, at 8.5 whales. A photographic study in southeast Alaska showed that at least 2 of 28 humpback whales seen in both 2003 and 2004 had new entanglement scars in 2004 (Neilson et al. 2005). Of a total of 179 individuals seen during both years, at least 53% showed some kind of scarring from fishing gear entanglement (Neilson et al. 2005). The minimum mean annual mortality rate for sperm whales in Alaska fisheries is 3.8 animals. Small numbers of fin and killer whales also succumb to commercial fisheries annually (Muto et al. 2018).

Of the pinniped species, the highest incidental mean annual mortality rates attributable to commercial fisheries have been reported for the Western Stock of Steller sea lions (31) and the PWS stock of harbor seals (24) (Muto et al. 2018). Raum-Suryan et al. (2009) reported that Steller sea lions get entangled in and ingest fishing gear; packing and rubber bands were the most common neck entanglements, followed by rope, nets, and monofilament line. Ingested fishing gear consisted mainly of salmon fishery flashers, longline gear, hook and line, spinners/spoons, and bait hooks (Raum-Suryan et al. 2009). The incidence of entanglement was determined to be 0.26%.

Lewison et al. (2004) estimated that 30,000 to 75,000 loggerheads are taken as bycatch in longlines in 2000 in the Pacific; although the estimate for leatherbacks was lower (20,000 to 40,000). Entanglement of sea turtles in seismic gear is also a concern; there have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore of West Africa (Weir 2007). The probability of entanglements would be a function of turtle density in the study area, which is expected to be low. Towing of hydrophone streamers or other equipment is not expected to significantly interfere with sea turtle movements, including migration, unless they were to become entrapped as indicated above.

Entanglement in fishing gear and hooking can also lead to mortality of seabirds. Between 2009 and 2014, six short-tailed albatross mortalities were reported during commercial fishing activities in Alaska during both hook-and-line and longline fishing (Good et al. 2017). Bycatch of marbled murrelet in Alaska gillnet fisheries may be substantial, on the order of hundreds of birds annually, and was listed as the second most important human cause for this species' decline in its 2006 Alaska status review (Piatt et al. 2007).

There might also be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey area. The proposed operations in the survey area would be limited (up to 18 days), and the addition of the proposed survey 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 to marine mammals or sea turtles.

4.1.8.5 Whaling and Harvesting

Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives. In the GOA, the only marine mammals that are currently hunted are Steller sea lions, harbor seals, and sea otters. The hunt is described in § 4.1.5, above. Considering the limited time that the planned seismic surveys would take place close to shore relative to the year-round, widespread nature of subsistence hunting, the proposed project is not expected to have any significant impacts to the availability of Steller sea lions, harbor seals, or sea otters for subsistence harvest. Also, the planned project would not result in directed lethal takes of marine mammals.

4.1.8.6 Tourism

Tourism employed almost 40,000 people in Alaska in 2014–2015, representing 9% of employment and 5% of labor income statewide, with visitor spending totaling $1.94 billion (McDowell Group 2016). Over two million people visited Alaska during that time, with almost half as cruise ship passengers. Visitor spending in southwest Alaska, however, represented only 5% of the total ($93 million) and ~1500 jobs, with a smaller industry here than in southcentral and southeastern Alaska. However, in contrast to other areas, wildlife viewing and fishing were the activities most commonly reported by tourists visiting the Kodiak area (McDowell Group 2017). Whalewatching and sportfishing are both important tourist activities from Kodiak and north throughout the Kenai Peninsula. The primary tourist season in Alaska is from May through September, with peak season mid-June to mid-August. Because the proposed survey is planned to take place, for the most part, before the peak tourist season, overall effects on tourism would likely be small. Additionally, the survey would occur primarily offshore, out of the viewshed of the coast and beyond the range of most whale watching and sportfishing activities.

4.1.9 Unavoidable Impacts

Unavoidable impacts to the species of marine mammals and turtles occurring in the proposed survey area would be limited to short-term, localized changes in behavior of individuals. For 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 is a temporary phenomenon that does not involve injury, and if it were to occur, it would be limited to a few individuals 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.

4.1.10 Coordination with Other Agencies and Processes

This Draft EA has been prepared by LGL on behalf of L-DEO and NSF pursuant to NEPA. Potential impacts to marine mammals, endangered species, and critical habitat have also been assessed in the document; therefore, it will be used to support the ESA Section 7 consultation process with NMFS and USFWS and other regulatory processes, such as EFH consultation. This document will also be used as supporting documentation for an IHA application submitted by L-DEO, on behalf of itself, NSF and the other Proposing Institutions, to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for the proposed seismic survey. L-DEO would coordinate with the Navy to avoid any space-use conflict.

4.2 No Action Alternative

An alternative to conducting the proposed activity is the "No Action" Alternative, i.e., do not issue an IHA and do not conduct the operations. If the research were not conducted, the "No Action" alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed 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 architecture for the subduction zone and variability in slip behavior of the Alaska Peninsula subduction zone, and that would add to the comprehensive assessment of geohazards for the GOA region, such as earthquake and tsunami hazards, would not be conducted. The No Action Alternative would not meet the purpose and need for the proposed activity.

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APPENDIX A: DETERMINATION OF MITIGATION ZONES

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic survey 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. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with 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. 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). The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the differences in tow depth between the calibration survey (6 m) and the proposed survey (12 m); whereas the shallow water in the GoM may not exactly replicate the shallow water environment at the proposed survey site, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water L-DEO model, which are essentially a measure of the energy radiated by the source array.

For the 36-airgun array, the 150-dB Sound Exposure Level (SEL)[2] corresponds to deep-water maximum radii of 10,553 m for 12-m tow depth (Fig. A-1) and 7244 m for a 6-m tow depth (Fig. A-2), yielding a scaling factor of 1.4568 to be applied to the shallow-water 6-m tow depth results. Similarly, the 165 dB SEL corresponds to deep-water maximum radii of 1864 m for 12-m tow depth (Fig. A-1) and 1284 m for for 6-m tow depth (Fig. A-2), yielding a scaling factor of 1.4517. The 185 SEL corresponds to deep-water maximum radii of 181 m for 12-m tow depth (Fig. A-1) and 126 m for 6-m tow depth (Fig. A-2), yielding a scaling factor of 1.4331. Measured 160-, 175-, and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun array towed at 6 m depth were 17.5 km, 2.84 km, and 0.24 km, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth difference between 6 and 12 m yields distances of 25,494 m, 4123 m, and 344 m for the 160-, 175-, and 195-dB sound levels, respectively.

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 (Fig. A-3). For intermediate-water depths, a correction factor of 1.5 was applied to the deep-water model results. For shallow water, a scaling of the field measurements obtained for the 36-airgun array was used. The 150-dB SEL level corresponds to a deep-water radius of 431 m for the 40-in^3 airgun at 12-m tow depth (Fig. A-3) and 7244 for the 36-airgun array at 6-m tow depth (Fig. A-2), yielding a scaling factor of 0.0595. Similarly, the 165-dB SEL level corresponds to a deep-water radius of 77 m for the 40-in^3 airgun at 12-m tow depth (Fig. A-3) and 1284 m for the 36-airgun array at 6-m tow depth (Fig. A-2), yielding a scaling factor of 0.060. The 185-dB SEL level corresponds to a deep-water radius of 7.5 m for the 40-in^3 airgun at 12-m tow depth (Fig. A-3) and 126.3 m for the 36-airgun array at 6-m tow depth (Fig. A-2), yielding a scaling factor of 0.0594. Measured 160-, 175-, and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun array towed at 6-m depth were 17.5 km, 2.8 km, and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the difference in array sizes and tow depths yields distances of 1041 m, 170 m, and 14 m, respectively.

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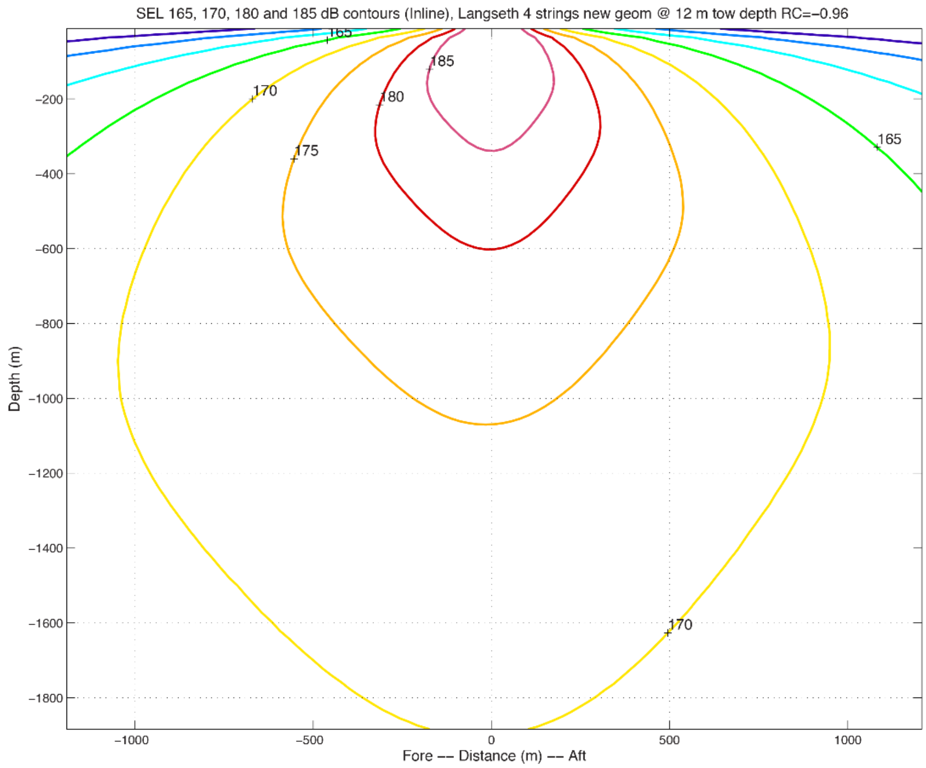
[2] SEL (measured in dB re 1 µ$Pa^2 \cdot s$) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.



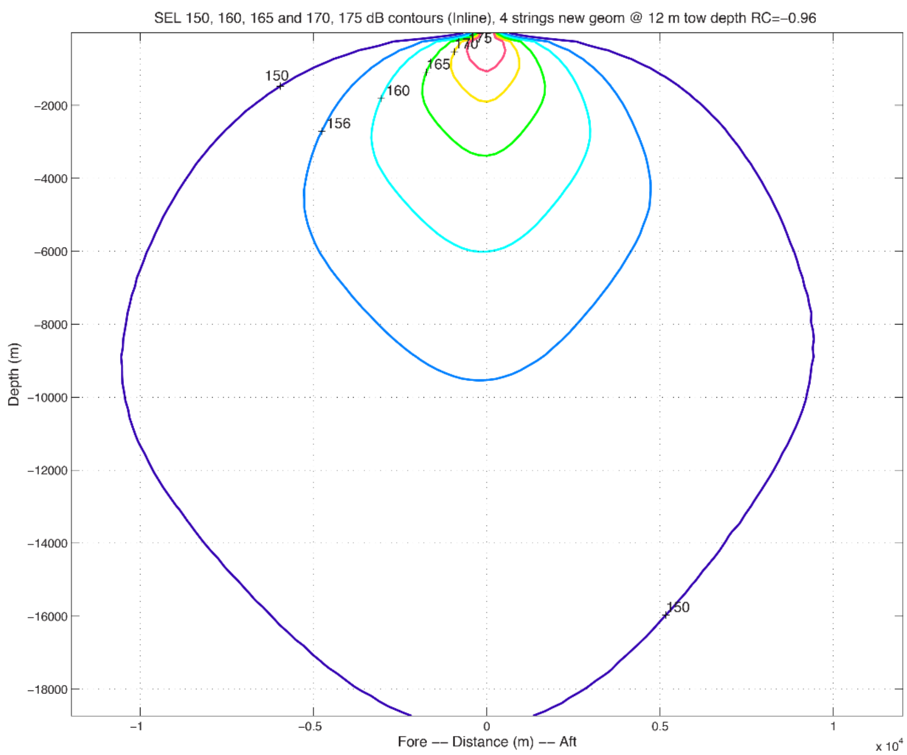


FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth planned for use during the proposed survey in the Gulf of Alaska. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy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

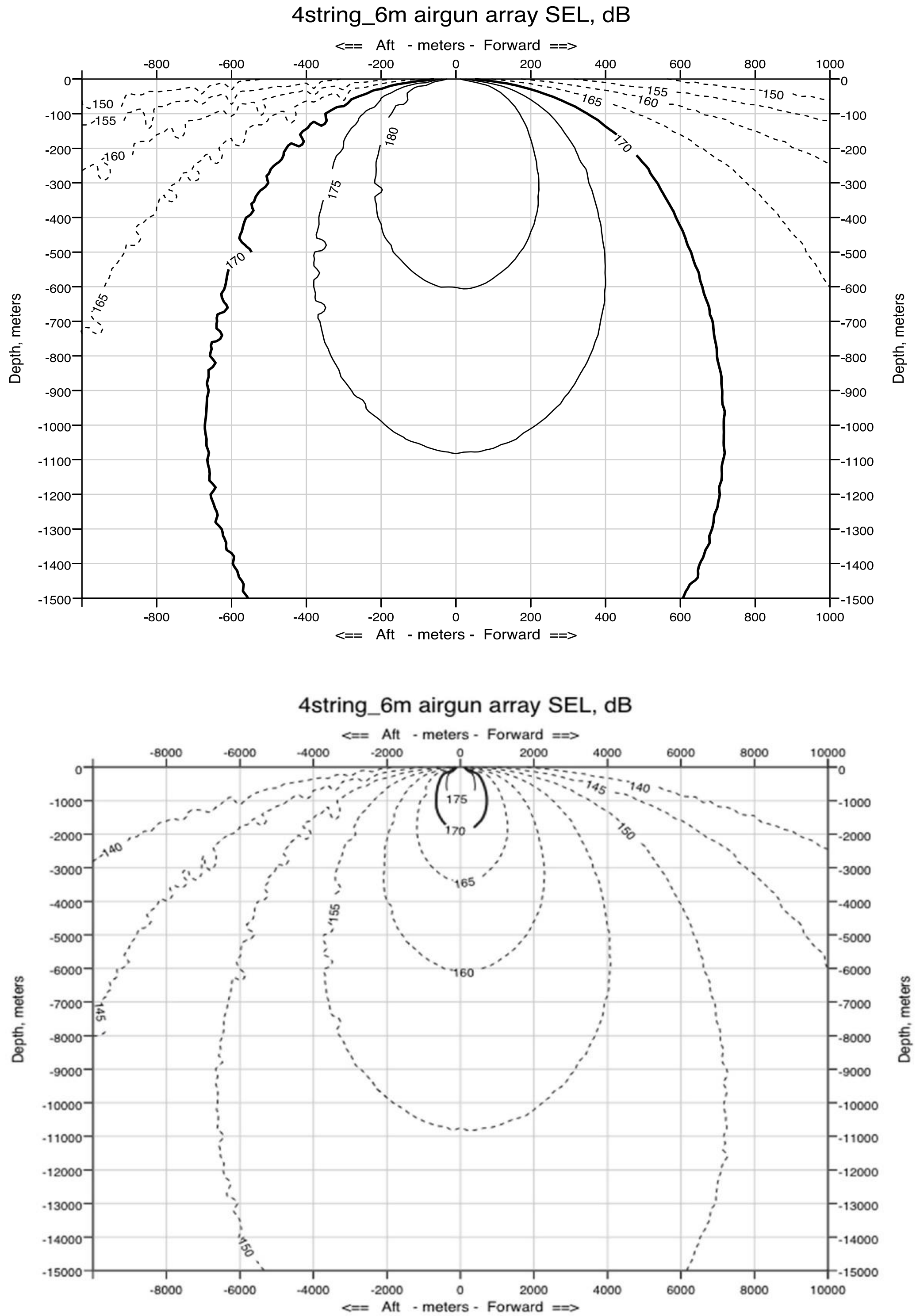


Figure A-2. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150 dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

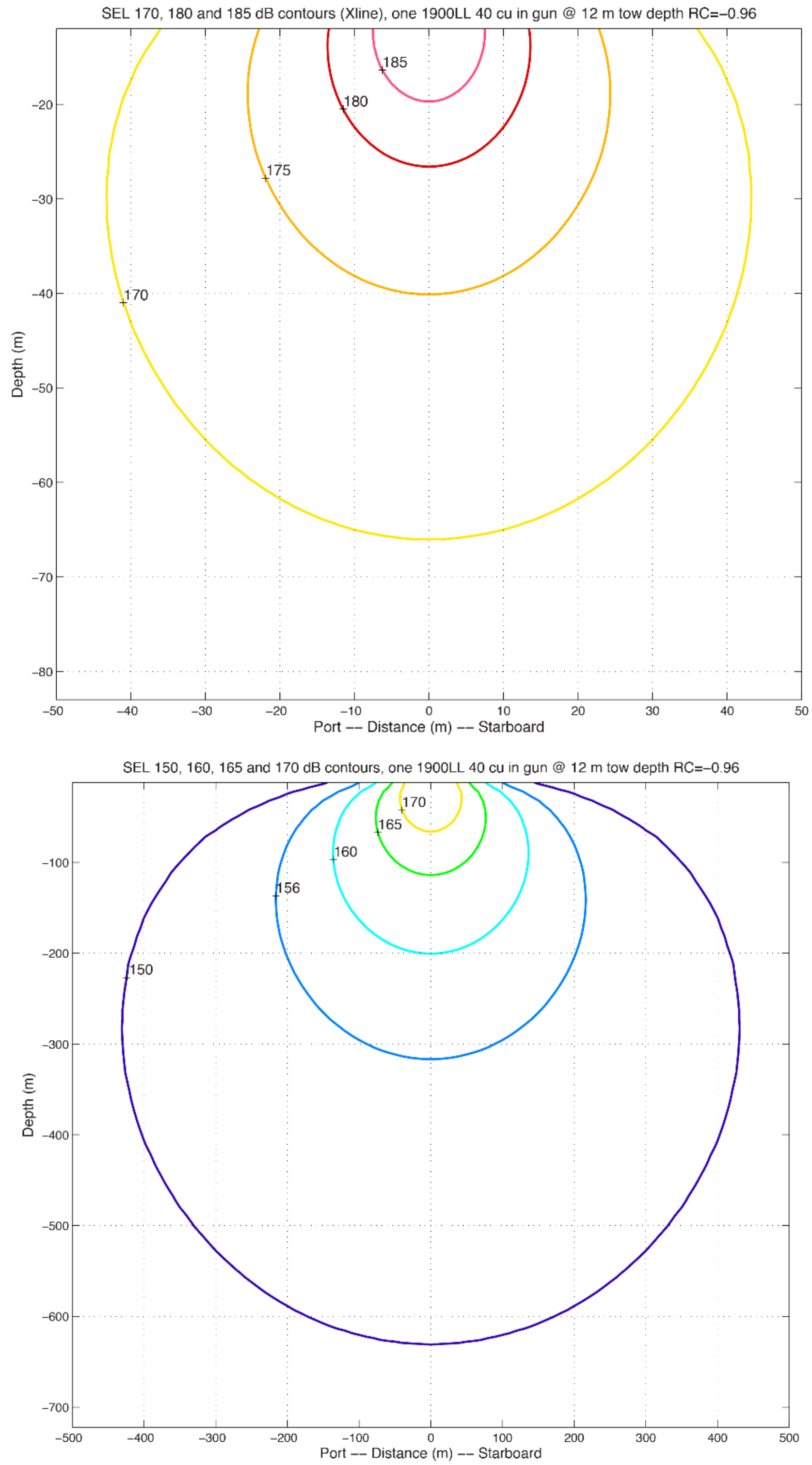


FIGURE A-3. Modeled deep-water received SELs from a single 40-in³ airgun towed at a 12-m depth, which is planned for use as a mitigation airgun during the proposed survey in the Gulf of Alaska. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth 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[3] 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-4) 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

[3] 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 survey in the GOA. 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]
		<100 m	1,041[3]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]
		100–1000 m	10,100[2]
		<100 m	25,494[3]

[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] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

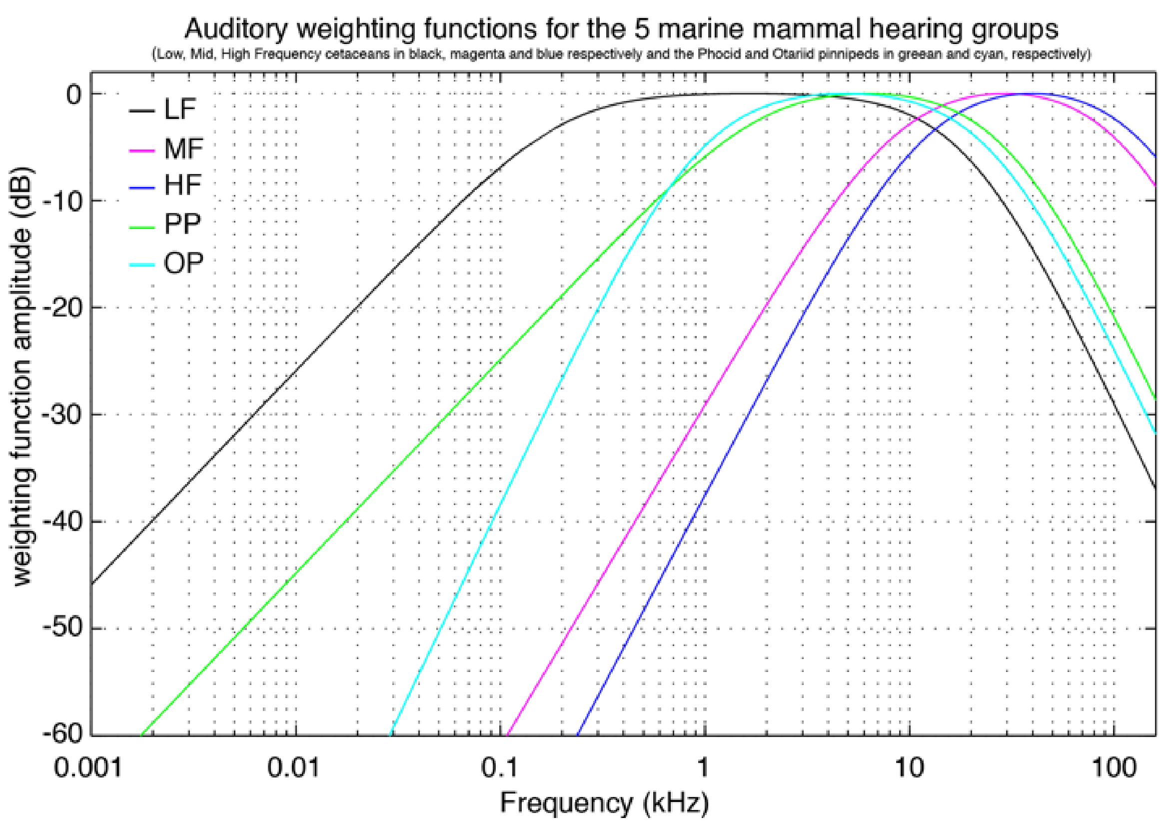


FIGURE A-4. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance Spreadsheet.

(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 2.57222 m/s and a 1/Repetition rate of 155.2355 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-5 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-10–A-12 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-13 shows the impact of weighting functions by hearing group for the single mitigation airgun. Figures A-14–A-15 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-16 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-17–A-18 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot.

Table A-9 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 (Airgun shooting Supplement to Alaska Amphibious Community Seismic Experiment (AACSE))
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 399.3 m. Source velocity of 5 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)	2.57222
1/Repetition rate^ (seconds)	155.2355

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

^Time between onset of successive pulses.

	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Modified farfield SEL	232.9819	232.8352	233.0978	232.8352	232.079
Source Factor	1.27997E+21	1.23745E+21	1.31459E+21	1.23745E+21	1.0397E+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)	**40.1**	**0.0**	**0.1**	**1.3**	**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-5).

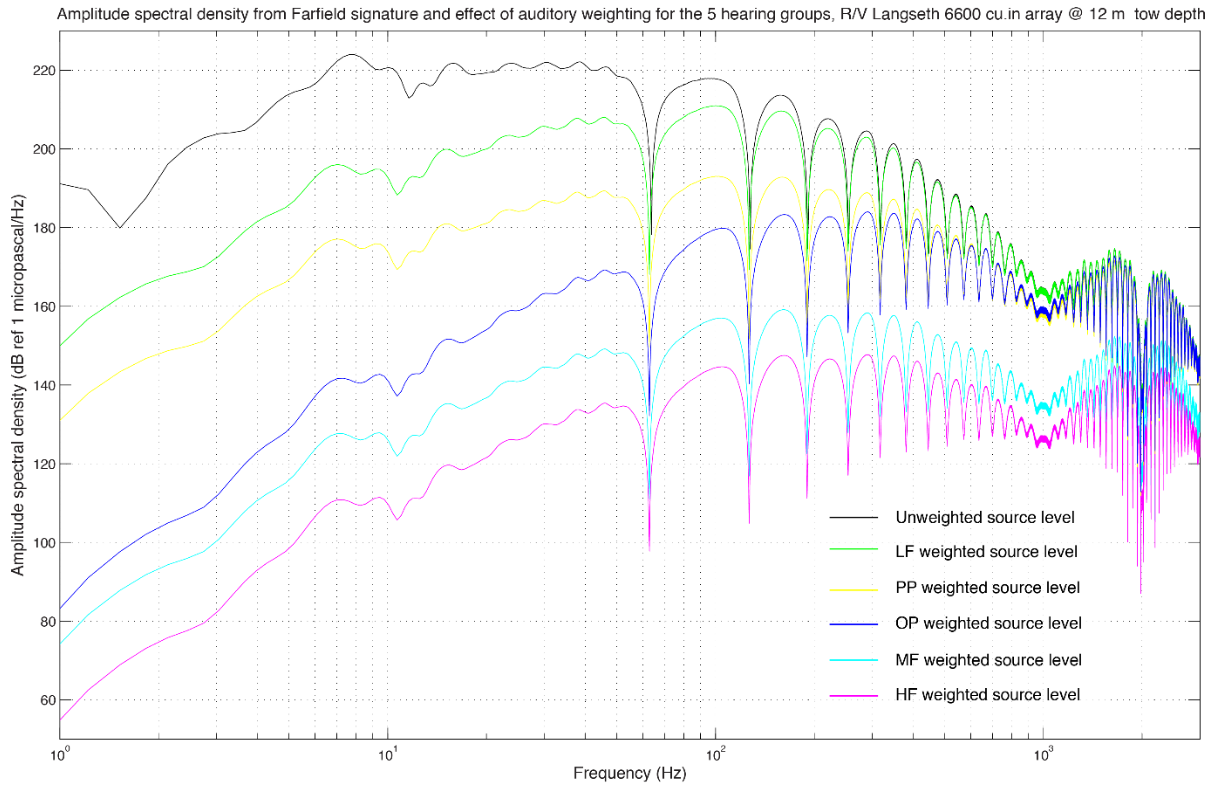


FIGURE A-5. Modeled amplitude spectral density of the 36-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are 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.

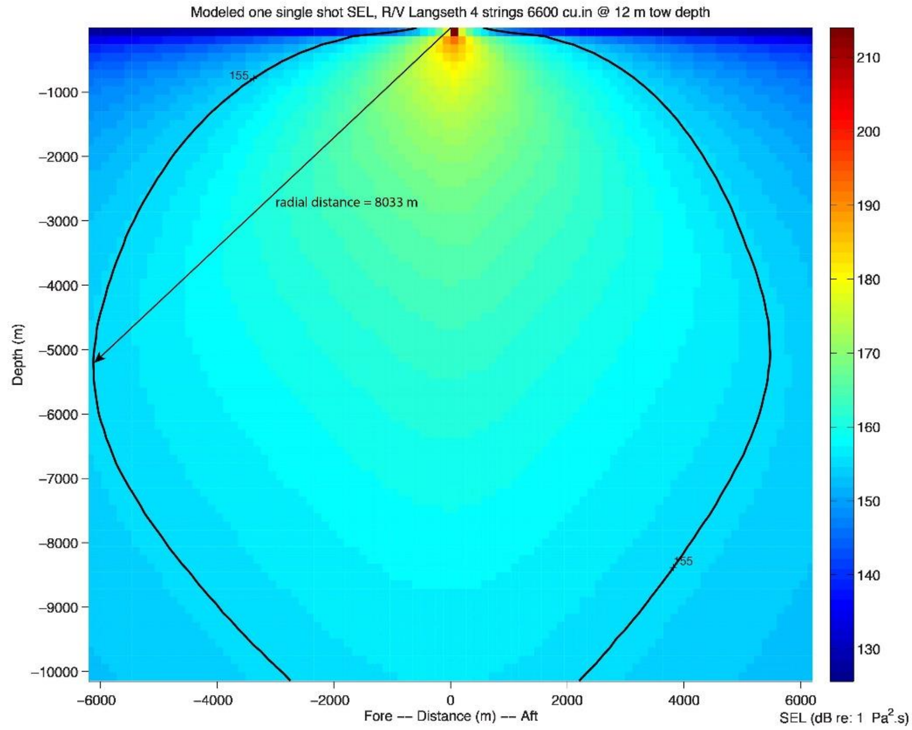


FIGURE A-6. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 155-dB SEL isopleth (8033 m). Radial distance allows us to determine the modified farfield SEL using a propagation of $20\log_{10}$(radial distance).

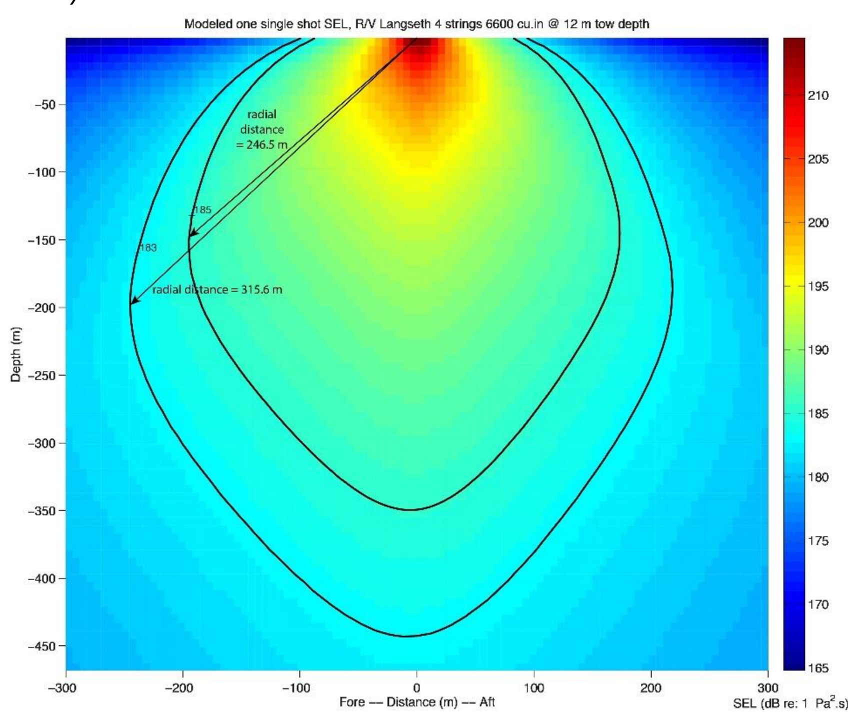


FIGURE A-7. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths (315.6 and 246.5 m, respectively).

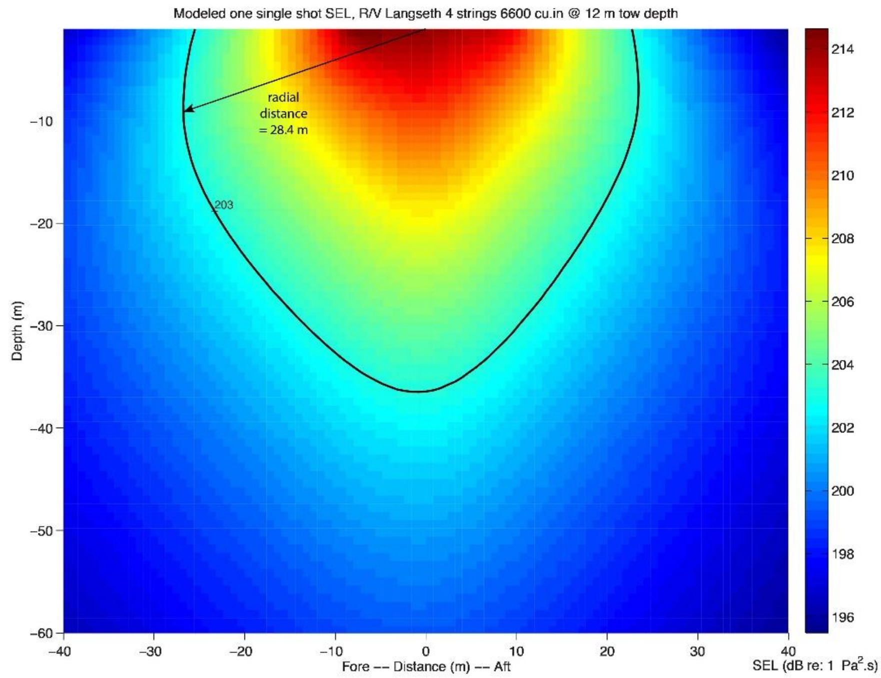


FIGURE A-8. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 203-dB SEL isopleth (28.4 m).

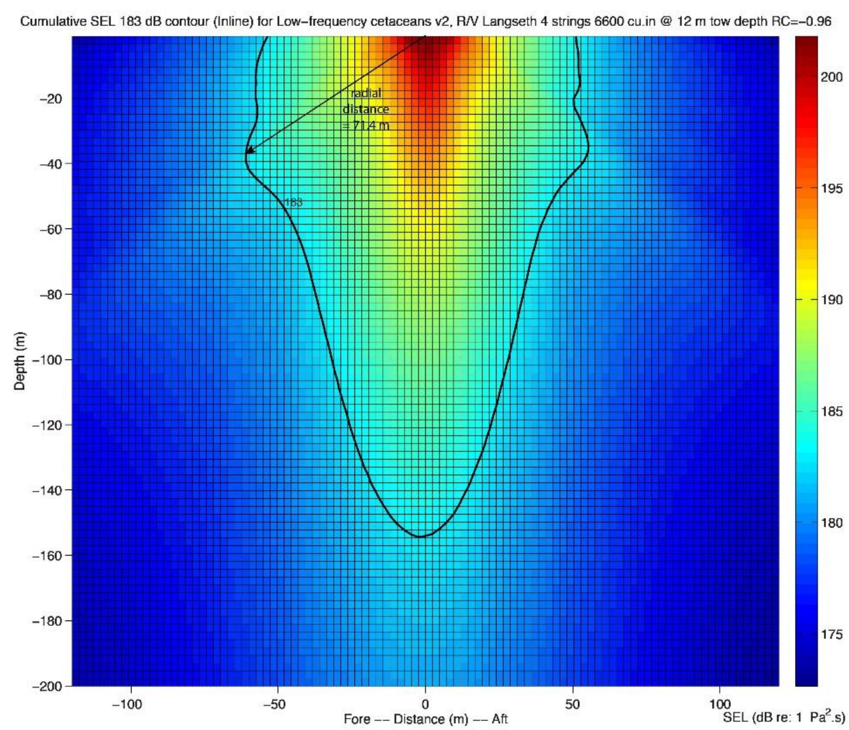


FIGURE A-9. Modeled received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-7 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 survey in the GOA.

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	13.57	364.67	51.59	10.62
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.

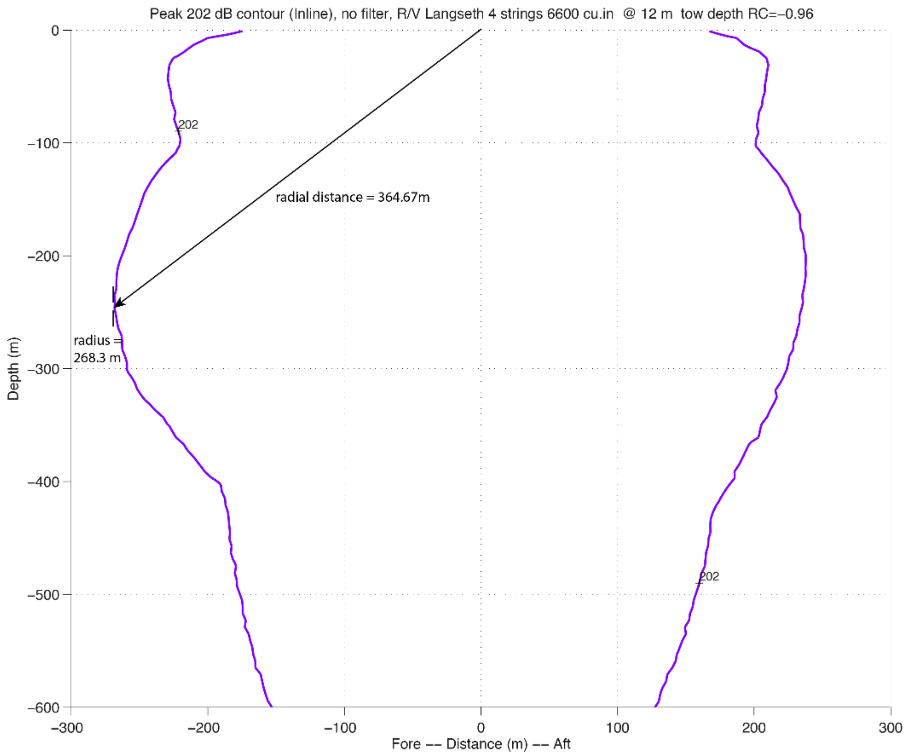


FIGURE A-10. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

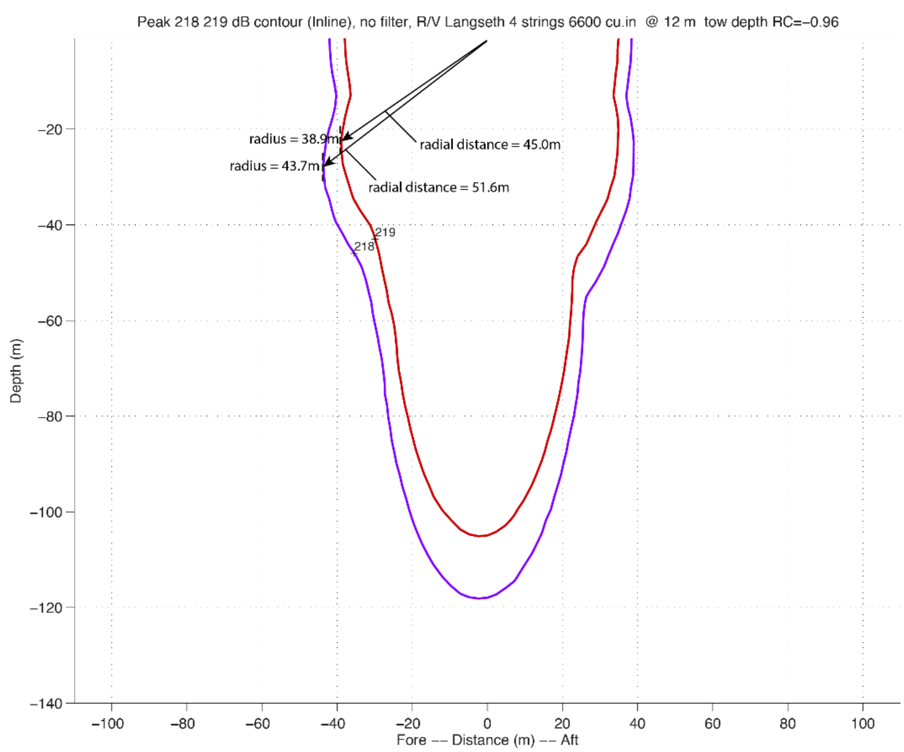


FIGURE A-11. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

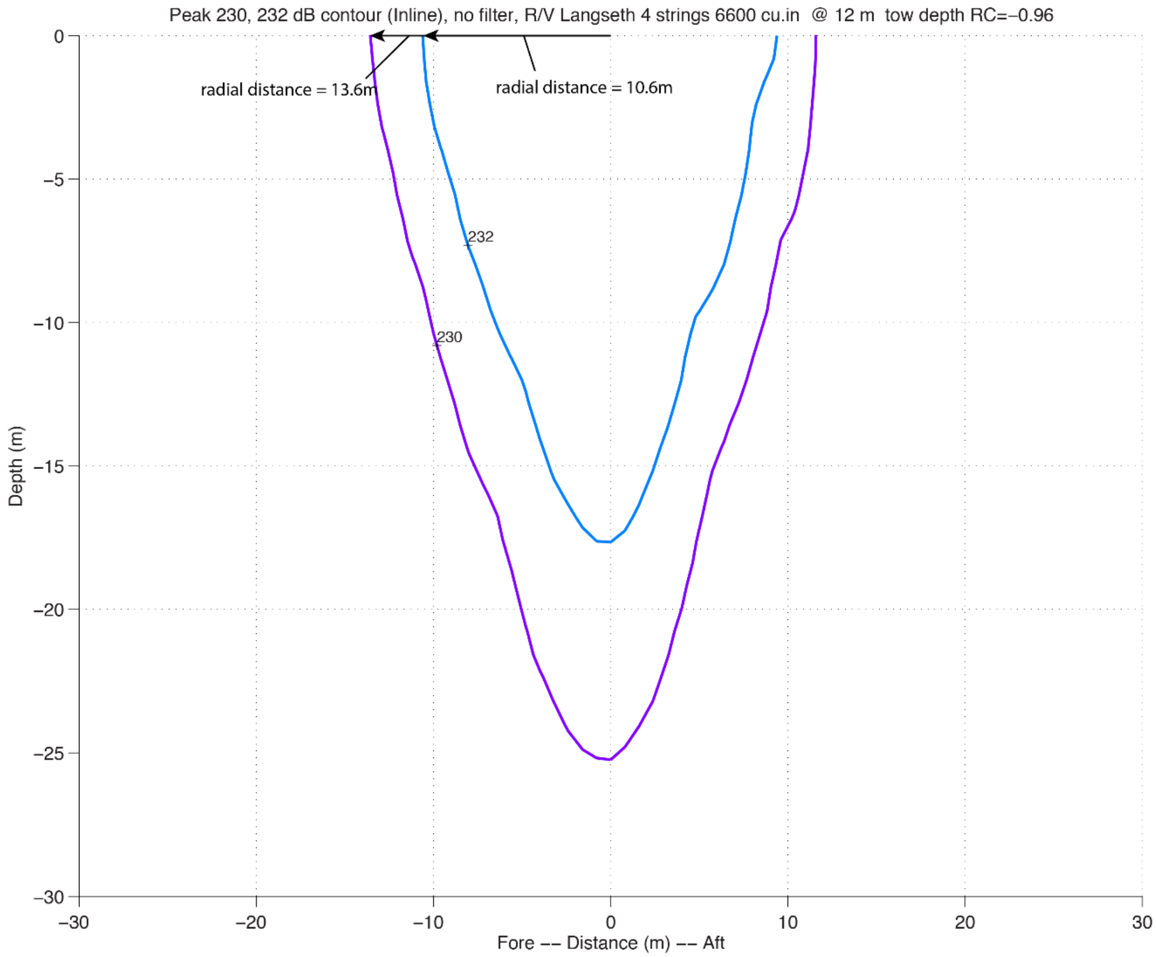


FIGURE A-12. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

TABLE A-5. Level A threshold distances for different marine mammal hearing groups. 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.

