NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on the National Science Foundation's Proposed Marine Geophysical Survey of the Aleutian Arc by the Research Vessel Marcus G. Langseth and the Issuance of an Incidental Harassment Authorization by the National Marine Fisheries Service, Permits and Conservation Division, 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 and Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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Donna S. Wieting
Director, Office of Protected Resources

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1 Introduction

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

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

The action agencies for this consultation are the National Science Foundation (NSF) and the NMFS, Office of Protected Resources, Permits and Conservation Division. Two federal actions are considered in this biological opinion (opinion). The first is the NSF's proposed funding of a seismic survey in the Andreanof segment of the Aleutian Islands, Alaska, starting in September and continuing into October of 2020. The survey is 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 proposed issuance of an incidental harassment authorization (IHA), pursuant to section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a)(5)(D), authorizing non-lethal "takes" of marine mammals incidental to the planned seismic survey from Level B harassment, as defined by the MMPA.

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

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

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on the following threatened and endangered species, and designated critical habitat: blue whales (*Balaenoptera musculus)*, fin whales (*Balaenoptera physalus)*, the Western North Pacific population of gray whales (*Eschrichtius robustus*), the Mexico distinct population segment (DPS) and Western North Pacific DPS of humpback whales (*Megaptera novaeangliae*), North Pacific right whales (*Eubalaena japonica*), sei whales (*Balaenoptera borealis*), sperm whales (*Physeter microcephalus*), the Western DPS of Steller sea lions (*Eumetopias jubatus*), the Central North Pacific DPS and East Pacific DPS of green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), the North Pacific Ocean DPS of loggerhead turtle (*Caretta caretta*), Mexico's Pacific Coast breeding colonies and all other areas of olive ridley turtle (*Lepidochelys olivacea*); the lower Columbia River evolutionary significant unit (ESU), upper Columbia River spring-run ESU, Puget Sound ESU, Snake River fall-run ESU, Snake River spring/summer ESU, and Upper Willamette River ESU of chinook salmon (*Oncorhynchus tshawytscha)*; the Hood Canal summer-run ESU of chum salmon (*Oncorhynchus keta*), the lower Columbia River ESU of coho salmon (*Oncorhynchus kisutch*), the Snake River ESU of sockeye salmon (*Oncorhynchus nerka*); the lower Columbia River DPS, middle Columbia River DPS, Snake River Basin DPS, upper Columbia River DPS, and upper Willamette River DPS of steelhead trout (*Oncorhynchus mykiss*); and the Southern DPS of green sturgeon (*Acipenser medirostris*).

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 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. The 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 seismic survey in this proposed action will collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as a NSF program priority.

The NSF and the NMFS Permits and Conservation Division have conducted similar actions in the past that were subject to ESA section 7 consultations that concluded 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. Regionally relevant examples include opinions for the following seismic surveys: Gulf of Alaska (2004), Aleutian Islands (2005), Northeast Pacific Ocean (2007), Gulf of Alaska (2008), Northeast Pacific Ocean (2008), Northeast Pacific Ocean (2009), North Pacific Ocean (2010), Northeast Pacific Ocean (2012), Western Gulf of Alaska (2019), and Northeast Pacific Ocean (2019). The proposed marine seismic survey in the Adreanof segment of the Aleutian Islands, Alaska that is the subject of this consultation is part of this on-going NSF research program.

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, the MMPA IHA application, and the notice of a proposed IHA prepared pursuant to the MMPA. Our communication with the NSF and NMFS Permits and Conservation Division regarding this consultation is summarized as follows:

- On November 13, 2019, the NSF submitted a request via email for NMFS to provide a list of ESA-listed species and designated critical habitat that may occur within the area where the seismic survey is proposed in the Alaskan Aleutian Islands, as well as suggested data sources for marine mammal and sea turtle abundance and densities in the survey area.
    - On January 6, 2020, NFMS responded to the NSF request via email.
- On March 27, 2020, NSF provided an initiation package via email that included a request for ESA section 7 consultation letter and a draft EA.
    - On April 17, 2020, NFMS requested via email a higher resolution map to assess vessel proximity to Kasatochi Island Steller sea lion rookery.
    - On April 20, 2020, we received via email the requested map of the Kasatochi Island portion of the proposed survey from NSF.
- On April 24, 2020, we provided the NSF with an ESA section 7 initiation letter via email for the proposed seismic survey in the Andreanof segment of the Aleutian Islands in Alaska, to be conducted in September and October of 2020.
- On March 27, 2020, Lamont-Doherty (L-DEO) submitted an IHA application via email to NMFS Permits and Conservation Division and shared a copy of the submission with ESA Interagency Cooperation Division.
    - L-DEO submitted a revised version of the IHA application via email, which NMFS Permits and Conservation Division deemed adequate and complete, on June 25, 2020.
- On March 31, 2020 we sent the NSF consultation initiation package via email to the NMFS Alaska Regional Office for their review.
- On July 29, 2020 we received the comments via email from the NMFS Alaska Regional Office on the NSF's draft EA.
- On July 29, 2020 we received an initiation packet via email from the NMFS Permits and Conservation Division requesting ESA section 7 consultation on the IHA for the seismic survey in the Andreanof segment of the Aleutian Islands in Alaska, September and October of 2020.

- On July 31, 2020, we provided via email the NMFS Permits and Conservation Division with an ESA section 7 initiation memo for the Aleutian Island seismic survey IHA.

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 (50 C.F.R. §402.02).

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): In this consultation, we describe the actions proposed by the NSF and NMFS Permits and Conservation Division in detail, including measures to avoid and minimize impacts to ESA-listed species and designated critical habitat.

Action Area (Section 4): We describe the proposed action and those aspects (or stressors) of the proposed action that may have effects on the physical, chemical, and biotic environment. We describe the action area with the spatial extent of the stressors from the action.

Potential Stressors (Section 5): We identify the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat.

Endangered Species Act Resources That May be Affected (Section 6): We identify the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area that may be affected by the proposed action.

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

Status of the Species Likely to be Adversely Affected (Section 8): We examine the status of ESA-listed species that may be adversely affected by the proposed action throughout the action area.

*Environmental Baseline (*Section 9): We describe the environmental baseline as the condition of ESA-listed species or its designated critical habitat in the action area, without the consequences caused by the proposed action. 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 proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impacts of State or private actions that are contemporaneous with the consultation in process. The consequences to ESA-listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

Effects of the Action (Section 10): Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. These are broken into analyses of exposure, response, and risk, as well as a programmatic analysis as described below for the species and/or critical habitat that are likely to be adversely affected by the action.

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. Similarly, we identify the critical habitat likely to be exposed and the critical habitat unit. 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. We also consider whether the action will result in impacts to the essential physical and biological features of designated critical habitat. We assess the consequences of the 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 also considers the impacts of the proposed action on the function of the physical and biological features and the conservation value of designated critical habitat.