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}	**40.1**	0	0.1	1.3	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 in³ 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.

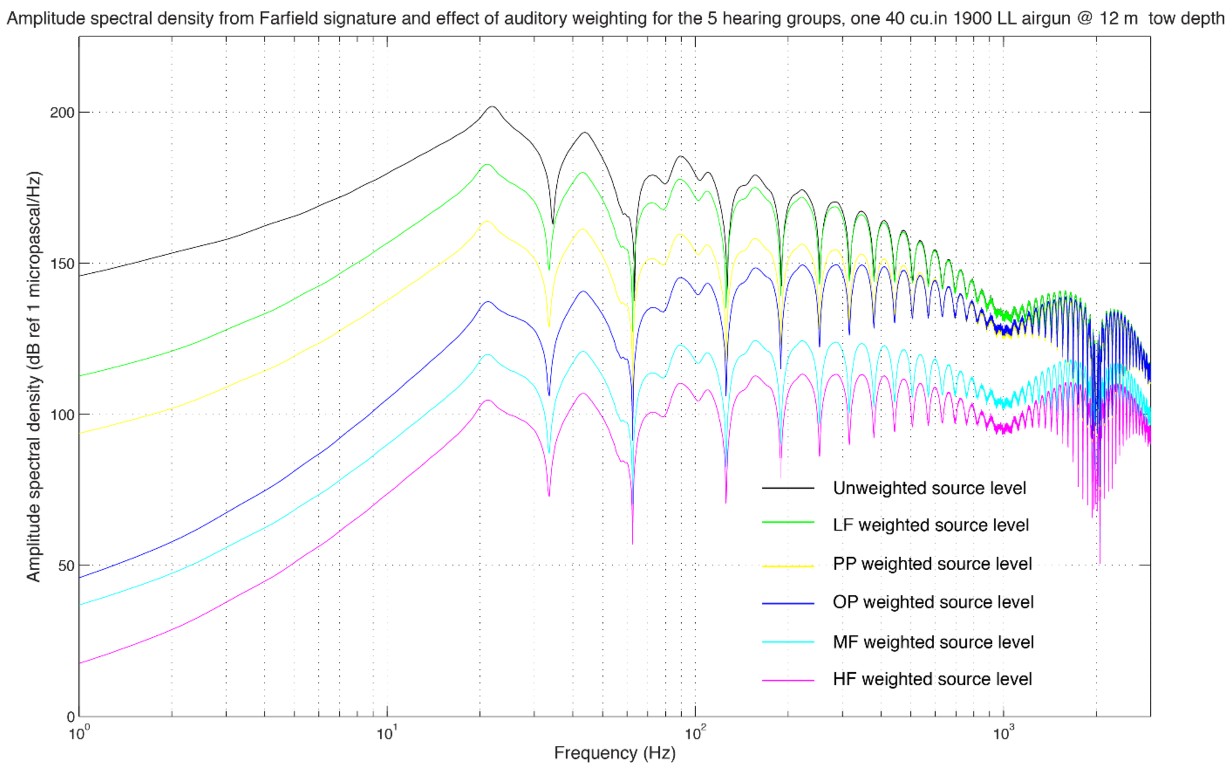


FIGURE A-13. Modeled amplitude spectral density of the 40-in³ airgun farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are 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	one 40 cu.in 1900LL airgun @ a 12 m tow depth
Please include any assumptions	
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)	2.57222	5 knots
1/Repetition rate^ (seconds)	155.2355	

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

^Time between onset of successive pulses.

		Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
	Modified farfield SEL	202.9907	202.8948	204.368	202.8948	202.3491
	Source Factor	1.28256E+18	1.25455E+18	1.7612E+18	1.25455E+18	1.10642E+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)	**0.0**	**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-13).

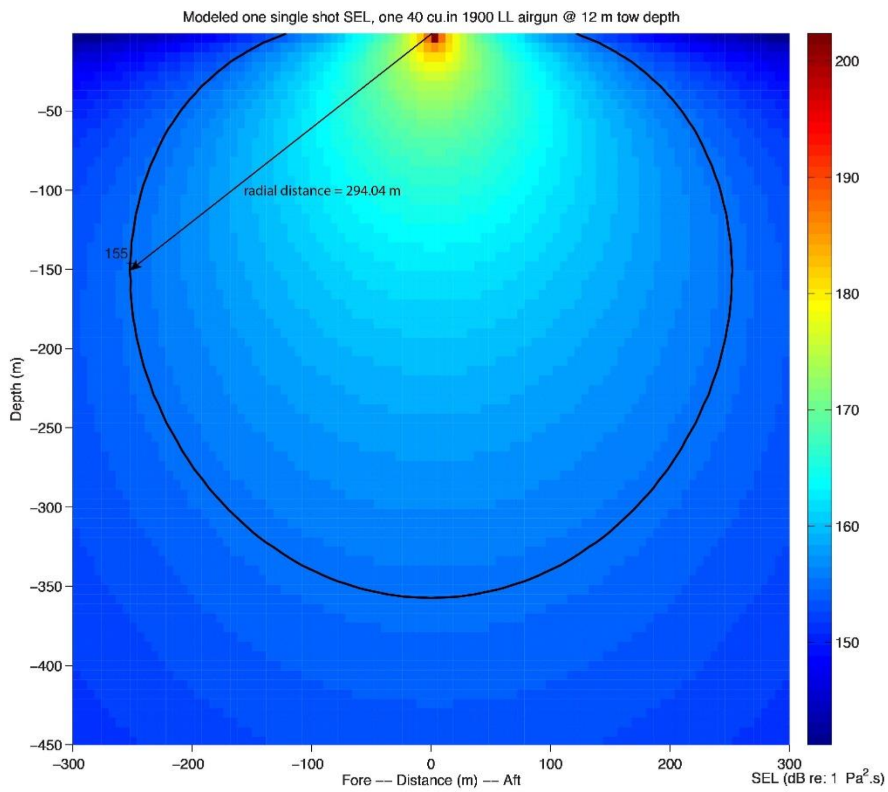


FIGURE A-14. Modeled received sound levels (SELs) in deep water from one 40-in³ airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (294.04 m).

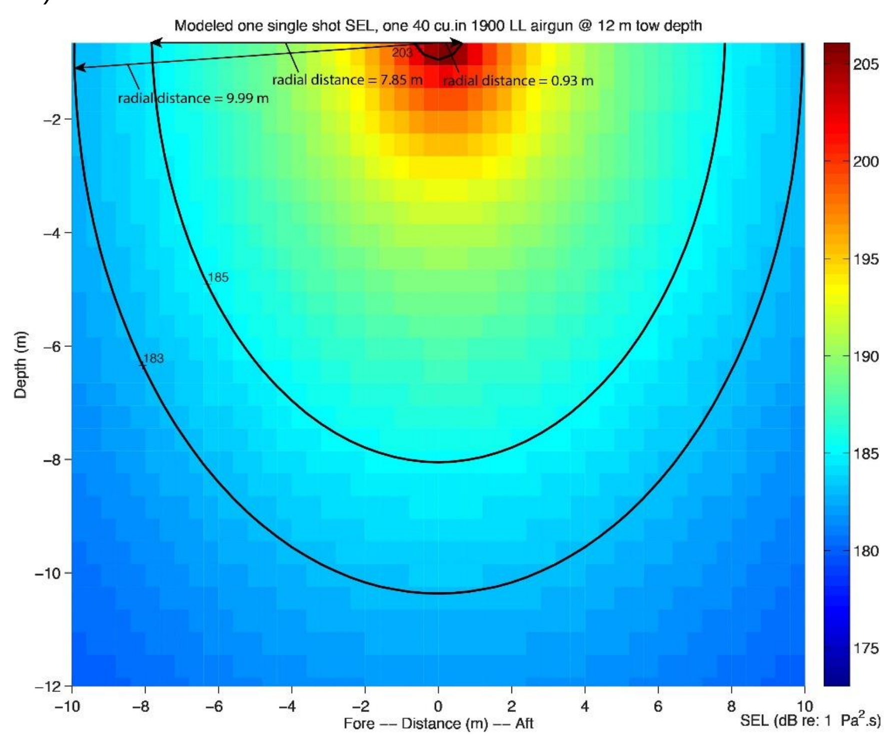


FIGURE A-15. Modeled received sound levels (SELs) in deep water from one 40-in³ airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183–185 dB and 203 dB SEL isopleths.

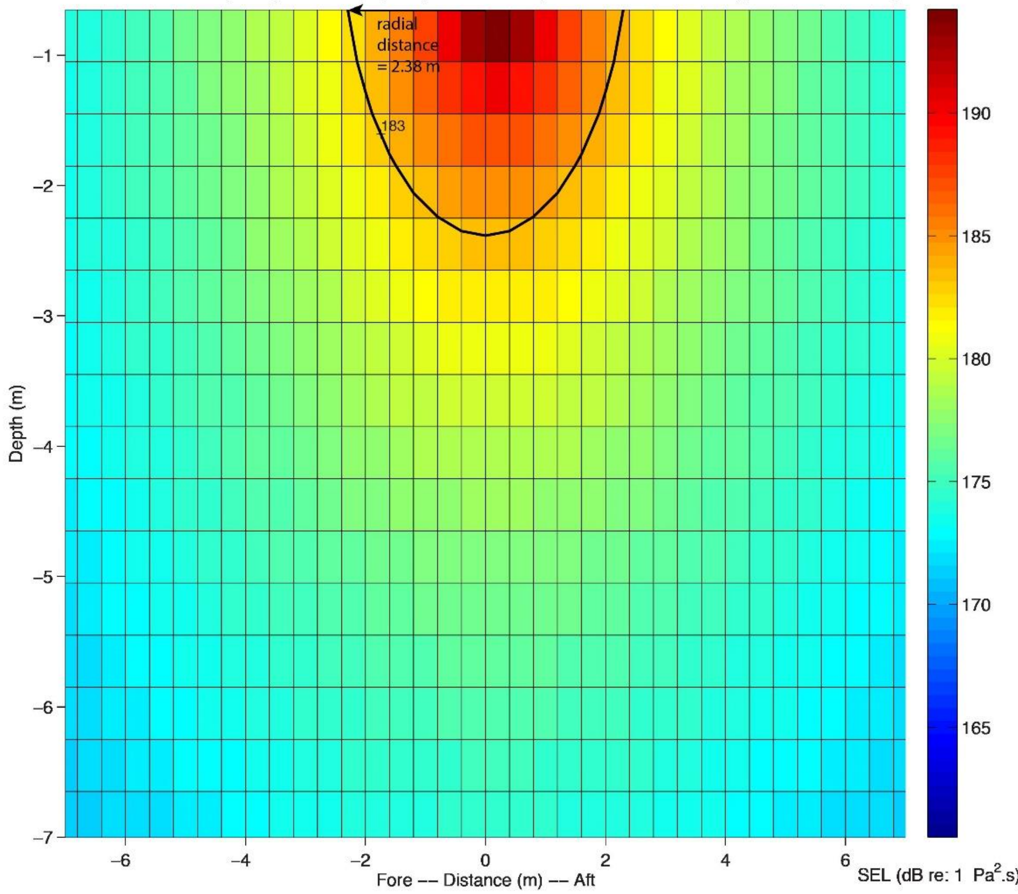


FIGURE A-16. Modeled received sound exposure levels (SELs) from one 40-in^3 mitigation at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-15 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 survey in the GOA.

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)	1.76	N.A.	12.47	1.98	N.A.
Modified Farfield Peak	223.93	N.A.	223.92	223.95	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.

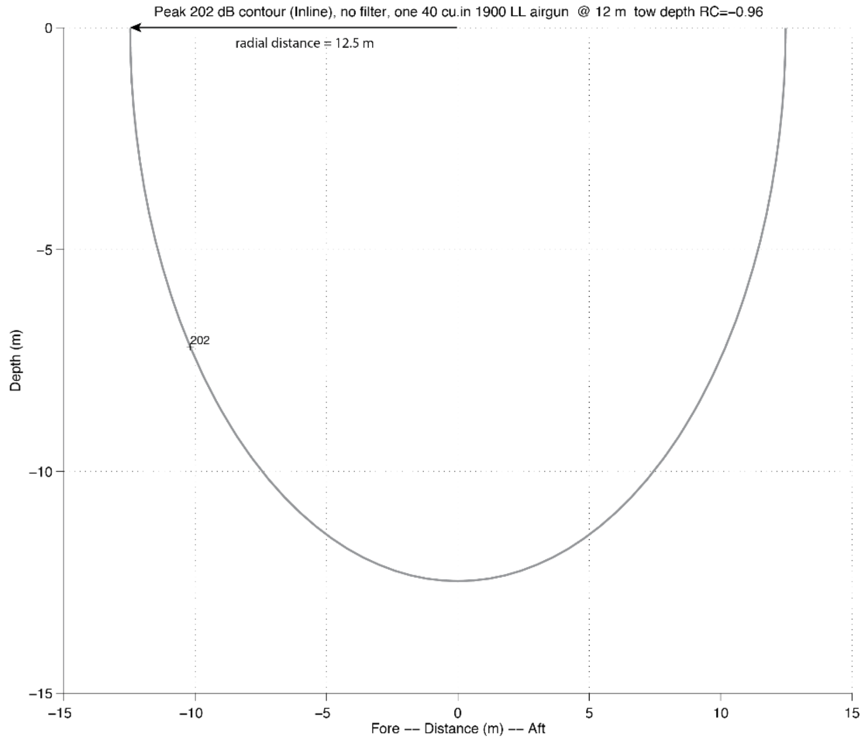


FIGURE A-17. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB Peak isopleth.

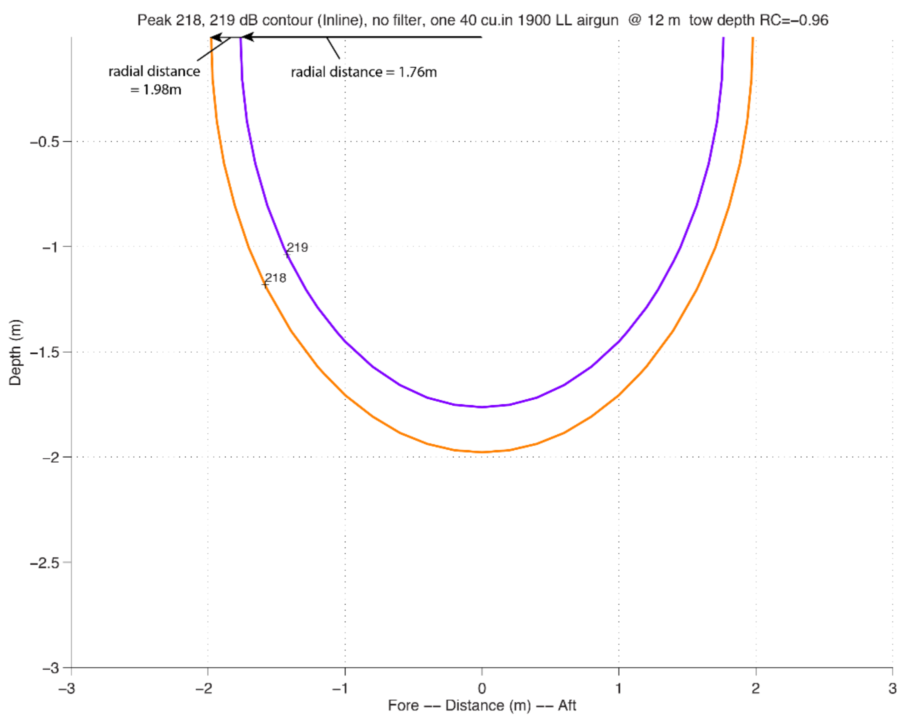


FIGURE A-18. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distances from the source geometrical center to the 218 and 219-dB Peak isopleths.

TABLE A-9. 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 survey in the GOA.

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]
		<100 m	14[4](100[3])	170[4]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	181[1]	1,864[1]
		100–1000 m	272[1]	2,796[2]
		<100 m	344[4]	4,123[4]

[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.
[4] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

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APPENDIX B: MARINE MAMMAL DENSITIES

Sources of Marine Mammal Densities

For the proposed survey, we consulted with NMFS regarding which marine mammal density sources to use for developing take estimates. In response, NMFS recommended the use of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the GOA (DoN 2014). To develop densities specific to the GOA, the Navy conducted two comprehensive marine mammal surveys in the Temporary Marine Activities Area (TMAA) in the GOA prior to 2014. The first survey was conducted from 10 to 20 April 2009 and the second was from 23 June to 18 July 2013. Both surveys used systematic line-transect survey protocols including visual and acoustic detection methods (Rone et al. 2010; Rone et al. 2014). The data were collected in four strata that were designed to encompass the four distinct habitats within the TMAA and greater GOA: Inshore – all waters <1000 m deep; Slope – from 1000 m water depth to the Aleutian trench/subduction zone; Offshore – waters offshore of the Aleutian trench/subduction zone; Seamount – waters within defined seamount areas (Rone et al. 2014).

Rone et al. (2014) provided stratified line-transect density estimates used in this analysis for fin, humpback, blue, sperm, and killer whales, as well as northern fur seals (Table B-1). Abundance estimates for unidentified large whales were prorated among blue, fin, and humpback whales within each stratum and proportionately incorporated into each species density estimate. Data from a subsequent survey in 2015 were used to calculate alternative density estimates for several species (Rone et al. 2017); however, the reported densities for blue, fin and humpback whales were not prorated for unidentified large whale sightings so the densities from Rone et al. (2014) were maintained. The density estimates for Dall's porpoise in Rone et al. (2017) were somewhat larger than those in Rone et al. (2014), so the larger densities were used as a cautionary approach.

There were insufficient sightings data from the 2009, 2013 and 2015 line-transect surveys to calculate reliable density estimates for other marine mammal species in the GOA. DoN (2014) derived gray whale densities in two zones, nearshore (0–2.25 n.mi from shore) and offshore (from 2.25–20 n.mi. from shore). In our calculations, the nearshore density was used to represent the Inshore zone and the offshore density was used to represent the Slope zone. This approach assumes a higher density of gray whales across a larger area and should yield a conservative estimate of potential exposures.

Harbor porpoise densities in DoN (2014) were derived from Hobbs and Waite (2010) which included additional shallow water depth strata. The density estimate from the 100 m to 200 m depth strata was used to represent the entire Inshore zone (<1000 m) in this analysis. Similarly, harbor seals typically remain close to shore so minimal estimates were used for the three deep water zones and a one thousand fold increase of the minimal density was used to represent the entire inshore zone (DoN 2014).

Densities for Minke whale, Pacific white-sided dolphin, and Cuvier's and Baird's beaked whales were based on Waite (2003; *in* DoN 2009). Although sei whale sightings and Stejneger's beaked whale acoustic detections were recorded during the Navy funded GOA surveys, data were insufficient to calculate densities for these species, so predictions from a global model of marine mammals densities were used (Kaschner et al. 2012 *in* DoN 2014). Steller sea lion and northern elephant seal densities were calculated using shore-based population estimates divided by the area of the GOA Large Marine Ecosystem (DoN 2014). The North Pacific right whale, Risso's dolphin, and California sea lion are only rarely observed in or near the survey area, so minimal densities were used to represent their potential presence.

All densities were corrected for perception bias [$f(0)$] but only harbor porpoise densities were corrected for availability bias [$g(0)$], as described by the respective authors.

The northern sea otter density was calculated by dividing the Southwest Alaska Stock abundance estimate (54,772; USFWS 2014) by the total area of water <40 m deep within this stock's range (75,336 km^2). Sea otters generally occur in shallow (<35 m), nearshore waters in areas with sandy or rocky bottoms, where they feed on a wide variety of sessile and slow-moving benthic invertebrates (Rotterman and Simon-Jackson 1988). Although the proposed survey lines in shallow water are near Kodiak Island and along the southeastern part of the Alaska Peninsula where densities are likely to be relatively high, sea otters prefer sheltered coastal waters over open-water areas where most of the proposed survey will take place (Figure 1). Therefore, the resulting density of 0.7270 individuals/km^2 was multiplied by the area of water <40 m deep potentially ensonified to 160 dB rather than the entire Inshore area (<1000 m deep) used for other species.

TABLE B-1. Densities of marine mammals in the Gulf of Alaska survey area. Species listed as "Endangered" under the ESA are in italics.

Species	Estimated Density (#/1000 km^2)				Source
	Inshore <1000 m	**Slope** (1000 m to Aleutian Trench)	**Offshore** (Offshore of Aleutian Trench)	**Seamount** (In Defined Seamount Areas)	
LF Cetaceans					
North Pacific right whale	0.01	0.01	0.01	0.01	DoN (2014)
Humpback whale	129.00	0.20	1.00	1.00	Rone et al. (2014)
Blue whale	0.50	0.50	0.50	2.00	Rone et al. (2014)
Fin whale	71.00	14.00	21.00	5.00	Rone et al. (2014)
Sei whale	0.10	0.10	0.10	0.10	Kaschner et al. (2012) *in* DoN (2014)
Minke whale	0.60	0.60	0.60	0.60	Waite (2003) *in* DoN (2009)
Gray whale	48.57	2.43	0.00	0.00	DoN (2014)
MF Cetaceans					
Sperm whale	0.00	3.30	1.30	0.36	Rone et al. (2014)
Killer whale	5.00	20.00	2.00	2.00	Rone et al. (2014)
Pacific white-sided dolphin	20.80	20.80	20.80	20.80	Waite (2003) *in* DoN (2009)
Cuvier's beaked whale	2.20	2.20	2.20	2.20	Waite (2003) *in* DoN (2009)
Baird's beaked whale	0.50	0.50	0.50	0.50	Waite (2003) *in* DoN (2009)
Stejneger's beaked whale	0.01	1.42	1.42	1.42	Kaschner et al. (2012) *in* DoN (2014)
Risso's dolphin	0.01	0.01	0.01	0.01	DoN (2014)
HF Cetaceans					
Harbor Porpoise	47.30	0.00	0.00	0.00	Hobbs and Waite (2010) *in* DoN (2014)
Dall's porpoise	218.00	196.00	37.00	24.00	Rone et al. (2017)
Otariid Seals					
Steller sea lion	9.80	9.80	9.80	9.80	DoN (2014)
California sea lion	0.01	0.01	0.01	0.01	DoN (2014)
Northern fur seal	15.00	4.00	17.00	6.00	Rone et al. (2014)
Phocid Seal					
Northern elephant seal	2.20	2.20	2.20	2.20	DoN (2014)
Harbor seal	10.00	0.01	0.01	0.01	DoN (2014)
Marine Fissiped					
Northern Sea Otter	727.03	0.00	0.00	0.00	USFWS (2014)

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APPENDIX C: MARINE MAMMAL TAKE CALCULATIONS

TABLE C-1. Densities of marine mammals and areas ensonified above threshold levels used to calculate potential takes from the proposed Gulf of Alaska survey. Species listed as "Endangered" under the ESA are in italics.

	Estimated Density (#/1000 km^2)					NMFS Level B 160 dB Daily Ensonified Area				Level A Ensonified Area (km^2)							
Species	Inshore <1000 m	Slope 1000 m to Aleutian Trench	Offshore Offshore of Aleutian Trench	Seamount Within Defined Seamount Areas	Regional Population Size	Inshore <1000 m	Slope 1000 m to Aleutian Trench	Offshore Offshore of Aleutian Trench	Seamount Within Defined Seamount Areas	Inshore <1000 m	Slope 1000 m to Aleutian Trench	Offshore Offshore of Aleutian Trench	Seamount Within Defined Seamount Areas	Total Level B Takes	Total Level A Takes	Total Takes	% of Pop. (Total Takes)
LF Cetaceans																	
North Pacific right whale	0.01	0.01	0.01	0.01	400	2,454	855	1,449	150	7	7	1	4	1	1	2	0.50
Humpback whale	129.00	0.20	1.00	1.00	21,063	2,454	855	1,449	150	7	7	1	4	5,730	1	5,731	27.21
Blue whale	0.50	0.50	0.50	2.00	1,647	2,454	855	1,449	150	7	7	1	4	49	1	50	3.04
Fin whale	71.00	14.00	21.00	5.00	18,680	2,454	855	1,449	150	7	7	1	4	3,913	1	3,914	20.95
Sei whale	0.10	0.10	0.10	0.10	27,197	2,454	855	1,449	150	7	7	1	4	9	1	10	0.04
Minke whale	0.60	0.60	0.60	0.60	25,000	2,454	855	1,449	150	7	7	1	4	54	1	55	0.22
Gray whale	48.57	2.43	0.00	0.00	20990	2,454	855	1,449	150	7	7	1	4	2,183	1	2,184	10.40
MF Cetaceans																	
Sperm whale	0.00	3.30	1.30	0.36	26,300	2,454	855	1,449	150	2	2	0	1	86	1	87	0.33
Killer whale	5.00	20.00	2.00	2.00	8,500	2,454	855	1,449	150	2	2	0	1	587	1	588	6.92
Pacific white-sided dolphin	20.80	20.80	20.80	20.80	988,333	2,454	855	1,449	150	2	2	0	1	1,838	1	1,839	0.19
Cuvier's beaked whale	2.20	2.20	2.20	2.20	20,000	2,454	855	1,449	150	2	2	0	1	195	1	196	0.98
Baird's beaked whale	0.50	0.50	0.50	0.50	25,300	2,454	855	1,449	150	2	2	0	1	45	1	46	0.18
Stejneger's beaked whale[1]	0.01	1.42	1.42	1.42	25,300	2,454	855	1,449	150	2	2	0	1	64	1	65	0.26
Risso's dolphin	0.01	0.01	0.01	0.01	838,000	2,454	855	1,449	150	2	2	0	1	1	1	2	0.00
HF Cetaceans																	
Harbor Porpoise	47.30	0.00	0.00	0.00	79,261	2,454	855	1,449	150	49	43	5	25	2,090	3	2,093	2.64
Dall's porpoise	218.00	196.00	37.00	24.00	1,186,000	2,454	855	1,449	150	49	43	5	25	13,677	21	13,698	1.15
Otariid Seals																	
Steller sea lion	9.80	9.80	9.80	9.80	53,303	2,454	855	1,449	150	2	2	0	1	866	1	867	1.63
California sea lion	0.01	0.01	0.01	0.01	296,750	2,454	855	1,449	150	2	2	0	1	1	1	2	0.00
Northern fur seal	15.00	4.00	17.00	6.00	1,100,000	2,454	855	1,449	150	2	2	0	1	1,184	1	1,185	0.11
Phocid Seal																	
Northern elephant seal	2.20	2.20	2.20	2.20	239,000	2,454	855	1,449	150	8	7	1	4	195	1	196	0.08
Harbor seal	10.00	0.01	0.01	0.01	129,000	2,454	855	1,449	150	8	7	1	4	443	1	444	0.34
Marine Fissiped																	
Northern Sea Otter[2]	727.03	0.00	0.00	0.00	54,771	594	855	1,449	150	2	2	0	1	7,768	2	7,770	14.19

[1] Abundance estimate not available, but acoustic monitoring suggests Stejneger's beaked whales are at least as abundant as Baird's beaked whale in the GOA (Baumann-Pickering et al. 2014), so use of Baird's beaked whale abundance estimate should result in a cautionary estimate of the percent of the population potentially taken.

[2] Inshore zone defined as waters <40 m deep.

APPENDIX D: ENSONIFIED AREAS FOR MARINE MAMMAL TAKE CALCULATIONS

TABLE D-1. Areas ensonified above threshold levels used to calculate potential takes from the proposed Gulf of Alaska survey.

Survey Zone	Criteria	Daily Ensonified Area (km^2)	Total Survey Days	25% Increase	Total Ensonified Area (km^2)	Relevant Isopleth (m)
Shallow (<40 m)[1]	160 dB	474.8	18	1.25	10,683.7	25,493
Inshore (<1000 m)[2]	160 dB	1963.1	18	1.25	44,170.3	10,100
Slope (1000 m to Aleutian Trench)	160 dB	684.1	18	1.25	15,392.8	6,733
Offshore (Offshore of Aleutian Trench)	160 dB	1159.5	18	1.25	26,087.8	6,733
Seamount (Within Defined Seamount Areas)	160 dB	119.8	18	1.25	2,695.2	6,733
All zones	LF Cetacean	19.6	18	1.25	441.1	40.1
All zones	MF Cetacean	6.6	18	1.25	149.6	13.6
All zones	HF Cetacean	131.1	18	1.25	2,950.8	268.3
All zones	Otariid	5.2	18	1.25	116.6	10.6
All zones	Phocid	21.4	18	1.25	480.6	43.7

[1] Used in the calculation of potential takes of the Northern Sea Otter.
[2] Includes area ensonified above 160 dB in waters <100 m deep using an isopleth distance of 25,493 m.

Attachment 2

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

MAY 3 1 2019

Refer to NMFS No.: OPR-2018-00010

Holly Smith
Environmental Compliance Officer
2415 Eisenhower Avenue
Alexandria, Virginia 22314

RE: Endangered Species Act Section 7 Formal Consultation on the National Science Foundation's proposed funding and conduct of a high-energy marine geophysical survey by the research vessel *Marcus G. Langseth* in the Western Gulf of Alaska during June 2019 and National Marine Fisheries Service Permits and Conservation Division's issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act

Dear Ms. Smith:

Enclosed is the National Marine Fisheries Service's (NMFS) biological opinion on the effects of the National Science Foundation's proposal to fund and conduct a high-energy marine geophysical survey by the research vessel *Marcus G. Langseth* in the Western Gulf of Alaska during June 2019 on threatened and endangered species and critical habitat that has been designated for those species under NMFS's jurisdiction. This consultation also considers the NMFS Permits and Conservation Division's issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act .We have prepared the biological opinion pursuant to section 7(a)(2) of the Endangered Species Act, as amended (ESA; 16 U.S.C. 1536(a)(2)).

Based on our assessment, we concluded that these activities may affect but is not likely to adversely affect beluga whale (*Delphinapterus leucas*) Cook Inlet DPS; gray whale (*Eschrichtius robustus*) Western North Pacific Population; green turtle (*Chelonia mydas*) (Central North Pacific DPS or East Pacific DPS); leatherback turtle (*Dermochelys coriacea*); loggerhead turtle (*Caretta caretta*); olive ridley turtle (*Lepidochelys olivacea*) (Mexico's Pacific coast breeding colonies or other areas); chinook salmon (*Oncorhynchus tshawytscha)* (lower Columbia River ESU, Puget Sound ESU, Snake River fall-run ESU, Snake River spring/summer ESU, and Upper Willamette River ESU); chum salmon (*Oncorhynchus keta*) Hood Canal summer-run ESU; coho salmon (*Oncorhynchus kisutch*) lower Columbia River ESU; sockeye salmon (*Oncorhynchus nerka*) Snake River ESU; steelhead trout (*Oncorhynchus mykiss*) (lower Columbia River DPS, middle Columbia River DPS, Snake River Basin DPS, upper Columbia River DPS, and upper Willamette River DPS); and green sturgeon (*Acipenser medirostris*) Southern DPS.

We conclude the proposed action is not likely to jeopardize the continued existence of blue whales (*Balaenoptera musculus)*, fin whales (*Balaenoptera physalus)*, Mexico DPS of humpback whales (*Megaptera novaeangliae*), Western North Pacific DPS of humpback whales, North Pacific right whales (*Eubalaena japonica*), sei whales (*Balaenoptera borealis*), sperm whales (*Physeter microcephalus*), and Western DPS of Steller sea lions (*Eumetopias jubatus*).

We also conclude the proposed action will not destroy or adversely modify designated critical habitat for the North Pacific right whale and Western DPS of Steller sea lion.

This concludes section 7 consultation on this action. The National Science Foundation is required to reinitiate formal consultation on this action, where it retains discretionary involvement or control over the action and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this consultation; or (4) a new species is listed or critical habitat designated that may be affected by the action.

If you have any questions regarding this biological opinion, please contact me at (301) 427-8495 or cathy.tortorici@noaa.gov or Greg Fulling at (301) 427-8498 or greg.fulling@noaa.gov.

Sincerely,

Cathryn E. Tortorici
Chief, ESA Interagency Cooperation Division
Office of Protected Resources

National Marine Fisheries Service
Endangered Species Act Section 7
Biological Opinion

Title:	Biological Opinion on the Lamont-Doherty Earth Observatory's Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the Western Gulf of Alaska and National Marine Fisheries Service Permits and Conservation Division's Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Action Agency:	National Science Foundation-Division of Ocean Sciences and the National Oceanic Atmospheric Administration National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division
Publisher:	Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Approved:	Donna S. Wieting Donna S. Wieting Director, Office of Protected Resources
Date:	MAY 3 1 2019

Consultation Tracking number: OPR-2018-00010

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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concur with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

The action agencies for this consultation are the National Science Foundation (NSF) and the NMFS's Permits and Conservation Division. Two federal actions are considered in this biological opinion (opinion). The first is the NSF's proposal to fund a seismic survey in the Western Gulf of Alaska in June 2019, in support of an NSF-funded collaborative research project, led by Columbia University's Lamont-Doherty Observatory (L-DEO). The second is the NMFS' Permits and Conservation Division proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" by Level B harassment (as defined by the Marine Mammal Protection Act (MMPA)) of marine mammals incidental to the planned seismic survey, pursuant to section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371 (a)(5)(D).

This consultation, opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§401-16), and agency policy and guidance was conducted by the NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we"). This opinion and incidental take statement were prepared by the NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division

(NMFS ESA Interagency Cooperation Division) in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. §402.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on endangered and threatened marine mammals, sea turtles, and fishes and designated critical habitat for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The NSF is proposing to fund and conduct a marine seismic survey for scientific research purposes and data collection in the Western Gulf of Alaska in June 2019. In conjunction with this action, the NMFS Permits and Conservation Division will issue an IHA under the MMPA for incidental takes of marine mammals that could occur during the NSF seismic survey. This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of the two proposed federal actions on threatened and endangered species, and has been prepared in accordance with section 7 of the ESA. Both the NSF and the NMFS Permits and Conservation Divisionhave conducted similar actions in the past and have been the subject of ESA section 7 consultations. The previous opinions for NSF's seismic surveys in the Western Gulf of Alaska (2011), Northeast Pacific (2012), Northeast Atlantic (2013), and Hawaii (2018) and the issuance of an IHA determined that the authorized activities were not likely to jeopardize the continued existence of ESA-listed species, or result in the destruction or adverse modification of designated critical habitat.

1.2 Consultation History

This opinion is based on information provided in the NSF draft environmental assessment (EA) prepared pursuant to the National Environmental Policy Act, MMPA IHA application, a notice of a proposed IHA prepared pursuant to the MMPA, monitoring reports from similar activities, published and unpublished scientific information on threatened and endangered species and their surrogates, scientific and commercial information such as reports from government agencies and the peer-reviewed literature, biological opinions on similar activities, and other sources of information. Our communication with the NSF and NMFS Permits and Conservation Division regarding this consultation is summarized as follows:

- On October 1, 2018, the NSF requested a list of ESA-listed species/critical habitat list that may occur with the area of a proposed seismic survey in Western Gulf of Alaska in June 2019, as well as suggested data sources for marine mammal and sea turtle abundance and densities in the action area. The NSF provided a map with track lines and an EA from seismic survey conducted in 2011 with geographic overlap.
- On October 18, 2018, we responded to the NSF request and provided a list of ESA-listed species and designated critical habitat (via email) that may occur in the action area in the

Western Gulf of Alaska, as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.

- On November 16, 2018, NSF provided a section 7 consultation package that included a request for consultation letter and draft EA.
- On November 16, 2018 we determined there is sufficient information to initiate formal consultation.
- On November 19, 2018, NSF and Lamont-Doherty (L-DEO) provided an IHA application to NMFS ESA Interagency Cooperation Division and NMFS Permits and Conservation Division.
- On November 26, 2018 we sent the NMFS Alaska Regional Office the draft EA and IHA for review.
- On December 22, 2018, consultation was held in abeyance for 38 days due to a lapse in appropriations and resulting partial government shutdown. Consultation resumed on January 28, 2019.
- On February 20, 2019 we received the comments from the NMFS Alaska Regional Office on the NSF's draft EA.
- On March 20, 2019 we provided the NSF with an initiation letter for the section 7 consultation of the Western Gulf of Alaska Seismic Survey.
- On March 21, 2019 we received the initiation packet from the NMFS Permits and Conservation Division requesting consultation on the NSF/L-DEO Gulf of Alaska Seismic Survey.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"*Jeopardize the continued existence of*" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. §402.02.

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02). An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and those aspects (or stressors) of the proposed action that may have direct or indirect effects on the physical, chemical, and biotic environment.

Action Area (Section 4): We describe the proposed action and those aspects (or stressors) of the proposed action that may have direct or indirect effects on the physical, chemical, and biotic environment, we identify any interrelated and interdependent actions, and describe the action area with the spatial extent of those stressors.

Interrelated and Interdependent Actions (Section 5): We identify any interrelated and interdependent actions. *Interrelated* actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility, apart from the action under consideration.

Potential Stressors (Section 6): We identify the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat.

Species and Critical Habitat Not Likely to be Adversely Affected (Section 7): We identify the ESA-listed species and designated critical habitat that are likely to either not be affected or are not likely to be adversely affected by the stressors.

Species and Critical Habitat Likely to be Adversely Affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species and designated critical habitat that are likely to co-occur with the proposed stressors in space and time that are likely to be adversely affected and evaluate the status of those species and habitat.

Status of the Species Likely to be Adversely Affected (Section 9): We describe the status of ESA-listed species and designated critical habitat range-wide and identify those species and habitats that are likely to occur in the action area.

*Environmental Baseline (*Section 10): We describe the environmental baseline in the action area including: past and present impacts of federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed federal projects that have already undergone formal or early section 7 consultation; and impacts of state or private actions that are contemporaneous with the consultation in process.

Effects of the Action (Section 11): We identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or sub-populations to which those individuals belong. We also consider whether the action may affect designated critical habitat. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond to the stressors given their probable exposure and consider how the action may affect designated critical habitat. We also assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis. The risk analysis considers the impacts of the proposed action on the essential features and conservation value of designated critical habitat.

Integration and Synthesis (Section 12): In this section we integrate the analyses in the opinion to summarize the consequences from the proposed action to ESA-listed species and designated critical habitat under NMFS' jurisdiction.

Cumulative Effects (Section 13): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 CFR §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Conclusion (Section 14): With full consideration of the status of the species and the designated critical habitat, we consider the effects of the action within the action area on populations or sub-populations and on essential features of designated critical habitat when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or
- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (50 C.F.R. §402.14).

In addition, we include an incidental take statement (Section 15) that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures. ESA section 7 (b)(4); 50 C.F.R. §402.14(i). We also provide discretionary conservation recommendations that may be implemented by action agency (Section 16) (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which reinitiation of consultation is required (Section 17) (50 C.F.R. §402.16).

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of *Google Scholar*, and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the NSF and NMFS Permits and Conservation Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- National Oceanic and Atmospheric Administration (NOAA) technical memorandums;

- Monitoring reports; and
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies.

Two federal actions were evaluated in this opinion. The first is the NSF's proposal to fund the research vessel *Marcus G. Langseth* (*Langseth*), operated by the L-DEO of Columbia University, to conduct a seismic survey in the western Gulf of Alaska (GOA) in 2019. The second is the NMFS' Permits and Conservation Division proposal to issue an IHA authorizing non-lethal "takes" by Level B harassment pursuant to section 101 (a)(5)(D) of the MMPA.

The information presented here is based primarily upon the EA provided by NSF as part of the initiation package, and the NMFS Permits and Conservation Division's IHA initiation package.

3.1 National Science Foundation's and Lamont-Doherty Earth Observatory's Proposed Activities

The NSF proposes to fund the use of the *Langseth*, operated by the L-DEO of Columbia University, to conduct a seismic survey in the Western GOA.

The NSF's proposed action will involve a seismic survey in the Western GOA. The research goal of the survey would be to collect 2D wide-angle seismic reflection/refraction data off the Alaska Peninsula and provide valuable information regarding geohazards like tsunamis and earthquakes. An airgun array, multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler will be implemented as energy sources.

3.1.1 Seismic Survey Overview and Objectives

Researchers from L-DEO, Cornell University, Colgate University, University of Washington, University of California Santa Cruz, University of Colorado Boulder, University of New Mexico, Washington University in St. Louis, and NSF (herein collectively referred to as the Proposing Institutions), have proposed to conduct a seismic survey using the *Langseth* in the western GOA in the Northeast Pacific Ocean (see Section 4 Action Area, Figure 1).

The proposed survey would take advantage of passive seismic equipment already deployed in support of the Alaska Amphibious Community Seismic Experiment (AACSE). The survey would employ active sources (airguns), and data collected would supplement the overall project goals of AACSE, which involve imaging the architecture of the subduction zone and understanding variability in slip behavior of the Alaska Peninsula subduction zone. The proposed activity, however, has independent utility from the AACSE and would provide unique higher resolution imaging of the subduction zone that is not possible with the AACSE data alone. Data collected would be in support of research that meets NSF program priorities and NSF's critical need to foster an understanding of Earth processes.

AACSE deployed 75 ocean bottom seismometers offshore of the Alaska Peninsula (see Section 4 Action Area, Figure 2) in spring 2017, and this array will remain on the seafloor for 15 months until the end of summer 2019. The proposed study consists of a 19 day cruise to collect a wide-angle reflection/refraction dataset using a subset of the AACSE array. This project focuses on two subduction zone segments — the Semidi segment and the SW Kodiak Aperity. The addition of active sources (airguns) to the AACSE would directly contribute to the overall project goals of imaging the architecture for the subduction zone and understanding the structures controlling how and where the planet's largest earthquakes occur. In particular, the 3D P-wave velocity model derived from this seismic experiment would be beneficial for future AACSE passive array studies by providing the structure underneath a subset of the AACSE ocean bottom seismometer array. Data from this project would be made available for general scientific community use, referred to as "open access." The seismic data could be used to evaluate earthquake and tsunami hazards.

To collect these data, the *Langseth* would tow an array of 36 airguns at a depth of 12 meters (m) (39.4 feet [ft]) as an energy source with a total volume of ~6,600 cubic inches (in^3) (108,154.6 cubic centimeters [cm^3]). The receiving system would consist of previously deployed Ocean Bottom Seismometers, onshore seismometers, and 4 km streamers carrying hydrophones (towed for a portion of the survey). In addition, a multibeam echosounder, sub-bottom profiler, and acoustic Doppler current profiler will continuously operate from the Langseth during the entire cruise, but not during transit to and from the survey areas.

The project consists of a number of tracklines that cross the trench onto the Pacific plate and shorter connecting tracklines. The representative tracklines shown in Figure 1 have a total length of 4,400 kilometers (km) (2,375.8 nautical miles [nmi]). 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, 25 percent has been added in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed. During the survey, approximately 13 percent of the line km would take place in shallow water (<100 m; <328 ft), 27 percent would occur in intermediate water depths (100–1,000 m; 328-3,281 ft), and the rest (60 percent) would occur in deep water (>1,000 m; >3,280.8 ft).

The survey is expected to consist of up to 18 days of seismic operations and ~1 day of transit. The *Langseth* would leave from and return to port in Kodiak, Alaska likely during late spring (end of May/early June) 2019. Tentative sail dates are 1–19 June 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.

3.1.2 Source Vessel Specifications

The seismic survey will involve one source vessel, the U.S.-flagged R/V *Langseth*. The *Langseth* is owned by the NSF L-DEO. The Langseth will tow an airgun array as a sound source along predetermined lines (Figure 1). The *Langseth* has a length of 72 m (235 ft), a beam of 17 m (56 ft), and a maximum draft of 5.9 m (19.4 ft). Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bowthruster. The *Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic data acquisition is typically approximately 9.3 km per hour (5 kts; 5.75 mph). When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km per hour (10 kts; 11.6 mph) and has a range of approximately 13,500 (km) (7,289.4 nmi). No chase vessel will be used during seismic survey activities. The *Langseth* will also serve as the platform from which vessel-based protected species observers (acoustic and visual) will listen and watch for animals (e.g., marine mammals and sea turtles).

3.1.3 Airgun-Array and Acoustic Receivers Description

During the seismic surveys, the *Langseth* will deploy an airgun array as an energy source. An airgun is a device used to emit acoustic energy pulses downward through the water column and into the seafloor, and generally consists of a steel cylinder that is charged with high-pressure air. Release of the compressed air into the water column generates a signal that reflects (or refracts) off the seafloor and/or sub-surface layers having acoustic impedance contrast. When fired, a brief (approximately 0.1 second) pulse (or shot) of sound is emitted by all airguns nearly simultaneously. The airguns are silent during the intervening periods with the array typically fired on a fixed distance (or shot point) interval. As the airgun arrays are towed along the survey lines, the return signal is recorded by listening devices (e.g., receiving system – seismometers or towed hydrophone streamer) and later analyzed with computer interpretation and mapping systems used to depict the sub-surface.

The airgun array for this two two-dimensional seismic survey will consist of 36 Bolt airguns with a total discharge volume of 6,600 cubic inches (in^3) (108,154.6 cm^3). The airguns will be configured as four identical linear arrays or "strings." The four airgun strings will be towed behind the *Langseth* and will be distributed across an area approximately 24 m (78.7 ft) by 16 m (52.5 ft) (Table 1). The airgun shot interval would be 399.3 m (1,310.0 ft) (~155 seconds) at a speed of 5 knots (kts) (5.8 miles per hour).

Table 1. Source array specifications for the proposed survey.

Source array specifications	
Energy source	36 inline 45-in^3 airguns
Source output (downward)-36 air gun array	Zero to peak = 230.9 dB re 1 μPa-m Peak to peak = 236.7 dB re 1 μPa-m
Air discharge volume	~ 6,600-in^3
Dominant frequency components	0 to 188 hertz
Tow depth	12-m

The sound signals produced by the airguns attenuates as it moves away from the source, decreasing in amplitude, but also increasing in signal duration. Because the actual sound source originates from the 36 airgun array rather than a single point source, the highest sound levels measurable at any location in the water is less than the nominal source level. The nominal “farfield” calculation does not take into account airgun array effect where the summing of the individual airguns when fired at the same time has destructive interferences which reduce the levels. In addition, the effective source level for sound propagating in near-horizontal directions will be substantially lower than the nominal source level applicable to downward propagation because of the direction (e.g., downward versus horizontal) of the sound from the airgun array. Near the sea surface, the sound field includes reflections from the air-water (i.e., surface) interface. The “ghost” effect (i.e., the free-surface reflection from air-water interface that interferes with the primary pulse) near the water interface causes cancellation (much of the primary energy) in the near-horizontal sound field while vertical propagation is increased.

The receiving system would primarily consist of previously deployed Ocean Bottom Seismometers and onshore seismometers . As the airgun arrays are towed along the survey lines, these seismometers would receive and store the returning acoustic signals internally for later analysis. However, a 4 km streamer would be towed along with the air gun array during the first 6 surveys lines moving east to west, to receive the reflected signals and transfer the data to the on-board processing system.

3.1.3.1 Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the seismic survey from the *Langseth*. The Kongsberg EM 122 multi-beam echosounder and Knudsen Chirp 3260 sub-bottom profiler will map the ocean floor during the seismic survey. The Teledyne RDI 75 kiloHz (kHz) Ocean Surveyor acoustic Doppler current profiler will measure water current velocities. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound sources will operate continuously from the *Langseth*, including simultaneously with the airgun array, but not during transit to and from the seismic survey areas.

3.1.3.2 Multi-Beam Echosounder

The ocean floor will be mapped with the Kongsberg EM122 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at 10.5 to 13 (usually 12) kHz. The transmitting beamwidth is one or two degrees (°) fore-aft and 150° (maximum) athwartship (i.e., perpendicular to the ship's line of travel). This multi-beam echosounder emits "pings" with a maximum sound source level is 242 dB re: 1 µPa-m (root mean square [rms]). Each ping consists of eight (in water greater than 1,000 m [3,281 ft]) or four (in water less than 1,000 m [3,281 ft]) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore-aft. Continuous sound wave signals increase from 2 to 15 milliseconds in water depths up to 2,600 m (8,530 ft), and frequency modulated chirp signals up to 100 milliseconds are used in water greater than 2,600 m (8,530 ft). The successive transmissions span an overall cross-track angular extent of about 150 degrees (°), with two millisecond gaps between the pings for successive sectors.

3.1.3.3 Sub-Bottom Profiler

The ocean floor will also be mapped with the Knudsen 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near sea floor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27° cone, which is directed downward by a 3.5 kHz transducer in the hull of the *Langseth*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 dB re: 1 µPa m (rms). The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pulses at one second intervals followed by a five second pause. The sub-bottom profiler is capable of reaching depths of 10,000 m (3,2808.4 ft).

3.1.3.4 Acoustic Doppler Current Profiler

The Teledyne RDI 75 kHz Ocean Surveyor acoustic Doppler current profiler will be mounted on the hull of the *Langseth* to measure the speed of the water currents. The acoustic Doppler current profiler will operate at a frequency of 75 kHz and a maximum sound source level of 224 dB re: 1 µPa m (rms) over a conically-shaped 30° beam.

3.1.4 Mitigation and Monitoring

Mitigation is a measure that avoids or reduces the severity of the effects of the action on ESA-listed species. Monitoring is used to observe or check the progress of the mitigation over time and to ensure that any measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

The NMFS Permits and Conservation Division will require and the NSF and L-DEO will implement the mitigation and monitoring measures listed below. These mitigation and monitoring measures are required during the seismic surveys to reduce potential for injury or harassment to marine mammals and sea turtles. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this opinion:

- Proposed exclusion and buffer zones;
- Power-down procedures;
- Shut-down procedures;
- Ramp-up procedures;
- Visual monitoring;
- Passive acoustic monitoring;
- Ship strike avoidance measures; and
- Additional mitigation measures considered.

We discuss the proposed exclusion and buffer zones in more detail in the next section. Details for the other mitigation and monitoring measures (e.g., power-down, shut-down, and ramp-up procedures, etc.) can be found in Appendix A.

3.1.4.1 Proposed Exclusion and Buffer Zones

The NSF identifies in its draft EA that the L-DEO will implement exclusion zones around the *Langseth* to minimize any potential adverse effects of air gun sound on MMPA and ESA-listed species. These zones are areas where seismic airguns would be powered down or shut down to reduce exposure of marine mammals and sea turtles to acoustic impacts. These exclusion zones are based upon modeled sound levels at various distances from the *Langseth,* described below.

The LGL Limited, (the environmental research associates who prepared the draft EA) used modeling by L-DEO to predict received sound levels, in relation to distance and direction from thirty-six 45-in^3 Generator-Injector airguns in intermediate and deep water. In 2003, empirical data concerning 190, 180, and 160 dB re 1 μPa (rms) distances were acquired during the acoustic calibration study of the R/V *Ewing*'s air gun array in a variety of configurations in the northern Gulf of Mexico Tolstoy et al. (2004) and in 2007 to 2009 aboard the *Langseth* (Diebold et al., 2010; Tolstoy et al., 2009). As a 36-airgun array at the same tow and water depths were not measured, the estimates provided here were extrapolated from other results, using conservative assumptions. Results of the propagation measurements (Tolstoy et al., 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the array was different in the Gulf of Mexico calibration study (6 m) from in the proposed survey (12 m). Because propagation varies with array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

For deep and intermediate water depths, the field measurements in the Gulf of Mexico cannot be easily used to derive radii for proposed exclusion and buffer zones used for purposes of mitigation and monitoring. This is due to the fact that, at those sites, the calibration hydrophone for the 36 airgun acoustic calibration study was located at a roughly constant depth of 350 to 500 m (1,148.3 to 1,640.4 ft), which may not interect 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 approximately 2,000 m (6,561.7 ft). 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 airgun array tow depth are in good agreement. 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 Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating radii for mitigation purposes. In shallow water (less than 100 m [328.1 ft]), the depth of the calibration hydrophone (18 m [59.1 ft]) used during the Gulf of Mexico calibration study was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Tolstoy et al. (2009) for the 36 airgun array at a tow depth of 6 m can be used to derive radii for mitigation. The proposed action will not be conducted in water depths less than 100 m (328.1 ft).

The NMFS Permits and Conservation Division will require the NSF and L-DEO to implement exclusion zones around the *Langseth* to minimize any potential adverse effects of the sound from the airgun array on MMPA and ESA-listed species. The exclusion zones are areas within which occurrence of a marine mammal triggers a power-down or shut-down of the airgun array, to reduce exposure of marine mammals and sea turtles to sound levels expected to have adverse effects on the species or habitats. These exclusion zones are based upon modeled sound levels at various distances from the *Langseth*, and correspond to the respective species sound threshold for ESA harm (e.g., injury) and harassment.

The NSF and L-DEO applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals are "harassed" based on definitions provide in the MMPA (16 U.S.C. §1362(18)(a)). The NSF and L-DEO concluded that ESA-listed marine mammals would be exposed to the airgun array during the proposed seismic survey activities. These acoustic thresholds were also used to develop radii for buffer and exclusion zones around the sound source to determine appropriate mitigation measures. Table 2 shows the distances at which rms sound levels are expected to be received from the airgun array. These thresholds are used to develop radii for exclusion zones around a sound source and the necessary power-down or shutdown criteria to limit marine mammals and sea turtles' exposure to harmful levels of sound (NOAA, 2016). The 160 dB re 1 μPa (rms) distance is the safety criteria as specified by NMFS (1995) for cetaceans, as required by the NMFS during other L-DEO seismic projects (Holst & Smultea, 2008; Holst et al., 2005; Holst, 2008; Smultea et al., 2004). It is also the threshold at which the NMFS' Permits and Conservation Division is proposing to issue authorization for incidental take of marine mammals. The 175 dB rms isopleth represents our best understanding of the threshold at which sea turtles exhibit significant behavioral responses to seismic airguns (McCauley et al., 2000a); Popper et al. (2014).

In their IHA application, L-DEO proposed to establish exclusion zones based upon modeled radial distances to auditory injury zones. However, the NMFS Permits and Conservation Division proposed an alternative 500 m exclusion zone. Potential radial distances to auditory injury zones were calculated on the basis of maximum peak pressure using values provided by the L-DEO. The 500 m (1,640.4 ft) radial distance of the standard exclusion zone is intended to be precautionary in the sense that it will be expected to contain sound exceeding peak pressure injury criteria for all cetacean and pinniped hearing groups, while also providing a consistent, reasonably observable zone within which protected species observers will typically be able to conduct effective observational effort. Although significantly greater distances may be observed from an elevated platform, NMFS believes that 500 m is a reasonable visual monitoring zone for protected species observers to observe marine mammals using the naked eye during typical conditions.

A practicable criterion such as this has the advantage of simplicity while still providing in most cases an exclusion zone larger than relevant auditory injury zones for marine mammals, given realistic movement of the airgun array and receiver, and is considered sufficient to reduce or avoid most adverse impacts to marine mammals from exposure to the sound source.

An exclusion zone is a defined area within which occurrence of a marine mammal triggers mitigation action in order to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). Protected species observers (PSO) will establish a default (minimum) exclusion zone with a 500 m radius for visual monitoring for the 36 airgun arrays. The 500 m exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described in the IHA), if a marine mammal appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut-down, depending on the circumstance. In addition to the 500 m exclusion zone for the 36 airgun array, a 100 m (328.1 ft) exclusion zone will be established for the single 40 in^3 airgun. A power-down occurs when a marine mammal is detected outside the exclusion zone and appears likely to enter (or is already within the exclusion zone when first detected), and the airgun array is reduced from 36 airguns to a single airgun. A shut-down occurs when a marine mammal is detected outside the exclusion zone and appears likely to enter (or is already within the exclusion zone when first detected), and the single airgun array is turned off entirely. Additionally, a power-down of the 36 airgun arrays will last no more than a maximum of 30 minutes at any given time; thus, the airgun array will be shut-down entirely if, after 30 minutes of power-down, a marine mammal remains inside the 500-m exclusion zone.

The PSOs will also establish and monitor a 1,000 m (3,280.8 ft) buffer zone. During use of the airgun arrays, occurrence of marine mammals within the buffer zone (but outside the 500 m exclusion zone) will be communicated to the operator to prepare for the potential power-down or shut-down of the airgun array. The PSOs will monitor the entire extent of the modeled MMPA Level B harassment zone (or, as far as they are able to see, if they cannot see to the extent of the estimated MMPA Level B harassment zone). An exclusion zone of 100 m would be used as a shut-down distance for sea turtles. The buffer zone will correspond to the predicted 175 dB re: 1 µPa (rms) behavioral threshold distances and the exclusion zone will correspond to the predicted 195 dB re: 1 µPa (rms) threshold distances to which sound source levels will be received from the single airgun array and 36 airgun array in intermediate and deep water depths described in Table 2.

Table 2. Predicted distances to which sound levels ≥160, 175, and 195 dB re 1 μPa_{rms} could be received from the single and 36-airgun array towed at 12 m.

Air gun Configuration	Water Depth (m)	Predicted rms radii (m)		
		160 dB	175 dB	195 dB
Single bolt airgun (40 in^3)	>1,000 m	431	77	8
	100-1,000 m	647	116	11
	<100	1,041	170	14
36 airguns (6,600 in^3)	>1,000 m	6,733	1,864	181
	100-1,000 m	10,100	2,796	272
	<100	25,494	4,123	344

3.1.5 Additional Mitigation

Due to the importance of the action area for sensitive lifestages of marine mammals certain activities will occur (e.g., the expected elevated density of North Pacific right whales in their critical habitat means that additional measures are prudent), the NSF and L-DEO have agreed to additional mitigation measures which include:

- Shut-down when a large whale with a calf or an aggregation of large whales is observed regardless of the distance from the *Langseth*.
- Shutdown when a North Pacific right whale or group of North Pacific right whales is observed at any distance.
- When conducting seimic activities through North Pacific right whale critical habitat (Figure 3 below), NSF must restrict any surveys to daylight hours, to facilitate the ability of PSOs to observe any right whales that may be present.
- Additionally, when transiting through North Pacific right whale critical habitat while heading to/from port, NSF must reduce speed to 5 kts to reduce the potential for ship strike.
- Steller sea lions have designated critical habitats such as rookeries and major haulouts in the action area (Figure 3 below), and the timing of the of NSF's survey overlaps with the breeding season of Steller sea lions. As such, NSF must observe a three nautical mile exclusion zone around these critical habitats. This means that NSF will avoid transiting through and operating seismic airguns in these areas.

The tracklines of this survey either traverse or are proximal to the Biologically Important Areas (BIA) for three ESA-listed baleen whale species including fin, North Pacific right, and humpback whales in U.S. waters of the Gulf of Alaska (Ferguson et al., 2015). The North Pacific Right whale feeding BIA east of the Kodiak Archipelago is primarily used between June and September. The fin whale feeding BIA that stretches from Kenai Peninsula through the Alaska Peninsula is primarily used between June and August. For the North Pacific Right whale, gray whale, and fin whale feeding BIAs, NSF's survey planned for June 1 through June 19, 2019 could overlap with a period where BIAs represent an important habitat. However, only of a portion of seismic survey days would actually occur in or near these BIAs, and all survey efforts should be completed by mid-June, still in the early window of primary use for all these BIAs. Additionally, there are mitigation measures in place that should further reduce take number and severity for fin whales and North Pacific right whales. These include the requirement to shutdown the acoustic source if a fin whale, within the fin whale BIA, is observed within 1,500 m (4,921.26 ft) of the source and the requirement to shutdown if a North Pacific right whale is observed at any distance from the source. Additionally, humpback whale feeding BIAs in the region are primarily used between July and August or September. NSF's survey efforts should be completed before peak use of these feeding habitats. For all habitats, no physical impacts to BIA habitat are anticipated from seismic activities. While SPLs of sufficient strength have been known to cause injury to fish and fish and invertebrate mortality, in feeding habitats, the most likely impact to prey species from survey activities would be temporary avoidance of the affected area and any injury or mortality of prey species would be localized around the survey and not of a degree that would adversely impact marine mammal foraging. The duration of fish avoidance of a given area after survey effort stops is unknown, but a rapid return to normal recruitment, distribution and behavior is expected. Given the short operational seismic time near or traversing BIAs, as well as the ability of cetaceans and prey species to move away from acoustic sources, NMFS expects that there would be, at worst, minimal impacts to animals and habitat within the designated BIAs.

3.2 National Marine Fisheries Service's Proposed Activities

On November 20, 2018, NMFS Permits and Conservation Division received a request from the NSF for an IHA to take marine mammals incidental to conducting a marine seismic survey in the Western GOA. On December 20, 2018, NMFS Permits and Conservation Division deemed the NSF's application for an IHA to be adequate and complete. The NSF's request is for take of a small number of 21 species of marine mammals by MMPA Level B harassment. Neither the NSF nor NMFS Permits and Conservation Division expects mortality to result from the proposed activities therefore the NMFS' Permits and Conservation Division is proposing to issue an IHA authorizing non-lethal "takes" of marine mammals incidental to the planned seismic survey. Since the planned seismic survey is not expected to exceed one year, the IHA will be valid for a period of one year from the date of issuance from June 1, 2019, through May 31, 2020. The NMFS Permits and Conservation Division does not expect subsequent MMPA IHAs will be issued for this proposed action. The IHA will authorize the incidental harassment of the following ESA-listed marine mammal species: blue whales, fin whales, Mexico distinct population segment (DPS) and Western North Pacific DPS humpback whales, North Pacific right whales, sei whales, sperm whales, and Steller sea lion. The IHA will also authorize incidental take for other marine mammals listed under the MMPA. The proposed IHA identifies requirements that the NSF and L-DEO must comply with as part of its authorization that are likely to be protective of ESA-listed species. These requirements are described above and contained in Appendix A.

On April 9, 2019, NMFS Permits and Conservation Division published a notice of proposed IHA and request for comments in the *Federal Register* (84 FR 14200). The public comment period closed on May 9, 2019. Appendix A (see Section 19) contains the proposed incidental harassment authorization. The text in Appendix A (see Section 19 was taken directly from the proposed IHA (84 FR 14200 to 14240) provided to NMFS ESA Interagency Cooperation Division and NMFS Permits and Conservation Division in the consultation initiation package.

4 Action Area

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02).

The proposed survey would occur within the area of ~52–58°N, ~150–162°W, within the Economic Exclusive Zone of Alaska in water depths ranging from ~15 to ~6,184 m (~49.2 to 20,288.7 ft). The project consists of a number of tracklines that cross the trench onto the Pacific plate and shorter connecting tracklines. Representative survey tracklines are shown in Figure 1. The representative tracklines shown in Figure 1 have a total length of 4,400 km (2,375.8 nmi). There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. Deviation in actual track lines, including 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, within the constraints of any federal authorizations issued for the activity, tracklines may shift from those shown in Figure 1 and could occur anywhere within the coordinates noted above and illustrated by the box in the inset map on Figure 1. Tentative sail dates are June 1-19, 2019.

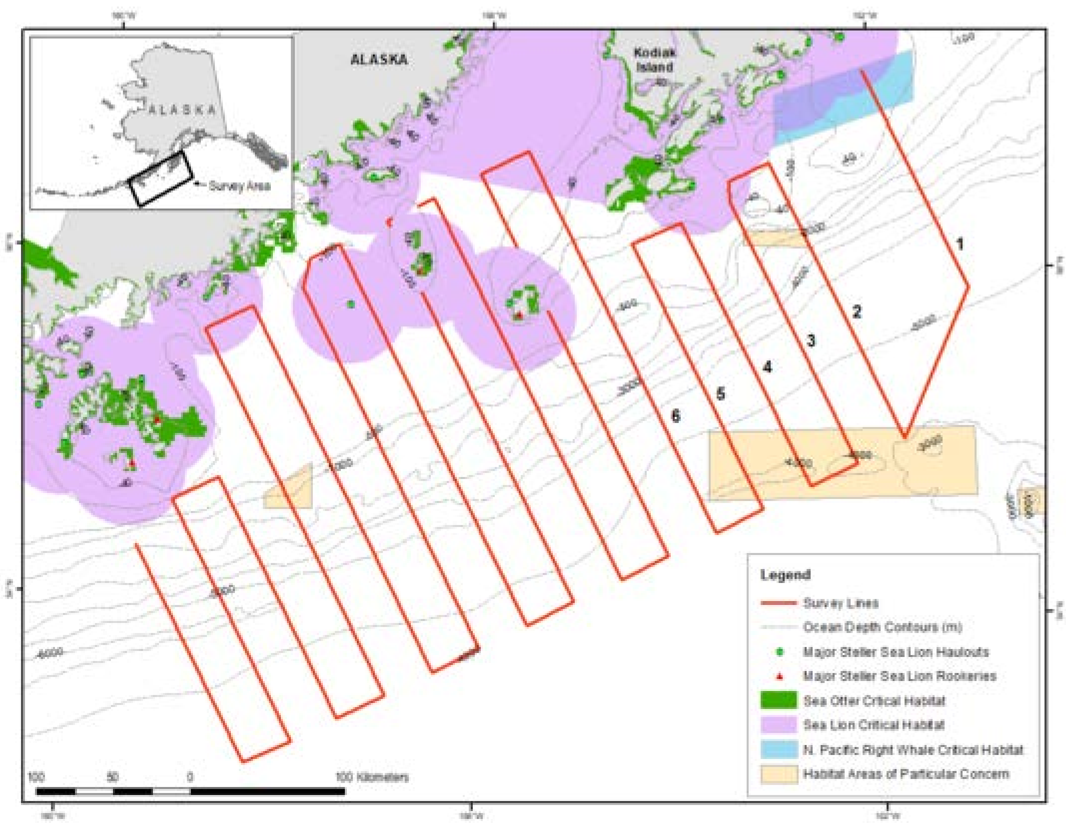

Figure 1. Map of the National Science Foundation's Western Gulf of Alaska seismic survey for this consultation.

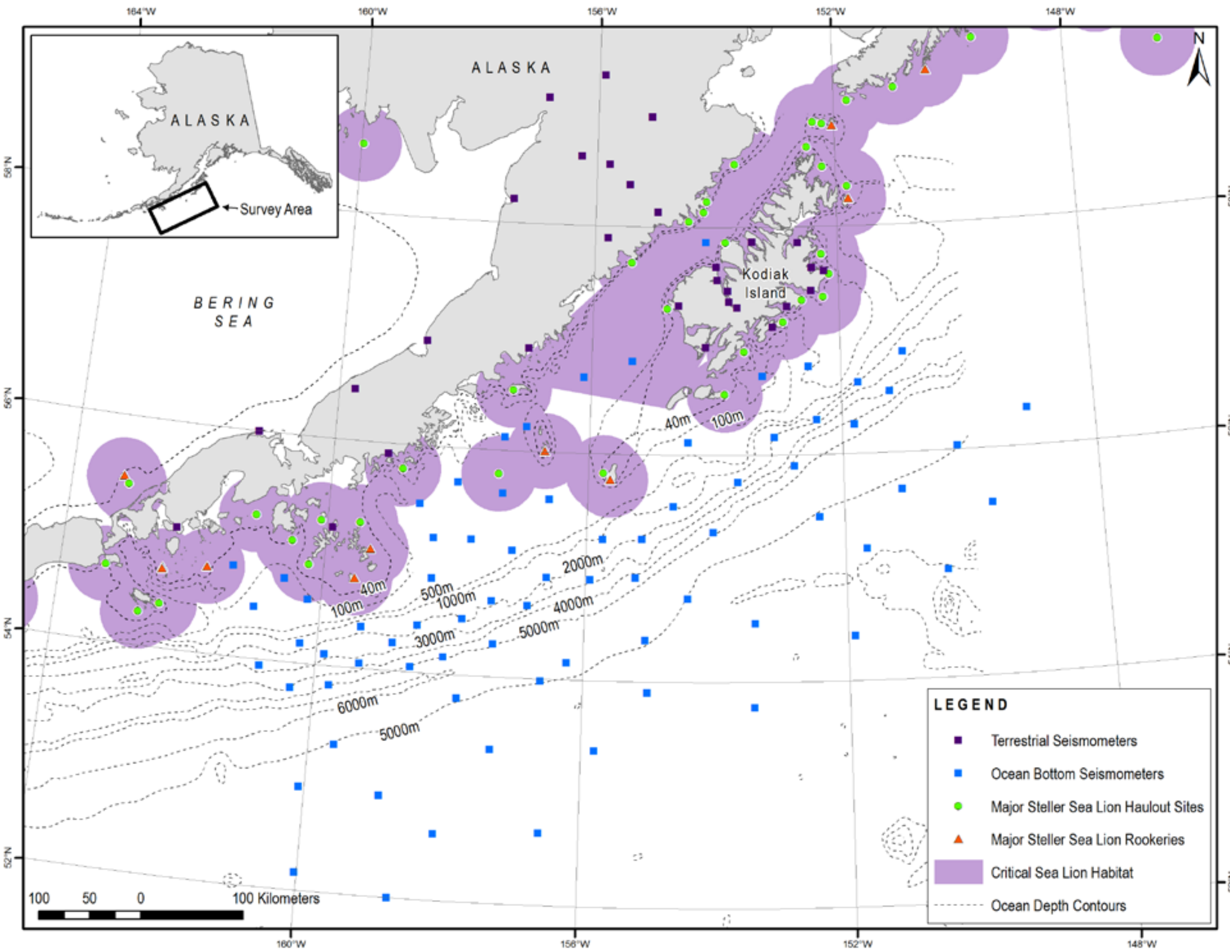

Figure 2. Map of previously deployed seismic receiver locations along the Alaskan Peninsula, including both terrestrial and ocean bottom seismometers.

5 Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility apart from the action under consideration.

The two proposed actions considered during this consultation are interdependent. The NSF's sponsoring and conducting the proposed marine seismic survey is interdependent on NMFS Permits and Conservation Division's proposal to issue an IHA under the MMPA, as it will not have an independent use if not for the actual activity the NSF proposed. Likewise, the NSF's proposed action will not carry forward without the IHA from the NMFS Permits and Conservation Division to exempt marine mammal take under the MMPA. For this consultation, we consider all vessel transit associated with seismic survey activities that will be conducted under the IHA as interdependent. Thus, we evaluate the effects of these activities on ESA-listed species and include all waters traversed during such transits as part of the action area. No actions from the proposed NSF program were considered interrelated.

6 Potential Stressors

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may directly or indirectly induce an adverse response either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to result from the proposed activities. These can be categorized as pollution (e.g., fuel, oil, trash), vessel strikes, acoustic and visual disturbance (vessels, echosounders, and seismic airguns), and entanglement in towed seismic equipment. Below we provide a brief introduction to these stressors and their potential effects to ESA-listed species and designated critical habitat. Detailed information on the effects of these potential stressors can be found in our effects analysis in Section 11. Notably, the proposed action includes several conservation measures described in Section 11.2 that are designed to minimize effects that may result from these potential stressors. While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action (Section 11).

6.1 Pollution

The operation of the *Langeth* as a result of the proposed action may result in pollution from exhaust, fuel, oil, trash, and other debris. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Chance et al., 2015; Duce et al., 1991). Emissions also cause increased greenhouse gases (carbon dioxide, methane, nitrous oxide, and other fluorinated gases) that can deplete the ozone, affect natural earth cycles, and ultimately contribute to climate change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species most commonly through entanglement or ingestion (Gall & Thompson, 2015).While lethal and non-lethal effects to air breathing marine animals such sea turtles, birds, and marine mammals are well documented, marine debris also adversely affects marine fish (Gall & Thompson, 2015).

NSF proposes to include guidance on the handling and disposal of marine trash and debris in its permits. While this is expected to reduce the amount of pollution that may result from the proposed action, pollution remains a potential stressor.

6.1.1 Pollution by Oil or Fuel Leakage

Research vessels used in NSF-funded seismic surveys have spill-prevention plans, which will allow a rapid response to a spill in the event one occurred.The potential of pollution from fuel or oil leakages is extremely unlikely. An oil or fuel leak will likely pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately to the extent possible. In the event that a leak should occur, the amount of fuel and oil onboard the *Langseth* is unlikely to cause widespread, high-dose contamination (excluding the remote possibility of severe damage to the vessel) that will impact ESA-listed species directly or pose hazards to their food sources. Because the potential for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that pollution by oil or fuel leakage is not likely to adversely affect ESA-listed species, and will not be analyzed further in this opinion.

6.2 Vessel Strikes

Seismic surveys necessarily involve vessel traffic within the marine environment, and the transit of any vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. Vessel strikes are known to adversely affect ESA-listed sea turtles, fishes, and marine mammals (Brown & Murphy, 2010; Laist et al., 2001; NMFS & USFWS, 2008; Work et al., 2010). The probability of a vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the species (Conn & Silber, 2013; Hazel et al., 2007; Jensen & Silber, 2004; Laist et al., 2001; Vanderlaan & Taggart, 2007). If an animal is struck by a vessel, it may experience minor, non-lethal injuries, serious injuries, or death.

Vessel traffic associated with the proposed action carries the risk of vessel strikes of marine mammals. In general, the probability of a vessel collision and the associated response depends, in part, on the size and speed of the vessel. The *Langseth* has a length of 72 m (235 ft) and the operating speed during seismic data acquisition is typically approximately 9.3 km per hour (5 kts). When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km per hour (10 kts). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 km per hour (10 kts), with faster travel, especially of large vessels (80 m [262.5 ft] or greater), being more likely to cause serious injury or death (Conn & Silber, 2013; Jensen & Silber, 2004; Laist et al., 2001; Vanderlaan & Taggart, 2007).

Several conservation measures proposed by the NMFS Permits and Conservation Divisionand/or NSF would minimize the risk of vessel strike. In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species. Nevertheless, vessel strikes remain a potential stressor associated with the proposed action.

While vessel strikes of marine mammals during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal being struck by a vessel associated with seismic surveys. The *Langseth* will be traveling at generally slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a vessel strike (Kite-Powell et al., 2007; Vanderlaan & Taggart, 2007). Our expectation of vessel strike is discountably small due to the hundreds of thousands of kilometers the *Langseth* has traveled without a vessel strike, general expected movement of marine mammals away from or parallel to the *Langseth*, as well as the generally slow movement of the *Langseth* during most of its travels (Hauser & Holst, 2009; Holst, 2010; Holst & Smultea, 2008). In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes. All factors considered, we have concluded the potential for vessel strike from the research vessel is highly improbable. Because the potential for vessel strike is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that vessel strike is not likely to adversely affect ESA-listed species and will not be analyzed further in this opinion.

6.3 Acoustic Noise, Vessel Noise, and Visual Disturbance

The proposed action would produce a variety of different sounds including those associated with vessel operations, echosounders, and airguns that may produce an acoustic disturbance or otherwise affect ESA-listed species. It would also involve the presence of vessels (and associated gear) that produce a visual disturbance that may affect ESA-listed marine mammals and sea turtles.

Vessels associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface, such as sea turtles and marine mammals, and more generally disrupt their behavior. Studies have shown that vessel operation can result in changes in the behavior of cetaceans and sea turtles (Hazel et al., 2007; Holt et al., 2009; Luksenburg & Parsons, 2009; Noren et al., 2009; Patenaude et al., 2002; Richter et al., 2003; Smultea et al., 2008). In many cases, particularly when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Blane & Jaakson, 1994a; Evans et al., 1992; Evans et al., 1994). Nonetheless, it is generally not possible to distinguish responses to the visual presences of vessels from those to the sounds associated with those vessels. Moreover, at close distances animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance.

Unlike vessels, which produce sound as a byproduct of their operations, echosounders and seismic airguns are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those species. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC, 2003c, 2005), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007). Other ESA-listed species such as such as sea turtles are often considered less sensitive to anthropogenic sound, but given that much less is known about how they use sound, the impacts of anthropogenic sound are difficult to assess (Nelms et al., 2016; Popper et al., 2014). Nonetheless, depending on the circumstances exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses (see Section 11.3.2.1).

Several of the mitigation measures associated with the proposed action such as daylight transit, ramp-up and shut-down procedures associated with the seismic airgun survey protocols are specifically designed to minimize effects that may result from the stressor of seismic airgun sounds. In addition, while not specifically designed to do so, several aspects of the proposed vessel strike avoidance measures would minimize effects associated with vessel disturbance. However, even with these measures, visual and acoustic disturbances are considered a potential stressor.

6.3.1 Vessel Noise

The research vessel may cause auditory disturbance to ESA-listed marine mammals and more generally disrupt their behavior. We expect the *Langseth* will add to the local noise environment in the action area due to the propulsion and other noise characteristics of the vessel's machinery.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity and length (Kipple & Gabriele, 2007; McKenna et al., 2012; Richardson et al., 1995). Source levels for 593 container ship transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al., 2013). Ship noise levels could vary 5 to 10 dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 km away (Polefka, 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71 to 141 Hz, root-mean-square pressure re 1 uPa ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel) to 186 ± 2 dB (oil tanker). McKenna et al (2012) in a study off Southern California documented different acoustic levels and spectral shapes observed from different modern ship-types.

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Amaral & Carlson, 2005; Au & Green, 2000; Bain et al., 2006; Bauer, 1986; Bejder et al., 1999; Bejder & Lusseau., 2008; Bejder et al., 2009; Bryant et al., 1984; Corkeron, 1995; Erbe, 2002b; Félix, 2001; Goodwin & Cotton, 2004; Lemon et al., 2006; Lusseau, 2003; Lusseau, 2006; Magalhaes et al., 2002; Nowacek et al., 2001; Richter et al., 2003; Scheidat et al., 2004; Simmonds, 2005; Watkins, 1986; Williams et al., 2002; Wursig et al., 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane & Jaakson, 1994b; Evans et al., 1992; Evans et al., 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

The contribution of vessel noise by the *Langseth* is likely small in the overall regional sound field. The *Langseth*'s passage past a marine mammal or sea turtle will be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau, 2006). In addition, the *Langseth* will be traveling at slow speeds, reducing the amount of noise produced by the propulsions system and the probability of a vessel strike for marine mammals (Kite-Powell et al., 2007; Vanderlaan & Taggart, 2007). The distance between the research vessel and observed marine mammals, per avoidance protocols, will also minimize the potential for acoustic disturbance from engine noise. Because the potential acoustic interference from engine noise will be undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise is not likely to adversely affect ESA-listed species, and will not be analyzed further.

6.4 Gear Entanglement

The towed seismic equipment associated with the proposed seismic surveys may pose a risk of entanglement to ESA-listed species. Entanglement can result in death or injury of marine mammals and sea turtles (Duncan et al., 2017; Moore et al., 2009; Van der Hoop et al., 2013). Marine mammal and sea turtle entanglement, or by-catch, is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entangled marine mammals and sea turtles may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/or be hit by vessels due to an inability to avoid them. For smaller animals like sea turtles, death is usually quick, and due to drowning. However, large whales, like North Pacific right whales, can typically pull gear, or parts of it, off the ocean floor, and are generally not in immediate risk of drowning. Nonetheless, depending on the entanglement, towing gear for long periods may prevent a whale from being able to feed, migrate, or reproduce (Lysiak et al., 2018; Van der Hoop et al., 2017).

Towed gear from the seismic survey activities pose a risk of entanglement to ESA-listed marine mammals. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglements have occurred in towed gear from seismic survey vessels. The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the large whales considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, mysticetes and possibly sperm whales are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. Instances of such entanglement events with ESA-listed marine mammals are unknown to us.

Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed species, entanglements are highly unlikely and considered discountable. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed species to be discountable, not likely to adversely affect any ESA-listed species, and will not be analyzed further in this opinion.

The potential stressors considered to be of most concern to ESA-listed species within the action area due to the proposed action are sounds fields produced by the seismic airgun array, multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. These sound sources associated with seismic survey research activities may adversely affect the ESA-listed marine mammals and are evaluated in detail in Section 11.

7 Species and Critical Habitat Not Likely to be Adversely Affected

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area (as described in Table 3) but are not likely to be adversely affected by the proposed action. NMFS uses two criteria to identify the ESA-listed or critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are interrelated to or interdependent with the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the species ESA-listed in Table 3 and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial, insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that couldresult from the action and that would be an adverse effect if it did impact a listed species),but it is very unlikely to occur.

In this section, we evaluate effects on several ESA-listed species and designated critical habitat that may be affected, but are not likely to be adversely affected, by the proposed action. These species and critical habitat potentially occurring within the action area are listed in Table 3. For the ESA-listed species, we focus specifically on stressors associated with the NSF's seismic survey activities and their effects on these species. The effects of other stressors associated with the proposed action, which are also not likely to adversely affect ESA-listed species, are evaluated in Section 11.1.