Cumulative Effects (Section 11): 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.

Integration and Synthesis (Section 12): We begin with problem formulation that identifies and integrates the stressors of the action with the species' and critical habitat status and the environmental baseline and formulate risk hypotheses based on the anticipated exposure of listed species and critical habitat to stressors and the likely response of species and habitats to this exposure. We consider the effects of the action within the action area on populations or subpopulations and on physical and biological features when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or

- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

Conclusion (Section 13): The results of our jeopardy and damage or adverse modification analyses are summarized in this section.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (50 C.F.R. §402.14(h)(3)).

In addition, we include an *Incidental Take Statement* (Section 14) 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* (Section 15) that may be implemented by action agency (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which *Reinitiation of Consultation* (Section 17) is required (50 C.F.R. §402.16).

2.1 Evidence Available for the Consultation

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of *Google Scholar*, 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 (50 C.F.R. § 402. 02).

Two federal actions are evaluated in this opinion. The first is the NSF's proposal to fund the research vessel (R/V) *Marcus G. Langseth* (*Langseth*), an NSF-owned vessel operated by the L-DEO of Columbia University, to conduct a seismic survey in the Andreanof segment of the Aleutian Island Arc in Alaska. The second is the NMFS Permits and Conservation Division proposal to issue an IHA authorizing non-lethal "takes" from Level B harassment, pursuant to section 101 (a)(5)(D) of the MMPA, associated with the Aleutian Arc seismic survey.

The information presented here is based primarily upon information in the consultation initiation packages submitted to us by the NSF and the NMFS Permits and Conservation Division.

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

Researchers from Woods Hole Oceanographic Institute (WHOI) and L-DEO will conduct the seismic survey using the R/V *Langseth* to seismically image the basic architecture of oceanic-arc crust along and across the Andreanof segment of the Aleutian Arc in Alaska (see Figure 1). The proposed study will collect two-dimensional (2D) seismic reflection/refraction data along and across the volcanic island arc. Crust created in volcanic arcs are the building blocks for continental crust. The geological data collected can add to the understanding of geohazards, like tsunamis and earthquakes, in the Alaska region.

To collect these data, the R/V *Langseth* would tow an array of 36 airguns at a depth of 9 meters (m) 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 for return acoustic signals would consist of ocean bottom seismometers (OBSs) and a towed hydrophone streamer with a nominal length of 8 km.

Additional bottom mapping and water velocity measurements will occur using a multibeam echosounder, sub-bottom profiler, and acoustic Doppler current profiler, that will continuously operate from the R/V *Langseth* during the survey. These devices will not operate during transit to and from the survey areas, and therefore will not be emanating acoustic energy except during seismic survey operations.

The total survey line transects to be acquired is expected to be ~3224 km. During the survey, approximately one percent of the line km will be in shallow water (<100 m), 26 percent will occur in intermediate water depths (100–1000 m), and the rest (73 percent) will occur in deep water (>1000 m).

The survey is expected to consist of approximately 16 days of seismic operations, 14 days of equipment deployment/retrieval, six days of transits between seismic transects, two days of transiting to and from port, and 5 days for contingencies (e.g., weather, etc.) that might delay survey activities. The R/V *Langseth* would leave from and return to port in Dutch Harbor, Unalaska, Alaska (Amaknak Island). The transit and surveys are planned for September 2–October 19, 2020.

3.1.1 Source Vessel Specifications

The seismic survey will involve one source vessel, the U.S.-flagged R/V *Marcus G. Langseth*. No chase vessel will be used during seismic survey activities. The R/V *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 R/V *Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals.

The proposed operating speed during seismic data acquisition is approximately 8.3 km per hour (4.5 kts; 5.17 mph). When not towing seismic survey gear, the R/V *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 nm). The R/V *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).

3.1.2 Description of Airgun-Array and Acoustic Receivers

During the seismic surveys, the R/V *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.

For the majority of this 2D seismic survey (90 percent of transect line km), the R/V *Langseth* will tow a full 36 Bolt airgun array (plus 4 spares) at a depth of 9 meters (m; 29.5 feet [ft]) as an energy source with a total volume of approximately 6,600 cubic inches (in^3; 108,154.6 cubic centimeters [cm^3]). In certain locations (Figure 1), only half the array (18 airguns) would be operated, with a total discharge volume of approximately 3300 in^3.

The full airgun array will be configured as four identical linear arrays or "strings." The four airgun strings will be towed behind the R/V *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 50 m (164 ft; approximately 22 seconds) during multi-channel seismic with the hydrophone streamer and 278 m (912 ft; approximately 120 seconds) during refraction surveying to OBSs.

Table 1. Source array specifications for the proposed survey.

Source array specifications		
Energy source	36-airgun array	18-airgun array
Source output (downward, referenced at 1 meter)	Zero to peak = 259 dB re 1 µPa-m Peak to peak = 265 dB re 1 µPa-m	Zero to peak = 252 dB re 1 µPa-m Peak to peak = 259 dB re 1 µPa-m
Air discharge volume	approximately 6,600 in^3	approximately 3,300 in^3
Dominant frequency components	2 to 188 Hz	2 to 188 Hz
Tow depth	9 m	9 m

The receiving system for return acoustic signals consists of OBSs and a towed hydrophone streamer with a nominal length of 8 km. As the airgun arrays are towed along the survey lines, the seismometers would receive and store the returning acoustic signals internally for later analysis, and the hydrophone streamer would transfer the data to the on-board processing system. A total of 50 OBSs (approximately 90 cm height and maximum diameter of 97 cm) would be deployed with minimal disturbance to the seafloor and subsequently retrieved by R/V *Langseth* prior to MCS surveying.

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

A multibeam echosounder (MBES), sub-bottom profiler (SBP), and acoustic Doppler current profiler (ADCP) will continuously operate from the R/V *Langseth* during the seismic survey, but not during transit to and from the survey areas. The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP will map the ocean floor during the seismic survey. The Teledyne RDI 75 kiloHz (kHz) Ocean Surveyor ADCP will measure water current velocities.

The MBES 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). The MBES emits "pings" with a maximum sound source level of 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 two 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.

The ocean floor will also be mapped with the Knudsen 3260 SBP. The SBP is normally operated to provide information about the near seafloor sedimentary features and the bottom topography that is mapped simultaneously by the MBES. 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 SBP is capable of reaching depths of 10,000 m (3,2808 ft).

The Teledyne RDI 75 kHz Ocean Surveyor ACDP will be mounted on the hull of the *Langseth* to measure the speed of the water currents. The ACDP 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.

3.1.3 Mitigation, Monitoring and Reporting

The NSF is obligated to enact mitigation measures to ensure their action results in the least practicable adverse impact on marine mammal species or stocks and to reduce the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Mitigation is a measure that avoids or reduces the severity of the effects of the action on ESA resources. 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 to ESA-listed species and designated critical habitat are successful.