Table 3. Endangered Species Act-listed threatened and endangered species and critical habitat potentially occurring in the action area that may be affected, but are not likely to be adversely affected.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Beluga Whale (*Delphinapterus leucas*) – Cook Inlet DPS	E – 73 FR 62919	76 FR 20179	82 FR 1325
Gray Whale (*Eschrichtius robustus*) – Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Sea Turtles			
Green Turtle (*Chelonia mydas*) – Central North Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359 01/1998
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359 01/1998

Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) All Other Areas	T – 43 FR 32800	-- --	-- --
Olive Ridley Turtle (*Lepidochelys olivacea*) Mexico's Pacific Coast Breeding Colonies	E – 43 FR 32800	-- --	63 FR 28359
Fishes			
Chinook Salmon (*Oncorhynchus tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chinook Salmon (*Oncorhynchus tshawytscha)* – Puget Sound ESU	T – 70 FR 37160	70 FR 52629	72 FR 2493
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543	80 FR 67386 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Spring/Summer Run ESU	T – 70 FR 37160	64 FR 57399	81 FR 74770 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629	72 FR 57303
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629	76 FR 52317
Chum Salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251	78 FR 41911
Sockeye Salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543	80 FR 32365
Steelhead Trout (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629	78 FR 41911
Steelhead Trout (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629	74 FR 50165
Steelhead Trout (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629	81 FR 74770 (Draft)

Steelhead Trout (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629	72 FR 57303
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629	76 FR 52317
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 75 FR 13012	76 FR 65323	2010 (Outline)

E=Endangered
ESU=Evolutionary Significant Unit
PT=Proposed Threatened
DPS=Distinct Population Segment

7.1 Endangered Species Act-Listed Cetaceans

7.1.1 Beluga Whale – Cook Inlet Distinct Population Segment

Beluga whales belonging to the Cook Inlet DPS are not expected to occur within the area of operations and very few have been seen within the GOA (Laidre et al., 2000). During ice-free months, Cook Inlet beluga whales typically concentrate near rivermouths (Rugh et al., 2010). Fall-winter-spring distribution of this stock is not fully understood, but evidence indicates this population inhabits upper Cook Inlet year-round (Hansen & Hubbard, 1999). Given the timing of the NSF surveys (June) it is unlikely beluga whales would occur within the area of operations and rather, they are expected to be located in upper Cook Inlet feeding on migrating salmon.

In the unlikely chance belugas are in the action area during the proposed survey activities, exposure to the predicted sound levels from acoustic stressors are not expected to exceed the current auditory thresholds which would cause adverse effects. As such effects to the Cook Inlet DPS of beluga whales from acoustic stressors are considered discountable.

We also conclude that because of the extremely low numbers of the Cook Inlet DPS of beluga whales and rare occurrence in the GOA, exposure to stressors such as vessel strike and direct strike or entanglement of towed equipment would be unlikely and therefore discountable. Therefore, we have determined that the Cook Inlet DPS of beluga whales is not likely to be adversely affected by the proposed action. As a result, this species will not be carried forward in this opinion.

7.1.2 Gray Whale – Western North Pacific Population

The Eastern and Western North Pacific populations of gray whales were once considered geographically separated along either side of the ocean basin, but recent photo-identification, genetic, and satellite tracking data refute this. Two individuals from the Western North Pacific population of gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the GOA, and south to the Washington and Oregon coasts in one case (Mate et al., 2011), and to the southern tips of Baja California and back to Sakhalin Island in another (IWC, 2012a). Comparisons of catalogues of Eastern and Western North Pacific populations of gray whales have thus far identified 24 individuals from the Western North Pacific population of gray whales occurring on the eastern side of the basin during winter and spring (Burdin et al., 2011; Weller et al., 2013). During one field season off Vancouver Island, individuals from the Western North Pacific population of gray whales were found to constitute six of 74 (8.1 percent) of photo-identifications (Weller et al., 2012). In addition, two genetic matches with the Western North Pacific population of gray whales off Santa Barbara, California have been made (Lang et al., 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al., 2012).

From this overview, it is apparent that individuals from the Western North Pacific population of gray whales could be found within the action area. Furthermore, PSO's will not be able to identify individual animals in the field as belonging to either the Eastern North Pacific or Western North Pacific population of gray whales. It is possible that an individual or individuals from the Western North Pacific Population of gray whale could be unintentionally impacted by the proposed seismic surveys. However, given their low potential occurrence in the action area (approximately 20 to 30 individuals) and relative size compared to individuals from the Eastern North Pacific population of gray whales (approximately 0.7 percent with 140 for Western North Pacific population of gray whales versus 20,125 for the Eastern North Pacific population of gray whales), we find it highly unlikely that any individuals from the Western North Pacific population of gray whales will be affected by the proposed activities. During all of the photo-identification work the same researchers (mentioned above) have conducted on the Eastern North Pacific population of gray whales in the Eastern North Pacific Ocean, they have never encountered a gray whale from the Western North Pacific population. The few photo-identification matches from other collaborating researchers have occurred primarily in the spring during the migration (Weller et al., 2012), which is not when the majority of field work will occur under the NSF's proposed activities.

We also conclude that because of the extremely low numbers of the western North Pacific gray whale stock in the North Pacific Ocean and rare occurrence in the GOA, exposure to stressors such as vessel strike or entanglement of towed equipment would be unlikely and discountable. Therefore, we have determined that the western North Pacific DPS of gray whales is not likely to be adversely affected by the proposed action. As a result, this species will not be carried forward in this opinion.

7.2 Endangered Species Act-Listed Sea Turtles

7.2.1 Green Turtle, Loggerhead Turtle, and Olive Ridley Turtle

Sea turtles from the Cheloniidae family have been documented in the GOA, but rarely. Members of the Cheloniidae family (loggerhead, green, olive ridley sea turtles) typically occur in the warm, subtropical areas of the Pacific such as southern California and Hawaii. The ocean waters of the GOA have an average sea surface temperature in summer in the upper 100 m

(328 ft) of approximately 51.8 degrees Fahrenheit (°F) (11° Celsius [°C]). Most hard-shell turtles seek optimal seawater temperatures near 65°F and are cold-stressed at seawater temperatures below 50°F (Davenport, 1997). At temperatures below 15°C (59°F), green and ridley sea turtles become semidormant, hardly move and come to the surface at intervals up to 3 hours (Milton & Lutz, 2003). Loggerhead sea turtles exposed to excessive low temperatures have experienced abrupt failure in pH homeostasis and a sharp increase in blood lactate levels (Milton & Lutz, 2003). At 10°C (50°F) loggerhead sea turtles were lethargic and “floated” (Milton & Lutz, 2003).

Furthermore, in Alaska, only nine green sea turtle occurrences, two olive ridley occurrences, and two loggerheads were documented between 1960 and 2006 (DON, 2006; Hodge & Wing, 2000). Most of these sightings involved individuals that were either cold-stressed, likely to become cold-stressed, or already deceased (Hodge & Wing, 2000; McAlpine et al., 2002). Thus, the NSF area of operations is considered to be outside the normal range for sea turtle species of the Cheloniidae family. Because Chelonid sea turtles occur in the GOA only rarely, we do not expect individual Chelonid sea turtles to co-occur with NSF activities in the GOA. Therefore, the likelihood of Chelonid sea turtles being exposed to the stressors with the proposed action, is discountable and these species are unlikely to be adversely affected by the proposed action. As a result, these species will not be carried forward in this opinion.

We would not expect a NSF vessel to strike any Chelonid sea turtles in the GOA. First, as discussed above, this family of sea turtles are rare in the action area and are not expected to co-occur with NSF activities that take place over a limited amount of time (i.e., 19 days) in the GOA. Second, the NSF implements mitigation measures to avoid striking protected marine species including the use of PSOs. For these reasons, the likelihood of a NSF vessel associated with seimic activities in the GOA to strike a Chelonid sea turtle is so low as to be discountable.

7.2.2 Leatherback Sea Turtle

Leatherback sea turtles have seldom been encountered in the GOA (e.g., only 19 sightings of the species in the GOA since 1960), and no data or density estimates are available for this species in the action area. Due to their low expected occurrence in the action area and the limited duration of the proposed action (i.e., 19 days), this species is not expected to be located within the action area during the NSF’s activities. For these reasons, the NSF did not include this species in the acoustic effects analysis. Therefore, the likelihood of a leatherback sea turtle being impacted by the NSF’s seismic survey acoustic stressors is discountable.

We would also not expect a NSF vessel to strike a leatherback sea turtle in the GOA. First, as discussed above, leatherback sea turtles are rare in the action area and are not expected to co-occur with NSF activities that take place over a limited amount of time (i.e., 19 days) in the GOA. Second, the NSF implements mitigation measures to avoid striking protected marine species including the use of PSOs. For these reasons, the likelihood of a NSF vessel associated with seimic activities in the GOA to strike a leatherback sea turtle is so low as to be discountable.

As discussed above, we have determined that the likelihood of NSF seismic activities in the GOA impacting leatherback sea turtles is discountable. This conclusion is largely based on the low abundance of this species in the action area and the low likelihood that any leatherback turtles would occur in the action area during seismic activities. Therefore, we have determined that leatherback sea turtles are not likely to be adversely affected by the proposed action. As a result, this species will not be carried forward in this opinion.

7.3 Endangered Species Act-Listed Fishes

7.3.1 Criteria and Thresholds to Predict Impacts to Fishes

A description of fish hearing according to their species' groups and sensitivity to sound is provided in the Sections 7.3.3 and 7.3.4. For many of the acoustic stressors affecting fishes in the action area during the NSF's seismic activities, the NMFS relied primarily on the recommendations in the 2014 *ANSI Guidelines.* Where applicable, the NMFS developed or use other thresholds based upon what the NMFS considers to be the most appropriate given our current understanding of the effects of anthropogenic sounds on fishes as well as the best available science on the subject. For fishes, permanent threshold shift (PTS) has not been documented in any of the studies researching fish hearing and potential impairment from various sound sources. This is attributed to the ability for regeneration of inner ear hair cells in fishes, which differs from other marine animals. For this reason, thresholds for fish hearing impairment only includes the SPL related to the potential onset of TTS. TTS in fishes is considered recoverable, although the rate of recovery is based upon the degree of the TTS sustained. Thus, auditory damage or impairment in fishes is considered recoverable over some duration; and auditory thresholds are based solely on the onset of TTS for fishes.

For auditory impairment (e.g., TTS) and barotrauma (e.g. physical injuries) in fishes, the NMFS apply dual metric criteria which includes both a peak pressure metric and cumulative sound exposure level (SEL_{cum}). As with other marine animals, the NMFS also applies an rms threshold for some acoustics sources to assess whether behavioral responses may be elicited during some sound exposures.

7.3.2 Impulsive Sound Source Criteria (Airguns) – Fishes

Impulsive sound sources such as airguns are known to injure and kill fishes or elicit behavioral responses. For airguns, the NMFS analyzed impacts from sound produced by airguns using the recommendations consistent with the *ANSI Guidelines* (Popper et al., 2014). These dual metric criteria are utilized to estimate zones of effects related to mortality and injury from air gun exposure. NMFS assumes that a specified effect will occur when either metric (peak SPL *or* $SEL_{cum)}$ is met or exceeded.

In the 2014 *ANSI Guidelines*, airgun thresholds are derived from the thresholds developed for impact pile driving exposures (Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b). This use of a dual metric criteria is consistent with the current impact hammer criteria NMFS applies for fishes with swim bladders (FHWG Agreement in Principle 2008, Stadler and Woodbury 2009).

The interim criteria developed by the Fisheries Hydroacoustic Working Group include dual metric criteria wherein the onset of physical injury would be expected if either the peak SPL exceeds 206 dB re 1 μPa, or the SEL_{cum}, exceeds 187 dB re 1 μPa^2-s for fish two grams or larger, or 183 dB 1 μPa^2-s for fish smaller than two grams. However, at the time the interim criteria were developed, very little information was available regarding fish and pile driving effects. Therefore, the criteria largely used information available from airgun exposures. As such, it is also often applied to other impulsive sound sources. In addition, the 2008 interim criteria did not specifically separate thresholds according to severity of hearing impairment such as TTS to recoverable injury to mortality, which was done in the 2014 *ANSI Guidelines*. Nor do they differentiate between fish with swim bladders and those without, despite the presence of a swim bladder affecting hearing capabilities and fish sensitivity to sound. The 2008 interim criteria based the lower SEL_{cum} thresholds (187 and 183) upon when TTS or minor injuries would be expected to occur. Therefore, these criteria establish the starting point when the whole spectrum of potential physical effects may occur for fishes, from TTS to minor, recoverable injury, up to lethal injury (i.e., either resulting in either instantaneous or delayed mortality). sensitivity (Popper & Hastings, 2009); (Casper et al., 2012) Popper et al., 2014c). Because some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities and influence of a swim bladder, and the fact that none of the ESA-listed fishes in the action area have a swim bladder associated with hearing, our analysis of ESA-listed fishes considered in this consultation is focused upon fishes with swim bladders not used in hearing. Categories and descriptions of hearing sensitivities are further defined in this document (modified from Popper et al., 2014c) as the following[1]:

- Fishes with a swim bladder that is not involved in hearing, lack hearing specializations and primarily detect particle motion at frequencies below 1 kHz include all Pacific salmon species and green sturgeon.

For the NSF's seismic activities, airgun thresholds for fishes with swim bladders not involved in hearing are 210 SEL_{cum} and >207 SPL_{peak} for onset of mortality and 203 SEL_{cum} and >207 SPL_{peak} for onset of injury[2]. Criteria and thresholds to estimate TTS in fishes exposed to sound produced by airguns are >186 SEL_{cum}[3]. Exposure to sound produced from airguns at a cumulative sound exposure level of 186 dB (re 1 μPa^2-s) has resulted in TTS in fishes (Popper et

[1] The 2014 ANSI Guidelines provide distinctions between fish with and without swim bladders and fish with swim bladders involved in hearing. None of the ESA-listed fish species considered in this consultation have swim bladders involved with their hearing abilities, but all do have swim bladders. Thus, we simplified the distinction to fishes with swim bladders.

[2] Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 μPa]), > indicates that the given effect would occur above the reported threshold.

[3] Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa2-s]), NC = effects from exposure to sound produced by airguns is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

al., 2005)[4]. For potential behavioral responses of fishes (i.e. sub-injury) from exposure to anthropogenic sounds, there are no formal criteria yet established. This is largely due to the sheer diversity of fishes, their life histories and behaviors, as well as the inherent difficulties conducting studies related to fish behavior in the wild. The NMFS applies a conservative threshold of 150 dB rms (re 1 μPa) to assess potential behavioral responses of fishes from acoustic stimuli, described below.

In a study conducted by McCauley et al. (McCauley et al., 2003), fish were exposed to airguns and observed to exhibit alarm responses from sound levels of 158 to 163 dB (re 1 μPa). In addition, when the 2008 criteria were being developed, one of the technical panel experts, Dr. Mardi Hastings, recommended a "safe limit" of fish exposure, meaning where no injury would be expected to occur to fishes from sound exposure, set at 150 dB rms (re 1 μPa) based upon her research (Hastings, 1990). This "safe limit" was also referenced in a document investigating fish effects from underwater sounds generated from construction (Sonalysts 1997) where the authors mention two studies conducted by Dr. Hastings that noted no physical damage to fishes occurred when exposed to sound levels of 150 dB rms at frequencies between 100-2,000 Hz. In that same report, the authors noted they also observed fish behavioral responses during sound exposure of 160 dB rms, albeit at very high frequencies. More recently, Fewtrell and McCauley (Fewtrell & McCauley, 2012) exposed fishes to air gun sound between 147-151 dB SEL, and observed alarm responses in fishes as well as tightly grouped swimming or fast swimming speeds.

None of the current research available on fish behavioral response to sound make recommendations for a non-injury threshold. The studies mentioned here, as with most data available on behavioral responses to anthropogenic sound for fishes, have been obtained through controlled laboratory studies. In other cases, behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not show normal behavioral responses which makes it difficult to extrapolate caged fish behavior to wild, unconfined fishes, (Hawkins et al., 2014; Popper & Hawkins, 2014). It is also important to mention, that some of the information regarding fish behavior while exposed to anthropogenic sounds has been obtained from unpublished documents such as monitoring reports, grey literature, or other non-peer reviewed documents with varying degrees of quality. Therefore, behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild. Nonetheless, potential behavioral responses must be considered as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until new data indicate otherwise, NMFS believes a 150 dB rms (re 1 μPa) threshold for behavioral responses of fishes is appropriate. This criterion is used as a guideline to establish a sound level where responses of fishes may occur and could be a concern. For ESA-listed fishes, NMFS applies this criterion when considering the life stage affected, and any adverse effects that could occur from behavioral responses such as attentional disruption, which could lead to reduced foraging

[4] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 SEL_{cum}.

success, impaired predatory avoidance, leaving protective cover, release of stress hormones affecting growth rates, poor reproductive success rates and disrupted migration.

7.3.3 Salmonids

Data on sound production in species in the family Salmonidae is scarce, but they do appear to produce some sounds during spawning that may be used for intraspecific signally, including high and low frequency drumming sounds likely produced by the swimbladder (Neproshin and Kulikova 1975, and Neproshin 1972 as reviewed in Kuznetsov, 2009). Salmonidae are all thought to have similar auditory systems and hearing sensitivities (Popper, 1977; Popper et al., 2007; Wysocki et al., 2007). Based on the information available, we assume that the ESA-listed salmonid species have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins & Johnstone, 1978; Knudsen et al., 1992, 1994).

Some individual ESA-listed salmonid fish may experience TTS as a result of NSF's seismic stressors. TTS is short term in duration with fish being able to replace hair cells when they are damaged (Lombarte et al., 1993; Smith et al., 2006). Furthermore, the fish species considered in this opinion lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. To our knowledge, no studies have examined the fitness implications when a fish, without notable hearing specialization, experiences TTS. Popper et al. (2014) suggested that fishes experiencing TTS may have a decreased ability to communicate, detect predators or prey, or assess their environment. However, these species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al., 2014). Additionally, hearing is not thought to play a role in salmonid migration (e.g., (Putnam et al., 2013). Because any TTS experienced would be temporary and the ESA-listed fish species considered in the opinion are able to rely on alternative mechanisms for these essential life functions, instances of TTS would not kill or injure any fish, nor would any such instances create the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

The precise expected response of ESA-listed salmonids to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for this taxon. Given the signal type and level of exposure to the low frequency sounds produced during the seismic survey activities (from the airgun array or the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler), we do not expect frequent exposure or significant responses from any exposures (including significant behavioral adjustments, TTS or PTS, injury, or mortality). Based on the discussions above, it is likely that the proposed seismic survey activities will be audible to ESA-listed salmonids found within the action area, and as such, may elicit minor behavioral responses.The most likely response to the airgun array and multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler, if any, will be minor temporary changes in behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the NSF's acoustic survey in the GOA would not be expected to appreciably reduce the likelihood of the survival of ESA-listed salmonids by reducing the reproduction, numbers, or distribution of those ESUs, or DPSs. Therefore, the effect of exposure to acoustic stressors that may result in TTS is insignificant. Any TTS experienced by these fish would not rise to the level of take and would not have fitness level consequences at the individual or population level. Thus the seismic stressors of the proposed NSF seismic survey is not likely to adversely affect the ESA-listed salmonid species. As a result, the discussion of ESA-listed salmonids is not carried forward in this opinion.

7.3.4 Green Sturgeon – Southern Distinct Population Segment

There is no available information on the hearing capabilities of green sturgeon specifically, although the hearing of two species of sturgeon have been studied. While sturgeon have swimbladders, they are not known to be used for hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction of the origin of sound. Meyer and Popper (2002) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (which is considered to have specialized hearing abilities and can hear up to 5 kHz) than to the oscar (which can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon can be considered to have any specialized hearing abilities (Meyer & Popper, 2002). Lovell et al. (2005) also studies sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. We assume that the hearing sensitivities for these other species of sturgeon are representative of the hearing sensitivities of all green sturgeon DPSs.

Based on the above review, it is likely that the proposed seismic survey activities will be audible to ESA-listed green sturgeon found within the action area, and as such, may elicit a behavioral response.

The precise expected response of ESA-listed sturgeon to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for this taxon. Given the signal type and level of exposure to the low frequency sounds produced during the seismic survey activities (from the airgun array or the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler), and the fact that most sturgeon are found in a nearshore coastal areas, we do not expect frequent exposure or significant responses from any exposures (including significant behavioral adjustments, TTS or PTS, injury, or mortality). The most likely response of ESA-listed green sturgeon exposed to the airgun array and multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler, if any, will be minor temporary changes in behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take. If these behavioral reactions were to occur, we do not expect that they will have fitness impacts for the individual, the population, or the DPS. Therefore, the potential effect of the proposed seismic survey on green sturgeon is considered insignificant.

The research vessel associated with the proposed action will transit waters that may be occupied by green sturgeon when in route to the proposed seismic survey tracklines. As such, there is a possibility that the research vessel associated with the proposed action may strike an individual green sturgeon. However, we find the likelihood of such an event to be extremely low, and thus discountable. This is because only one seismic vessel will be used, which will be traveling at relatively slow speeds, and because green sturgeon tend to occupy the lower parts of the water column where vessel strikes will not occur. Similarly, the stressors of pollution, visual disturbance, and entanglement associated with the proposed action are considered insignificant stressors to green sturgeon since these stressors mostly reside at the water's surface, and will not reach waters inhabited by green sturgeon at meaningful levels.

In summary, we conclude that the proposed action is not likely to adversely affect the southern DPS of ESA-listed green sturgeon because any effects will be insignificant. As a result, discussion of the green sturgeon are not carried forward in this opinion.

7.4 Designated Critical Habitat Not Likely to be Adversely Affected

The proposed action will take place within the GOA, within the area of ~52–58°N, ~150–162°W, within the Economic Exclusive Zone of Alaska in water depths ranging from ~15 to ~6,184 m. This action area includes designated critical habitat for two marine mammal species: North Pacific right whales (73 FR 19000) and Steller sea lions (58 FR 45269).

7.4.1 North Pacific Right Whales

In 2008, NMFS designated critical habitat for the North Pacific right whale, which includes an area in the Southeast Bering Sea and an area south of Kodiak Island in the GOA. Designated critical habitat for the North Pacific right whale is influenced by large eddies, submarine canyons, or frontal zones which enhance nutrient exchange and act to concentrate prey. North Pacific right whale designated critical habitat is adjacent to major ocean currents and characterized by relatively low circulation and water movement. The designated critical habitat supports feeding by North Pacific right whales because they contain specific physical and biological features essential for the species that include: nutrients, physical oceanography processes, certain species of zooplankton (copepods), and a long photoperiod due to the high latitude (73 FR 19000).

Critical feeding-season habitat has been designated by NMFS for the North Pacific right whale in the western GOA and in the southeast Bering Sea (71 FR 38277, 73 FR 2008). The bulk of the critical habitat lies in the Bering Sea with a small portion in the GOA located southeast of Kodiak Island (Figure 3). A single proposed survey line running south from Kodiak Island crosses this critical habitat.

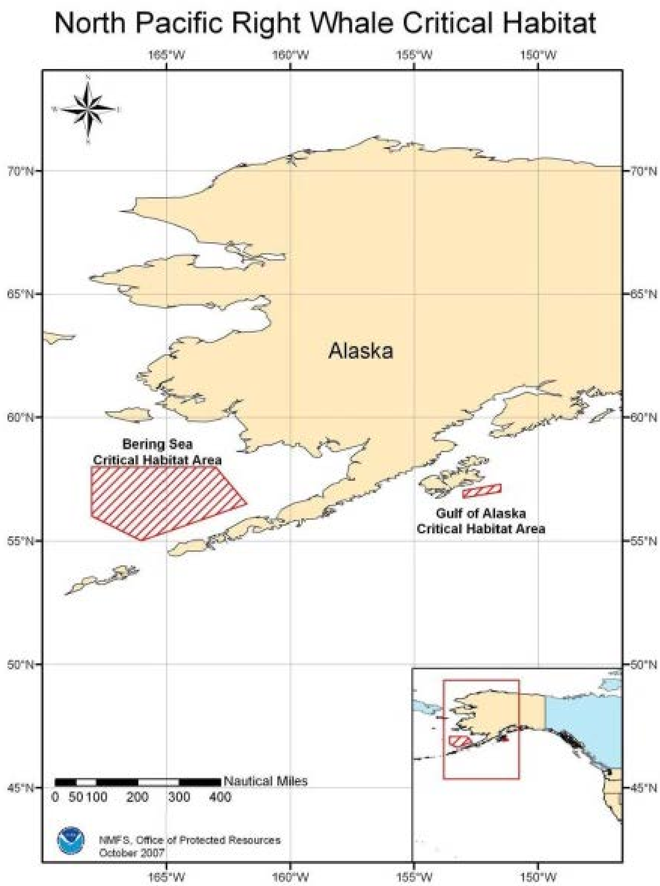

Figure 3. Map identifying designated critical habitat for the endangered North Pacific right whale in the Southeast Bering Sea and south of Kodiak Island in the GOA.

Recent evidence suggests that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun lead to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 km (0.6 nmi), the maximum distance to which sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question.

In particular, three-dimensional seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, are of concern (McCauley et al., 2017). This is in part because in order for such activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton (McCauley et al., 2017).

Given the results from McCauley et al. (2017) and that copepod prey are identified as being part of one physical and biological feature of North Pacific Right whale critical habitat, it is possible that the proposed action may affect designated right whale critical habitat.

The majority of copepod prey available to North Pacific right whale habitat are expected to be near the surface (Witherington et al., 2012), but results of McCauley et al. (2017) provide little information on the effects to copepods at the surface since their analyses excluded zooplankton at the surface bubble layer. Nonetheless, given that airguns primarily transmit sound downward, and that those associated with the proposed action will be towed at depths of 12 m (39.4 ft), we expect that sounds from airgun array will be relatively low at the surface and as such, will effect copepod prey within the right whale critical habitat less than that reported in McCauley et al. (2017). Furthermore, in contrast to the intensive three-dimensional seismic surveys discussed in McCauley et al. (2017), the proposed seismic surveys are two-dimensional, and are designed as exploratory surveys, covering a small portion of critical habitat in a relatively short amount of time (~ 6 hours). Such seismic surveys are less likely to have significant effects on zooplankton given the high turnover rate of zooplankton and currents in the Alaska Current, which will circulate zooplankton in North Pacific right whale critical habitat within the action area (see Richardson et al., 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduce the impact of seismic surveys on zooplankton at the population level).

In summary, while the proposed seismic survey may temporarily alter copepod abundance in designated North Pacific right whale critical habitat, we expect such effects to be insignificant because most copepods will be near the surface where sound from airgun arrays is expected to be relatively low and the high turnover rate of zooplankton and ocean circulation will minimize any effects. Therefore, we find that the proposed action is not likely to adversely affect designated North Pacific right whale critical habitat because any effects will be insignificant. As a result, discussions of North Pacific right whale habitat are not carried forward in this opinion.

7.4.2 Steller Sea Lion – Western Distinct Population Segment

In 1997, NMFS designated critical habitat for the Steller sea lion. The designated critical habitat includes specific rookeries, haul-outs, and associated areas, as well as three foraging areas that are considered to be essential for health, continued survival, and recovery of the species.

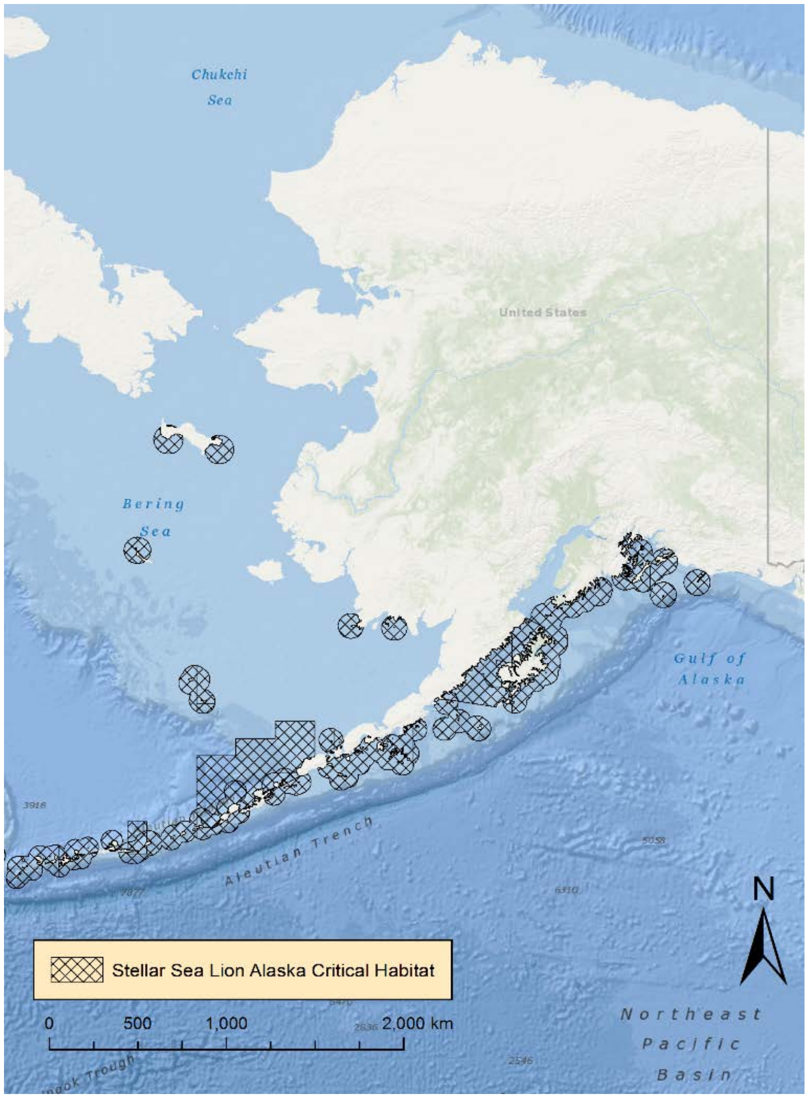

Figure 4: Map depicting Alaskan designated critical habitat for the Western distinct population segment of Steller sea lion.

In Alaska, areas include major Steller sea lion rookeries, haul-outs and associated terrestrial, air, and aquatic zones (Figure 4). Designated critical habitat includes a terrestrial zone extending 0.9 km (0.5 nmi) landward from each major rookery and haul-out; it also includes air zones extending 0.9 km above these terrestrial zones and aquatic zones. Aquatic zones extend 0.9 km (0.5 nmi) seaward from the major rookeries and haul-outs east of 144° West. In addition, NMFS designated special aquatic foraging areas as critical habitat for the Steller sea lion. These areas include the Shelikof Strait (in the GOA), Bogoslof Island, and Seaguam Pass (the latter two are in the Aleutians). These sites are located near Steller sea lion abundance centers and include important foraging areas, large concentrations of prey, and host large commercial fisheries which often interact with the species. The physical and biological features identified for the aquatic areas of Steller sea lion designated critical habitat that occur within the action area are those that support foraging, such as adequate prey resources and available foraging habitat (58 FR 45269).

While Steller sea lions do rest in aquatic habitat, there was insufficient information available at the time critical habitat was designated to include aquatic resting sites as part of the critical habitat designation (58 FR 45269).

Steller sea lion critical habitat also includes a “no approach” zone within 3 nmi of rookeries. Steller sea lions both occupy rookeries and pup from late-May through early-July (NMFS, 2008), which coincides with NSF’s proposed survey. Thus, we are requiring that the proposed survey avoid transiting or surveying within 3 nmi of any rookeries.

The total amount of time the seismic survey would occur near Steller sea lion critical habitat is limited and minimized by mitigation measures which NSF has agreed to follow (e.g, greater than 3 nmi [5.56 km]). Therefore, the short duration of the potential exposure, and the expected minor effects to prey species, lead us to conclude that the Steller lion critical habitat would not be adversely affected by the proposed action. We expect that the disruption of Steller sea lion rookeries and effects to the prey species would be insignificant, and would not affect the conservation value of the critical habitat. Therefore, it will not be carried forward in this opinion.

7.4.3 Effects to Designated Critical Habitat

While the proposed seismic activities would overlap with the physical and biological features (i.e., prey availability, haulout or rookeries) of the designated critical habitats described in Sections 7.4.1 through 7.4.2, very few if any, effects to these habitats are expected. The proposed seismic activities will not significantly alter the prey available to either species given the short duration of the seismic survey within either critical habitat. We do not expect the proposed seismic activities to affect the copepod prey or fish concentrations within the action area. In conclusion, the proposed seismic activities may affect but are not expected to adversely affect any of the physical or biotic features of the designated critical habitats. Given the nature of the NSF’s survey, it is extremely unlikely that any of the physical and biological features essential to the conservation of the these two species found in this habitat will be altered proposed research activities are not likely to adversely affect the conservation value of the designated critical habitat for the either species. Therefore, discussion of either species’ critical habitat will not be carried forward in this opinion.

8 Species Likely to be Adversely Affected

This section identifies the ESA-listed species that occur within the action area that may be affected by the NSF’s seismic survey (Table 4). All of the species potentially occurring within the action area are ESA-listed in Table 4, along with their regulatory status, designated critical habitat, and recovery plan references.

Table 4. Threatened and endangered species that may be affected by the National Science Foundation's proposed action of a marine seismic survey in the Western Gulf of Alaska.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	-- --
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	07/2010 75 FR 47538
Gray Whale (*Eschrichtius robustus*) Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	-- --	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Western North Pacific DPS	E – 81 FR 62259	-- --	11/1991
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011 76 FR 43985
Sperm Whale (*Physeter microcephalus*)	E – 35 FR 18319	-- --	12/2010 75 FR 81584
Pinnipeds			
Steller Sea Lion (*Eumetopias jubatus*) – Western DPS	E – 55 FR 49204	58 FR 45269	73 FR 11872 2008

E=Endangered
T=Threatened
DPS=Distinct Population Segment

9 Status of Species Likely to be Adversely Affected

This section examines the status of each species that are likely to be adversely affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," throughout their ranges which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the *Federal Register*, status reviews, recovery plans, and on these NMFS Web sites: http://www.nmfs.noaa.gov/pr/species/index.htm, among others.

9.1.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 5).

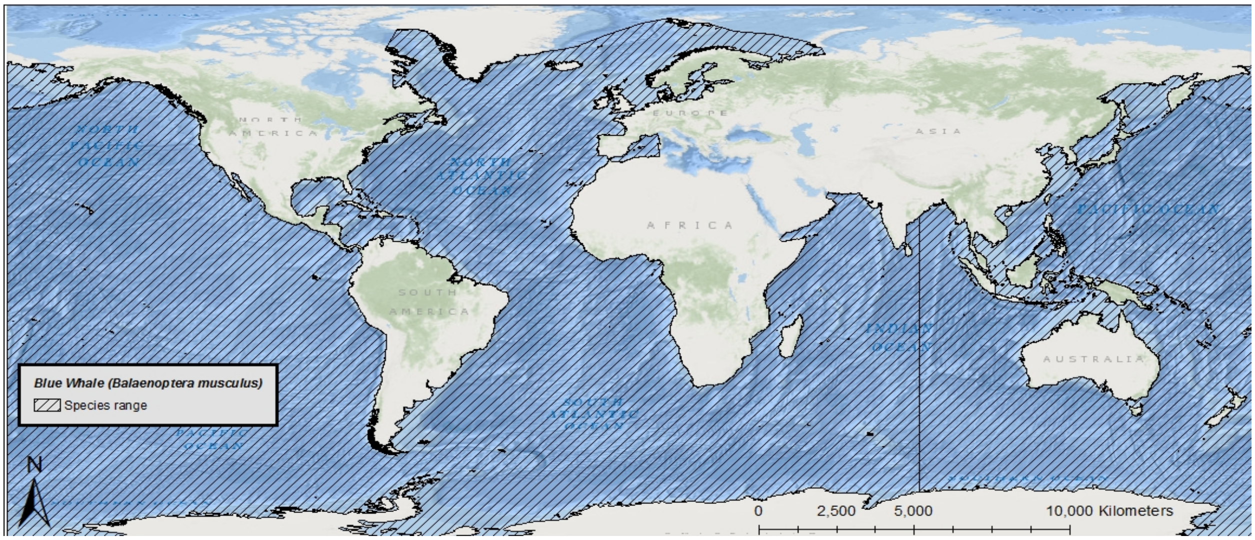

Figure 5. Map identifying the range of the endangered blue whale.

Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat “rostrum” when viewed from above, proportionally smaller dorsal fin, and a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific Ocean. The blue whale was originally listed as endangered on December 2, 1970 (Table 4).

Information available from the recovery plan (NMFS, 1998), recent stock assessment reports (Carretta et al., 2017; Hayes et al., 2017; Muto et al., 2017), and status review (COSEWIC, 2002) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to twelve months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (7,936.6 pounds) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m (295.3 to 393.7 ft).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the blue whale.

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC, 2007b). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC, 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in United States (U.S.) waters: the Eastern North Pacific Ocean (current best estimate N=1,647, N_{min}=1,551;) (Payne et al., 1990), Central North Pacific Ocean (N=81, N_{min}=38), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95 percent confidence intervals 1,160 to 4,500 (Branch, 2007). While no rangewide estimate for pygmy blue whales exists (Thomas et al., 2016), the latest estimate for pygmy blue whales off the west coast of Australia is 662 to 1,559 individuals based on passive acoustic monitoring (McCauley & Jenner, 2010), or 712 to 1,754 individuals based on photographic mark-recapture (Jenner et al., 2008).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis et al., 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent) (Branch, 2007).

Little genetic data exist on blue whales globally. Data from Australia indicates that at least populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al., 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al., 2012). Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock population at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore (Figure 5). In the North Atlantic Ocean, the blue whale range extends form the subtropics to the Greenland Sea. They are most frequently sighted in waters of eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the GOA and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies can be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the "Antarctic Convergence" (located between 48 and 61° South latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

Vocalization and Hearing

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

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

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson & Richardson, 1995), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten, 1998; Mellinger & Clark, 2003). Vocalizations are predominantly songs and calls. Blue whale calls have high acoustic energy, with reports of 186 to 188 dB re: 1 µPa-m (Cummings & Thompson, 1971; McDonald et al., 2001) and 195 dB re: 1 µPa-m (Aburto et al., 1997) source levels. Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (80 to 30 Hz), with seasonally variable occurrence.

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings & Thompson, 1971; McDonald et al., 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Mellinger & Clark, 2003; Payne & McVay, 1971). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al., 1998), and have only been attributed to males (McDonald et al., 2001; Oleson et al., 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al., 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to approximately 22.5 Hz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al., 2006b). McDonald et al. (2009) observed a 31percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al., 2001; Mellinger & Clark, 2003; Rankin et al., 2005; Thompson et al., 1996), some variability appears to exist among different geographic areas (Rivers, 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al., 2006; Mellinger & Clark, 2003). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al., 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford & Moore, 2005).

In Southern California, blue whales produce two predominant call types: Type B and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al., 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al., 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. Blue whale D calls are down-swept in frequency (100 to 40 Hz) with duration of several seconds. These calls are similar worldwide and are associated with feeding animals; they may be produced as call-counter-call between multiple animals (Oleson et al., 2007b). In the SOCAL Range Complex region, D call are produced in highest numbers during the late spring and early summer, and in diminished numbers during the fall, when A-B song dominates blue whale calling (Hildebrand et al., 2011; Hildebrand et al., 2012; Oleson et al., 2007c).

Calling rates of blue whales tend to vary based on feeding behavior. Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al., 2004). Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 m [100 ft] whales, while deeper diving whales (greater than 50 m [165 ft]) were likely feeding and calling less.

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

Direct studies of blue whale hearing have not been conducted, but it assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Ketten, 1997; Richardson et al., 1995). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al., 2001; Oleson et al., 2007c; Stafford & Moore, 2005). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hz to 35 kHz (Southall et al., 2007).

Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were taken from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are affected by anthropogenic noise, threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

See the 1998 Final Recovery Plan for the Blue Whale for complete downlisting/delisting criteria for each of the following recovery goals.

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere.
2. Estimate the size and monitor trends in abundance of blue whale populations.
3. Identify and protect habitat essential to the survival and recovery of blue whale populations.
4. Reduce or eliminate human-caused injury and mortality of blue whales.
5. Minimize detrimental effects of directed vessel interactions with blue whales.
6. Maximize efforts to acquire scientific information from dead stranded, and entangled blue whales.
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales.
8. Establish criteria for deciding whether to delist or downlist blue whales.

9.1.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere (Figure 6).

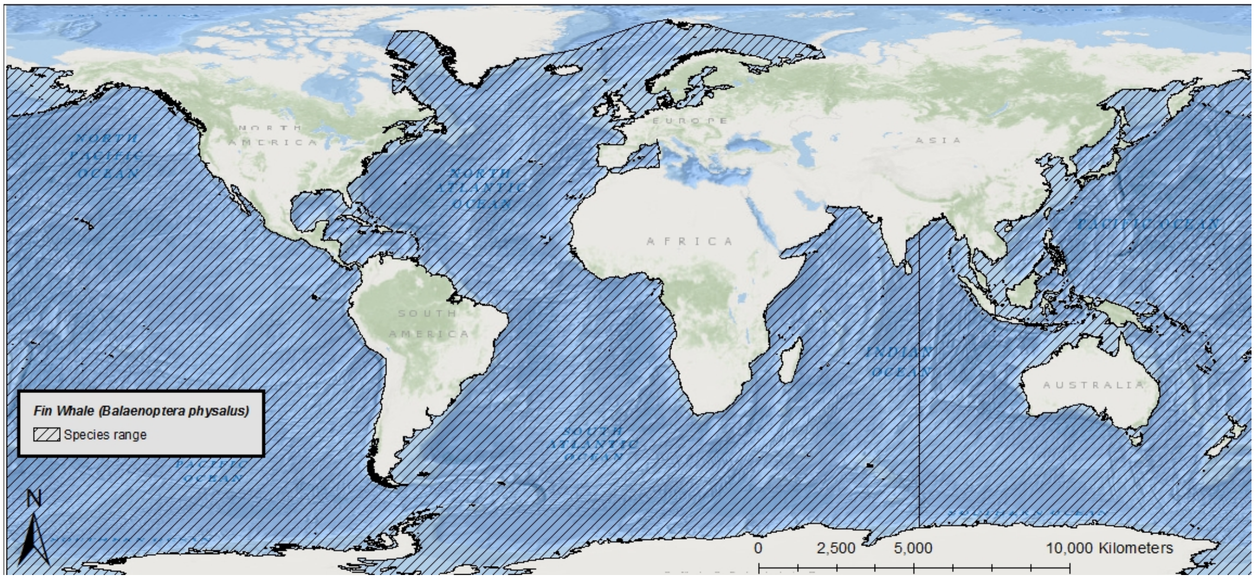

Figure 6. Map identifying the range of the endangered fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS, 2010b), recent stock assessment reports (Carretta et al., 2017; Hayes et al., 2017; Muto et al., 2017), and status review (NMFS, 2011b) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi & Wada, 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in United States waters, where the best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of stock was not surveyed (Palka, 2012). There are three stocks in United States Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al., 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al., 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al., 2016).

Current estimates indicate approximately 10,000 fin whales in United States Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al., 2016). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within oceans basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

There are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere where they appear to be reproductively isolated. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds, 1988; Thompson et al., 1992; Watkins, 1981; Watkins et al., 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hz range, but only males are known to produce these (Clark et al., 2002; Patterson & Hamilton, 1964). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ± 4 dB re 1 microPascal (μPa) at 1 m (Charif et al., 2002; Clark et al., 2002; Edds, 1988; Richardson et al., 1995; Sirovic et al., 2007; Watkins, 1981; Watkins et al., 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hz), and can be repeated over the course of many hours (Watkins et al., 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark & Charif, 1998). Richardson et al. (1995) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins, 1981; Watkins et al., 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al., 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (DON, 2010, 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al., 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hz calls has been reported as 189 ± 5.8 dB re 1 µPa at 1 m (Weirathmueller et al., 2013). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Cummings & Thompson, 1994; Edds, 1988; Watkins, 1981). In general, source levels for fin whale vocalizations are 140 to 200 dB re 1 µPa at 1 m (see also Clark & Gagnon, 2004; as compiled by Erbe, 2002b). The source depth of calling fin whales has been reported to be about 50 m (164 ft) (Watkins et al., 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20 Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al., 1992; Watkins et al., 1987).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Edds-Walton, 1997; Payne & Webb, 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al., 2002). These vocal bouts last for a day or longer (Tyack, 1999). Also, it has been suggested that some fin whale sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack, 1999).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten, 1997; Richardson et al., 1995). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten, 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 2 kHz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA, 2018).

Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the *Environmental Baseline* (Section 10) of this opinion. See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

9.1.3 Humpback Whale – Mexico Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 7).

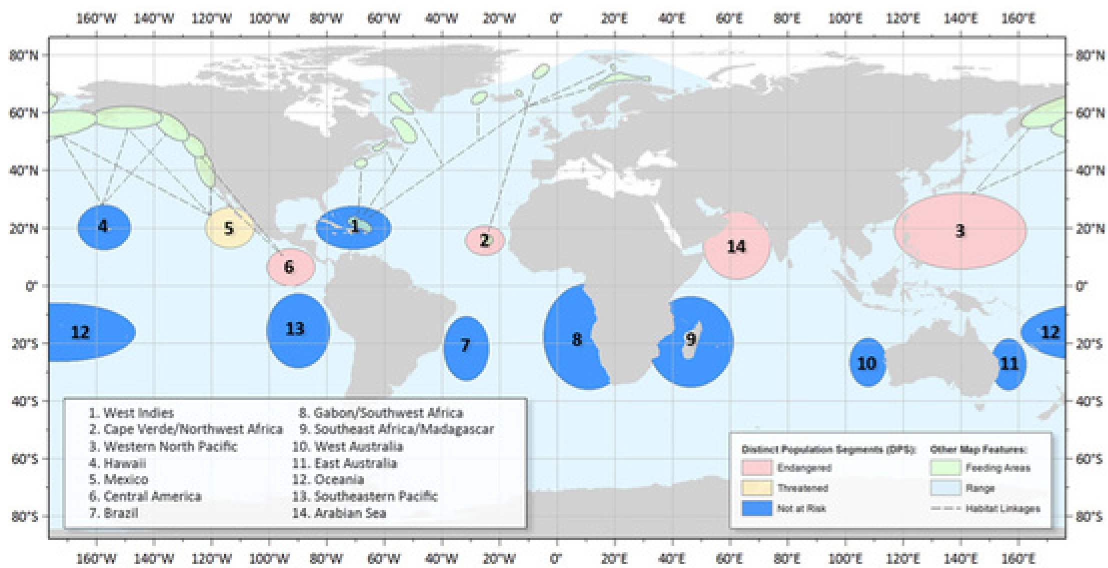

Figure 7. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al., 2015).

Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico) (Table 4).

Information available from the recovery plan (NMFS, 1991), recent stock assessment reports (Carretta et al., 2016; Muto et al., 2016; Waring et al., 2016), the status review (Bettridge et al., 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al., 2015).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Mexico DPS of humpback whales.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman & Palumbi, 2003). The current abundance of the Mexico DPS is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes (Bettridge et al., 2015).

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western GOA, and Bering Sea feeding grounds (Table 4) (81 FR 62259).

NMFS recently conducted a global status review and changed the status of humpback whales under the ESA (81 FR 62260; September 8, 2016). Under the final rule, 14 DPSs of humpback whales are recognized worldwide. Humpback whales in the action area may belong to the Mexico or Hawaii DPSs (81 FR 62260).

In the final rule changing the status of humpback whales under the ESA (81 FR 62260; September 8, 2016), the abundances of the Mexico and Hawaii DPSs throughout their range were estimated to be 3,264 (CV = 0.06) and 11,398 (CV = 0.04) whales, respectively. The Mexico DPS has an unknown trend. The growth rate of the Hawaii DPS was estimated to be increasing annually between 5.5 and 6.0 percent (Table 5).

Within the GOA, the abundance estimate for humpback whales is estimated to be 2,089 (CV = 0.09) animals and includes whale from the Hawaii DPS (89%), Mexico DPS (10.5%), and Western North Pacific DPS (0.5%[5]) (NMFS, 2016; Wade et al., 2016a).

[5] For the endangered Western North Pacific DPS, NMFS chose the upper limit of the 95% confidence interval from the Wade et al. (2016) estimate in order to be conservative due the their status.

Table 5. Probability of encountering humpback whales from each DPS in the North Pacific Ocean (columns) in various feeding areas (on left). Gray highlighted area represents the action area Adapted from Wade et al. (2016).

Summer Feeding Areas	North Pacific Distinct Population Segments			
	Western North Pacific DPS (endangered)[1]	Hawaii DPS (not listed)	Mexico DPS (threatened)	Central America DPS (endangered)[1]
Kamchatka	100%	0%	0%	0%
Aleutian I/Bering/Chukchi	4.4%	86.5%	11.3%	0%
Gulf of Alaska	0.5%	89%	10.5%	0%
Southeast Alaska / Northern BC	0%	93.9%	6.1%	0%
Southern BC / WA	0%	52.9%	41.9%	14.7%
OR/CA	0%	0%	89.6%	19.7%

[1] For the endangered DPSs, these percentages reflect the 95% confidence interval of the probability of occurrence in order to give the benefit of the doubt to the species and to reduce the chance of underestimating potential takes.

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al., 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144 to 174 dB (Au & Green, 2000; Frazer & Mercado, 2000; Richardson et al., 1995; Winn et al., 1970). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz to 10 kHz with most energy below 3 kHz (Silber, 1986; Tyack, 1983). Such sounds can be heard up to 9 km (4.9 nautical miles) away (Tyack, 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al., 1995; Tyack, 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89 Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 µPa at 1 m) (Au & Green, 2000; Erbe, 2002a; Payne, 1985; Richardson et al., 1995; Thompson et al., 1986). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al., 1995). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hz (NOAA, 2013). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz.

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al., 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson & Richardson, 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Clark & Clapham, 2004; Gabriele & Frankel., 2002; Helweg et al., 1992; Schevill et al., 1964; Smith et al., 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark & Clapham, 2004; Gabriele & Frankel., 2002; McSweeney et al., 1989). (Au et al., 2006) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al., 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne & McVay, 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151 and 189 dB re: 1 μPa-m and high frequency harmonics extending beyond 24 kHz (Au et al., 2006; Winn et al., 1970).

Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al., 1985; Dunlop et al., 2008; Silber, 1986; Simao & Moreira, 2005). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

“Feeding” calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz to 2 kHz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 μPa-m (D'Vincent et al., 1985; Thompson et al., 1986). The fundamental frequency of feeding calls is approximately 500 kHz (D'Vincent et al., 1985; Thompson et al., 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with Digital Acoustic Recording Tags[6] (DTAGs) (Stimpert et al., 2007). Underwater lunge behavior was associated with

[6] DTAG is a novel archival tag, developed to monitor the behavior of marine mammals, and their response to sound, continuously throughout the dive cycle. The tag contains a large array of solid-state memory and records continuously from a built-in hydrophone and suite of sensors. The sensors sample the orientation of the animal in three dimensions with sufficient speed and resolution to capture individual fluke strokes. Audio and sensor

nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 µPa), with the majority of acoustic energy below 2 kHz.

NMFS categorizes humpback whales in the low-frequency cetacean functional hearing group, with an applied frequency range between 7 Hz and 35 kHz (NMFS, 2018).. Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz (Ketten & Mountain, 2014). Research by Au et al. (2001) and Au et al. (2006) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re: 1 µPa-m or frequency sweep of 3.1 to 3.6 kHz. In addition, the system had some low frequency components (below 1 kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN, 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Mexico DPS still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

recording is synchronous so the relative timing of sounds and motion can be determined precisely (Johnson & Tyack, 2003)

Critical Habitat

No critical habitat has been designated for the Mexico Distinct Population Segment of humpback whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the *Environmental Baseline* (Section 10) of this opinion. See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

9.1.4 Humpback Whale – Western North Pacific Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 7).

Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico) (Table 4).

Information available from the recovery plan (NMFS, 1991), recent stock assessment reports (Carretta et al., 2016; Muto et al., 2016; Waring et al., 2016), the status review (Bettridge et al., 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al., 2015).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Western North Pacific DPS of humpback whales.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman & Palumbi, 2003). The current abundance of the Western North Pacific DPS is 1,059. A population growth rate is currently unavailable for the Western North Pacific DPS of humpback whales.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Western North Pacific DPS has less than 2,000 individuals total, and is made up of two sub-populations, Okinawa/Philippines and the Second West Pacific. Thus, while its genetic diversity may be protected from moderate environmental variance, it could be subject to extinction due to genetic risks due to low abundance (Bettridge et al., 2015).

The Western North Pacific DPS is composed of humpback whales that breed/winter in the area of Okinawa and the Philippines, another unidentified breeding area (inferred from sightings of whales in the Aleutian Islands area feeding grounds), and those transiting from the Ogasawara area. These whales migrate to feeding grounds in the northern Pacific Ocean, primarily off the Russian coast.

NMFS recently conducted a global status review and changed the status of humpback whales under the ESA (81 FR 62260; September 8, 2016). Under the final rule, 14 DPSs of humpback whales are recognized worldwide. Humpback whales in the action area may belong to the Mexico or Hawaii DPSs (81 FR 62260).

In the final rule changing the status of humpback whales under the ESA (81 FR 62260; September 8, 2016), the abundances of the Mexico and Hawaii DPSs throughout their range were estimated to be 3,264 (CV = 0.06) and 11,398 (CV = 0.04) whales, respectively. The Mexico DPS has an unknown trend. The growth rate of the Hawaii DPS was estimated to be increasing annually between 5.5 and 6.0 percent.

Within the GOA, the abundance estimate for humpback whales is estimated to be 2,089 (CV = 0.09) animals and includes whale from the Hawaii DPS (89%), Mexico DPS (10.5%), and Western North Pacific DPS (0.5%[7]) (NMFS, 2016; Wade et al., 2016a) (Table 5**)**.

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al., 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency

[7] For the endangered Western North Pacific DPS, NMFS chose the upper limit of the 95% confidence interval from the Wade et al. (2016) estimate in order to be conservative due the their status.

range of 20 Hz to 4 kHz with estimated source levels from 144 to 174 dB (Au et al., 2006; Au et al., 2000b; Frazer & Mercado, 2000; Richardson et al., 1995; Winn et al., 1970). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz to 10 kHz with most energy below 3 kHz (Silber, 1986; Tyack, 1983). Such sounds can be heard up to 9 km (4.9 nmi) away (Tyack, 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al., 1995; Tyack, 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89 Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re 1 µPa at 1 m) (Au et al., 2006; Au et al., 2000b; Erbe, 2002a; Payne, 1985; Richardson et al., 1995; Thompson et al., 1986). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al., 1995). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hz (NOAA, 2013). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz.

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al., 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson & Richardson, 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Clark & Clapham, 2004; Gabriele & Frankel., 2002; Helweg et al., 1992; Schevill et al., 1964; Smith et al., 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark & Clapham, 2004; Gabriele & Frankel., 2002; McSweeney et al., 1989). Au et al. (2000a) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al., 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne & McVay, 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151 and 189 dB re 1 µPa at 1 m and high frequency harmonics extending beyond 24 kHz (Au et al., 2006; Winn et al., 1970).

Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al., 1985; Dunlop et al., 2008; Silber, 1986; Simao & Moreira, 2005). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz to 2 kHz, less than one second in duration, and have source levels of 162 to 192 dB re 1 at 1 m (D'Vincent et al., 1985; Thompson et al., 1986). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al., 1985; Thompson et al., 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with DTAGs (Stimpert et al., 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re 1 µPa at 1 m), with the majority of acoustic energy below 2 kHz.

NMFS categorizes humpback whales in the low-frequency cetacean functional hearing group, with an applied frequency range between 7 Hz and 35 kHz (NMFS, 2018).. Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz (Ketten & Mountain, 2014). Research by Au et al. (2001) and Au et al. (2006) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re 1 µPa at 1 m or frequency sweep of 3.1 to 3.6 kHz. In addition, the system had some low frequency components (below 1 kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Status

Humpback whales were originally listed as endangered as a result of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN, 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whale-watching noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Western North Pacific DPS of humpback whales still faces a risk of extinction.

Critical Habitat

No critical habitat has been designated for the Western North Pacific Distinct Population Segment of humpback whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section of this opinion. See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

9.1.5 North Pacific Right Whale

North Pacific right whales are found in temperate and sub-polar waters of the North Pacific Ocean (Figure 8).

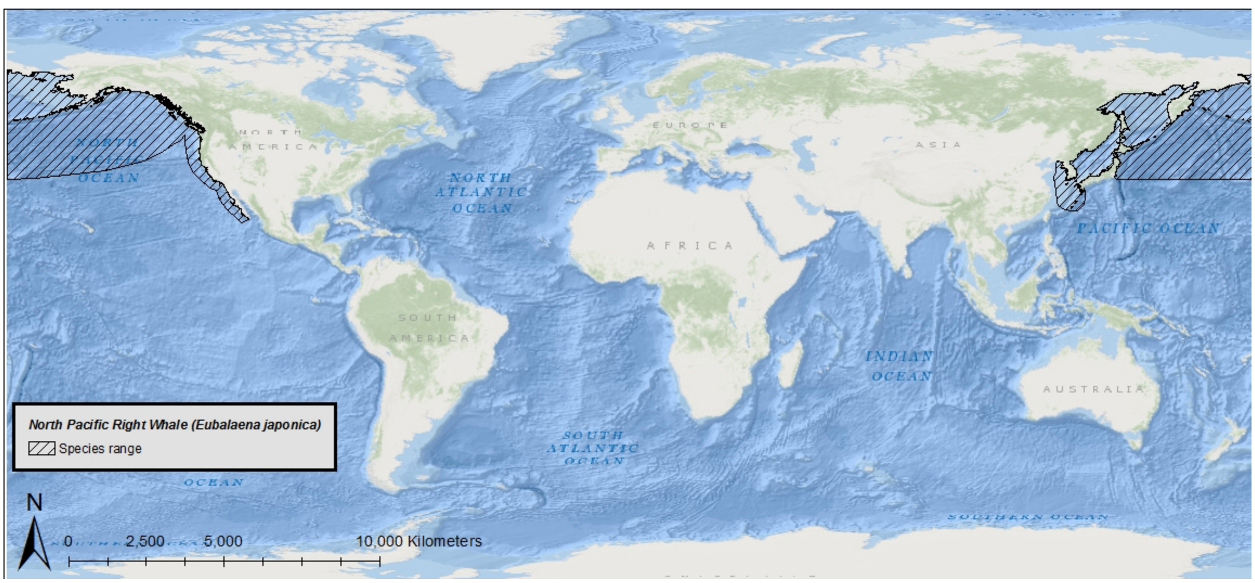

Figure 8. Map identifying the range of the endangered North Pacific right whale.

The North Pacific right whale is a baleen whale found only in the North Pacific Ocean and is distinguishable by a stocky body, lack of dorsal fin, generally black coloration, and callosities on the head region. The species was originally listed with the North Atlantic right whale (i.e., "Northern" right whale) as endangered on December 2, 1970. The North Pacific right whale was listed separately as endangered on March 6, 2008.

Information available from the recovery plan (NMFS, 2013) recent stock assessment reports (Muto et al., 2017), and status review (NMFS, 2012a, 2017c) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

North Pacific right whales can live, on average, 50 or more years. They have a gestation period of approximately one year, and calves nurse for approximately one year. Sexual maturity is reached between nine and ten years of age. The reproduction rate of North Pacific right whales remains unknown. However, it is likely low due to a male-biased sex ratio that may make it difficult for females to find viable mates. North Pacific right whales mostly inhabit coastal and continental shelf waters. Little is known about their migration patterns, but they have been observed in lower latitudes during winter (Japan, California, and Mexico) where they likely calve and nurse. In the summer, they feed on large concentrations of copepods in Alaskan waters. North Pacific right whales are unique compared to other baleen whales in that they are skim feeders meaning that they continuously filtering through their baleen while moving through a patch of zooplankton.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Pacific right whale.

The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals. There are two currently recognized stocks of North Pacific right whales, a Western North Pacific stock that feeds primarily in the Sea of Okhotsk, and an Eastern North Pacific stock that feeds in eastern north Pacific Ocean waters off Alaska, Canada, and Russia. Several lines of evidence indicate a total population size of less than 100 for the Eastern North Pacific stock. Based on photo-identification from 1998 through 2013 (Wade et al., 2011a) estimated 31 individuals, with a minimum population estimate of 26 individuals (Muto et al., 2017). Genetic data have identified 23 individuals based on samples collected between 1997 and 2011 (Leduc et al., 2012). The Western North Pacific stock is likely more abundant and was estimated to consist of 922 whales (95 percent confidence intervals 404 to 2,108) based on data collected in 1989, 1990, and 1992 (IWC, 2001; Thomas et al., 2016). The population estimate for the Western North Pacific stock is likely in the low hundreds (Brownell Jr. et al., 2001). While there have been several sightings of Western North Pacific right whales in recent years, with one sighting identifying at least 77 individuals, these data have yet to be compiled to provide a more recent abundance estimate (Thomas et al., 2016). There is currently no information on the population trend of North Pacific right whales.

As a result of past commercial whaling, the remnant population of North Pacific right whales has been left vulnerable to genetic drift and inbreeding due to low genetic variability. This low diversity potentially affects individuals by depressing fitness, lowering resistance to disease and parasites, and diminishing the whales' ability to adapt to environmental changes. At the population level, low genetic diversity can lead to slower growth rates, lower resilience, and poorer long-term fitness (Lacy, 1997). Marine mammals with an effective population size of a few dozen individuals likely can resist most of the deleterious consequences of inbreeding (Lande, 1991). It has also been suggested that if the number of reproductive animals is fewer than fifty, the potential for impacts associated with inbreeding increases substantially. Rosenbaum et al. (2000) found that historic genetic diversity of North Pacific right whales was relatively high compared to North Atlantic right whales, but samples from extant individuals showed very low genetic diversity, with only two matrilineal haplotypes among the five samples in their dataset.

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20 and 60° North latitude. Prior to exploitation by commercial whalers, concentrations of North Pacific right whales were found in the GOA, Aleutian Islands, south central Bering Sea, Sea of Okhotsk, and Sea of Japan. There has been little recent sighting data of North Pacific right whales occurring in the central North Pacific and Bering Sea. However, since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months. In the Western North Pacific Ocean where the population is thought to be somewhat larger, North Pacific right whales have been sighted in the Sea of Okhotsk and other areas off the coast of Japan, Russia, and South Korea (Thomas et al., 2016). Although North Pacific right whales are typically found in higher latitudes, they are thought to migrate to more temperate waters during winter to reproduce, and have been sighted as far south as Hawaii and Baja California.

Vocalization and Hearing

Given their extremely small population size and remote location, little is known about North Pacific right whale vocalizations (Marques et al., 2011). However, data from other right whales is informative. Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey path presence (Biedron et al., 2005; Tyson & Nowacek, 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald & Moore, 2002; Parks & Tyack, 2005). A large majority of vocalizations occur in the 300 to 600 Hz range with up and down sweeping modulations (Vanderlaan et al., 2003). Vocalizations below 200 Hz and above 900 Hz were rare (Vanderlaan et al., 2003). Calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al., 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al., 2012a). Blows are associated with ventilation and are generally inaudible underwater (Parks & Clark, 2007). Up calls are 100 to 400 Hz (Gillespie & Leaper, 2001). Gunshots appear to be largely or exclusively male vocalization (Parks et al., 2005b).

Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al., 2001). Moans are usually produced within 10 m (33 ft) of the surface (Matthews et al., 2001). Up calls were detected year-round in Massachusetts Bay except July and August and peaking in April (Mussoline et al., 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al., 2011; Morano et al., 2012; Mussoline et al., 2012). Estimated source levels of gunshots in non-surface active groups are 201 dB re 1 µPa peak-to-peak (Hotchkin et al., 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar top their mothers' screams (Parks et al., 2003; Parks & Tyack, 2005). Source levels for these calls in surface active groups range from 137 to 162 dB re 1 µPa at 1 m (rms), except for gunshots, which are 174 to 192 dB re 1 µPa at 1 m (rms) (Parks & Tyack, 2005). Up calls may also be used to reunite mothers with calves . North Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short term periods due to exposure to vessel noise (Parks & Clark, 2007; Parks et al., 2007a; Parks et al., 2005a; Parks et al., 2011; Parks et al., 2010; Parks et al., 2012b; Parks et al., 2006), particularly the peak frequency (Parks, 2009). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al., 2003; Nowacek et al., 2004).

There is no direct data on the hearing range of North Pacific right whales. However, based on anatomical modeling, the hearing range for North Atlantic right whales is predicted to be from 10 Hz to 35 kHz (NOAA, 2018) with functional ranges probably between 15 Hz to 18 kHz (Parks et al., 2007b).

Status

The North Pacific right whale is endangered because of past commercial whaling. Prior to commercial whaling, abundance has been estimated to have been more than 11,000 individuals. Current threats to the survival of this species include hunting, ship strikes, climate change, and fisheries interactions (including entanglement). The resilience of North Pacific right whales to future perturbations is low due to its small population size and continued threats. Recovery is not anticipated in the foreseeable future (several decades to a century or more) due to small population size and lack of available current information.

Critical Habitat

In 2008, NMFS designated critical habitat for the North Pacific right whale, which includes an area in the Southeast Bering Sea and an area south of Kodiak Island in the GOA (Figure 3). These areas are influenced by large eddies, submarine canyons, or frontal zones which enhance nutrient exchange and act to concentrate prey. These areas are adjacent to major ocean currents and are characterized by relatively low circulation and water movement. Both critical habitat areas support feeding by North Pacific right whales because they contain the designated physical and biological features (previously referred to as primary constituent elements), which include:

nutrients, physical oceanographic processes, certain species of zooplankton, and a long photoperiod due to the high latitude. Consistent North Pacific right whale sightings are a proxy for locating these elements.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover North Pacific right whale populations. These threats will be discussed in further detail in the *Environmental Baseline* (Section 10) of this opinion. See the 2013 Final Recovery Plan for the North Pacific right whale for complete downlisting/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

9.1.6 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 9).

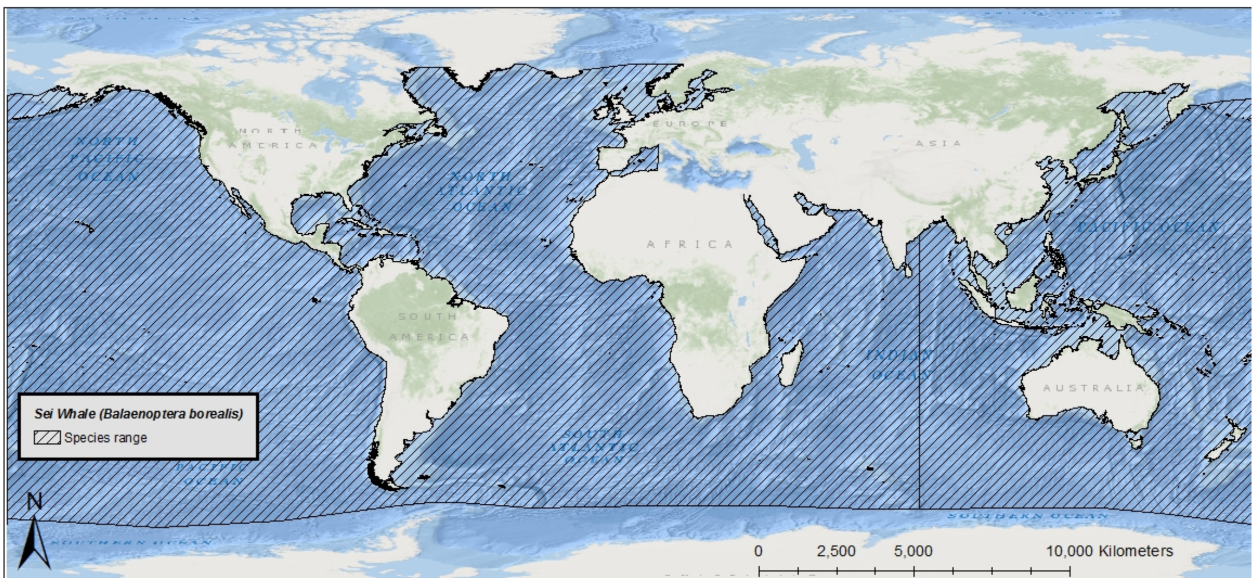

Figure 9. Map identifying the range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970 (Table 4).

Information available from the recovery plan (NMFS, 2011c), recent stock assessment reports (Carretta et al., 2017; Hayes et al., 2017; Muto et al., 2017), and status review (NMFS, 2012b) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sei whale.

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC, 2016; Thomas et al., 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=178, N_{min}=93), and Eastern North Pacific (N=519, N_{min}=374). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific Ocean sei whales (Wada & Numachi, 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific Ocean sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic Ocean (Baker & Clapham, 2004; Huijser et al., 2018). Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al., 1991; Huijser et al., 2018; Kanda et al., 2011; Kanda et al., 2006; Kanda et al., 2015; Kanda et al., 2013).

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hz range of one to three second durations (McDonald et al., 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson & Richardson, 1995). Source levels of 189 ±5.8 dB re: 1 μPa at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al., 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten, 1997; Richardson et al., 1995). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten, 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA, 2018).

Status

The sei whale is endangered as a result of past commercial whaling. Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the *Environmental Baseline* (Section 10) of this opinion. See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

9.1.7 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 10).

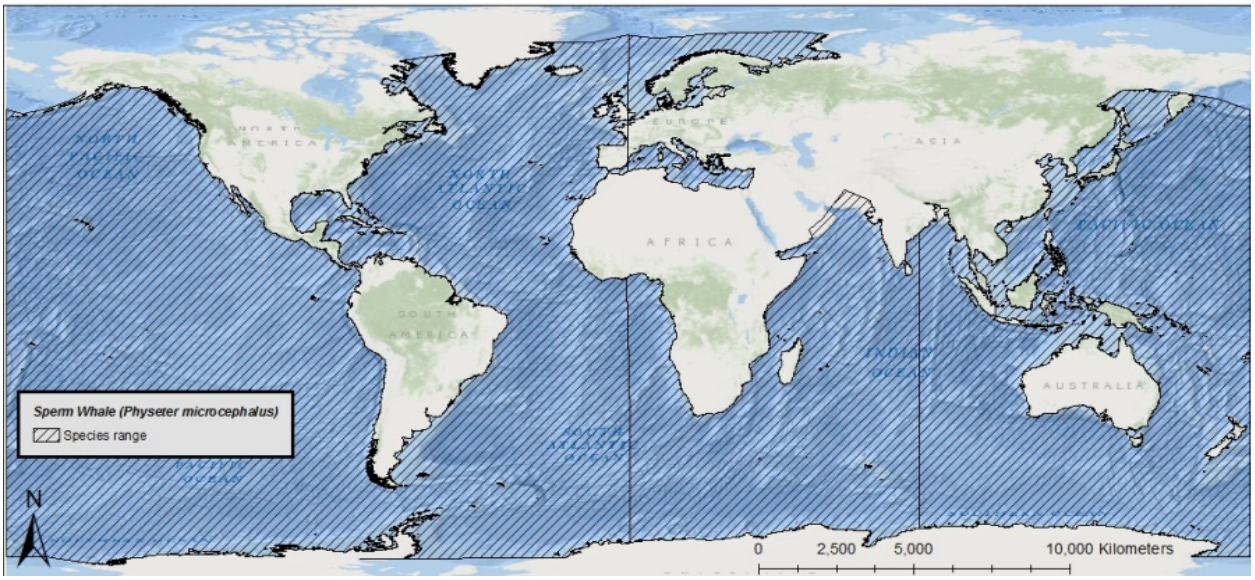

Figure 10. Map identifying the range of the endangered sperm whale.

Sperm whales are the largest toothed whale and distinguishable from other whales by its extremely large heard, which takes up to 25 to 35 percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS, 2010a), recent stock assessment reports (Carretta et al., 2017; Hayes et al., 2017; Muto et al., 2017), and status review (NMFS, 2015) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead, 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity is reached between seven and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 m (1,968 ft) or more, and are uncommon in waters less than 300 m (984 ft) deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sperm whale.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead, 2009). The higher estimates may be approaching population sizes prior to commercial whaling. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two to three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consists of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two to three U.S. stocks that occur in the Pacific Ocean, the California/Oregon/Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 3,354 individuals (N_{min}=2,539). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm & Gyllensten, 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al., 2011; Rendell et al., 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al., 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles.

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold, 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins, 1977) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. Another class of sound, "squeals," are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al., 2007). The source levels of clicks can reach 236 dB re: 1 μPa at 1 m, although lower source level energy has been suggested at around 171 dB re 1 μPa at 1 m (Goold & Jones, 1995; Mohl et al., 2003; Weilgart & Whitehead, 1993; Weilgart & Whitehead, 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold & Jones, 1995; Weilgart & Whitehead, 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re 1 µPa at 1 m (Madsen et al., 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris & Harvey, 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold & Jones, 1995; Miller et al., 2004; Weilgart & Whitehead, 1993; Weilgart & Whitehead, 1997; Whitehead & Weilgart, 1991). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al., 2005; Miller et al., 2004). Clicks are also used during social behavior and intragroup interactions (Weilgart & Whitehead, 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins & Schevill, 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell & Whitehead, 2004; Weilgart & Whitehead, 1997). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al., 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Pavan et al., 2000; Weilgart & Whitehead, 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart & Whitehead, 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis & Alexiadou, 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder & Ridgway, 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten, 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten, 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al., 1985; Watkins & Schevill, 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al., 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al., 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and one kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold & Jones, 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al., 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA, 2018).

Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the *Environmental Baseline* (Section 10) of this opinion. See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals.

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

9.1.8 Steller Sea Lion – Western Distinct Population Segment

The Steller sea lion ranges from Japan, through the Okhotsk and Bering Seas, to central California. It consists of two morphologically, ecologically, and behaviorally separate DPSs: the Eastern, which includes sea lions in Southeast Alaska, British Columbia, Washington, Oregon, and California; and the Western, which includes sea lions in all other regions of Alaska, as well as Russia and Japan (Figure 11).

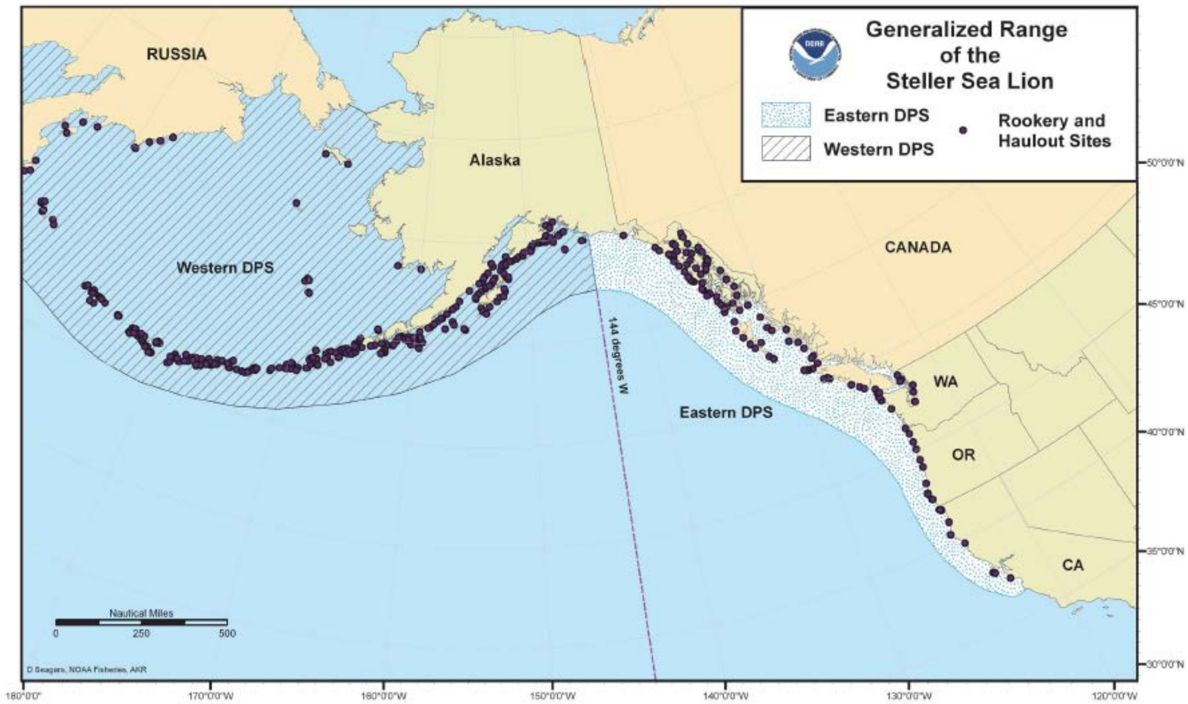

Figure 11. Map identifying the range of the endangered Western distinct population segment of Steller sea lion.

Steller sea lion adults are light blonde to reddish brown and slightly darker on the chest and abdomen. At the time of their initial listing, Steller sea lions were considered a single population listed as threatened. On May 5, 1997, following a status review, NMFS established two DPSs of Steller sea lions, and issued a final determination to list the Western DPS as endangered under the ESA. The Eastern DPS of Steller sea lion was delisted on November 4, 2013, and the Western DPS of Steller sea lion retained its endangered status (78 FR 66139) (Table 4).

We used information available in the final listing, the revised Recovery Plan (NMFS, 2008), and the most recent stock assessment report (Muto et al., 2017) to summarize the status of the Western DPS of Steller sea lions, as follows.

Life History

Within the Western DPS of Steller sea lions, pupping and breeding occurs at numerous major rookeries from late May to early July. Male Steller sea lions become sexually mature at three to seven years of age. They are polygynous, competing for territories and females by age ten or eleven. Female Steller sea lions become sexually mature at three to six years of age and reproduce into their early 20's. Most females breed annually, giving birth to a single pup. Pups are usually weaned in one to two years. Females and their pups disperse from rookeries by August to October. Juveniles and adults disperse widely, especially males. Their large aquatic ranges are used for foraging, resting, and traveling. Steller sea lions forage on a wide variety of demersal, semi-demersal, and pelagic prey, including fish and cephalopods. Some prey species form large seasonal aggregations, including endangered salmon and eulachon species. Others are available year round.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Western DPS of the Steller sea lion.

As of 2017, the best estimate of abundance of the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups (total N_{min}= 54,267) (Muto et al., 2018). This represents a large decline since counts in the 1950s (N=140,000) and 1970s (N=110,000).

Using data collected from 1978 through 2017, there is strong evidence that pup and non-pup counts of western stock Steller sea lions in Alaska were at their lowest levels in 2002 and 2003, respectively, and have increased at 1.78 percent and 2.14 percent , respectively, between 2002 and 2017 (Sweeney et al., 2016). Western DPS Steller sea lion site counts decreased 40 percent from 1991 through 2000, an average annual decline of 5.4 percent; however, counts increased three percent between 2004 through 2008, the first recorded population increase since the 1970s (NMFS, 2008). Overall, there are strong regional differences across the range in Alaska, with positive trends in the GOA and eastern Bering Sea east of Samalga Pass (~170°W) and generally negative trends to the west in the Aleutian Islands. Non-pup trends in 2002- 2017 in Alaska have a longitudinal gradient with highest rates of increase generally in the east (eastern GOA) and steadily decreasing rates to the west.

Based on the results of genetic studies, the Steller sea lion population was reclassified into two DPSs: Western and Eastern. The data which came out of these studies indicated that the two populations had been separate since the last ice age (Bickham et al., 1998). Further examination of the Steller sea lions from the GOA (i.e., the Western DPS) revealed a high level of haplotypic diversity, indicating that genetic diversity had been retained despite the decline in abundance (Bickham et al., 1998).

Steller sea lions are distributed mainly around the coats to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaido, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California (Figure 11). The Western DPS includes Steller sea lions that reside in the central and western GOA, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia).

Vocalization and Hearing

Steller sea lions hear within the range of 0.5 to 32 kHz (Kastelein et al., 2005). Males and females apparently have different hearing sensitivities, with males hearing best at 1 to 16 kHz (best sensitivity at the low end of the range) and females hearing from 16 to 25 kHz (best hearing at the upper end of the range) (Kastelein et al., 2005).

Status

The species was ESA-listed as threatened in 1990 because of significant declines in population sizes. At the time, the major threat to the species was thought to be reduction in prey availability. To protect and recover the species, NMFS established the following measures: prohibition of shooting at or near Steller sea lions; prohibition of vessel approach to within 5.6 km (3 nmi) of specific rookeries, within 0.8 km (0.4 nmi) of land, and within sight of other listed rookeries; and restriction of incidental fisheries take to 675 Steller sea lions annually in Alaskan waters. In 1997, the Western DPS of Steller sea lions was reclassified as endangered because it had continued to decline since its initial ESA-listing in 1990. Despite the added protection (and annual incidental fisheries take of 26 individuals), the Western DPS of Steller sea lions is likely still in decline (though the decline was slowed or stopped in some portions of the range). The reasons for the continued decline are unknown but may be associated with nutritional stress as a result of environmental change and competition with commercial fisheries. The Western DPS of Steller sea lions appears to have little resilience to future perturbations.

Critical Habitat

In 1997, NMFS designated critical habitat for the Steller sea lion. The designated critical habitat includes specific rookeries, haul-outs, and associated areas, as well as three foraging areas that are considered to be essential for health, continued survival, and recovery of the species.

In Alaska, areas include major Steller sea lion rookeries, haul-outs and associated terrestrial, air, and aquatic zones. Designated critical habitat includes a terrestrial zone extending 0.9 km (0.5 nmi) landward from each major rookery and haul-out; it also includes air zones extending 0.9 km above these terrestrial zones and aquatic zones. Aquatic zones extend 0.9 km (0.5 nmi) seaward from the major rookeries and haul-outs east of 144° West. In addition, NMFS designated special aquatic foraging areas as critical habitat for the Steller sea lion. These areas include the Shelikof Strait (in the GOA), Bogoslof Island, and Seaguam Pass (the latter two are in the Aleutians). These sites are located near Steller sea lion abundance centers and include important foraging areas, large concentrations of prey, and host large commercial fisheries which often interact with the species. The physical and biological features identified for the aquatic areas of Steller sea lion designated critical habitat that occur within the action area are those that support foraging, such as adequate prey resources and available foraging habitat (58 FR 45269). While Steller sea lions do rest in aquatic habitat, there was insufficient information available at the time critical habitat was designated to include aquatic resting sites as part of the critical habitat designation (58 FR 45269).

Recovery Goals

See the 2008 Revised Recovery Plan for the Steller sea lion for complete downlisting/delisting criteria for each of the following recovery goals.

1. Baseline population monitoring.
2. Insure adequate habitat and range for recovery.
3. Protect from over-utilization for commercial, recreational, scientific, or educational purposes.
4. Protect from diseases, contaminants, and predation.
5. Protect from other natural or anthropogenic actions and administer the recovery program.