NMFS Permits and Conservation Division will require mitigation and monitoring measures that the NSF will implement as part of their IHA authorization under the MMPA. These mitigation and monitoring measures are required during the seismic survey to reduce potential for injury or harassment to marine species protected under the ESA and MMPA. The following mitigation and monitoring measures are described further below:

- Proposed exclusion and buffer zones;
- Visual monitoring by NMFS-approved protected species observers;
- Passive acoustic monitoring;
- Shutdown procedures;
- Ramp-up procedures;
- Vessel strike avoidance measures; and
- Additional mitigation measures considered.

Additional details for mitigation and monitoring measures can be found in Appendix A; NMFS Permits and Conservation Division proposed incidental harassment authorization.

3.1.3.1 Proposed Exclusion and Buffer Zones

The NMFS Permits and Conservation Division will require the NSF and L-DEO to implement exclusion zones around the R/V *Langseth* to minimize potential adverse effects of the sound from the airgun array on MMPA and ESA-listed species. 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). In the case of the proposed action, the exclusion zones are areas within which occurrence of a marine mammal triggers a shutdown of the airgun array, to reduce exposure of marine mammals to sound levels expected to have adverse effects on the species or their designated critical habitat.

The NSF noted in its draft EA that the L-DEO will implement mitigation zones around the R/V *Langseth* to minimize any potential adverse effects of airgun array sound on MMPA and ESA-listed species. The NSF and L-DEO applied acoustic thresholds to determine whether ESA-listed marine mammals would be exposed to the airgun array during seismic survey activities and 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)). In their IHA application, L-DEO proposed to establish exclusion zones based upon modeled radial distances to auditory injury zones. Potential radial distances to auditory injury zones were calculated on the basis of maximum peak pressure.

The mitigation zones were developed using MMPA Level A and Level B (160 dB re 1µPa_{rms}) thresholds, based upon predicted received sound levels in relation to distance and direction from the half (18) and full (36) airgun array, using modeling by L-DEO for deep water (>1000 m) and empirical measurements from Crone et al. (2014) for intermediate (100–1000 m) and shallow water depths (<100 m). Although Level A and Level B harassment are not used under the ESA, these mitigation zones do provide protections for ESA-listed species of marine mammals in particular.

The NMFS Permits and Conservation Division proposed an alternative 500-m exclusion zone rather than the exclusion zone proposed by NSF. The 500-m (1,640.4-ft) radial exclusion zone encompasses the entire area where sound from the survey could permanently injure marine mammals. The 500-m zone also provides a consistent, reasonably observable zone within which protected species observers (PSOs) will typically be able to conduct effective observations. Although significantly greater distances may be observed from an elevated platform, NMFS believes that 500-m is a reasonable visual monitoring zone for PSOs 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.

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 shutdown, depending on the circumstance. The PSOs will also establish and monitor a 1,000-m (3,280.8-ft) buffer zone. The buffer zone is an area beyond the exclusion zone to be monitored for the presence of marine mammals that may enter the exclusion 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 shutdown of the airgun array. During pre-clearance monitoring , the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals within the buffer zone would also prevent airgun operations from beginning (i.e., ramp-up). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 m exclusion zone, out to a radius of 1,000 m from the edges of the airgun array (500–1,000 m).

Sea turtles are not expected to be in the action area, but if by some chance a sea turtle was encountered during the proposed seismic survey, an exclusion zone of 100 m would be used as a shutdown distance for sea turtles.

3.1.3.2 Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained visual PSOs to scan the ocean surface for the presence of protected species. The area to be scanned visually includes the exclusion zone, within which observation of certain protected species requires shutdown of the acoustic source, and a buffer zone. Visual monitoring of the exclusion zone and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of protected species to reduce or eliminate the potential for acoustic injury and minimize the potential for more severe behavioral reactions in animals close to the vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-clearance, and (2) during airgun use, aid in establishing and maintaining the exclusion zone by alerting the visual observer and crew of marine mammals that are outside of, but may approach and enter, the exclusion zone.

L-DEO must use dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval.

At least one of the visual and two of the acoustic PSOs (acoustic monitoring discussed below) aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience shall be designated as the lead for the entire protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator and ensure all PSO requirements are met. To the maximum extent practicable, the experienced PSOs should be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

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). Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

Visual PSOs will immediately communicate all observations to the on duty acoustic PSO(s), including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination. Any observations of marine mammals by crew members shall be relayed to the PSO team. During good conditions (e.g., daylight hours; Beaufort sea state[1] (BSS) 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

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.

3.1.3.3 Passive Acoustic Monitoring

Acoustic monitoring means the use of trained personnel (sometimes referred to as passive acoustic monitoring (PAM) operators, herein referred to as acoustic PSOs) to operate PAM equipment to acoustically detect the presence of marine mammals. PAM would take place in addition to the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. PAM would be monitored in real time so that the visual observers can be advised when cetaceans are detected.

The R/V *Langseth* will use a towed PAM system, which must be monitored by at least one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source. 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 (acoustic and visual but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

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

[1] BSS scale from 0-12 to standardize weather conditions, with 0 being no wind and calm seas, and 12 being hurricane-force winds with 45+ ft seas.

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:

- Sea state is less than or equal to BSS 4;
- No marine mammals (excluding delphinids) detected solely by PAM in the applicable exclusion zone in the previous two hours;
- 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
- 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.

3.1.3.4 Shutdown Procedures

The shutdown of an airgun array requires the immediate de-activation of all individual airgun elements of the array. Any PSO on duty will have the authority to delay the start of survey operations or to call for shutdown of the acoustic source if a protected species is detected within the applicable exclusion zone. The operator must also establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch. When both visual and acoustic PSOs are on duty, all detections will be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs. When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a protected species appears within or enters the applicable exclusion zone and/or (2) a marine mammal (other than delphinids, see below) is detected acoustically and localized within the applicable exclusion zone, the acoustic source will be shut down. When shutdown is called for by a PSO, the acoustic source will be immediately deactivated. Additionally, shutdown will occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) in the exclusion zone. If the acoustic PSO cannot confirm presence within the exclusion zone, visual PSOs will be notified but shutdown is not required.

Upon implementation of shutdown, the source may be reactivated after the protected species 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 of 15 minutes for small odontocetes and pinnipeds, and 30 minutes for all other species.

The shutdown requirement can be waived for small dolphins if an individual is visually detected within the exclusion zone. As defined here, the small dolphin group is intended to encompass those members of the Family Delphinidae most likely to voluntarily approach the source vessel for purposes of interacting with the vessel and/or airgun array (e.g., bow riding). This exception to the shutdown requirement applies solely to specific genera of small dolphins (*Lagenorhynchus* and *Lissodelphis*). Shutdown requirements for small dolphins under all circumstances represent practicability concerns without likely commensurate benefits for the animals in question. Small dolphins are generally the most commonly observed marine mammals in the specific geographic region and would typically be the only marine mammals likely to intentionally approach the vessel. Visual PSOs shall 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 or one of the species with a larger exclusion zone).