10 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 C.F.R. §402.02).

A number of human activities have contributed to the status of populations of ESA-listed cetaceans in the action areas. Some human activities are ongoing and appear to continue to affect cetacean populations in the action areas for this consultation. Some of these activities, most notably commercial whaling, occurred extensively in the past and continue at low levels that no longer appear to significantly affect cetacean populations, although the effects of past reductions in numbers persist today. The following discussion summarizes these impacts, which include climate change, oceanic temperature regimes, whaling and subsistence harvest, vessel strike, whale watching, fisheries, fisheries interactions, aquaculture, pollution, aquatic nuisance species, sound, military activities, and scientific research.

10.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC, 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C under RCP2.6, 1.1 to 2.6°C under RCP 4.5, 1.4 to 3.1°C under RCP6.0, and 2.6 to 4.8°C under RCP8.5 with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC, 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al., 2018).

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al., 2018). The IPCC Special Report on the Impacts of Global Warming (IPCC, 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (IPCC, 2018). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al., 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC, 2018). Average global warming up to 1.5°C as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (IPCC, 2018).

Several of the most important threats contributing to the extinction risk of ESA-listed species are related to impacts to prey availability due to changes in ocean temperatures, ocean currents and ocean acidification. The main concerns regarding impacts of global climate change are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean [ocean acidification; (IPCC, 2014)]. As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100 (IPCC, 2014). These impacts are particularly concerning for those animals which serve as prey for ESA-listed species.

Ocean acidification negatively affects organisms such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs), the latter being an important part of the food web in Alaska waters. Some studies in the nutrient-rich regions have found that food supply may play a role in determining the resistance of some organisms to ocean acidification (Markon et al., 2018; Ramajo et al., 2016). Reduction in prey items can create a collapse of the zooplankton populations and thereby result in potential cascading reduction of prey at various levels of the food web, thereby reducing the availability of the larger prey items of marine mammals.

Current climate models predict strong shifts in the climate of Gulf of Alaska over the coming decades. Two of the most important changes, the warming of the upper ocean and a shift toward a more acidic ocean, are already occurring according to observational evidence, and are very likely to continue into the future, with the magnitude of increase depending on CO_2 concentration pathways (Gattuso et al., 2015). Other process that may potentially be important in the GOA include changes in ocean circulation and stratification, changes in precipitation and attendant changes in the timing and magnitude of freshwater input into the ocean, and changes in sea level height. The mean sea surface temperature is expected to gradually increase until at some point it will exceed the range that has been experienced historically, while the same pattern of decadal variation characteristic of the Pacific Decadal Oscillation will likely persist into the future (Overland & Wang, 2007). Model projections indicate that by 2050 most of the North Pacific will have warmed by an average of 1.2-1.8° C.

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Macleod et al., 2005); (Robinson et al., 2005); (Kintisch, 2006); (Learmonth et al., 2006); (McMahon & Hays, 2006); (Evans & Bjørge, 2013); (IPCC, 2014). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds & Isaac, 2007), recent research has indicated a range of consequences already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman, 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS & USFWS, 2015); (NMFS & USFWS, 2013a); (NMFS & USFWS, 2013b); (NMFS & USFWS, 2007b); (NMFS & USFWS, 2007a). These impacts will be exacerbated by sea level rise. The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al., 2006); (Baker et al., 2006).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al., 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. McMahon and Hays (2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. Macleod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction). Willis-Norton et al. (2015) acknowledged there will be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Payne et al., 1986; Payne et al., 1990; Clapham et al., 1999). Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures regimes, the timing of migration can change or negatively impact population sustainability (Simmonds & Eliott, 2009).

This review provides some examples of impacts to ESA-listed species and their habitats that may occur as the result of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats.

10.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Oceans can be altered due to periodic shifts in atmospheric patterns caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events, and the Pacific decadal oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action area (Beamish, 1993; Hare & Mantua, 2001; Mantua et al., 1997); (Benson & Trites, 2002; Mundy, 2005; Mundy & Cooney, 2005; Stabeno et al., 2004). For example, decade-scale climatic regime shifts have been related to changes in zooplankton in the North Atlantic Ocean (Fromentin & Planque, 1996), and decadal trends in the North Atlantic oscillation (Hurrell, 1995) can affect the position of the Gulf Stream (Taylor et al., 1998) and other circulation patterns in the North Atlantic Ocean that act as migratory pathways for various marine species, especially fish.

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua & Hare, 2002; Stabeno et al., 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer, 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Childers et al., 2005; Hare et al., 1999). Recent sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the GOA from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. More research needs to be done to determine if the region is indeed shifting to a colder Pacific decadal oscillation phase in addition to what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer terms trends in climate change and/or variability also have the potential to alter habitat conditions suitable for ESA-listed species in the action area on a much longer time scale. For example, from 1906 through 2006, global surface temperatures have risen 0.74° C and this trend is continuing at an accelerating pace. Twelve of the warmest years on record since 1850 have occurred since 1995 (Poloczanska et al., 2009). Possible effects of this trend in climate change and/or variability for ESA-listed marine species in the action area include the alteration of community composition and structure, changes to migration patterns or community structure, changes to species abundance, increased susceptibility to disease and contaminants, altered timing of breeding and nesting, and increased stress levels (Kintisch, 2006; Learmonth et al., 2006; Macleod et al., 2005; McMahon & Hays, 2006; Robinson et al., 2005). Climate change can influence reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (*Mirounga angustirostris*) during El Niño periods

(McMahon & Burton, 2005) as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sear surface temperature (Whitehead et al., 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that climate change and/or variability may have to these species from year to year in the action area (Kintisch, 2006; Simmonds & Isaac, 2007).

10.3 Whaling and Subsistence Harvesting

Large whale population numbers in the action area have historically been impacted by aboriginal hunting and early commercial exploitation, and some stocks were already reduced by 1864 (the beginning of the era of modern commercial whaling using harpoon guns as opposed to harpoons simply thrown by men). From 1864 through 1985, at least 2.4 million baleen whales (excluding minke whales [*Balaenoptera acutorostrata*]) and sperm whales were killed (Gambell, 1999). The large number of baleen whales harvested during the 1930s and 1940s has been shown to correspond to increased cortisol levels in earplugs collected from baleen whales, suggesting that anthropogenic activities, such as those associated with whaling, may contribute to increased stress levels in whales (Trumble et al., 2018). Prior to current prohibitions on whaling most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. In 1982, the International Whaling Commission issued a moratorium on commercial whaling beginning in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that field objections to the moratorium (i.e., Iceland and Norway). Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the moratorium. The reported catch and catch limits of large whale species from aboriginal subsistence whaling, special permit whaling, and commercial whaling can be found on the International Whaling Commission's website at: https://iwc.int/whaling. Additionally, the Japanese whaling fleet carries out whale hunts under the guise of "scientific research," though very few peer-reviewed papers have been published as a result of the program, and meat from the whales killed under the program is processed and sold at fish markets.

Norway and Iceland take whales commercially at present, either under objection to the moratorium decision or under reservation to it. These countries establish their own catch limits but must provide information on those catches and associated scientific data to the International Whaling Commission. The Russian Federation has also registered an objection to the moratorium decision but does not exercise it. The moratorium is binding on all other members of the International Whaling Commission. Norway takes minke whales in the North Atlantic Ocean within its Exclusive Economic Zone, and Iceland takes minke whales and fin whales in the North Atlantic Ocean, within its Exclusive Economic Zone (IWC, 2012b).

Under current International Whaling Commission regulations, aboriginal subsistence whaling is permitted for Denmark (Greenland, fin and minke whales, *Balaenoptera* spp.), the Russian

Federation (Siberia, gray [*Eschrichtius robustus*], and bowhead [*Balaena mysticetus*] whales), St. Vincent and the Grendaines (Bequia, humpback whales [*Megaptera novaeangliae*]) and the U.S. (Alaska, bowhead and gray whales). It is the responsibility of national governments to provide the International Whaling Commission with evidence of the cultural and subsistence needs of their people. The Scientific Committee provides scientific advice on safe catch limits for such stocks (IWC, 2012b). Based on the information on need and scientific advice, the International Whaling Commission then sets catch limits, recently in five-year blocks.

Scientific permit whaling has been conducted by Japan and Iceland. In Iceland, the stated overall objective of the research program was to increase understanding of the biology and feeding ecology of important cetacean species in Icelandic waters for improved management of living and marine resources based on an ecosystem approach. While Iceland states that its program was intended to strengthen the basis for conservation and sustainable use of cetaceans, it noted that it was equally intended to form a contribution to multi-species management of living resources in Icelandic waters. These whaling activities may or may not operate outside of the action area but the whales killed in these whaling expeditions are part of the populations of whales (e.g., fin, sei, and sperm) occurring within the action area for this consultation.

Most current whaling activities occur outside of the core study areas, but within the overall action area. Regardless, prior exploitation is likely to have altered population structure and social cohesion of all whale species within the action area, such that effects on abundance and recruitment continued for years after harvesting has ceased. ESA-listed whale mortalities since 1985 resulting from these activities can be seen below in Table 6 (IWC, 2017a, 2017b, 2017c).

Table 6. Endangered Species Act-listed whale mortalities as the result of whaling since 1985.

Species	Commercial Whaling	Scientific Research	Subsistence
Blue Whale	-- --	-- --	-- --
Fin Whale	706	310	385
Humpback Whale	-- --	-- --	123
North Pacific Right Whale	-- --	-- --	-- --
Sei Whale	-- --	1,563	3
Sperm Whale	388	56	-- --

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al., 2014). Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs in the Atlantic, Pacific, and Southern Oceans whether it be under objection of the International Whaling Commission, for aboriginal subsistence purposes, or under International Whaling Commission scientific permit 1985 through 2013. Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

Historically, commercial whaling caused all of the large whale species to decline to the point where they faced extinction risks high enough to list them as endangered species. Since the end of large-scale commercial whaling, the primary threat to the species has been eliminated. Many whale species have not yet fully recovered from those historic declines. Scientists cannot determine if those initial declines continue to influence current populations of most large whale species in the Artic, Atlantic, Indian, Pacific, and Southern Oceans. For example, the North Atlantic right whale has not recovered from the effects of commercial whaling and continue to face very high risks of extinction because of their small population sizes and low population growth rates. In contrast, populations of species such as the humpback whale have increased substantially from post-whaling population levels and appear to be recovering despite the impacts of vessel strikes, interactions with fishing gear, and increased levels of ambient sound.

10.4 Vessel Strike

Vessels have the potential to affect animals through strikes, sound, and disturbance associated with their physical presence. Responses to vessel interactions include interruption of vital behaviors and social groups, separation of mothers and young, and abandonment of resting areas (Boren et al., 2001; Constantine, 2001; Mann et al., 2000; Nowacek et al., 2001; Samuels et al., 2000). Whale watching, a profitable and rapidly growing business with more than nine million participants in 80 countries and territories, may increase these types of disturbance and negatively affected the species (Hoyt, 2001).

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales). This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al., 1993; Wiley et al., 1995). As vessels to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. All sizes and types of vessels can hit whales, but most lethal and sever injuries are caused by vessels 80 m (262.5 ft) or longer (Laist et al., 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 km per hour (14 kts) (Laist et al., 2001). Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al., 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported and most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff et al., 2011). Kraus et al. (2005) estimated that 17 percent of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al., 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of five and 17 percent and conservatively estimated that vessel strike mortality may be as high as 7.8, 2.0, and 2.7 times the recommended limit for blue, humpback, and fin whale stocks in this area, respectively.

Of 11 species of cetaceans known to be threatened by vessel strikes in the northern hemisphere, fin whales are the mostly commonly struck species, but North Atlantic right, gray, humpback, and sperm whales are also struck (Laist et al., 2001; Vanderlaan & Taggart, 2007). In some areas, one-third of all fin whale and North Atlantic right whale strandings appear to involve vessel strikes (Laist et al., 2001). Vessel traffic within the action area can come from both private (e.g., commercial, recreational) and federal vessel (e.g., military, research), but traffic that is most likely to result in vessel strikes comes from commercial shipping.

The potential lethal effects of vessel strikes are particularly profound on species with low abundance. However, all whale species have the potential to be affected by vessel strikes. The latest five-year average mortalities and serious injuries related to vessel strikes for the ESA-listed cetacean stocks within U.S. waters likely to be found in the action area are given in Table 7 below (Hayes et al., 2017; Henry et al., 2017). Data represent only known mortalities and serious injuries; more, undocumented mortalities and serious injuries for these and other stocks found within the action area have likely occurred.

Table 7. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals within the action area.

Species	Pacific Stock	Alaska Stock
Blue Whale	0.6	NA
Fin Whale	1.8	0.4
Humpback Whale– Multiple ESA-listed DPSs	1	0.4
North Pacific Right Whale	0	NA
Sei Whale	0	NA
Sperm Whale	0	0

DPS=Distinct Population Segment
NA=Not Applicable

10.5 Whale Watching

Whale watching is a rapidly-growing industry with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories (O'Connor et al., 2009). As of 2010, commercial whale watching was a one billion dollar global industry per year (Lambert et al., 2010). Private vessels may partake in this activity as well. NMFS has issued certain regulations and guidelines relevant to whale watching. As noted previously, many of the cetaceans considered in this opinion are highly migratory, so may also be exposed to whale watching activity occurring outside of the study areas.

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, whale watching is not without potential negative impacts (reviewed in Parsons, 2012). Whale watching has the potential to harass whales by altering feeding, breeding, and social behavior or even injure them if the vessel gets too close or strikes the animal. Preferred habitats may be abandoned if disturbance levels are too high. Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al., 1993; Wiley et al., 1995).

Several studies have examined the short-term effects of whale watch vessels on marine mammals. (Au & Green, 2000; Corkeron, 1995; Erbe, 2002b; Felix, 2001; Magalhaes et al., 2002; Richter et al., 2003; Scheidat et al., 2004; Simmonds, 2005; Watkins, 1986; Williams et al., 2002). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel sound, and the number of vessels. In some circumstances, whales do not appear to respond to vessels, but in other circumstances, whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mother's sides, which leads to greater energy expenditures by the calves (NMFS, 2006).

Although numerous short-term behavioral responses to whale watching vessels were documented, little information is available on whether long-term negative effects result from whale watching (NMFS, 2006). Christiansen et al. (2014) estimated that cumulative time minke whales spent with whale watching boats in Iceland to assess the biological significance of whale watching disturbances and found that, through some whales were repeatedly exposed to whale watching boats throughout the feeding season, the estimated cumulative time they spent with boats was very low. Christiansen et al. (2014) suggested that the whale watching industry, in its current state, is likely not having any long-term negative effects on vital rates.

It is difficult to precisely quantify or estimate the magnitude of the risks posed to marine mammals in general from vessel approaches associated with whale watching. Given the proposed seismic survey activities will not occur within 70 km (37.8 nmi) of land, few (if any) whale watching vessels will be expected to co-occur with the proposed action's research vessel.

10.6 Fisheries Interactions

Fisheries constitute an important and widespread use of the ocean resources throughout the action area. Fisheries can adversely affect fish populations, other species, and habitats. Direct effects of fisheries interactions on marine mammals include entanglement and entrapment, which can lead to fitness consequences or mortality as a result of injury or drowning. Indirect effects include reduced prey availability, including overfishing of targeted species, and destruction of habitat. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by marine mammals.

Fisheries can have a profound influence on fish populations. In a study of restrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change. Marine mammals are known to feed on several species of fish that are harvested by humans (Waring et al., 2008). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of several populations.

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al., 2015). Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al., 2007); in an extensive analysis of global risks to marine mammals, incidental catch was identified as the most common threat category (Avila et al. 2018). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik, 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of cetaceans that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities. Between 1970 and 2009, two-thirds of mortalities of large whales in the Northwest Atlantic Ocean were attributed to human causes, primarily vessel strike and entanglement (Van der Hoop et al., 2013). In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch & Perry, 2014).

Cetaceans are also known to ingest fishing gear, likely mistaking it for prey, which can lead to fitness consequences and mortality. Necropsies of stranded whales have found that ingestion of net pieces, ropes, and other fishing debris has resulted in gastric impaction and ultimately death (Jacobsen et al., 2010). As with vessel strikes, entanglement or entrapment in fishing gear likely has the greatest impact on populations of ESA-listed species with the lowest abundance (e.g., Kraus et al., 2016). Nevertheless, all species of cetaceans may face threats from derelict fishing gear.

The latest five-year average mortalities and serious injuries related to fisheries interactions for the ESA-listed cetacean stocks within U.S. waters likely to be found in the action area are given in Table 8 below (Hayes et al., 2017; Henry et al., 2017). Data represent only known mortalities and serious injuries; more, undocumented moralities and serious injuries for these and other stocks found within the action area have likely occurred.

Table 8. Five-year annual average mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area.

Species	Pacific Stock	Alaska Stock
Blue Whale	0	NA
Fin Whale	0.2	0.2
Humpback Whale – Multiple ESA-listed DPSs	1.2	0.6
North Pacific Right Whale	0	NA
Sei Whale	0	NA
Sperm Whale	0.7	3.7

DPS=Distinct Population Segment
NA=Not Applicable

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al., 1985). Many cetacean species (particularly fin and humpback whales) are known to feed on species of fish that are harvested by humans (Carretta et al., 2016). Thus, competition with humans for prey in the action area is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed cetacean populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics. However, in general the effects of fisheries on whales through changes in prey abundance remain largely unknown in the action area.

10.7 Pollution

Within the action area, pollution poses a threat to ESA-listed marine mammals. Pollution can come in the form of marine debris, pesticides, contaminants, and hydrocarbons.

10.7.1 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al., 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al., 2010). Marine debris has been discovered to be accumulating in gyres throughout the oceans. Marine mammals often become entangled in marine debris, including fishing gear (Baird et al., 2015). Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (NRC, 2008) and continues to accumulate in the ocean and along shorelines within the action area.

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall & Thompson, 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and morality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including sea turtles and cetaceans. The ingestion of marine debris has been documented to result in blockage or obstruction of the digestive tract, mouth, and stomach lining of various species and can lead to serious internal injury or mortality (Derraik, 2002). In addition to interference with alimentary processes, plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik, 2002). Law et al. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 through 2008. More than 60 percent of 6,136 surface plankton net tows collected small, buoyant plastic pieces. Data on marine debris in some locations of the action area is largely lacking; therefore, it is difficult to draw conclusions as to the extent of the problem and its impacts on populations of ESA-listed species in the Gulf of Alaska, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

Cetaceans are also impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch & Perry, 2014; Li et al., 2016). Over half of cetacean species (including fin, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31 percent of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22 percent of individuals found stranded on shorelines (Baulch & Perry, 2014).

Given the limited knowledge about the impacts of marine debris on marine mammals, it is difficult to determine the extent of the threats that marine debris poses to marine mammals. However, marine debris is consistently present and has been found in marine mammals in and near the action area. Fin whales in the Mediterranean Sea are exposed to high densities of microplastics on the feeding grounds, and in turn exposed to a higher oxidative stress because of the presence of plasticizers, an additive in plastics (Fossi et al., 2016). In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al., 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impactions was the cause of both deaths. (Jacobsen et al., 2010) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that will carry derelict Asian fishing gear into eastern Pacific Ocean waters. In January and February 2016, 30 sperm whales stranded along the coast of the North Sea (in Germany, the Netherlands, Denmark, France, and Great Britain); of the 22 dissected specimens, nine had marine debris in their gastro-intestinal tracts. Most of it (78 percent) was fishing-related debris (e.g., nets, monofilament line) and the remainder (22 percent) was general debris (plastic bags, plastic buckets, agricultural foils) (Unger et al., 2016).

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al., 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Marine mammals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. While ingestion or entanglement from exposure to marine debris is likely to continue and occur for marine mammals in the action area through the duration of the project, the level of risk and degree of impact is unknown.

10.7.2 Pesticides and Contaminants

Exposure to pollution and contaminants have the potential to cause adverse health effects in marine species. Marine ecosystems receive pollutants from a variety of local, regional, and international sources, and their levels and sources are therefore difficult to identify and monitor (Grant & Ross, 2002). Marine pollutants come from multiple municipal, industrial, and household as well as from atmospheric transport (Garrett, 2004; Grant & Ross, 2002; Hartwell, 2004; Iwata, 1993). Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Garrett, 2004; Grant & Ross, 2002; Hartwell, 2004).

The accumulation of persistent organic pollutants, including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al., 2016), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al., 2007). Persistent organic pollutants may also facilitate disease emergence and lead to the creation of susceptible “reservoirs” for new pathogens in contaminated marine mammal populations (Ross, 2002). Recent efforts have led to improvements in regional water quality and monitored pesticide levels have declined, although the more persistent chemicals are still detected and are expected to endure for years (Grant & Ross, 2002; Mearns, 2001).

Numerous factors can affect concentrations of persistent pollutants in marine mammals, such as age, sex and birth order, diet, and habitat use (Mongillo et al., 2012). In marine mammals, pollutant contaminant load for males increases with age, whereas females pass on contaminants to offspring during pregnancy and lactation (Addison & Brodie, 1987; Borrell et al., 1995). Pollutants can be transferred from mothers to juveniles at a time when their bodies are undergoing rapid development, putting juveniles at risk of immune and endocrine system dysfunction later in life (Krahn et al., 2009). While exposure to pesticides and other contaminants is likely to continue and occur for marine mammals in the action area through the duration of the project, the level of risk and degree of impact is unknown.

10.7.3 Hydrocarbons

A nationwide study examining vessel oil spills from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in all U.S. waters (Dalton & Jin, 2010). In this study, "vessel" included numerous types of vessels, including barges, tankers, tugboats, and recreational and commercial vessels, demonstrating that the threat of an oil spill can come from a variety of boat types. Below we review the effects of oil spills on marine mammals more generally. Much of what is known comes from studies of large oil spills such as the *Deepwater Horizon* oil spill since no information exists on the effects of small-scale oil spills within the action area.

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant & Ross, 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci, 1990).

Perhaps the most famous oil spill in U.S. history occurred in the GOA when, in 1989, the *Exxon Valdez* released at least 11 million gallons of Alaskan crude oil into one of the largest and most productive estuaries in North America. The Alaska Department of Environmental Conservation estimated that 149 km of shoreline was heavily oiled and 459 km were at least lightly oiled. Oil spills, both small and large, occur widely along U.S. shores at refining and transfer facilities and extraction sites. The *Exxon Valdez* oil spill was the worst in U.S. history until the 2010 Deepwater Horizon event.

The *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of marine mammals to oil, causing reproductive failure, adrenal disease, lung disease, and poor body condition. Exposure also occurred via ingestion, inhalation, and maternal transfer of oil compounds to embryos; these effects are more difficult to assess, but likely resulted in sub-lethal effects and injury (Deepwater Horizon Trustees, 2016).

Cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci, 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin & Saulitis, 1997). For example, as a result of the *Deepwater Horizon* oil spill, sperm whales could have been exposed to toxic oil components through inhalation, aspiration, ingestion, and dermal exposure. There were 19 observations of 33 sperm whales swimming in *Deepwater Horizon* surface oil or that had oil on their bodies (Diaz 2015 as cited in Deepwater Horizon NRDA Trustees, 2016). The effects of oil exposure likely included physical and toxicological damage to organ systems and tissues, reproductive failure, and death. Whales may have experienced multiple routes of exposure at the same time, over intermittent timeframes and at varying rates, doses, and chemical compositions of oil based on observed impacts to bottlenose dolphins. Hydrocarbons also have the potential to impact prey populations, and therefore may affect ESA-listed species indirectly by reducing food availability.

As noted above, to our knowledge the past and present impacts of oil spills on ESA-listed species within the action area are limited to those associated with small-scale vessel spills. Nevertheless, we consider the documented effects of oil spills outside the action area, such as the *Deepwater Horizon* oil spill, examples of the possible impacts that oil spill can have on ESA-listed species.

10.8 Aquatic Nuisance Species

Aquatic nuisance species are aquatic and terrestrial organisms introduced into new habitats throughout the U.S. and other areas of the world that produce harmful impacts on aquatic ecosystems and native species (http://www.anstaskforce.gov). They are also referred to as invasive, alien, or non-indigenous species. Invasive species have been referred to as one of the top four threats to the world's oceans (Pughiuc, 2010; Raaymakers, 2003; Raaymakers & Hilliard, 2002; Terdalkar et al., 2005). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al., 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, and ballast water discharges from ocean-going vessels. Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer, 2010). Shifts in the base of food webs, a common result of the introduction of invasive species, can fundamentally alter predator-prey dynamics up and across food chains (Moncheva & Kamburska, 2002), potentially affecting prey availability and habitat suitability for ESA-listed species. They have been implicated in the endangerment of 48 percent of ESA-listed species (Czech & Krausman, 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts these invasive species may have on marine mammals in the action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed marine mammals is unknown.

10.9 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of anthropogenic sounds. These include, but are not limited to maritime activities, aircraft, seismic surveys (exploration and research), and marine construction (dredging and pile driving).Cetaceans generate and rely on sound to navigate, hunt, and communicate with other individuals and anthropogenic sound can interfere with these important activities (Nowacek et al., 2007). Therefore, the ESA-listed species considered in this opinion have the potential to be impacted by either increased levels of anthropogenic-induced background sound or high intensity, short-term anthropogenic sounds.

The addition of anthropogenic sound to the marine environment is a known stressor that can possibly harm marine animals or significantly interfere with their normal activities (NRC, 2005). Within the action area, ESA-listed marine mammals species considered in this opinion may be impacted by anthropogenic sound in various ways. For example, some sounds may produce a behavioral response, including but not limited to, avoidance of impacted habitat areas affected by irritating sounds, changes in in diving behavior, or (for cetaceans) changes in vocalization patterns (MMC, 2007).

Many researchers have described behavioral responses of marine mammals to sounds produced by boats and vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, and dredging and construction (reviewed in Gomez et al., 2016; and Nowacek et al., 2007). Most observations have been limited to short-term behavioral responses, which included avoidance behavior and temporary cessation of feeding, resting, or social interactions; however, in terrestrial species (e.g., Steller sea lion) habitat abandonment can lead to more long-term effects, which may have implications at the population level (Barber et al., 2010). Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds. Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. This can have a variety of implications for an animal’s fitness including, but not limited to, predator avoidance and the ability to reproduce successfully (MMC, 2007). Recent scientific evidence suggests that marine mammals, including several baleen whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (McDonald et al., 2006a; Parks, 2003; Parks, 2009). We assume similar inpacts have occurred and will continue to affect marine species in the action area.

10.9.1 Vessel Sound and Commercial Shipping

Much of the increase in sound in the ocean environment is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand, 2009b; McKenna et al., 2012; NRC, 2003c). Commercial shipping continues a major source of low-frequency sound in the ocean, particularly in the Northern Hemisphere where the majority of vessel traffic occurs. Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above 2 kHz. The low frequency sounds from large vessels overlap with many mysticetes predicted hearing ranges (7 Hz to 35 kHz) (NOAA, 2018) and may mask their vocalizations and cause stress (Rolland et al., 2012). The broadband sounds from large vessels may interfere with important biological functions of odontocetes, including foraging (Blair et al., 2016; Holt, 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al., 2013). Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 Hz (Ross, 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

Individuals produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Peak spectral levels for individual commercial vessels are in the frequency band of 10 to 50 Hz and range from 195 dB re: μPa^2-s at 1 m for fast-moving (greater than 37 km per hour [20 kts]) supertankers to

140 dB re: µPa^2-s at 1 m for small fishing vessels (NRC, 2003c). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (1 to 5 kHz) range and at moderate (150 to 180 dB re: 1 µPa at 1 m) source levels (Erbe, 2002b; Gabriele et al., 2003; Kipple & Gabriele, 2004). On average, sound levels are higher for the larger vessels, and increased vessel speeds result in higher sound levels. Measurements made over the period 1950 through 1970 indicated low frequency (50 Hz) vessel traffic sound in the eastern North Pacific Ocean and western North Atlantic Ocean was increasing by 0.55 dB per year (Ross, 1976, 1993, 2005). Whether or not such trends continue today is unclear. Most data indicate vessel sound is likely still increasing (Hildebrand, 2009a). However, the rate of increase appears to have slowed in some areas (Chapman & Price, 2011), and in some places, ambient sound including that produced by vessels appears to be decreasing (Miksis-Olds & Nichols, 2016). Efforts are underway to better document changes in ambient sound (Haver et al., 2018), which will help provide a better understanding of current and future impacts of vessel sound on ESA-listed species.

Sonar systems are used on commercial, recreational, and military vessels and may also affect cetaceans (NRC, 2003a). Although little information is available on potential effects of multiple commercial and recreational sonars to cetaceans, the distribution of these sounds would be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Nowacek et al., 2007). However, military sonar, particularly low frequency active sonar, often produces intense sounds at high source levels, and these may impact cetacean behavior (Southall et al., 2016). For further discussion of military sound on the ESA-listed species considered in this opinion, see Section 10.11.

10.9.2 Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes, helicopters, to large commercial airliners. These aircraft produce a variety of sounds that could potentially enter the water and impact marine mammals or startle pinnipeds. While it is difficult to assess these impacts, several studies have documented what appear to be minor behavioral disturbances in response to aircraft presence (Nowacek et al., 2007).

10.9.3 Seismic Surveys

There are seismic survey activities involving towed airgun arrays that may occur within the action area. They are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. These activities may produce noise that could impact ESA-listed cetaceans within the action area. These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of ten to 20 seconds for extended periods (NRC, 2003c). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB at dominant frequencies of five to 300 Hz (NRC, 2003a). Most of the sound energy is at frequencies below 500 Hz, which is within the hearing range of baleen whales (Nowacek et al., 2007). In the U.S., all seismic surveys involving the use of airguns with the potential to take marine mammals are covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic waters as well as the NSF and U.S. Geological Survey funds and/or conducts these activities in domestic and foreign waters, and in doing so, consults with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including authorized takes, can be found in recent biological opinions.

10.10 Marine Construction

Marine construction in the action area that produces sound includes drilling, dredging, pile-driving, cable-laying, and explosions. These activities are known to cause behavioral disturbance and physical damage (NRC, 2003a). While most of these activities are coastal, offshore construction does occur. All or some of these activities may occur within the action area and could affect ESA-listed marine mammal species.

10.11 Military Activities

The U.S. Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas in the United States and on the high seas. The U.S. Navy's activities are conducted off the coast of the Pacific Ocean and elsewhere throughout the world. Near the action area, the U.S. Navy's GOA Training and Testing range complex is southeast of the action area for the NSF's seismic survey. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include: routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The U.S. Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them. The majority of the training and testing activities the U.S. Navy conducts in the action area are similar, if not identical to activities that have been occurring in the same locations for decades, therefore the species located within the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals throughout the action area (NMFS, 2011a, 2017a). Anticipated impacts from harassment due to the U.S. Navy's activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals considered for these activities have previously undergone separate ESA Section 7 consultation. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from activities on ESA-listed resources in the GOA Training area.

10.12 Scientific Research Activities

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies of ESA-listed species in the GOA, of which extend into portions of the action area for the proposed action. Marine mammals have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of "take" of marine mammals in the action area from a variety of research activities.

Authorized research on ESA-listed marine mammals includes aerial and vessel surveys, close approaches, photography, videography, behavioral observations, active acoustics, remote ultrasound, passive acoustic monitoring, biological sampling (i.e., biopsy, breath, fecal, sloughed skin), and tagging. Research activities involve non-lethal "takes" of these marine mammals.

There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals all over the world, including for research in the action area. The consultations which took place on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects and were not determined to result in jeopardy to the species nor destruction or adverse modification of designated critical habitat.

10.13 Impact of the Baseline on Endangered Species Act-Listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed species considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes and whaling), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., whale watching) impacts.

Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult. This difficulty is compounded by the fact that many of the species in this opinion are wide ranging and subject to stressors in locations throughout and outside the action area.

We consider the best indicator of the aggregate impact of the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species. As noted in Section 10, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the

Environmental Baseline is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the *Environmental Baseline*. Therefore, while the *Environmental Baseline* may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the *Environmental Baseline* is preventing their recovery. However, is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the *Species and Critical Habitat Likely to be Adversely Affected* section of this opinion and what this means for the populations and critical habitats is discussed in the *Integration and Synthesis* (Section 12).

11 Effects of the Action

Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. This effects analyses section is organized following the stressor, exposure, response, risk assessment framework.

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The destruction and adverse modification analysis considers whether the action produces "a direct or indirect alteration that appreciably diminished the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." 50 C.F.R. 402.02.

11.1 Stressors Associated with the Proposed Action

The potential stressors we expect to result from the proposed action are:

1. Pollution by oil or fuel leakage;
2. Vessel strike;
3. Vessel noise;
4. Entanglement in towed hydrophone streamer; and

5. Sound fields produced by airgun array and multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler.

Based on a review of available information, during consultation we determined which of these possible stressors will be likely to occur and which will be discountable or insignificant for the species and habitats affected by these activites. These species and habitats were discussed in Section 7. The following section describes and discusses those stressors that are likely to adversely affect ESA-listed species – Sound fields produced by the airgun array and multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler.

11.1.1 Sound Fields Produced by the Airgun Array, Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler

During consultation we determined that sound fields produced by the airgun array, multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler may adversely affect ESA-listed species by introducing acoustic energy introduced into the marine environment. These stressors and the likely effects on ESA-listed marine mammals are discussed below beginning in Section 11.3.1.3.

11.2 Mitigation to Minimize or Avoid Exposure

As described in the *Description of the Proposed Action* (Section 3), the NSF's proposed action and the NMFS Permits and Conservation Division's proposed IHA requires monitoring and mitigation measures that includes the use of proposed exclusion and buffer zones, shut-down procedures, ramp-up procedures, visual monitoring with NMFS-approved protected species observers, and vessel strike avoidance measures in the presence of ESA-listed as species to minimize or avoid exposure. The NMFS Permits and Conservation Division's proposed IHA will contain additional mitigation measures to minimize or avoid exposure that are described in Appendix A (see Section 19).The NSF will use a 500 m (1,640.4 ft) exclusion zone for marine mammals. If marine mammals are detected in or about to enter the exclusion zone, the airgun array will be shut-down (i.e., shut off) immediately. The protected species observers will also establish and monitor a 1,000 m (3,280.8 ft) buffer zone. During use of the airgun arrays, occurrence of marine mammals within the buffer zone (but outside the 500 m exclusion zone) will be communicated to the operator to prepare for the potential power-down or shut-down of the airgun array.

For high risk circumstances, such as observation of a calf or aggregation of large whales (defined as 6 or more mysticetes or sperm whales), NSF will shutdown if these circumstances are observed at any distance.

A portion of NSF's proposed survey will also occur in the fin whale BIA (Ferguson et al., 2015). Because of the temporal and spatial overlap in the proposed survey and peak use of the fin whale BIA, NSF will implement a shutdown if a fin whale or group of fin whales is observed at within a 1,500 m (4,921.26 ft) radius from the acoustic source, within their BIA. NSF will refer to (Ferguson et al., 2015) for the location of the BIA, but waters around the Semidi Islands, Kodiak Island, and Chirikof Island generally define the portion of the BIA NSFis expected to transit through.

The expected elevated density of North Pacific right whales in their critical habitat means that additional measures are prudent for this area. When conducting seimic activities within North Pacific right whale critical habitat, NSF must do any such survey transit during daylight hours, to facilitate the ability of PSOs to observe any right whales that may be present. This measure is in addition to the requirement that NSF must implement a shutdown if a North Pacific right whale is observed at any distance. Furthermore, when transiting through North Pacific right whale critical habitat while heading to/from port, NSF must reduce speed to 5 kts to reduce the potential for ship strike.

Steller sea lions have designated critical habitats such as rookeries and major haulouts in the action area (Figure 3 above and Section 3.1.5), and the timing of the of NSF's survey overlaps with the breeding season of Steller sea lions. As such, NSF must observe a three nautical mile exclusion zone around these critical habitats. This means that NSF will avoid transiting through and operating seismic airguns in these areas.

11.3 Exposure and Response Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the action's effects on the environment in space and time, and identify the nature of that co-occurrence. The *Exposure Analysis* identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or sub-populations(s) those individuals represent. The *Response Analysis* evaluates the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure.

11.3.1 Exposure Analysis

Although there are multiple acoustic and non-acoustic stressors associated with the proposed action, the stressor of primary concern is the acoustic impacts of the airgun arrays. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} Joules cumulatively), second only to nuclear explosions (Moore & Angliss, 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold & Coates, 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al., 2004).

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array and multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. For this consultation, the NSF and NMFS Permits and Conservation Division estimated exposure to the sounds from the airgun array that will result in take, as defined under the MMPA, for all marine mammal species including those listed under the ESA.

Under the MMPA, take is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal (16 U.S.C. §1361 et seq.) and further defined by regulation (50 C.F.R. §216.3) as "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal. This includes, without limitation, any of the following:

- The collection of dead animals, or parts thereof
- The restraint or detention of a marine mammal, no matter how temporary
- Tagging a marine mammal
- The negligent or intentional operation of an aircraft or vessel
- The doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal
- Feeding or attempting to feed a marine mammal in the wild."

For purposes of the proposed action, harassment is defined under the MMPA as any act of pursuit, torment, or annoyance which:

- Has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or
- Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment). Under NMFS regulation, Level B harassment does not include an act that has the potential to injure a marine mammal or marine mammal stock in the wild.

Under the ESA take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct." Harm is defined by regulation (50 C.F.R. §222.102) as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering." NMFS does not have a regulatory definition of "harass." However, on December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering." NMFS' interim ESA harass definition does not perfectly equate to MMPA Level A or Level B harassment, but shares some similarities with both in the use of the terms "injury/injure" and a focus on a disruption of behavioral patterns.

For ESA-listed marine mammal species, consultations that involve the NMFS Permits and Conservation Division's incidental take authorization under the MMPA have historically relied on the MMPA definition of harassment. As a result, Level B harassment has been used in estimating the number of instances of harassment of ESA-listed marine mammals, whereas estimates of Level A harassment have been considered instances of harm and/or injury under the ESA depending on the nature of the effects.

We use the numbers of individuals expected to be taken from the MMPA's definition of Level A and Level B harassments to estimate the number ESA-listed species that are likely to be harmed or harassed as a result of the proposed actions. This is a conservative approach since we assume all forms of Level B harassment under the MMPA necessarily constitute harassment under the ESA and all forms of Level A harassment under the MMPA constitute harm under the ESA (e.g., NMFS, 2017b).

Therefore, under the ESA harassment is expected to occur during the program's activities and may involve a wide range of behavioral responses for ESA-listed marine mammals including but not limited to avoidance, changes in vocalizations or dive patterns, or disruption of feeding, migrating, or reproductive behaviors. The MMPA Level B harassment exposure estimates do not differentiate between the types of behavioral responses, nor do they provide information regarding the potential fitness or other biological consequences of the responses on the affected individuals. Therefore, in the following sections we consider the available scientific evidence to determine the likely nature of these behavioral responses and their potential fitness consequences in accordance with the definitions of "take" related to harm or harass under the ESA for ESA-listed species.

Our exposure analysis relies on two basic components: (1) information on species distribution (i.e., density within the action area), and (2) information on the level of exposure to sound at which species are likely to be affected (i.e., exhibit some response). Using this information, and information on the proposed seismic survey (e.g., active acoustic sound source specifications, trackline locations, months of operation, etc.), we then estimate the number of instances in which an ESA-listed species may be exposed to sound fields from the airgun array that are likely to result in adverse effects such asa harm or harassment. In many cases, estimating the potetnail exposure of animals to anthropogenic stressors is difficult due to limited information on animal density estimates in the action area and overall abundance, the temporal and spatial location of animals; and proximity to and duration of exposure to the sound source. For these reasons, we evaluate the best available data and information in order to reduce the level of uncertainty in making our final exposure estimates.

In this consultation, the best available density models used in our exposure analysis are habitat based in that they predict animal distributions based on sighting records and correlated environmental data. As such, they do not necessarily produce overall abundance estimates in line with those given in *Status of Species Likely to be Adversely Affected* (Section 9) which are not spatially explicit. In most cases, these density models predict much higher abundance estimates than those presented in Section 11.3.1.1 since they predict animal distributions well beyond areas that have been surveyed and are therefore considered conservative. Given this, it is not always relevant to compare exposure estimates to the abundances given in Section 11.3.1.1 since these abundance estimates were not used directly in estimating exposure. Instead, in some cases exposure estimates should be compared to abundance estimates derived from the density models used to estimate exposure.

For the purposes of calculating potential ESA take for marine mammals in this consultation, habitat-based stratified marine mammal density areas developed by the U.S. Navy for assessing potential impacts of training activities in the GOA (DON, 2014) were used. Consistent with (Rone et al., 2014), four strata were defined: Inshore: all waters <1,000 m deep; Slope: from 1,000 m water depth to the Aleutian trench/subduction zone; Offshore: waters offshore of the Aleutian trench/subduction zone; Seamount: waters within defined seamount areas. For this program, approximatley 40 percent of the trackline would take place in the Inshore zone, 21 percent in the Slope zone, 35 percent in the Offshore zone, and 4 percent in the Seamount zone.

11.3.1.1 Exposure Estimates of Endangered Species Act-Listed Marine Mammals

As discussed in the *Status of Species and Critical Habitat Likely to be Adversely Affected* section, there are seven ESA-listed marine mammal species that are likely to be affected by the proposed action: blue, fin, humpback, North Pacific right, sei, and sperm whales and Steller sea lions.