L-DEO must implement shutdown if a marine mammal species for which incidental take was not authorized under the MMPA IHA or in the ITS of this opinion, or a species for which authorization was granted under the MMPA IHA but the takes have been met, approaches the MMPA Level A or Level B harassment zones. L-DEO must also implement shutdown if any of the following are **observed at any distance**:

- Any large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult;
- An aggregation of six or more large whales; and/or
- A North Pacific right whale.

More details on shutdown procedures can be found in Section 18.1 (Appendix A – NMFS Permits and Conservation Division's proposed IHA).

3.1.3.5 Pre-Clearance and Ramp-Up Procedures

Ramp-up (sometimes referred to as a "soft start") means the gradual and systematic (step-wise) increase in emitted sound levels from an airgun array. The intent of ramp-up is to warn protected species of pending seismic operations and to allow sufficient time for those animals to leave the immediate vicinity. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an array's airguns are active and the full volume is achieved. Each stage should be approximately the same duration, and the total duration should not be less than approximately 20 minutes.

The intent of pre-clearance observation (30 minutes), which is done prior to the beginning of ramp-up, is to ensure no protected species are observed within the buffer zone. During pre-clearance is the only time observations of protected species in the buffer zone would prevent operations (i.e., the beginning of ramp-up).

All operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);

- Ramp-ups shall be scheduled so as to minimize the time spent with the source activated prior to reaching the designated run-in;

- One of the PSOs conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed;

- Ramp-up may not be initiated if any marine mammal is within the applicable exclusion or buffer zone. If a protected species is observed within the applicable 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 zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for all other species);

- Ramp-up shall begin by activating a single airgun of the smallest volume in the array and shall 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 shall not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed;

- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon detection of a protected species within the applicable exclusion zone. Once ramp-up has begun, detections of protected species within the buffer zone do not require shutdown, but such observation shall be communicated to the operator to prepare for the potential shutdown;

- 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. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;

- If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (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 minutes is not required; and

- 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 observations for 30 minutes.

More details on pre-clearance and ramp-up procedures can be found in Section 18.1 (Appendix A – NMFS Permits and Conservation Division's proposed incidental harassment authorization).

3.1.3.6 Vessel Strike Avoidance Measures

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine protected species. NMFS Permits and Conservation Division notes that these requirements do not apply in any case where compliance will create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. The vessel strike avoidance measures include the following:

1. Vessel operators and crews must maintain a vigilant watch for all protected species and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any protected species. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish protected species from other phenomena, and 2) be able to broadly identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

2. Vessel speeds must also be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

3. All vessels must maintain a minimum separation distance of 500-m from right whales. If a whale is observed but cannot be confirmed as a species other than a right whale, the vessel operator must assume that it is a right whale and take appropriate action.

4. All vessels must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

5. All vessels must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50-m from all other protected species, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

6. When protected species are sighted while a vessel is underway, the vessel shall take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal’s course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If protected species 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 does not apply to any vessel towing gear or any vessel that is navigationally constrained.

7. These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

3.1.3.7 Additional Mitigation

The survey area contains critical habitat for the Western DPS Steller sea lions and some survey track lines traverse through portions of designated aquatic zones that extend 20 nm (37 km) seaward of each major rookery and major haulout in Alaska that is situated west of longitude 144° West. Steller sea lion critical habitat also includes a “no approach” zone within 3 nm (5.5 km) of listed rookeries (50 CFR 223.202). There are strong regional differences in counts of Steller sea lions across the range of the western stock in Alaska, with positive trends in the Gulf of Alaska and eastern Bering Sea east of Samalga Pass (approximately 170°W) and generally negative trends to the west in the Aleutian Islands (Sweeney et al. 2017). The Steller sea lion Recovery Team recommended that waters extending 3,000 ft (0.9 km) from rookeries and major haulouts throughout the range of Steller sea lions be considered essential habitat that merits special management consideration (50 C.F.R. 226).

Due to the importance of the action area for Western DPS Steller sea lion designated critical habitat, the NSF has incorporated the following measures in survey requirements:

- The seismic survey vessel will not travel within 3 nm (5.5 km) of Steller sea lion listed rookeries.
- Seismic survey operations will maintain a distance such that the modeled MMPA Level B harassment zone would not infringe on the waters extending 3,000 feet (0.9 km) from Steller sea lion rookeries and major haulouts.

3.2 National Marine Fisheries Service’s Proposed Activities

On March 27, 2020, NMFS Permits and Conservation Division received a request from the L-DEO (operators of the R/V *Langseth* for NSF) for an IHA to take marine mammals incidental to conducting a marine seismic survey in the Andreanof segment of the Aleutian Islands in Alaska. The L-DEO submitted a revised version of the application, which NMFS Permits and Conservation Division deemed adequate and complete, on June 25, 2020.

The NSF, L-DEO and the NMFS Permits and Conservation Division do not expect mortality to result from the proposed activities; therefore, the NMFS Permits and Conservation Division is proposing the issuance of an IHA authorizing non-lethal “takes” of marine mammals incidental to the planned seismic survey under the MMPA. The MMPA IHA will authorize the incidental harassment of the following ESA-listed marine mammal species: blue whales, fin whales, Western North Pacific DPS gray whale, Mexico DPS and Western North Pacific DPS humpback whales, North Pacific right whales, sei whales, sperm whales, and Western DPS 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 MMPA authorization that are likely to be protective of ESA-listed species. These requirements are described above and contained in Appendix A.

On July 28, 2020, NMFS Permits and Conservation Division published a notice of proposed IHA (Appendix A) and request for comments in the Federal Register (85 FR 45389). The public comment period closed on August 27, 2020.

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 approximately 49–53.5°N and approximately 172.5–179.5°W in the U.S. Exclusive Economic Zone of Alaska in water depths ranging from approximately 35 to 7,100 m (114.8 to 23,293.9 ft). Representative survey tracklines are shown in Figure 1. Deviations in actual track lines could be necessary for reasons such as 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, track lines may shift from those shown in Figure 1 and could occur anywhere within the coordinates noted above.

The study consists of one east-west transect (approximately 531 km long), and two north-south transects (approximately 420 km and 280 km long) that will be surveyed using OBSs first (locations in Figure 1) and then again a second time using MCS. There connecting transects (approximately 479 km long) and a survey of the Amlia Fracture Zone (approximately 283 km long) that will only be acquire data once using MCS. The total survey line distance to be acquired will be approximately 3,224 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 their analysis of potential effects of the proposed action, the NSF added an additional 25 percent of effort to the proposed line km to be surveyed to compensate for any of these contingencies.

R/V *Langseth* would leave from and return to port in Dutch Harbor, Alaska. Therefore, the action area includes the survey areas, as well as transit routes to/from Dutch Harbor and between transect lines.

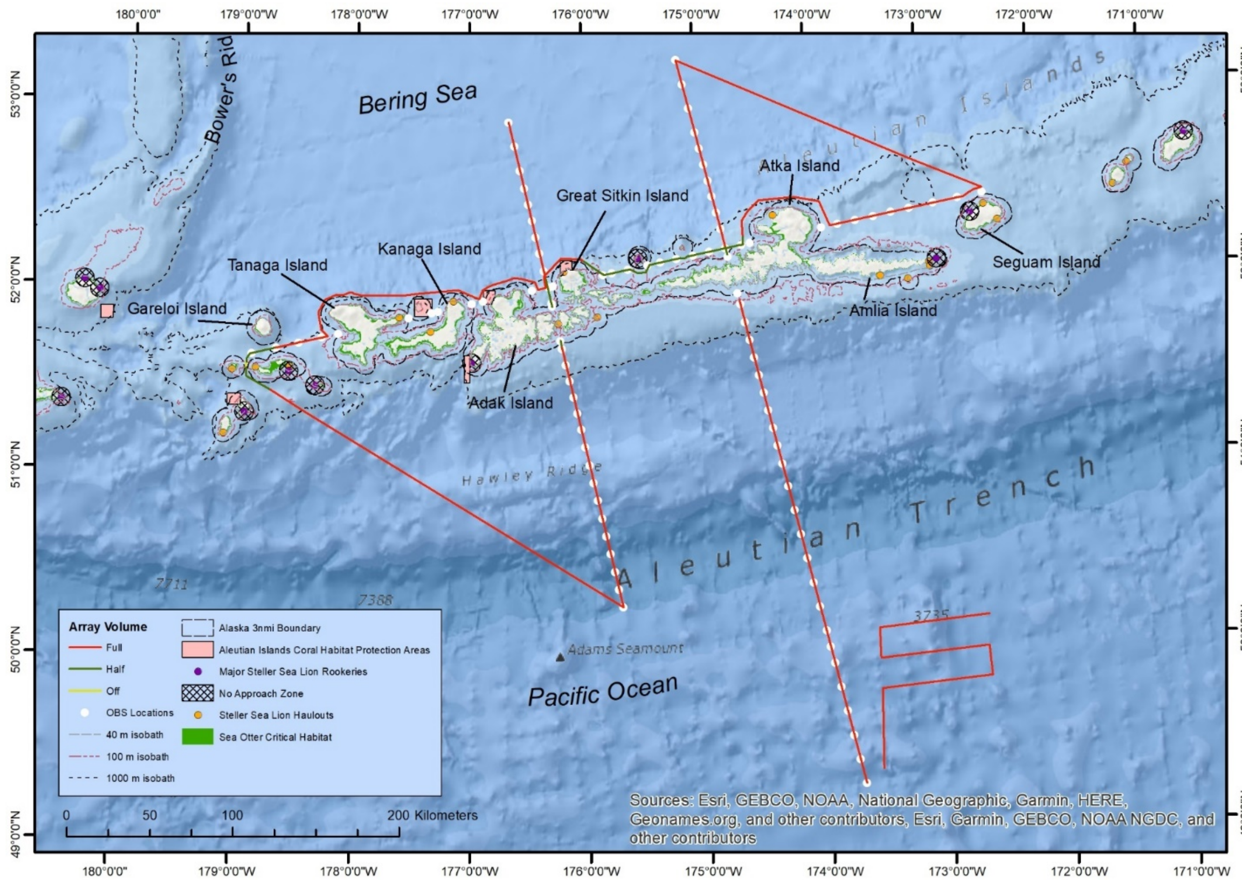

Figure 1. Map of the National Science Foundation's proposed seismic survey in the Andreanof segment of the Aleutian arc, Alaska.

5 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 (research vessel, MBES, SBP, ADCP, and seismic airgun array), and entanglement in towed seismic equipment. These stressors and their potential effects to ESA-listed species and designated critical habitat are introduced in the subsections that follow. Detailed information on the effects of these potential stressors can be found in our effects analysis in Section 9. The proposed action includes several conservation (monitoring and mitigation) measures described in Section 3.1.3 that are designed to minimize effects that may result from some of 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.

5.1 Pollution

The operation of the R/V *Langeth* as a result of the proposed action may result in pollution from fuel, oil, trash, and other debris.

5.1.1 Marine Debris

The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can have adverse effects on marine species most commonly through entanglement or ingestion (Gall and 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 and Thompson 2015). The NSF proposes to include guidance on the handling and disposal of marine trash and debris in during the seismic survey to reduce the amount of this type of pollution.

5.1.2 Pollution by Oil or Fuel Leakage

Research vessels used in NSF-funded seismic surveys have spill-prevention plans, which allow a rapid response to a spill in the event one occurs. In the event that a leak should occur, the amount of fuel and oil onboard the R/V *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.

5.2 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 and Murphy 2010; Laist et al. 2001; NMFS and USFWS 2008; Work et al. 2010). 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 protected species. 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 and Silber 2013; Hazel et al. 2007; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007). The R/V *Langseth* has a length of 72 m (235 ft) and the proposed operating speed during seismic data acquisition is approximately 8.3 km per hour (4.5 kts). When not towing seismic survey gear, the R/V *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 and Silber 2013; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007).

Several conservation measures proposed by the NMFS Permits and Conservation Division and/or NSF would minimize the risk of vessel strike (e.g., use of protected species observers, vessel strike avoidance measures, see Section 3.1.3). The R/V *Langseth* will be traveling at generally slow speeds, reducing the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). 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. 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 R/V *Langseth* has traveled hundreds of thousands of kilometers without a vessel strike (Hauser and Holst 2009; Holst 2010; Holst and Smultea 2008).

5.3 Acoustic Noise, Vessel Noise, and Visual Disturbance

The proposed action would produce a variety of sounds, including those associated with vessel operations, and the use of an MBES, ADCP, SBP, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. The presence of the survey vessel and the survey gear can also produce a visual disturbance that may affect ESA-listed marine species.

The visual or auditory disturbances associated with the proposed action could disrupt behavior of ESA-listed species that spend time near the surface. Studies have shown that vessel operation can result in changes in the behavior of marine mammals and sea turtles (Hazel et al. 2007; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009; Patenaude et al. 2002; Richter et al. 2003; Smultea et al. 2008). 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 and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002b; Félix 2001; Goodwin and 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). Animals may not even differentiate between visual and acoustic disturbances created by vessels at close distances and may simply respond to the combined disturbance. In cases 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 and Jaakson 1994a; Evans et al. 1992; Evans et al. 1994). Several authors suggest that the noise generated during motion is probably an important factor (Blane and 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.