During the proposed action, ESA-listed marine mammals may be exposed to sound from four sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The NSF and the NMFS Permits and Conservation Division provided estimates of the expected number of ESA-listed marine mammals exposed to received levels greater than or equal to 160 dB re: 1 μPa (rms) for these sources. Our exposure estimates stem from the best available information on marine mammal densities and a predicted radius (rms) (Table 9 and Table 10) along seismic survey tracklines. Based upon information presented in the *Response Analysis*, ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress or even strand.

11.3.1.2 Exposure of Endangered Species Act-Listed Marine Mammals to Airguns

The NSF applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals are "harassed," based on definitions provided in the MMPA (16 U.S.C. §1362(18)(a)). We used these same values to determine the type and extent of take for ESA-listed marine mammals. An estimate of the number of marine mammals that will be exposed to sounds from the airgun array is also included in the NSF's draft EA. The NSF and NMFS Permits and Conservation Division did not provide any take estimates from sound sources other than the airgun array, although other equipment producing sound will be used during airgun array operations (e.g., the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler).

A pulse of sound from the airgun displaces water around the airgun and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect ESA-listed marine mammals considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);

- Behavioral responses; and
- Non-auditory physical or physiological effects.

In their *Federal Register* notice of the proposed incidental harassment authorization, the NMFS Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed the levels produced by the airgun array. Therefore, the NMFS Permits and Conservation Division did not expect additional harmful exposure from sound sources other than the airgun array. We agree with this assessment and similarly focus our analysis on exposure from the airgun array. The the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are also expected to affect a smaller ensonified area within the larger sound field produced by the airgun array and is not expected to be of sufficient duration that will lead to the onset of TTS or PTS for an animal.

During the development of the IHA, the NMFS Permits and Conservation Division also conducted an independent exposure analysis that was informed by comments received during the public comment period that was required on the proposed IHA and a draft EA prepared pursuant to the National Environmental Policy Act. The exposure analysis also included estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at MMPA Level A harassment thresholds in the absence of monitoring and mitigation measures.

In this section, we describe the NSF and NMFS Permits and Conservation Division's analytical methods to estimate the number of ESA-listed marine mammal species that might be exposed to the sound field and experience an adverse response. We also rely on acoustic thresholds to determine sound levels at which marine mammals are expected to exhibit a response that may be considered take under the ESA such as harm or harassment, then utilize these thresholds to calculate ensonified areas, and finally, either multiply these areas by available data on marine mammal density or use the sound field in the water column as a surrogate to estimate the number of marine mammals exposed to sounds by the airgun array.

For our ESA section 7 consultation, we evaluated both the NSF and the NMFS Permit and Conservation Division's exposure estimates of the number of ESA-listed marine mammals that will be "taken" relative to the definition of MMPA Level B harassment, which we have adopted to evaluate harassment of ESA-listed marine mammals in this consultation. We adopted the Permits and Conservation Division's analysis because, after our independent review, we determined it utilized the best available information and methods to evaluate exposure to ESA-listed marine mammals. Below we describe the exposure analysis for ESA-listed marine mammals.

Acoustic Thresholds

To determine at what point during exposure to airgun arrays (and other active acoustic sources) marine mammals are considered "harassed" under the MMPA and ESA, NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for exclusion zones around a sound source and the necessary mitigation requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA, 2018). For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 µPa (rms). This value is based on observations of behavioral responses of mysticetes, but is used for all marine mammal species. For the proposed action, the NMFS Permits and Conservation Division continued to rely on this historic NMFS acoustic threshold to estimate the number of takes by MMPA Level B harassment, and accordingly, take of ESA-listed marine mammals that are proposed in the incidental harassment authorization.

For physiological responses to active acoustic sources, such as TTS and PTS, the NMFS Permits and Conservation Division relied on NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA, 2018). Unlike NMFS' 160 dB re: 1 µPa (rms) MMPA Level B harassment threshold (which does not include TTS nor PTS), these TTS and PTS auditory thresholds differ by species hearing group (Table 9). Furthermore, these acoustic thresholds are a dual metric for impulsive sounds, with one threshold based on peak SPL (0-pk SPL) but does not include duration of exposure. The other metric, the cumulative sound exposure criteria incorporate auditory weighting functions based upon a species group's hearing sensitivity, and thus susceptibility to TTS and PTS, over the exposed frequency range and duration of exposure. The metric that results in the largest distance from the sound source (i.e., produces the largest field of exposure) is used in estimating total range to potential exposure and effect, since it is the more precautionary criteria. In recognition of the fact that the requirement to calculate MMPA Level A harassment ensonified areas can be more technically challenging to predict due to the duration component and the use of weighting functions in the new SEL_{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.

In using these acoustic thresholds to estimate the number of individuals that may experience auditory injury, the NMFS Permits and Conservation Division classify any exposure equal to or above the acoustic threshold for the onset of PTS (219 dB for low-frquency cetaceans, 230 dB for mid-frequency cetaceans, and 232 dB for otariid pinnipeds; see Table 9) as auditory injury, and thus MMPA Level A harassment, and harm under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 µPa (rms) acoustic threshold is classified as MMPA Level B harassment, which would also be considered ESA harassment.

Table 9. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds (NOAA, 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF,24 hour)	7 Hertz to 35 kiloHertz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	213 dB peak SPL 168 dB SEL
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 Hour)	150 Hertz to 160 kiloHertz	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	224 dB peak SPL 170 dB SEL
Otariid Pinnipeds (Steller Sea Lion) (LE, MF, 24 Hour) - Underwater	60 Hertz to 39 kiloHertz	$L_{pk,flat}$: 232 dB $L_{E,MF,24h}$: 203 dB	212 dB peak SPL 170 dB SEL

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
LF=Low-Frequency
MF=Mid-Frequency
*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al., 2007) (approximation).
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) 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 1 $\mu Pa^2 s$. 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 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.

Exposure Estimates

In this section, we first evaluate the likelihood that marine mammals will be exposed to sound fields from the seismic survey at or above 160 dB re: 1 µPa (rms) based upon the information described above, and the acoustic thresholds correlating to onset of PTS or TTS provided in

Table 9. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect marine mammals to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methodology for estimating the number of ESA-listed species that might be exposed to the sound field used by the NSF and NMFS Permits and Conservation Division were largely the same. Both estimated the number of marine mammals predicted to be exposed to sound levels that will result in MMPA Level A and Level B harassment by using radial distances to predicted isopleths. Both used those distances to calculate the ensonified area around the airgun array for the 160 dB re: 1 µPa (rms) zone, which corresponds to the MMPA Level B harassment and ESA harassment threshold for ESA-listed marine mammals. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25 percent contingency (associated with turns, airgun array testing, and repeat coverage for any areas where initial data quality is sub-standard) was added to the number of exposures using the ArcGIS-based quantitative method devised by the NSF and used by the NMFS Permits and Conservation Division. This calculation assumes 100 percent turnover of individuals within the ensonified area on a daily basis, that is, each individual exposed to the seismic survey activities is a unique individual.

Based on information provided by the NSF, we have determined that marine mammals are likely to be exposed to sound levels at or above the threshold at which TTS and behavioral harassment will occur. From modeling by the L-DEO, the NSF provided sound source levels of the airgun array (Table 10) and estimated distances for the 160 dB re: 1 µPa (rms) sound levels as well as MMPA Level A harassment thresholds generated by the two airgun array configurations and water depth. The predicted and modeled radial distances for the various MMPA Level A and B thresholds for ESA-listed marine mammals for the *Langseth*'s airgun arrays can be found in Table 11 and Table 12.

Table 10. Modeled sound source levels (dB) modified farfield signature for the R/V *Marcus G. Langseth*'s 6,600 in^3 36 airguns array, and single-bolt 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)	**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	252.52
6,600 in^3 airgun array (SEL_{cum})	232.98	232.84	233.10	232.08

40 in^3 airgun (Peak SPL_{flat})	223.93	N.A.	223.92	N.A.
40 in^3 airgun (SEL_{cum})	202.99	202.89	204.37	202.35

NA=Not Available

Table 11. Predicted distances to which sound levels ≥160 dB re 1 μParms could be received from the single and 36-airgun array towed at 12 m.

Airgun Configuration	Water Depth (m)	Predicted rms radii (m)
		160 dB
Single bolt airgun (40-in^3)	>1,000-m	431[1]
	100-1,000-m	647[2]
	<100	1,041[3]
36 airguns (6,600-in^3)	>1,000-m	6,733[1]
	100-1,000-m	10,100[2]
	<100	25,494[3]

[1] Distance is based on NSF/L-DEO model results.
[2] Distance is based on NSF/L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the Gufl of Mexico with scaling applied to account for differences in tow depth.

Table 12. Modeled threshold distances in m from the R/V *Marcus G. Langseth*'s four string airgun array (36-airgun configuration) corresponding to Marine Mammal Protection Act Level A harassment thresholds. The largest distance (in bold) of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and MMPA Level A harassment threshold distances.

Functional Hearing Group	36-airgun Configuration Peak SPL_{flat} PTS SEL_{cum}
Low Frequency Cetaceans	38.9 m **40.1** m
Mid Frequency Cetaceans	**13.6** m

	0 m
Otariid Pinnipeds	**10.6** m 0 m

Note: 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 takes by MMPA Level A harassment. However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional 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 proposed seismic surveys, the user spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

To develop densities specific to the GOA, the U.S. Navy conducted two comprehensive marine mammal surveys in the Temporary Marine Activities Area in the GOA prior to 2014. The first survey was conducted from 10 to 20 April 2009 and the second was from 23 June to 18 July 2013. Both surveys used systematic line-transect survey protocols including visual and acoustic detection methods (Rone et al., 2014). These data were collected in four strata that were designed to encompass the four distinct habitats within the Temporary Marine Activities Area and greater GOA. (Rone et al., 2014) provided stratified line-transect density estimates used in this analysis for blue, fin, humpback, and sperm whales. Although sei whales were recorded during the U.S. Navy funded GOA surveys, data were insufficient to calculate densities for this species, so predictions from a global model of marine mammals densities were used (Kaschner et al. 2012 *in* (DON, 2014).

The North Pacific right whale is rarely observed in or near the majority of the survey area, so minimal densities were used to represent their potential presence. However, in the North Pacific right whale critical habitat off of Kodiak Island, it is reasonable to expect a higher density. In this critical habitat area, the Alaska Fisheries Science Center (LOA application available here: https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-research-and-other-activities) used a conservative density estimate of 0.0053 animals/km^2 based on acoustic detections (Rone et al., 2014) and photo identifications throughout the entirety of the GOA. For the portion of NSF's activities that occur in North Pacific right whale critical habitat, NMFS used this more conservative density estimate.

Steller sea lion densities were calculated using shore-based population estimates divided by the area of the GOA Large Marine Ecosystem (DON, 2014).

All densities were corrected for perception bias [$f(0)$] as described by the respective authors. 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 that are stratified by the water depth (habitat) zones present within the survey area. Alternative density estimates available for species in this region are not stratified by water depth and therefore do not reflect the known variability in species distribution relative to habitat features. The calculated exposures that are based on these densities are best estimates for the proposed survey.

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". Estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the proposed seismic survey in GOA if no animals moved away from the survey vessel are shown in Table 13. The authorized takes requested by the NMFS Permit and Conservation Division and NSF are given in the right-most column (*Requested Take Authorization*) Table 13. The NSF requested takes for North Pacific right whale was one Level B harassment and one Level A harrasment. However, the NMFS Permit and Conservation Division and the Interagency and Cooperation Division increased the Level B takes based on the density-based calculations to mean group size per of 11 takes (Shelden et al., 2005), (Waite et al., 2003) and (Wade et al., 2011b). No MMPA Level A takes or ESA harm of North Pacific rights will be authorized.

For all species, including those for which densities were not available or expected to be low, the *Requested Take Authorization* was for at least the mean group size for species where that number was higher than the calculated take. Exposure estimates provided by NSF assume that the proposed survey would be fully completed. The calculated takes were increased by 25 percent by assuming additional survey operations would take place (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 during the proposed activities.

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa (rms) for marine mammals on one or more occasions were estimated assuming that the marine area that would be within the 160 dB re 1 μPa (rms) isopleth around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involved selecting a seismic trackline(s) that could be surveyed on one day (~222 km) with a proportion occurring in the marine mammal density zones (inshore, slope, offshore, and seamount) that is roughly similar to that of the entire survey. The area expected to be ensonified on a specific day was determined by entering the planned survey lines into a Map-Info GIS, using GIS to identify the relevant areas by "drawing" the applicable 160 dB re 1 μPa (rms) TTS and PTS threshold buffers around each line. The ensonified areas, increased by 25 percent, were then multiplied by the number of survey days (18 days). This is equivalent to adding an additional 25 percent to the proposed line km. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the *Langseth* approaches.

Take estimates of the numbers of ESA-listed cetaceans and pinnipeds that could be exposed to seismic sounds with received levels equal to injurious thresholds (e.g., MMPA Level A) thresholds for various hearing groups Table 13 if there were no mitigation measures (power downs or shut downs when PSOs observered animals approaching or are inside the esonification zones), are also given in Table 13. Those numbers likely overestimate actual MMPA Level A takes and ESA take because the predicted Level A esonification zones are small and mitigation measures would further reduce the chances of, if not eliminate, any such takes.

The resulting estimates of the number of marine mammals that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the GOA survey area includes 4,699 ESA-listed cetaceans: 49 blue whales, 3,913 fin whales, 631 humpback whales (2 DPS's), 11 North Pacific right whale, 9 sei whales, 86 sperm whales, and 2,168 Steller sea lions (Table 13). In terms of the ESA, this represents: 2 blue whales harmed and 47 harrassed; 16 fin whales harmed and 3,897 harmed; 4 humpback whales (2 DPS's) harmed and 627 harrassed; 11 North Pacific right whales harassed; 2 sei whales harmed and 7 harrassed; 86 sperm whales harassed; and 3 Steller sea lions harmed and 2,196 harmed (Table 13).

Table 13. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation and National Marine Fisheries Service NMFS Permits and Conservation Divisionduring National Science Foundation's seismic survey in the Western Gulf of Alaska.

Species	Potential Permanent Threshold Shift and Harm	Potential Temporary Threshold Shift and Behavioral Harassment	Total
Blue Whale	2	47	49
Fin Whale	16	3,897	3,913
Humpback Whale – Mexico DPS	3	599	602
Humpback Whale – Western Pacific DPS	1	28	29
North Pacific Right Whale	0	11	11
Sei Whale	2	7	9
Sperm Whale	0	86	86
Cetaceans Total	**24**	**4,4675**	**4,699**
Steller Sea Lion	3	2,165	2,168

North Pacific Right Whales. Note that for North Pacific right whales the NMFS Permits and Conservation Division proposed to authorize a larger number of incidental takes than the number of incidental takes requested by NSF. This is based on evidence of a much higher density of this species within the critical habitat south of Kodiak Island. The density value of 0.0053 animals/km^2 is based on detections from the GOALS II survey (4 individuals) (Rone et al., 2014), the assumed use of the critical habitat by all right whales in the GOA (Wade et al., 2011b), and a conservative correction factor (4), all divided by the area of the critical habitat (3,042.2 km^2). To account for this habitat, NMFS used the Alaska Protected Resources Division Species Distribution Mapper (*https://www.fisheries.noaa.gov/resource/data/alaska-endangered-species-and-critical-habitat-mapper-web-application*) to determine a conservative approximation of NSF's survey path through the critical habitat based on the representative tracks in Figure 1 of the IHA Application. This measured distance was 35 km. Because the majority of this habitat is inside of the 100 m isopleth, the predicted distance to the 160 dB received sound level would be ~25.5 km. This resulted in a portion of the North Pacific righ whale critical habitat 35 km long by 51 km wide (25.5 km on each side of the survey track), or 1,785 km^2 being ensonified. Applying the higher density of 0.0053 animals/km^2 to this area, results in an estimate of 9.46 North Pacific right whales exposed to Level B harassment in the critical habitat. No further correction, such as the 25 percent operation day increase, is needed for the estimate in the critical habitat, because the density of 0.0053 animals/ km^2 has already been corrected to be highly conservative. To account for the rest of the survey occurring outside of the critical habitat, the minimal density presented in (DON, 2014), 0.00001 individuals/km^2, was used for the remainder of the survey. The expected take in the rest of the survey is 1.10 individuals. Summing these two estimates for take, in both the critical habitat and remainder of survey, results in an expected take of 10.56 individuals (rounded to 11 individuals). With ESA-listed marine mammals one calculated take was conservatively assumed to be a take by ESA (Table 13), however no takes by Level A harassment or harm under the ESA are proposed for authorization for North Pacific right whale given the low density of the species and NMFS evaluation of the effectiveness of mitigation and monitoring measures.

The estimated instances of take for North Pacific right whales appears high compared to stock abundance (35.5 percent), but realistically 11 right whales are not likely to experience harassment. Given the higher assumed density of whales in the critical habitat area off of Kodiak Island, the vast majority of estimated takes would occur in that area. Overall, right whales are very rarely detected (visual or acoustic) in the GOA, and most evidence of the region's importance for the species is based historic whaling records (Muto et al., 2018) . North Pacific right whales are much more commonly detected in their Bering Sea critical habitat (73 FR 19000, April 8, 2008; (Muto et al., 2018). Given this evidence, only a small portion of the North Pacific right whale population is expected to be present in the GOA and the Kodiak Island critical habitat. As such, it is more realistic to believe there will be multiple takes of the few individuals present, comprising less than a third of the overall population. Additionally, NSF proposed survey will only impact the North Pacific right whale critical habitat for a very short portion of their survey and there are additional mitigation measures in place to further minimize any acoustic impacts on North Pacific right whales.

Blue Whale. The expected instances of take of the Central North Pacific stock of blue whales appears high when compared to the overall abundance of the stock. However, in reality 49 blue whales are not likely to be harmed (2) or harassed (47) given the mitigation measures in place. However, based on the numbers there is the potential that there will be 2 instances of harm and 47 instances of harassment under the ESA. Blue whales belonging to this stock appear to feed in summer in waters southwest of Kamchatka, south of the Aleutians, and in the GOA (Stafford, 2003); (Watkins et al., 2000). Because of this large summer range of this species compared to the size of NSF's action area, it is more likely that there will be multiple takes of a smaller number of individuals that would occur within the action area, and the percentage of the stock taken will be less than a third of the individuals.

Fin Whales. While the expected take of Northeast Pacific stock of fin whales appears to impact a high percentage of the population (123.5 percent), in reality 3,913 fin whales are not likely to be harmed (16) or harassed (3,897). The range of the Northeast Pacific fin whale stock extends through much of the north Pacific (Muto et al., 2018), and NSF's actions are located in a small portion of this range in the GOA and will occur within a period of less than a month. Given the range of the species and the comparatively small action area, combined with the short duration of the survey, it is more likely that there will be multiple takes of a few individuals rather than limited takes of a larger number of animals that are in the action area during the proposed survey and entirely unlikely that more than a third of the stock would be exposed to the seismic survey.

Humpback Whales. For humpback whales, takes are apportioned between the different stocks or DPSs present based on Wade et al. (2016b). With this apportionment, the expected instances of take of the Central North Pacific stock's Mexico DPS appears high (18.44 percent of the estimated DPS abundance). In reality, 631 humpback whales (regardless of DPS) are not likely to be harmed (4) or harassed (627), as it is more likely that a smaller number of individuals will experience multiple takes. The GOA is an important center of humpback whale abundance, and NSF's survey affects a portion of the GOA. The highest densities of humpback whales in the GOA are observed between July and August (Ferguson et al., 2015), while NSF's survey is planned for June, so the survey should not overlap with peak abundance. Additionally, there are other areas of high humpback whale density in the Aleutian Islands and Bering Sea (Muto et al., 2018). This evidence, plus the Central North Pacific stock's large range relative to NSF's action area, along with the short duration of the survey, mean that it is more likely that there will be multiple takes of a few individuals that occur in NSF's action area, and fewer than a third of the individuals in the stock will be taken.

Steller Sea Lion. NSF modeling predicts that the western DPS of Steller sea lion could be exposed to sound from seismic airguns that may result in 2,168 exposures that could result in 3 instances of harm and 2,165 instances of harassment. Most harassment will be in the form of some behavioral responses of Steller sea lions and given the level of mitigation in place during the surveys harm is not likely to be realized. Ranges to some behavioral impacts could take place at distances exceeding 100 km (54 nmi), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Harassment of Steller sea lions would be short term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely.

11.3.1.3 Exposure of Endangered Species Act-Listed Marine Mammals to Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler

The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are the three additional active acoustic systems that will operate during the proposed seismic surveys on the. *Langseth*. The multi-beam echosounder system, sub-bottom profiler, and acoustic Doppler current profiler have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: 1 μPa (rms) threshold. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler systems operate at generally higher frequencies than airgun array operations (10 to 13.5 kHz for the multi-beam echosounder, 3.5 kHz for the sub-bottom profiler, and 75 kHz for the acoustic Doppler current profiler). As such, the frequencies will attenuate more rapidly than those from airgun array sound sources. For these reasons ESA-listed marine mammals would likely experience higher levels of sound from the airgun array well before the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound of equal amplitude since these other sound sources would drop off faster than the airgun arrays.

While the airgun array is not operational, visual protected species observers will remain on duty to collect sighting data. If ESA-listed marine mammals or sea turtles closely approach the vessel, the *Langseth* will take evasive actions to avoid a ship-strike and simultaneously avoid exposure to very high source levels. Ship strike has already been ruled out as a discountable effect. We also rule out high-level ensonification of ESA-listed marine mammals (multi-beam echosounder sound source level equals 242 dB re: 1 μPa [rms], sub-bottom profiler sound source level equals 222 dB re: 1 μPa [rms], and acoustic Doppler current profiler sound source level equals 224 dB re: 1 μPa [rms]), because it presents a low risk for auditory or other damage to occur. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multi-beam echosounders, sub-bottom profilers, and acoustic Doppler current profilers similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury. To be susceptible to TTS, a marine mammal will have to pass at very close range and match the vessel's speed and direction; we expect a very small probability of this during the proposed seismic surveys. An individual will have to be located well within 100 m (328.1 ft) of the vessel to experience a single multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler pulse that could result in TTS (LGL Ltd., 2008). It is possible, however, that some small number of ESA-listed marine mammals (fewer than those exposed to the airgun array) could experience low-level exposure to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. We are unable to quantify the level of exposure from the secondary sound sources, but do not expect any exposure at levels sufficient to cause more than behavioral responses (e.g. avoidance of the sound source) in some species capable of hearing frequencies produced by the multi-beam echosounder system, sub-bottom profiler, and acoustic Doppler current profiler.

11.3.2 Response Analysis

A pulse of sound from the airgun displaces water around the airgun and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as ESA-listed marine mammals and sea turtles considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed marine mammals and sea turtles in the action area.

As discussed in *The Assessment Framework* (Section 2) of this opinion, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on the environment or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

11.3.2.1 Potential Response of Marine Mammals to Acoustic Sources

Marine Mammals and Hearing Threshold Shifts

Exposure of marine mammals to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. A TTS results in a temporary change to hearing sensitivity (Finneran & Schlundt, 2013), and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing, has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa & Liberman, 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. A TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action (Kastak, 2005; Ketten, 2012; Schlundt et al., 2000).

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue, fin, humpback, North Pacific right, and sei) have an estimated functional hearing frequency range of 7 Hz to 35 kHz (Southall et al., 2007). Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB SEL or approximately 196 to 201 dB re: 1 µPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al., 2007). A PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al., 2007). In terms of exposure to the *Langseth*'s airgun array, an individual will need to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re: 1 µPa (peak) (Caldwell & Dragoset, 2000). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, or 202 dB for high-frequency cetaceans, PTS could occur. A marine mammal will have to be within 38.9 m (127.3 ft) for low-frequency cetaceans or 13.6 m (45.3 ft) for mid-frequency cetaceans of the *Langseth*'s 36 airgun array to be within the MMPA Level A harassment threshold isopleth and risk PTS (Table 12).

Research and observations show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If sea lions are exposed to active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sea lions may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003; Götz and Janik 2011; Kvadsheim et al. 2010). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

NSF modeling predicts that the western DPS of Steller sea lion (western U.S. stock) could be exposed to sound from seismic sources that may result in 2,165 instances of harassment and 3 instances of harm, but no mortality of Steller sea lions given the level of mitigation in place during the surveys. Ranges to some behavioral impacts could take place at distances exceeding 100 km (54 nmi), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Behavioral reactions would be short term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely.

Overall, we do not expect TTS to result in long-term affects to any ESA-listed marine mammals as a result of exposure to the airgun array for several reasons. We expect that most individuals will move away from the airgun array as it approaches; however, a few individuals may be exposed to sound levels that may result in TTS or PTS, but we expect the probability to be low. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the vessel and sound source and thus avoid exposures that will induce TTS or PTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons, as acoustic energy accumulates to higher levels animals would be expected to move away and therefore unlikely to accumulate more injurious levels. Furthermore, mitigation measures will be in place to initiate a power-down if individuals enter or are about to enter the 500 m (1,640.4 ft) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. As stated in the *Exposure Analysis*, each individual is expected to potentially be exposed to 160 dB re: 1 μPa (rms) levels. We do not expect this to produce a cumulative TTS or other physical injury for several reasons. We expect that individuals will recover from TTS between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals, to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS or PTS.

Marine Mammals and Auditory Interference (Masking)

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Francis & Barber, 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson, 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis & Barber, 2013).

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales and South Island Hector's dolphins. The proposed seismic surveys could mask whale calls at some of the lower frequencies for these species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans, 1998; NMFS, 2006h). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz , and though the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the strongest spectrum levels of airguns are below 200 Hz (2 to 188 Hz for the *Langseth*'s airgun array).

Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS, 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls will be expected to pose a somewhat greater risk of masking. The *Langseth*'s airguns will emit a 0.1 second pulse when fired approximately every 16 to 60 seconds. Therefore, pulses will not "cover up" the vocalizations of ESA-listed marine mammals to a significant extent (Madsen et al., 2002). We address the response of ESA-listed marine mammals stopping vocalizations as a result of airgun sound in the *Marine Mammals and Behavioral Responses* section below.

Although sound pulses from airguns begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as in shallow water environments, airgun sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add significantly to acoustic background (Guerra et al., 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

The sound localization abilities of marine mammals suggest that, if signal and sound come from different directions, masking will not be as severe as the usual types of masking studies might suggest (Richardson, 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain & Dahlheim, 1994; Bain et al., 1993; Dubrovskiy & Giro, 2004). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au, 1975; Au et al., 1974; Lesage et al., 1999; Moore & Pawloski, 1990; Romanenko & Kitain, 1992; Thomas et al., 1990). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Au, 1993; Dahlheim, 1987; Foote et al., 2004; Holt et al., 2009; Lesage et al., 1993; Lesage et al., 1999; Parks, 2009; Terhune, 1999).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency as 18 kHz, in contrast to the pronounced effect at higher frequencies. Studies have noted direction hearing at frequencies as low as 0.5 to 2 kHz in several marine mammals, including killer whales (Richardson et al., 1995). This ability may be useful in reducing masking at these frequencies. In summary, high levels of sound generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects, such as that used in echolocation by toothed whales.

Marine Mammals and Behavioral Responses

We expect the greatest response of marine mammals to airgun sounds in terms of number of responses and overall impact to be in the form of changes in behavior. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case some of these repsonses could equate to harassment of individuals but are unlikely to result in meaningful behavioral responses at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al., 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al., 2012); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Francis & Barber, 2013). Although some studies are available which address responses of ESA-listed marine mammals considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-ESA-listed or species outside the action area are also considered here. Animals generally respond to anthropogenic perturbations as they will predators, increasing vigilance, and altering habitat selection (Reep et al., 2011). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis & Barber, 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect it possible for marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus.

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds for airguns. Whales continue calling while seismic surveys are operating locally (Greene Jr et al., 1999; Jochens et al., 2006; Madsen et al., 2002; McDonald et al., 1993; McDonald et al., 1995; Nieukirk et al., 2004; Richardson et al., 1986; Smultea et al., 2004; Tyack et al., 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio et al., 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al., 1994; Clark & Gagnon, 2006; McDonald et al., 1995). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al., 2012). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates and found no evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re: 1 µPa (rms) (Wilcock et al., 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio & Clark, 2009). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al., 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re: 1 µPa (peak-to-peak) (Madsen et al., 2002; McCall Howard, 1999). For the species considered in this consultation, some exposed individuals may cease calling in response to the *Langseth*'s airgun array. If individuals ceased calling in response to the *Langseth*'s airgun array during the course of the proposed seismic surveys, the effect is expected to be temporary and brief given the ship is constantly moving when seismic airguns are active. Animals may resume or modify calling at a later time or location once the acoustic stressor has diminished..

There are numerous studies of the responses of some baleen whales to airguns. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re: 1 µPa (rms) (the level used in this Opinion to determine the extent of acoustic effects for marine mammals) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al., 1995). Activity of individuals seems to influence response (Robertson et al., 2013), as feeding individuals respond less than mother and calf pairs and migrating individuals (Harris et al., 2007; Malme & Miles, 1985; Malme et al., 1984; Miller et al., 1999; Miller et al., 2005; Richardson et al., 1995; Richardson et al., 1999). Surface duration decreased markedly during exposure to airgun sounds, especially while individuals were engaged in traveling or non-calf social interactions (Robertson et al., 2013). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re: 1 µPa (rms) exposures at distances of 20 to 30 km (10.8 to 16.2 nmi), but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152 to 178 dB re: 1 µPa [rms]) (Harris et al., 2007; Ljungblad et al., 1988; Miller et al., 1999; Miller et al., 2005; Richardson et al., 1995; Richardson et al., 1999; Richardson et al., 1986). Responses such as stress may occur and the threshold for displacement may simply be higher while feeding. Bowhead whale calling rate was found to decrease during migration in the Beaufort Sea as well as temporary displacement from seismic sources (Nations et al., 2009). Calling rates decreased when exposed to seismic airguns at received levels of 116 to 129 dB re: 1 µPa (possibly but not knowingly due to whale movement away from the airguns), but did not change at received levels of 99 to 108 dB re: 1 µPa (Blackwell et al., 2013). Despite the above information and exposure to repeated seismic surveys, bowhead whales continue to return to summer feeding areas and when displaced, appear to re-occupy within a day (Richardson et al., 1986). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether though they tolerate repeat exposures, they may still experience a stress response.

Gray whales respond similarly. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 µPa (rms) (Bain & Williams, 2006; Gailey et al., 2007; Johnson et al., 2007; Malme & Miles, 1985; Malme et al., 1984; Malme et al., 1986; Malme et al., 1988; Würsig et al., 1999; Yazvenko et al., 2007a; Yazvenko et al., 2007b). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re: 1 µPa (rms) and slight behavioral changes at 140 to 160 re: 1 µPa (rms) (Malme & Miles, 1985; Malme et al., 1984). As with bowhead whales, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al., 1984). (Johnson et al., 2007) reported that gray whales exposed to airgun sounds during seismic surveys off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002 through 2005.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: 1 µPa (rms) when females with calves were present, or 7 to 12 km (3.8 to 6.5 nmi) from the acoustic source (McCauley et al., 2000a; McCauley et al., 1998). A startle response occurred as low as 112 dB re: 1 µPa (rms). Closest approaches were generally limited to 3 to 4 km (1.6 to 2.2 nmi), although some individuals (mainly males) approached to within 100 m (328.1 ft) on occasion where sound levels were 179 dB re: 1 µPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 µPa (rms).

Natural sources of sound also influence humpback whale behavior. Migrating humpback whales showed evidence of a Lombard effect in Australia, increasing vocalization in response to wind-dependent background noise (Dunlop et al., 2014a). Since natural resources of noise alone can influence whale behavior, additional anthropogenic sources could also add to these effects.

Multiple factors may contribute to the degree of response exhibited by migrating humpback whales. In a preliminary study examining the responses by migrating humpback whales of exposure to a 20 in^3 airgun, researchers found that the humpback whales' behavior seemed to be influenced by social effects; "whale groups decreased dive time slightly and decreased speed towards the source, but there were similar responses to the control" (i.e., towed airgun, not in operation) (Dunlop et al., 2014b). Whales in groups may pick up responses by other individuals in the group and react. The results of this continued study are still pending, and will examine the effects of a full size commercial airgun array on humpback whale behavior (Dunlop et al., 2014b).

Feeding humpback whales appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150 to 169 dB re: 1 μPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 μPa (rms) (Malme et al., 1984; Malme et al., 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airguns. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir, 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone, 2003; Stone & Tasker, 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities) as well as whales being more distant during seismic operations (Moulton et al., 2006a; Moulton et al., 2006b; Moulton & Miller, 2005). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1 μPa (rms) (Moulton & Miller, 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al., 2000; Madsen et al., 2006; Miller et al., 2009; Moulton et al., 2006a; Moulton & Miller, 2005; Stone, 2003; Stone & Tasker, 2006; Weir, 2008). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al., 2006; Gordon et al., 2004; Jochens et al., 2006; Madsen et al., 2006; Winsor & Mate, 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens & Biggs, 2003; Jochens & Biggs, 2004; Mate et al., 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold, 1999; Watkins et al., 1985; Watkins & Schevill, 1975). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a non-random distribution of satellite-tagged sperm whales at and beyond 5 km (2.7 nmi) from airgun arrays, suggesting individuals were not displaced or move away from the airgun array at and beyond these distances in the Gulf of Mexico (Winsor & Mate, 2013). However, no tagged whales within 5 km (2.7 nmi) were available to assess potential displacement (Winsor & Mate, 2013). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 188 Hz) pulses produced by seismic airguns (Richardson et al., 1995). Sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold & Fish, 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 µPa lower at 1 kHz and 60 dB re: 1 µPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude, 2013). Reactions to impulse noise likely vary depending on the activity at time of exposure, for example, in the presence of abundant food or during breeding encounters toothed whales sometimes are extremely tolerant of noise pulses (NMFS, 2006b).

For whales exposed to airguns during the proposed seismic survey activities, behavioral changes stemming from exposure to the airgun array may result in loss of feeding opportunities. Similar to the species behavioral responses described above, we expect ESA-listed whales exposed to sound from the airgun array considered in this consultation will also exhibit an avoidance reaction, displacing individuals from the action area at least temporarily. However, we expect secondary foraging areas to be available that will allow whales to continue feeding even when displaced from some foraging areas in the action area. Although breeding may be occurring, we are unaware of any habitat features that whales will be displaced from that is essential for breeding if whales depart an area as a consequence of the *Langseth*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect these temporary disruptions to result in the loss of any breeding opportunities. Other essential behaviors such as travel or migration are also expected to continue by indivduals transiting through the area during these activities.

Steller sea lions may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003; Götz and Janik 2011; Kvadsheim et al. 2010). These behavioral changes are expected to be temporary and not persist, and significant behavioral reactions would not be expected in most cases, thus long-term consequences for individuals or the population are unlikely.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress, that can significantly affect life history. Other effects like neurological effects, bubble formation, and other types of organ or tissue damage could occur, but similar to stress.

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Busch, 2009; Gregory & Schmid, 2001; Gulland et al., 1999; St. Aubin & Geraci, 1988; St. Aubin et al., 1996; Thomson & Geraci, 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch, 2009; Cattet et al., 2003; Dickens et al., 2010; Dierauf & Gulland, 2001; Elftman et al., 2007; Fonfara et al., 2007; Kaufman & Kaufman, 1994; Mancia, 2008; Noda et al., 2007; Thomson & Geraci, 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al., 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan & Curry, 1998, 2002; Cowan, 2008; Herraez et al., 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf & Gulland, 2001). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner & Hall, 1997; Hunt et al., 2006; Keay, 2006; Romero et al., 2008; St. Aubin et al., 1996). For example, stress is lower in immature North Atlantic right whales (*Eubalaena glacialis*) than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al., 2006; Keay, 2006).

Loud noises generally increase stress indicators in mammals (Kight, 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic watergun (up to 228 dB re: 1 μPa m peak-to-peak and single pure tones (up to 201 dB re: 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S.; this decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al., 2012). These levels returned to baseline after 24 hours of traffic resuming. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities will be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS, 2006g). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are also expected to be accompanied by physiological stress responses (NMFS, 2006g; NRC, 2003b). As we do not expect individuals to experience any long-term affects from TTS , (see *Marine Mammals and Threshold Shifts*), we also do not expect any ESA-listed individual to experience a stress response at high levels. Although we assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, and these stress responses can exert deleterious effects on individuals if chronic or of long duration, the stressor (sounds associated with the airgun array or multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler) will dissipate in a short period as the vessel (and stressors) transits away without significant or long-term harm to the individual via the stress response.

Exposure to loud noise (e.g., airguns) can also adversely affect reproductive and metabolic physiology (Kight, 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. In fish eggs and embryos exposed to sound levels only 15 dB greater than background, increased mortality was found and surviving fry had slower growth rates (a similar effect was observed in shrimp), although the opposite trends have also been found in sea bream. Dogs exposed to loud music took longer to digest food. The small intestine of rats leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). Exposure to 12 hours of loud noise can alter elements of cardiac tissue. In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight, 2011).

It is possible that a marine animal's prior exposure to sounds from seismic surveys influence its future response. Although we have little information available to us as to what response individuals will have to future exposures to sources from seismic surveys compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response will likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (André et al., 1997; Gordon et al., 2006). We do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to sounds from seismic surveys that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis*).

Marine Mammals and Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (Iagc, 2004; IWC, 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20 airgun array (139,126.2 cm^3[8,490 in^3]) 22 km (11.9 nmi) offshore the general area at the time that stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al., 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al., 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Creel, 2005; Fair & Becker, 2000; Kerby et al., 2004; Moberg, 2000; Romano et al., 2004). At present, the factors of airgun arrays from seismic surveys that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings. We therefore do not expect ESA-listed marine mammals to strand as a result of the proposed seismic survey.

Responses of Marine Mammal Prey

Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed marine mammals. Unfortunately, species-specific information on the prey of ESA-listed marine mammals is not generally available. Until more specific information is available, we expect that teleost, cephalopod, and krill prey of ESA-listed marine mammals to react in manners similar to those fish and invertebrates described herein.

Some support has been found for fish or invertebrate mortality resulting from exposure to airguns, and this is limited to close-range exposure to high amplitudes (Bjarti, 2002; Falk & Lawrence, 1973; Hassel et al., 2003; Holliday et al., 1987; Kostyuchenko, 1973; La Bella et al., 1996; McCauley et al., 2000a; McCauley et al., 2000b; McCauley et al., 2003; Popper et al., 2005; Santulli et al., 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al., 2004; Dalen & Knutsen, 1986). We expect that if fish detect the sound and perceive it as a threat or some other signal that induces them to leave the area since they are capable of moving away from the sound source (e.g., airgun array) and will return to the area and available as prey for marine mammals.

There are reports showing sub-lethal effects to some fish species. Several fish species (various life stages) have been exposed to high-intensity sound sources (220 to 242 dB re: 1 µPa) at close distances, with some cases of injury and are presented below (Booman et al., 1996; McCauley et al., 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 µPa^{2}s, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al., 2005). Caged pink snapper (*Pelates spp.*) have experienced PTS when exposed over 600 times to received sound levels of 165 to 209 dB re: 1 µPa peak-to-peak. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen & Knutsen, 1986). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne et al., 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 µPa (Falk & Lawrence, 1973).

By far the most common response by fishes is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column. Although received sound levels were not reported, caged

Pelates spp., pink snapper, and trevally (*Caranx ignobilis*) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (McCauley & Fewtrell, 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (McCauley & Fewtrell, 2013a).

Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1 µPa 0-to-peak and alarm responses at greater than 177 dB re: 1 µPa 0-to-peak (Pearson et al., 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 re: 1 µPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski et al., 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 km (1.3 nmi) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re: 1 µPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 dB re: 1 µPa) despite airgun activity (Chapman & Hawkins, 1969). Whiting may also flee from sounds from airguns (Dalen & Knutsen, 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al., 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al., 2003; Hassel et al., 2004).

McCauley et al. (2000; 2000a) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 dB re: 1 µPa (rms), but responses tended to decrease over time, suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195 to 218 dB re: 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al., 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 m (65.6 to 164 ft) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al., 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 µPa peak-to-peak sound levels from an airgun (Bjarti, 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 µPa 0-to-peak (Dalen & Knutsen, 1986; Engås et al., 1996; Engås et al., 1993; Løkkeborg, 1991; Løkkeborg & Soldal, 1993; Turnpenny et al., 1994).

Increased swimming activity in response to airgun exposure on fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1 µPa 0-to-peak (Turnpenny & Nedwell, 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al., 1994). La Bella (La Bella et al., 1996) found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

Squid are know to be important prey for sperm whales. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 µPa (rms) by first ejecting ink and then moving rapidly away from the area (McCauley & Fewtrell, 2013b; McCauley et al., 2000a; McCauley et al., 2000b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 dB re: 1 µPa (rms). Norris and Mohl (1983, summarized in(Moriyasu et al., 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after three to 11 minutes. (Andre et al., 2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 Hz at 157 ±5 dB re: 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received SPL was 157 ±5 dB re: 1 µPa, with peak levels at 175 dB re: 1 µPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. Another laboratory story observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al., 2013).

Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Payne et al., 2013). However, feeding did increase in exposed individuals (Payne et al., 2013). Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed seismic surveys. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: 1 µPa (rms) isopleths could vacate the area and/or dive to greater depths.