We expect the R/V *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, but the contribution from these noise sources are likely to be relatively small in the overall regional sound field. 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).

Unlike vessels, which produce sound as a byproduct of their operations, survey equipment such as MBES, ADCP, SBP, and seismic airgun arrays are designed to actively produce deliberate and controlled sound. Depending on the circumstances, exposure to these anthropogenic sound sources may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses. The potential effects to ESA-listed species within the action area due to sounds fields produced by the proposed seismic survey equipment are evaluated in Section 9.

5.4 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 is a global problem that every year results in the death of hundreds of thousands of animals worldwide, particularly due to entanglement in fishing gear, or bycatch. 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.

The towed hydrophone streamer is rigid and as such should not encircle, wrap around, or in any other way entangle any of the large whales considered during this consultation. Furthermore, mysticetes (baleen whales) and possibly sperm whales are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. We have not found records of instances of entanglement events with ESA-listed marine mammals during seismic surveys.

6 ENDANGERED SPECIES ACT RESOURCES THAT MAY BE AFFECTED

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area that may be affected by the proposed action (Table 2). This section first identifies the species and designated critical habitat that may be affected, but are not likely to be adversely affected by the proposed action. The remaining species deemed likely to be adversely affected by the proposed action in the action area considered in this opinion are carried forward through the remainder of this opinion.

Table 2. Endangered Species Act-listed threatened and endangered species and critical habitat potentially occurring in the action area that may be affected

Species	ESA Status	Critical Habitat	Recovery Plan
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)
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
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, ESU=Evolutionary Significant Unit, DPS=Distinct Population Segment

6.1 Species Likely To Be Adversely Affected

This opinion considers blue, fin, Western North Pacific gray, humpback (Mexico and Western North Pacific DPSs), North Pacific right, sei and sperm whales, and Western DPS Steller sea lions as species likely to be adversely affected by the proposed actions.

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

NMFS uses two criteria to identify the ESA-listed species or critical habitat that are not likely to be adversely affected by the 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 co-occurs with a potential stressor but is not likely respond to the stressor is also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-listed species in Table 2 and we summarize our results below.

The probability of an effect on a species or designated critical habitat is a function of exposure intensity and susceptibility of a species or habitat to a stressor's effects (i.e., probability of response). An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly beneficial, insignificant, or extremely unlikely to occur. Beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. Insignificant effects relate to the size or severity of the impact and include 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. For effects that are extremely unlikely to occur, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did affect a listed species or habitat), but the probability of this effect occurring is extremely low.

7.1 Endangered Species Act-Listed Sea Turtles

7.1.1 Green Turtle, Loggerhead Turtle, and Olive Ridley Turtle

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 warmest waters around the Aleutian Islands are the near shore coastal surface waters in the summer season and, for Adak Island in the proposed action area, the average temperature is approximately degrees 7.8° Celsius (°C) (46 Fahrenheit [°F]) during August and September.[2] 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 and 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 and Lutz 2003). At 10°C (50°F) loggerhead sea turtles were lethargic and "floated" (Milton and Lutz 2003). Likely for these reasons, sea turtles from the Cheloniidae family have rarely been documented in Alaska; only nine green sea turtle occurrences, two olive ridley occurrences, and two loggerheads were documented between 1960 and 2006 (DON 2006; Hodge and Wing 2000). Most of these sightings involved individuals that were either cold-stressed, likely to become cold-stressed, or already deceased (Hodge and Wing 2000; McAlpine et al. 2002).

The NSF area of operations is considered to be outside the normal range for sea turtle species of the Cheloniidae family. Chelonid sea turtles are not expected to co-occur with NSF activities in the Aleutian Islands. Thus, it is highly unlikely that Chelonid sea turtles will be exposed to the stressors from the proposed action; therefore, the proposed action may affect, but is not likely to adversely affect green, olive ridley, and loggerhead sea turtles. As a result, these species will not be carried forward in this opinion.

7.1.2 Leatherback Sea Turtle

Documented encounters of leatherback sea turtles in the north Pacific include the Aleutian Islands (NMFS and USFWS 1998), although reports of leatherbacks in Alaskan waters are very rare. Only 19 leatherbacks have been reported in Alaska between 1960 and 2007.[3] Leatherback sea turtles are scrarce in the region of the action area and are not expected to co-occur with NSF activities that take place over a limited amount of time, therefore 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.

7.2 Endangered Species Act-Listed Fishes

7.2.1 Criteria and Thresholds to Predict Impacts to Fishes

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 *American National Standards Institute (ANSI) Guidelines* (Popper et al. 2014). Where applicable, the NMFS

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[2] NOAA National Centers For Environmental Information, https://www.nodc.noaa.gov/dsdt//cwtg/alaska.html accessed on 7/20/20.
[3] Alaska Dept of Fish and Game. http://www.adfg.alaska.gov/index.cfm?adfg=leatherbackseaturtle.main#:~:text=19%20leatherbacks%20have%20been%20reported,time%20in%20the%20open%20ocean. Accessed on 7/20/20.

developed or uses other thresholds considered the most appropriate given our current understanding of anthropogenic sound effects on fishes and the best available science.

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 of fishes to regenerate inner ear hair cells, which is different from other marine animals. Temporary threshold shift (TTS) in fishes is considered recoverable and the rate of recovery is based upon the degree of the TTS sustained. Auditory thresholds for fish hearing impairment only include the potential onset of TTS for fishes because of their ability to recover from auditory damage and impairment over some duration.

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).

Some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities and the influence of a swim bladder. None of the ESA-listed fishes that may occur in the action area have a swim bladder associated with hearing.

Categories and descriptions of hearing sensitivities for this consultation are defined (modified from Popper et al., 2014c) as the following[4]:

- 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[5]. Criteria and thresholds to estimate TTS in fishes exposed to sound produced by airguns are >186 SEL_{cum}[6]. Exposure to sound produced from airguns at a

[4] 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 that are not involved in hearing.

[5] 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.

[6] 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

cumulative sound exposure level of 186 dB (re 1 μPa^2-s) has resulted in TTS in fishes (Popper et al. 2005)[7]. For potential behavioral responses of fishes (i.e. sub-injury) from exposure to anthropogenic sounds, there are no formal criteria yet established, as discussed further below.

In a study conducted by 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. Alarm responses, as well as tightly grouped swimming or fast swimming speeds, were observed in fishes exposed to air gun sounds between 147-151 dB rms (Fewtrell and McCauley 2012).

The available research on fish behavioral response to sound does not include recommendations for a non-injury threshold. Most of the available data on behavioral responses to anthropogenic sound for fishes have been obtained through controlled laboratory studies. Some behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not exhibit normal behavioral responses, which makes it difficult to extrapolate caged fish behavior to unconfined wild fishes (Hawkins et al. 2014; Popper and Hawkins 2014). Some of the information regarding fish behavioral response 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.

Behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild, but we still must consider potential behavioral responses as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until the 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. This criterion applies for ESA-listed fishes 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 success, impaired predatory avoidance, leaving protective cover, release of stress hormones affecting growth rates, poor reproductive success rates and disrupted migration.

considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

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

A description of fish hearing according to their species' groups and sensitivity to sound is provided in the sections that follow.

7.2.2 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 signaling, including high and low frequency drumming sounds likely produced by the swim bladder (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). Hearing is not thought to play a role in salmonid migration (e.g., (Putnam et al. 2013).

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 may elicit minor behavioral responses. 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. The most likely responses to the airgun array and MBES, SBP, and ADCP, 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. It is possible that some individual ESA-listed salmonid fish may experience a TTS that 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), as a result of NSF's seismic stressors. Any temporary instances of TTS experienced by ESA-listed salmonid species would not be expected to kill or injure any fish, and unlikely to annoy a fish to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering, especially when considering they are able to rely on alternative mechanisms for these essential life functions.

The ESA-listed salmonid DPSs and ESUs considered in this opinion originate from estuarine systems in the lower continental U.S. (i.e.; Washington, Oregon and California), which are a significant distance away from the proposed survey area in the Aleutian Islands. It is not well-understood where these salmonids go when they head out into the Pacific Ocean (Meyers 1998). Alaska has many of its own salmon populations that are not ESA-listed and are considerably closer to the action area. It is possible that salmonids in the action area could be from ESA-listed populations, although it is more likely they will originate from more proximate sources that are not ESA-listed.

Based on the evidence available, stressors resulting from the NSF's acoustic survey in the Aleutian Islands, may affect, but is not likely to adversely affect ESA-listed salmonid species. As a result, the discussion of ESA-listed salmonids is not carried forward in this opinion.

7.2.3 Green Sturgeon – Southern Distinct Population Segment

There are reports of green sturgeon (*Acipenser medirostris*) occurring in Alaska, including one individual in the Bering Sea in 2006 (Colway and Stevenson 2007), but sightings are extremely rare.

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 swim bladders, 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 and Popper 2002). Lovell et al. (2005) also studied 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, including the Southern DPS in the action area.

Based on the above review, it is possible that the proposed seismic survey activities could be audible to ESA-listed green sturgeon. The expected response of ESA-listed sturgeon to low-frequency acoustic energy is not well 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 MBES, SBP, ACDP), 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. The most likely response of ESA-listed green sturgeon exposed to the airgun array and MBES, SBP, and ADCP, 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.

In summary, we conclude that the proposed action is not likely to adversely affect the southern DPS of ESA-listed green sturgeon because their occurrence in the action area is extremely rare and if any effects occurred, they would insignificant. As a result, discussion of the green sturgeon are not carried forward in this opinion.

7.3 Designated Critical Habitat Not Likely to be Adversely Affected

The proposed action will take place within the Andreanof portion of the Aleutian Islands, within the area of approximately 49–53.5°N, by approximately 172.5–179°W, within the EEZ of Alaska in water depths ranging from approximately 35 to 7100 m. This action area includes designated critical habitat for the Western Distinct Population Segment of Steller sea lions (58 FR 45269).

7.3.1 Steller Sea Lion – Western Distinct Population Segment

In 1997, NMFS designated critical habitat for the Steller sea lion (58 FR 45269). The designated critical habitat includes specific rookeries, haulouts, 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 2).

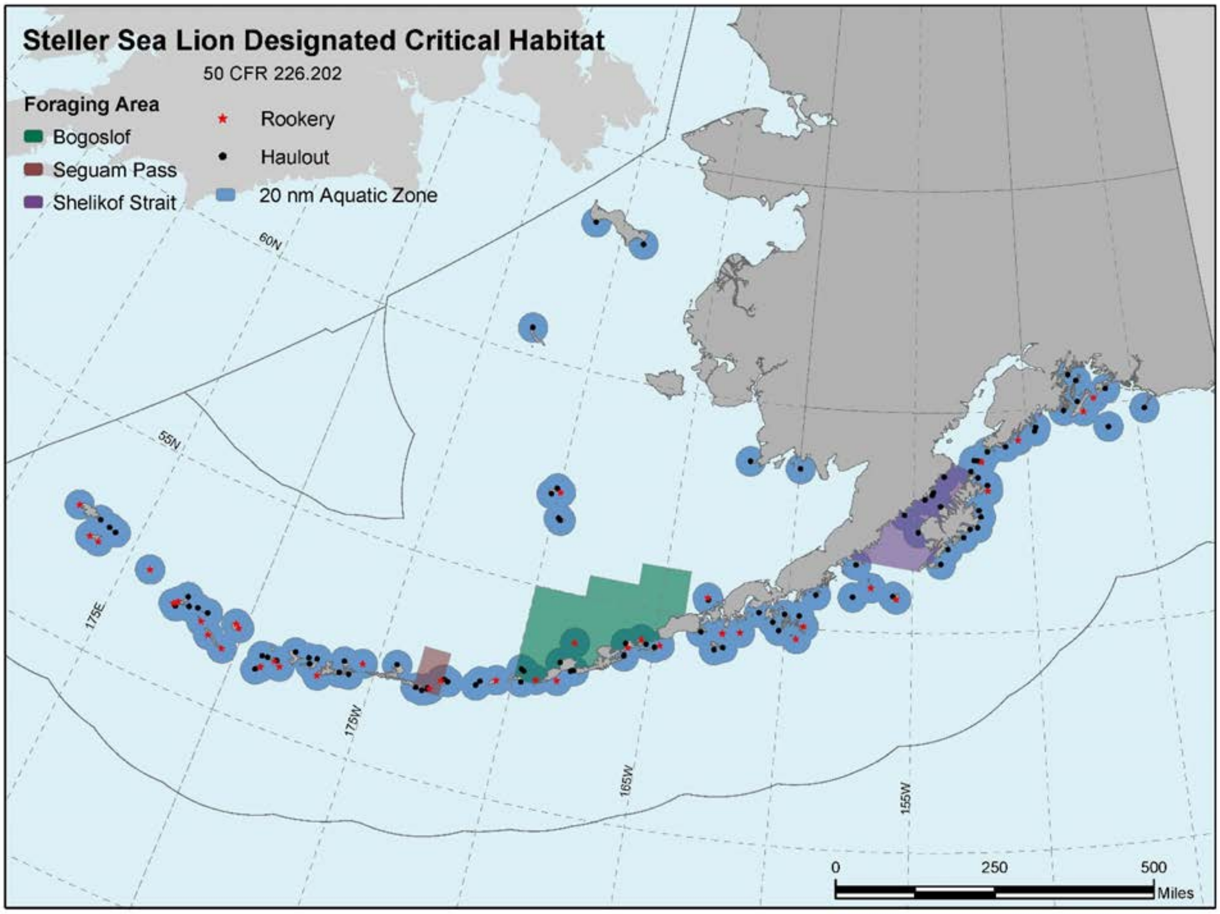

Figure 2. Map depicting designated critical habitat in Alaska for the Western distinct population segment Steller sea lion.