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We are not aware of any specific studies regarding sound effects on and the detection ability of other invertebrates such as krill (*Euphausiacea* spp.), the primary prey of most ESA-listed baleen whales. However, we do not expect krill populations to experience long-term effects from seismic sounds of airguns. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales. We do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed whales to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, these cetaceans and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

Marine Mammal Response to Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler

We expect ESA-listed whales to experience exposure to acoustic stressors from not only the airgun array, but also from the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler used during these seismic survey operate at a frequencies of 10.5 to 13 (usually 12) kHz, 3.5 kHz, and 75 kHz. These frequencies are within the functional hearing range of baleen whales, such as the ESA-listed blue, fin, humpback, North Pacific right, and sei whales, as well as sperm whales (NOAA, 2016). We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng et al., 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80 to 90 dB re: 1 µPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kHz mid-frequency sonar at received levels below 90 dB re: 1 µPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen et al., 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler systems (Ketten, 1997; Richardson et al., 1995).

Assumptions for humpback and sperm whale hearing are much different than for ESA-listed baleen whales. Humpback and sperm whales vocalize between 3.5 to 12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au, 2000; Carder & Ridgway, 1990; Erbe, 2002a; Frazer & Mercado, 2000; Goold & Jones, 1995; Levenson, 1974; Payne & Payne, 1985; Payne, 1970; Richardson et al., 1995; Silber, 1986; Thompson et al., 1986; Tyack, 1983; Tyack & Whitehead, 1983; Weilgart & Whitehead, 1993; Weilgart & Whitehead, 1997; Weir et al., 2007; Winn et al., 1970). The response of a blue whale to 3.5 kHz sonar supports this species' ability to hear this signal as well (Goldbogen et al., 2013). Maybaum (1990; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kHz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal will have to pass at close range and be swimming at speeds similar to the vessel. The animal will have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS. Sperm whales have stopped vocalizing in response to 6 to 13 kHz pingers, but did not respond to 12 kHz echosounders (Backus & Schevill, 1966; Watkins, 1977; Watkins & Schevill, 1975). Sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding, but not while traveling (Andre & Jurado, 1997; André et al., 1997).

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kHz multi-beam echosounder, similar in operating characteristics as that proposed for use aboard the *Langseth*, played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall et al., 2013). Although pathological data suggest a direct physical effect are lacking and the authors acknowledge that while the use of this type of sonar is widespread and commonplace globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multi-beam echosounder (Southall et al., 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Langseth*'s multi-beam echosounder. Although effects such as this have not been documented for ESA-listed species, the combination of exposure of this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than will otherwise be anticipated or has been documented to date (Ellison et al., 2012; Francis & Barber, 2013).

Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have not been correlated to use of these sonars. Stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by the *Langseth* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multi-beam echosounder. The sound energy received by any individuals exposed to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sources during the proposed seismic survey activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, fin, humpback, North Pacific right, sei, or sperm whales communication to appreciably occur due to the multi-beam echosounder's, sub-bottom profiler's, and acoustic Doppler current profiler's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multi-beam echosounder was less than three percent that of ship strike. Behavioral responses to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. Also, we do not expect hearing impairment such as TTS and other physical effects if the animal is in the area, as it would have to pass the transducers at close range in order to be subjected to sound levels that could cause these effect.

11.4 Risk Analysis

In this section, we assess the consequences of the responses to the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. For designated critical habitat, we assess the consequences of these responses on the value of the critical habitat for the conservation of the species for which the habitat had been designated.

We measure risks to individuals of endangered or threatened species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success.

We expect that up to 49 blue, 3,913 fin, 631 humpback, 11 North Pacific right, 9 sei, 86 sperm whales as well as 2,168 Steller sea lions (see Table 13), to be exposed to the airgun array within 160 dB re: 1 µPa (rms) ensonified areas during the seismic survey. When we do not expect individual ESA-listed marine mammals exposed to an action's effects to experience reductions in fitness, we will not expect the action to have adverse consequences on the viability of the populations those individuals belong or the species those populations comprise. As a result, if we conclude that ESA-listed animals are not likely to experience reductions in their fitness, we will conclude our assessment. If, however, we conclude that individual animals are likely to experience reductions in fitness, we will assess the consequences of those fitness reductions on the population(s) to which those individual belong.

Because of the mitigation measures in the incidental harassment authorization, and the nature of the seismic surveys, as described above, we do not expect any mortality to occur from the exposure to the acoustic sources that result from the proposed action. As described above, the proposed action will result in temporary harassment and potential harm to the exposed marine mammals. Harassment is not expected to have more than short-term effects on individual ESA-listed species (blue, fin, humpback, North Pacific right, sei, sperm whales, or Steller sea lions). While permited, harm under the ESA is not expected to occur with high probability given the mitigation measures in place for the proposed activity to protect ESA-listed species.. As such we do not expect ESA-listed marine mammals exposed to this action's effects to experience reductions in fitness, nor do we expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise. No critical habitat for these species will be adversely affected by activities associated with the proposed action.

12 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 11) to the *Environmental Baseline* (Section 10) and the *Cumulative Effects* (Section 13) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species Likely to be Adversely Affected* (Section 9).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion.

12.1 Blue Whale

No reduction in the distribution of blue whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

There are three stocks of blue whales designated in United States (U.S.) waters: the Eastern North Pacific Ocean (current best estimate N=1,647, N_{min}=1,551;) (Payne et al., 1990), Central North Pacific Ocean (N=81, N_{min}=38), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95 percent confidence intervals 1,160 to 4,500 (Branch, 2007).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis et al., 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent) (Branch, 2007).

The effects of seismic survey activities considered in this opinion are not expected to result in lethal take of any individual blue whale. The anticipated take in the form of non-lethal harm resulting to 2 individuals (PTS) and 47 individuals harassed as a result of TTS (behavioral responses, etc.) is not anticipated to result in a reduction in numbers for this species. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the abundance, distribution and reproduction of blue whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for blue whales. In conclusion, we believe the non-lethal effects associated with the proposed actions are not expected to appreciably reduce the likelihood of survival and recovery of blue whales in the wild.

12.2 Fin Whale

No reduction in the distribution of fin whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization. There are expected to be 16 individual harmed and 3,897 individual fin harassed as a result of the proposed seismic surveys.

There are three fin whale stocks in U.S. Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al., 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al., 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al., 2016).

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al., 2016). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

The effects of seismic survey activities considered in this opinion are not expected to result in lethal take of any individual fin whale. The anticipated take in the form of non-lethal harm resulting to 16 individuals (PTS) and 3,897 individuals being harassed as a result of TTS (behavioral responses, etc.) is not anticipated to result in a reduction in numbers for this species. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the fin whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable population in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for fin whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of fin whales in the wild.

12.3 Humpback Whale – Mexico Distinct Population Segment

No reduction in the distribution of the Mexico DPS of humpback whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman & Palumbi, 2003). The current abundance of the Mexico DPS is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be 3 individuals harmed and 599 individual humpback whales (Mexico DPS) harassed as a result of the proposed seismic surveys. Because we do not anticipate a reduction in numbers or reproduction of Mexico DPS of humpback whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the distribution of the Mexico DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Mexico DPS of humpback whales in the wild.

12.4 Humpback Whale – Western Pacific Population Segment

No reduction in the distribution of Western Pacific DPS of humpback whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman & Palumbi, 2003). The current abundance of the Western North Pacific DPS is 1,059. A population growth rate is currently unavailable for the Western North Pacific DPS of humpback whales.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be 1 individual harmed and 28 individuals humpback whales (Western Pacific DPS) harassed as a result of the proposed seismic surveys.

Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the distribution of Western Pacific DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for Western Pacific DPS of humpback whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Western Pacific DPS of humpback whales in the wild.

12.5 North Pacific Right Whale

No reduction in the distribution of North Pacific right whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization. There are expected to be no instances of harm and 11 instances of harassment of North Pacific right whales as a result of the proposed seismic surveys.The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals. There are two currently recognized stocks of North Pacific right whales, a Western North Pacific stock that feeds primarily in the Sea of Okhotsk, and an Eastern North Pacific stock that feeds in eastern North Pacific Ocean waters off Alaska, Canada, and Russia. Several lines of evidence indicate a total population size of less than 100 for the Eastern North Pacific stock. Based on photo-identification from 1998 to 2013 (Wade et al., 2011a) estimated 31 individuals, with a minimum population estimate of 26 individuals (Muto et al., 2017). Genetic data have identified 23 individuals based on samples collected between 1997 and 2011 (Leduc et al., 2012). The Western North Pacific stock is likely more abundant and was estimated to consist of 922 whales (95 percent confidence intervals 404 to 2,108) based on data collected in 1989, 1990, and 1992 (IWC, 2001; Thomas et al., 2016). The population estimate for the Western North Pacific stock is likely in the low hundreds (Brownell Jr. et al., 2001). While there have been several sightings of Western North Pacific right whales in recent years, with one sighting identifying at least 77 individuals, these data have yet to be compiled to provide a more recent abundance estimate (Thomas et al., 2016). There is currently no information on the population trend of North Pacific right whales.

The effects of seismic survey activities considered in this opinion are not expected to result in lethal take of any individual blue whale. The anticipated take in the form of 11 individuals being harassed as a result of TTS (behavioral responses, etc.) is not anticipated to result in a reduction in numbers for this species. There are no anticipated takes in the form of harm to this species. Because we do not anticipate a reduction in numbers or reproduction of North Pacific right whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2013 Final Recovery Plan for the North Pacific right whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of North Pacific right whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for North Pacific right whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of North Pacific right whales in the wild.

12.6 Sei Whale

No reduction in the distribution of sei whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC, 2016; Thomas et al., 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=178, N_{min}=93), and Eastern North Pacific (N=519, N_{min}=374). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be two individuals harmed and seven sei whales harassed as a result of the proposed seismic surveys. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2001 Final Recovery Plan for the sei whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of sei whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sei whales in the wild.

12.7 Sperm Whale

No reduction in the distribution of sperm whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead, 2009). The higher estimates may be approaching population sizes prior to commercial whaling. There are no reliable estimates for sperm whale abundance across the entire Pacific Ocean. However, estimates are available in the northeast Pacific Ocean, where abundance was estimated to be between 26,300 and 32,100 animals in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are available for two to three U.S. stocks that occur in the Pacific, the California/Oregon/Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 3,354 individuals (N_{min}=2,539). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be zero individuals harmed and 86 individual sperm whales harassed as a result of the proposed seismic surveys. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the sperm whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of sperm whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division’s issuance of an IHA will impede the recovery objectives for sperm whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sperm whales in the wild.

12.8 Steller Sea Lion – Western Distinct Population Segment

No reduction in the distribution of Steller sea lions from the Pacific Ocean are expected because of the NSF’s seismic survey activities and the Permits and Conservation Division’s issuance of an incidental harassment authorization.

As of 2017, the best estimate of abundance of the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups (total N_{min}= 54,267) (Muto et al., 2018). This represents a large decline since counts in the 1950s (N=140,000) and 1970s (N=110,000).

Using data collected from 1978 through 2017, there is strong evidence that pup and non-pup counts of western stock Steller sea lions in Alaska were at their lowest levels in 2002 and 2003, respectively, and have increased at 1.78 percent and 2.14 percent, respectively, between 2002 and 2017 (Sweeney et al., 2016) . Western DPS Steller sea lion site counts decreased 40 percent from 1991 through 2000, an average annual decline of 5.4 percent; however, counts increased three percent between 2004 through 2008, the first recorded population increase since the 1970s (NMFS, 2008). Overall, there are strong regional differences across the range in Alaska, with positive trends in the GOA and eastern Bering Sea east of Samalga Pass (~170°W) and generally negative trends to the west in the Aleutian Islands. Non-pup trends in 2002- 2017 in Alaska have a longitudinal gradient with highest rates of increase generally in the east (eastern GOA) and steadily decreasing rates to the west.

Based on the results of genetic studies, the Steller sea lion population was reclassified into two DPSs: Western and Eastern. The data which came out of these studies indicated that the two populations had been separate since the last ice age (Bickham et al., 1998). Further examination of the Steller sea lions from the GOA (i.e., the Western DPS) revealed a high level of haplotypic diversity, indicating that genetic diversity had been retained despite the decline in abundance (Bickham et al., 1998).

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be 3 individuals harmed and 2,165 individual Steller sea lions harassed as a result of the proposed seismic surveys. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Steller sea lions as a result of the proposed seismic survey activities and the Permits and Conservation Division’s issuance of an incidental harassment authorization, a reduction in the species’ likelihood of survival is not expected.

The 2008 Final Recovery Plan for the Steller sea lion lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Continue population monitoring.
- Insure adequate habitat and range for recovery
- Protect from over-utilization for commercial, recreational, scientific, or educational purposes.
- Protect from diseases, contaminants, and predation.
- Protect from other natural or anthropogenic actions and administer the recovery program.

Because no mortalities or effects on the distribution of Steller sea lions are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for Steller sea lions. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Steller sea lions in the wild.

13 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that those aspects described in the *Environmental Baseline* (Section 10) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, harvesting, vessel strikes, whale watching, fisheries interactions, pollution, aquatic nuisance species, disease, oil spills, anthropogenic sound, military activities, and scientific research activities to continue into the future for marine mammals.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. We conducted electronic searches of *Google* and other electronic search engines for other potential future state or private activities that are likely to occur in the action area. We are not aware of any state or private activities that are likely to occur in the action area during the foreseeable future that were not considered in the *Environmental Baseline* section of this opinion.

14 Conclusion

After reviewing the current status of the ESA-listed species, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of blue whales, fin whales, Mexico DPS of humpback whales, Western North Pacific DPS of humpback whales, North Pacific right whales, sei whales, sperm whales, and Steller sea lions or to destroy or adversely modify any of their designated critical habitat.

15 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct” (16 U.S.C. §1532(19)). “Harm” is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102).

Incidental take is take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. NMFS had not yet defined “harass” under the ESA in regulation. On December 21, 2016, NMFS issued interim guidance on the term “harass,” defining it as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.”

For purposes of this consultation, we relied on NMFS’ interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed marine mammals and the ESA interim definition of harassment to estimate the number of instances of harassment for ESA species.

ESA section 7(b)(4) states that take of ESA-listed marine mammals must be authorized under MMPA section 101(a)(5) before the Secretary can issue an incidental take statement for ESA-listed marine mammals. NMFS’ implementing regulations for MMPA section 101(a)(5)(D) specify that an IHA is required to conduct activities pursuant to any incidental take authorization for a specific activity that will “take” marine mammals. Once NMFS has authorized the incidental take of marine mammals under an IHA for the period of August 8, 2018, through August 7, 2019, under the MMPA, the incidental take of ESA-listed marine mammals is exempt from the ESA take prohibitions as stated in this incidental take statement pursuant to section 7(b)(4) and 7(o)(2).

Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

15.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent, of such incidental taking on the species and may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take for marine mammals may be exceeded. As such, if more tracklines are conducted during the seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation will be necessary.

15.1.1 Marine Mammals

We and the NMFS Permits and Conservation Division anticipate the proposed seismic survey in the GOA are likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 14). Behavioral (MMPA Level B) harassment is expected to occur at received levels at or above 160 dB re: 1 μPa (rms) for ESA-listed marine mammals. For all species of ESA-listed marine mammals, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form of MMPA Level B harassment, and is not expected to result in the death or injury of any ESA-listed individuals that will be exposed. It is believed that any PTS incurred in these marine mammals as a result of the proposed activity would be in the form of only a small degree of PTS, not total deafness, and would be unlikely to affect the fitness of any individuals, because of the constant movement of both the *Langseth* and of the marine mammals in the project areas, as well as the fact that the vessel is not expected to remain in any one area in which individual marine mammals would be expected to concentrate for an extended period of time (*i.e.*, since the duration of exposure to loud sounds will be relatively short). Also, as described above, we expect that marine mammals would be likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in PTS, given sufficient notice of the *Langseth's* approach due to the vessel's relatively low speed when conducting seismic surveys.

Table 14. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Gulf of Alaska by the incidental take statement.

Species	Potential Temporary Threshold Shift and Behavioral Harassment	Potential Permanent Threshold Shift and Harm
Blue Whale	47	2
Fin Whale	3,897	16
Humpback Whale – Mexico DPS	599	3
Humpback Whale – Western Pacific DPS	28	1
North Pacific Right Whale	11	0
Sei Whale	7	2
Sperm Whale	86	0

Steller Sea Lion – Western DPS	2,165	3

DPS=Distinct Population Segment

15.2 Effects of the Take

In this Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

15.3 Reasonable and Prudent Measures

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

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS Permits and Conservation Division must ensure that the NSF implements a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed IHA for the incidental taking of blue, fin, humpack (Mexico and Western Pacific DPSs), North Pacific right, sei, and sperm whales, and Steller sea lions pursuant to section 101(a)(5)(D) of the MMPA. In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and to inform the NMFS ESA Interagency Cooperation Division if take is exceeded.
- The NMFS Permits and Conservation Division must ensure that the NSF implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of marine mammals.

15.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the NSF and NMFS Permits and Conservation Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the NSF and NMFS Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the reasonable and prudent measures, the NSF, and the NMFS Permits and Conservation Division shall implement the following terms and conditions.

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the incidental harassment authorization, whichever comes sooner.
2. Any reports of injured or dead ESA-listed species must be provided to the ESA Interagency Cooperation Division immediately to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by email at cathy.tortorici@noaa.gov.

16 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We recommend the following conservation recommendations, which will provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect ESA-listed species as well as reduce harassment related to the authorized seismic survey activities.

1. We recommend that the NSF develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
2. We recommend that the NMFS Permits and Conservation Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future incidental harassment authorizations for seismic surveys.
3. We recommend the NSF use (and NMFS Permits and Conservation require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting threatened and endangered species.
4. We recommend the NSF and NMFS Permits and Conservation Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across protected species observer reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us

understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.

5. We recommend the NSF notify NMFS Permits and Conservation Division of any sightings of North Pacific right whales and provide sighting information within 48 hours.
6. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the *Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to protected species observers.

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

17 Reinitiation Notice

This concludes formal consultation for

National Science Foundation and Lamont-Doherty Earth Observatory's Proposed Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the Western Gulf of Alaska and National Marine Fisheries Service Permits and Conservation Division's Issuance of an IHA pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then (3) above may be met and reinitiation of consultation may be necessary.

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19 APPENDICES

19.1 Appendix A

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a marine geophysical survey in the Gulf of Alaska, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid from June 1, 2019 to May 31, 2020.

2. This IHA is valid only for marine geophysical activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Gulf of Alaska.

3. General Conditions

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

(b) The species authorized for taking are listed in Table 1

(c) The taking, by Level A and B harassment, is limited to the species listed in condition 3(b). Table 1 provides the authorized number of takes per species and stock.

(d) The taking, by serious injury or death of any of species listed in condition 3(b) of this IHA is prohibited.

(e) The taking, by Level A harassment, Level B harassment, serious injury, or death, of marine mammal species not identified in condition 3(b) is prohibited.

4. Mitigation Measures

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

(a) L-DEO must use at least six dedicated, trained, NMFS-approved Protected Species Observers (PSOs). The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements.

(b) At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience

(c) Visual Observation

(i) During survey operations (e.g., any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up, including nighttime ramp-ups, of the airgun array.

(ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

(iii) Visual PSOs must immediately communicate all marine mammal observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iv) During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(v) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) Acoustic PSOs must immediately communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

Exclusion zone and buffer zone

(i) PSOs must establish and monitor a 500 m exclusion zone and 1,000 m buffer zone. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 meters from the edges of the airgun array (0–500 meters). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 meter exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 meters). PSOs must monitor beyond 1,000 meters and enumerate any takes that occur beyond the buffer zone.

(f) Pre-clearance and Ramp-up

(i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds and 30 minutes for mysticetes and large odontocetes all other species).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon observation of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown or powerdown, but such observation must be communicated to the operator to prepare for the potential shutdown or powerdown.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown and powerdown (*e.g.*, mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-clearance watch of 30 min is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance of 30 min.

(g) Shutdown and Powerdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown or powerdown of the acoustic source if a marine mammal is detected within the 500 m exclusion zone (100 m when shutdown has been waived as described in 4(g)(v).

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown and powerdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up and powerdown) and (1) a marine mammal (excluding delphinids) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any questions regarding a PSO shutdown must be resolved after deactivation.

(iv) Shutdown must occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) (other than delphinids) in the 500 m exclusion zone. During daylight hours, if the acoustic PSO cannot confirm presence within exclusion zone, visual PSOs must be notified but shutdown is not required.

(v) The shutdown requirement shall be waived for small dolphins of the following genera: *Lagenorhynchus* and *Grampus.*

a. The acoustic source must be powered down to 40-in^3 airgun if an individual belonging to these genera is visually detected within the 500 m exclusion zone.

b. When the acoustic source is powered down to the 40-in^3 airgun due to the presence of dolphins specified in 4(g)(v), an exclusion zone of 100 m and Level B harassment zone of 430 m will be in effect for species other than specified dolphin genera that may approach the survey vessel.

c. Powerdown conditions must be maintained until delphinids, for which shutdown is waived, are no longer observed within the 500 m exclusion zone, following which full-power operations may be resumed without ramp-up. Visual PSOs may elect to waive the powerdown requirement if delphinids for which shutdown is waived appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and must use best professional judgment in making this decision.

d. If PSOs observe any behaviors in delphinids for which shutdown is waived that indicate an adverse reaction, then powerdown must be initiated.

e. Visual PSOs must use best professional judgment in making the decision to call for a shutdown if there is uncertainty regarding identification (i.e., whether the observed marine mammal(s) belongs to one of the delphinid genera for which shutdown is waived).

(vi) L-DEO must implement a shutdown when a large whale with a calf or an aggregation of large whales (defined as 6 or more mysticetes or sperm whales) is observed regardless of the distance from the *Langseth*.

(vii) L-DEO must implement a shutdown when a North Pacific right whale or group of North Pacific right whales is observed at any distance.

(viii) L-DEO must implement a shutdown when a fin whale or group of fin whales is observed, within the species' Gulf of Alaska feeding Biologically Important Area (BIA), within 1,500 m of the acoustic source.

(ix) L-DEO must implement a shutdown upon observation of any marine mammal species not authorized for take that is entering or approaching the vessel's respective Level B harassment zone.

(x) L-DEO must implement a shutdown upon observations of any authorized marine mammal species that has reached its total allotted number of takes by Level B harassment that is entering or approaching the vessel's respective Level B harassment zone.

(xi) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds and 30 minutes for mysticetes and large odontocetes) with no further observation of the marine mammal(s).

(h) Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for strike is minimized.

(i) Vessel speeds must be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

(ii) Vessels must maintain a minimum separation distance of 100 m from large whales (i.e., sperm whales and all baleen whales.

(iii) Vessels must attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those animals that approach the vessel.

(iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

(i) Actions to Minimize Additional Harm to Live Stranded (or Milling) Marine Mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(i) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise the IHA-holder that the shutdown around the animals' location is no longer needed.

(ii) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises the IHA-holder that all live animals involved have left the area (either of their own volition or following an intervention).

(ii) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with the IHA-holder will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(j) Sensitive Habitat Measures

(i) L-DEO must not approach within 3 n. mi. of all known Steller sea lion rookeries and major haul-outs.
(ii) L-DEO must conduct survey operations in the North Pacific right whale critical habitat during daylight hours only.
(iii) L-DEO must reduce vessel speed to at most 5 kn (knots) when transiting through North Pacific right whale critical habitat during darkness, or conditions of similarly limiting visibility.
(iv) While in the fin whale Gulf of Alaska feeding BIA, L-DEO must implement a shutdown if a fin whale or group of fin whales is observed within a 1,500 meter radius from the acoustic source.

(k) L-DEO must conduct outreach with subsistence communities near the planned seismic survey to identify and avoid areas of potential conflict.

5. Monitoring Measures

The holder of this IHA is required to abide by the following marine mammal and acoustic monitoring measures:

(a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (i.e., Fujinon or equivalent) solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

(b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

(i) PAM must include a system that has been verified and tested by the acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) At least one night-vision device suited for the marine environment for use during nighttime pre-clearance and ramp-up that features automatic brightness and gain control, bright light protection, infrared illumination, and/or optics suited for low-light situations (e.g., Exelis PVS-7 night vision goggles; Night Optics D-300 night vision monocular; FLIR M324XP thermal imaging camera or equivalents).

(iii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (i.e., Fujinon or equivalent) (at least one per PSO, plus backups).

(iv) Global Positioning Units (GPS) (at least one per PSO, plus backups).

(v) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (i.e., Canon or equivalent) (at least one per PSO, plus backups).

(vi) Compasses (at least one per PSO, plus backups).

(vii) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

(viii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must be independent, dedicated, trained visual and acoustic PSOs and must be employed by a third-party observer provider.

(ii) PSOs must have no tasks other than to conduct observational effort (visual or acoustic), collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and

(iii) PSOs must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(iv) PSOs can act as acoustic or visual observers (but not at the same time) as long as they demonstrate that their training and experience are sufficient to perform the task at hand.

(v) NMFS must review and approve PSO resumes.

(vi) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(vii) One visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(viii) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(ix) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

(x) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

a. Vessel names (source vessel and other vessels associated with survey) and call signs;

b. PSO names and affiliations;

c. Date and participants of PSO briefings (as discussed in General Requirement);

d. Dates of departures and returns to port with port name;

e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any protected species, the following information must be recorded:

a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

b. PSO who sighted the animal;

c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

f. Direction of vessel's travel (compass direction);

g. Direction of animal's travel relative to the vessel;

h. Pace of the animal;

i. Estimated distance to the animal and its heading relative to vessel at initial sighting;

j. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

k. Estimated number of animals (high/low/best);

l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

p. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and

q. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information should be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The draft report must include the following:

(i) Summary of all activities conducted and sightings of protected species near the activities;

(ii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iii) Summary of dates and locations of survey operations and all protected species sightings (dates, times, locations, activities, associated survey activities);

(iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(v) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system;

(vi) Raw observational data;

(vii) Summary of the information submitted in interim monthly reports as well as additional data collected as described above in Data Collection and the IHA;

(viii) Estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability;

(ix) Certification from the lead PSO as to the accuracy of the report

a. The lead PSO may submit statement directly to NMFS concerning implementation and effectiveness of the required mitigation and monitoring.

(x) A final report must be submitted within 30 days following resolution of any comments on the draft report.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS Region Stranding Coordinator (907-586-7209) as soon as feasible. The report must include the following information: Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to regional stranding coordinators as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the incident;

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

g. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

h. Estimated size and length of animal that was struck;

i. Description of the behavior of the marine mammal immediately preceding and following the strike;

j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

k. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

l. To the extent practicable, photographs or video footage of the animal(s).

(iii) Additional Information Requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted (example circumstances noted below), and an investigation into the stranding is being pursued, NMFS will submit a written request to the IHA-holder indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

a. Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

b. If available, description of the behavior of any marine mammal(s) observed preceding (i.e., within 48 hours and 50 km) and immediately after the discovery of the stranding.

c. In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

8. Renewals - On a case-by-case basis, NMFS may issue a one-year IHA renewal with an expedited public comment period (15 days) when 1) another year of identical or nearly identical activities is planned or 2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that allowed for under this IHA, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to expiration of the current IHA.

(b) The request for renewal must include the following:

(i) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, take estimates, or mitigation and monitoring requirements.

(ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures remain the same and appropriate, and the original findings remain valid.

__________________________________ _______________________

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

Date

Table 1: Numbers of Instances of Incidental Take of Marine Mammals Authorized During Gulf of Alaska Survey.

	Stock	Level B	Level A
North Pacific Right Whale	Eastern North Pacific	11	0
Humpback Whale	Central North Pacific (Hawaii DPS)	5,079	21
	Central North Pacific (Mexico DPS)	599	3
	Western North Pacific	28	1
Blue whale	Eastern North Pacific	47	2
	Central North Pacific		
Fin Whale	Northeast Pacific	3,897	16
Sei Whale	Eastern North Pacific	7	2
Minke Whale	Alaska	52	2
Gray Whale	Eastern North Pacific	2,146[1]	9
	Western North Pacific	28[1]	0
Sperm Whale	North Pacific	86	0
Killer Whale	Alaska Resident	279[2]	0
	Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	218[2]	0
	Offshore	90[2]	0
Pacific White-Sided Dolphin	North Pacific	1,838	0
Cuvier's Beaked Whale	Alaska	195	0
Baird's Beaked Whale	Alaska	45	0
Stejneger's Beaked Whale	Alaska	64	0
Risso's Dolphin	CA/OR/WA	16	0
Harbor Porpoise	Gulf of Alaska	1,830	51
	Southeast Alaska	203	6
Dall's Porpoise	Alaska	13,196	481
Steller Sea Lion	Eastern U.S.	2,165	3
	Western U.S.		
California Sea Lion	U.S.	1	1
Northern Fur Seal	Eastern Pacific	1,182	2
Northern Elephant Seal	California Breeding	193	2
Harbor Seal	South Kodiak	441	2

	Cook Inlet/Shelikof Strait		
	Prince William Sound		

[1] The authorized numbers of take attributed to the Eastern North Pacific and Western North Pacific stocks of Gray whale are approximations based on the relative sizes of these two stocks. The method is discussed more fully in the Federal Register Notices associated with this action.

[2] The authorized numbers of take attributed to the Alaska Resident, Gulf of Alaska, Aleutian Islands, and Bering Sea Transient, and Offshore stocks of killer whale are approximations based on the relative sizes of these two stocks. The method is discussed more fully in the Federal Register Notices associated with this action.

Attachment 3

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

Sean Higgins
Director, Office of Marine Operations
Lamont-Doherty Earth Observatory
61 Rt. 9W
Palisades, NY 10964

Dear Mr. Higgins:

Enclosed is an Incidental Harassment Authorization (IHA) issued to Lamont-Doherty Earth Observatory, under the authority of Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*) to take, by Level A harassment and Level B harassment only, small numbers of marine mammals incidental to a marine geophysical survey in the Gulf of Alaska, 2019.

You are required to comply with the conditions contained in the IHA, including all mitigation, monitoring and reporting requirements. Along with mitigation measures, the IHA requires monitoring for the presence and behavior of marine mammals during all activities associated with the project.

If you have any questions concerning the IHA or its requirements, please contact Amy Fowler, Office of Protected Resources, National Marine Fisheries Service, at (301) 427-8401.

Sincerely,

MAY 3 1 2019

Donna S. Wieting, Director
Office of Protected Resources

Enclosure

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

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a marine geophysical survey in the Gulf of Alaska, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid from June 1, 2019 to May 31, 2020.

2. This IHA is valid only for marine geophysical activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Gulf of Alaska.

3. General Conditions

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

(b) The species authorized for taking are listed in Table 1

(c) The taking, by Level A and B harassment, is limited to the species listed in condition 3(b). Table 1 provides the authorized number of takes per species and stock.

(d) The taking, by serious injury or death of any of species listed in condition 3(b) of this IHA is prohibited.

(e) The taking, by Level A harassment, Level B harassment, serious injury, or death, of marine mammal species not identified in condition 3(b) is prohibited.

4. Mitigation Measures

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

(a) L-DEO must use at least six dedicated, trained, NMFS-approved Protected Species Observers (PSOs). The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements.

(b) At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience

(c) Visual Observation

(i) During survey operations (e.g., any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up, including nighttime ramp-ups, of the airgun array.

(ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

(iii) Visual PSOs must immediately communicate all marine mammal observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iv) During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(v) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) Acoustic PSOs must immediately communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

Exclusion zone and buffer zone

(i) PSOs must establish and monitor a 500 m exclusion zone and 1,000 m buffer zone. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 meters from the edges of the airgun array (0–500 meters). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 meter exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 meters). PSOs must monitor beyond 1,000 meters and enumerate any takes that occur beyond the buffer zone.

(f) Pre-clearance and Ramp-up

(i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds and 30 minutes for mysticetes and large odontocetes all other species).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon observation of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown or powerdown, but such observation must be communicated to the operator to prepare for the potential shutdown or powerdown.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown and powerdown (*e.g.*, mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-clearance watch of 30 min is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance of 30 min.

(g) Shutdown and Powerdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown or powerdown of the acoustic source if a marine mammal is detected within the 500 m exclusion zone (100 m when shutdown has been waived as described in 4(g)(v).

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown and powerdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up and powerdown) and (1) a marine mammal (excluding delphinids) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any questions regarding a PSO shutdown must be resolved after deactivation.

(iv) Shutdown must occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) (other than delphinids) in the 500 m exclusion zone. During daylight hours, if the acoustic PSO cannot confirm presence within exclusion zone, visual PSOs must be notified but shutdown is not required.

(v) The shutdown requirement shall be waived for small dolphins of the following genera: *Lagenorhynchus* and *Grampus.*

a. The acoustic source must be powered down to 40-in^3 airgun if an individual belonging to these genera is visually detected within the 500 m exclusion zone.

b. When the acoustic source is powered down to the 40-in^3 airgun due to the presence of dolphins specified in 4(g)(v), an exclusion zone of 100 m and Level B harassment zone of 430 m will be in effect for species other than specified dolphin genera that may approach the survey vessel.

c. Powerdown conditions must be maintained until delphinids, for which shutdown is waived, are no longer observed within the 500 m exclusion zone, following which full-power operations may be resumed without ramp-up. Visual PSOs may elect to waive the powerdown requirement if delphinids for which shutdown is waived appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and must use best professional judgment in making this decision.

d. If PSOs observe any behaviors in delphinids for which shutdown is waived that indicate an adverse reaction, then powerdown must be initiated.

e. Visual PSOs must use best professional judgment in making the decision to call for a shutdown if there is uncertainty regarding identification (i.e., whether the observed marine mammal(s) belongs to one of the delphinid genera for which shutdown is waived).

(vi) L-DEO must implement a shutdown when a large whale with a calf or an aggregation of large whales (defined as 6 or more mysticetes or sperm whales) is observed regardless of the distance from the *Langseth*.

(vii) L-DEO must implement a shutdown when a North Pacific right whale or group of North Pacific right whales is observed at any distance.

(viii) L-DEO must implement a shutdown when a fin whale or group of fin whales is observed, within the species' Gulf of Alaska feeding Biologically Important Area (BIA), within 1,500 m of the acoustic source.

(ix) L-DEO must implement a shutdown upon observation of any marine mammal species not authorized for take that is entering or approaching the vessel's respective Level B harassment zone.

(x) L-DEO must implement a shutdown upon observations of any authorized marine mammal species that has reached its total allotted number of takes by Level B harassment that is entering or approaching the vessel's respective Level B harassment zone.

(xi) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds and 30 minutes for mysticetes and large odontocetes) with no further observation of the marine mammal(s).

(h) Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for strike is minimized.

  (i) Vessel speeds must be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

  (ii) Vessels must maintain a minimum separation distance of 100 m from large whales (i.e., sperm whales and all baleen whales.

  (iii) Vessels must attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those animals that approach the vessel.

  (iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

(i) Actions to Minimize Additional Harm to Live Stranded (or Milling) Marine Mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

  (i) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise the IHA-holder that the shutdown around the animals' location is no longer needed.

  (ii) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises the IHA-holder that all live animals involved have left the area (either of their own volition or following an intervention).

  (ii) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with the IHA-holder will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(j) Sensitive Habitat Measures

(i) L-DEO must not approach within 3 n. mi. of all known Steller sea lion rookeries and major haul-outs.
(ii) L-DEO must conduct survey operations in the North Pacific right whale critical habitat during daylight hours only.
(iii) L-DEO must reduce vessel speed to at most 5 kn (knots) when transiting through North Pacific right whale critical habitat during darkness, or conditions of similarly limiting visibility.
(iv) While in the fin whale Gulf of Alaska feeding BIA, L-DEO must implement a shutdown if a fin whale or group of fin whales is observed within a 1,500 meter radius from the acoustic source.

(k) L-DEO must conduct outreach with subsistence communities near the planned seismic survey to identify and avoid areas of potential conflict.

5. Monitoring Measures

The holder of this IHA is required to abide by the following marine mammal and acoustic monitoring measures:

(a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (i.e., Fujinon or equivalent) solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

(b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

(i) PAM must include a system that has been verified and tested by the acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) At least one night-vision device suited for the marine environment for use during nighttime pre-clearance and ramp-up that features automatic brightness and gain control, bright light protection, infrared illumination, and/or optics suited for low-light situations (e.g., Exelis PVS-7 night vision goggles; Night Optics D-300 night vision monocular; FLIR M324XP thermal imaging camera or equivalents).

(iii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (i.e., Fujinon or equivalent) (at least one per PSO, plus backups).

(iv) Global Positioning Units (GPS) (at least one per PSO, plus backups).

(v) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (i.e., Canon or equivalent) (at least one per PSO, plus backups).

(vi) Compasses (at least one per PSO, plus backups).

(vii) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

(viii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must be independent, dedicated, trained visual and acoustic PSOs and must be employed by a third-party observer provider.

(ii) PSOs must have no tasks other than to conduct observational effort (visual or acoustic), collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and

(iii) PSOs must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(iv) PSOs can act as acoustic or visual observers (but not at the same time) as long as they demonstrate that their training and experience are sufficient to perform the task at hand.

(v) NMFS must review and approve PSO resumes.

(vi) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(vii) One visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(viii) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(ix) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

(x) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

a. Vessel names (source vessel and other vessels associated with survey) and call signs;

b. PSO names and affiliations;

c. Date and participants of PSO briefings (as discussed in General Requirement);

d. Dates of departures and returns to port with port name;

e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any protected species, the following information must be recorded:

a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

b. PSO who sighted the animal;

c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

f. Direction of vessel's travel (compass direction);

g. Direction of animal's travel relative to the vessel;

h. Pace of the animal;

i. Estimated distance to the animal and its heading relative to vessel at initial sighting;

j. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

k. Estimated number of animals (high/low/best);

l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

p. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and

q. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information should be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The draft report must include the following:

(i) Summary of all activities conducted and sightings of protected species near the activities;

(ii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iii) Summary of dates and locations of survey operations and all protected species sightings (dates, times, locations, activities, associated survey activities);

(iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(v) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system;

(vi) Raw observational data;

(vii) Summary of the information submitted in interim monthly reports as well as additional data collected as described above in Data Collection and the IHA;

(viii) Estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability;

(ix) Certification from the lead PSO as to the accuracy of the report

a. The lead PSO may submit statement directly to NMFS concerning implementation and effectiveness of the required mitigation and monitoring.

(x) A final report must be submitted within 30 days following resolution of any comments on the draft report.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS Region Stranding Coordinator (907-586-7209) as soon as feasible. The report must include the following information: Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to regional stranding coordinators as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the incident;

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

g. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

h. Estimated size and length of animal that was struck;

i. Description of the behavior of the marine mammal immediately preceding and following the strike;

j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

k. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

l. To the extent practicable, photographs or video footage of the animal(s).

(iii) Additional Information Requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted (example circumstances noted below), and an investigation into the stranding is being pursued, NMFS will submit a written request to the IHA-holder indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

a. Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

b. If available, description of the behavior of any marine mammal(s) observed preceding (i.e., within 48 hours and 50 km) and immediately after the discovery of the stranding.

c. In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

8. Renewals - On a case-by-case basis, NMFS may issue a one-year IHA renewal with an expedited public comment period (15 days) when 1) another year of identical or nearly identical activities is planned or 2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that allowed for under this IHA, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to expiration of the current IHA.

(b) The request for renewal must include the following:

(i) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, take estimates, or mitigation and monitoring requirements.

(ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures remain the same and appropriate, and the original findings remain valid.

MAY 3 1 2019

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

Date

Table 1: Numbers of Instances of Incidental Take of Marine Mammals Authorized During Gulf of Alaska Survey.

	Stock	Level B	Level A
North Pacific Right Whale	Eastern North Pacific	11	0
Humpback Whale	Central North Pacific (Hawaii DPS)	5,079	21
	Central North Pacific (Mexico DPS)	599	3
	Western North Pacific	28	1
Blue whale	Eastern North Pacific	47	2
	Central North Pacific		
Fin Whale	Northeast Pacific	3,897	16
Sei Whale	Eastern North Pacific	7	2
Minke Whale	Alaska	52	2
Gray Whale	Eastern North Pacific	2,146[1]	9
	Western North Pacific	28[1]	0
Sperm Whale	North Pacific	86	0
Killer Whale	Alaska Resident	279[2]	0
	Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	218[2]	0
	Offshore	90[2]	0
Pacific White-Sided Dolphin	North Pacific	1,838	0
Cuvier's Beaked Whale	Alaska	195	0
Baird's Beaked Whale	Alaska	45	0
Stejneger's Beaked Whale	Alaska	64	0
Risso's Dolphin	CA/OR/WA	16	0
Harbor Porpoise	Gulf of Alaska	1,830	51
	Southeast Alaska	203	6
Dall's Porpoise	Alaska	13,196	481
Steller Sea Lion	Eastern U.S.	2,165	3
	Western U.S.		
California Sea Lion	U.S.	1	1
Northern Fur Seal	Eastern Pacific	1,182	2
Northern Elephant Seal	California Breeding	193	2
Harbor Seal	South Kodiak	441	2
	Cook Inlet/Shelikof Strait		
	Prince William Sound		

[1] The authorized numbers of take attributed to the Eastern North Pacific and Western North Pacific stocks of Gray whale are approximations based on the relative sizes of these two stocks. The method is discussed more fully in the Federal Register Notices associated with this action.

[2] The authorized numbers of take attributed to the Alaska Resident, Gulf of Alaska, Aleutian Islands, and Bering Sea Transient, and Offshore stocks of killer whale are approximations based on the relative sizes of these two stocks. The method is discussed more fully in the Federal Register Notices associated with this action.