Designated critical habitat in Alaska includes terrestrial, air, and aquatic zones associated with the major Steller sea lion rookeries and major haulouts. The terrestrial zone extends 3,000 feet (0.9 km) landward from each major rookery and major haulout, it also includes an air zone that extends 3,000 ft (0.9 km) above these terrestrial zones. Critical habitat includes an aquatic zone that extends 3,000 ft (0.9 km) seaward from the major rookeries and major haul-outs east of 144° West. To the west of that longitude, critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward of each major rookery and major haulout in Alaska. Steller sea lion critical habitat also includes a "no approach" zone within 3 nm (5.5 km) of listed rookeries (50 CFR 223.202).

Critical habitat for the Steller sea lion includes three special aquatic foraging areas in Alaska. Two of them are in the Aleutians, Bogoslof Island and Seaguam Pass, and Shelikof Strait is in the Gulf of Alaska. These important foraging areas are located near Steller sea lion abundance centers and concentrations of prey, which also attracts commercial fisheries.

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).

7.3.2 Effects to Designated Critical Habitat

The proposed seismic activities overlap with portions of the aquatic zones of the designated critical habitat for the Western DPS Steller sea lion. Very few effects to this habitat are expected for the reasons detailed below.

The proposed seismic activities will not significantly alter the prey available given the short duration of the seismic survey within the aquatic zone of critical habitat. If prey fish avoid the active survey operation area due to aversions from the sound source, it is expected to be temporary with no long term significant effects.

The majority of the survey will be conducted in deep water (73% >1000 m depth) and not in close proximity to rookeries and haulouts. A portion of the survey will approach these important terrestrial habitats and their associated aquatic zones, mostly on the north side of the islands. The total amount of time the seismic survey would occur near Steller sea lion critical habitat is limited (approximately five days total to survey the entire east-west trackline twice), and the vessel would be continuously moving during the entire survey.

There will be two important requirements that serve to minimize potential effects from the proposed seismic survey to Steller sea lion critical habitat physical and biological features. First, the survey vessel must stay outside the 3 nm (5.5 km) “no approach” zone of designated critical habitat. Second, the estimated radial distance for the Level B (160 dB re 1µPa_{rms}) MMPA harassment threshold will stay at least 3,000 ft (0.9 km) away from the listed rookeries and major haulouts. The Steller sea lion Recovery Team recommended that waters extending 3,000 ft (0.9 km) from rookeries and major haulouts throughout the range of Steller sea lions be considered essential habitat that merits special management consideration (CFR 50-226). Having this aquatic buffer will help maintain habitat quality and provide a refuge from the survey stressors.

When considering the mitigation measures NSF has agreed to follow and the limited of the potential exposure, we conclude that any disturbance to Steller sea lion designated critical habitat physical and biological features would be insignificant. In conclusion, the proposed seismic activities may affect, but are not likely to adversely affect any of the physical and biological features of the Western DPS Steller sea lion designated critical habitat.

8 Status of Species Likely to be Adversely Affected

The evaluation of adverse effects in this opinion begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers, or distribution" that 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 the NMFS Web site: https://www.fisheries.noaa.gov/species-directory/threatened-endangered.

This section examines the status of blue, fin, gray, humpback (Mexico and Western North Pacific DPSs), North Pacific right, sei and sperm whales.

8.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 3).

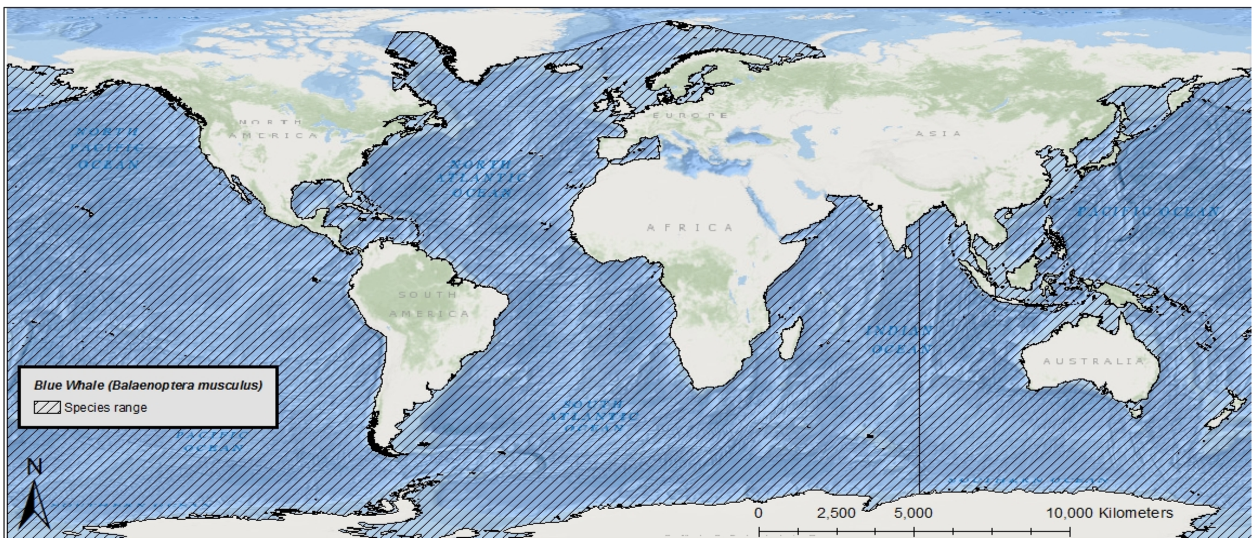

Figure 3. Map identifying the range of the endangered blue whale.

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.

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta 2019a; Carretta 2019b), and recent scientific publications were used to summarize the life history, population dynamics, and status of the species as follows.

8.1.1 Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 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).

8.1.2 Population Dynamics

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}[8]=1,551;), Central North Pacific Ocean (N=133, N_{min}=63), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440)(Waring et al. 2010{Carretta, 2019 #87).

Due to the location of the action, the Eastern North Pacific stock of blue whales is most likely to be in the action area.

Current estimates indicate a growth rate of just under three percent per year for the Eastern North Pacific stock (Calambokidis 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time.

Little genetic data exist on blue whales globally. Data from Australia indicates a recent population genetic bottleneck in that region, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Data from Antarctica also demonstrate a 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

[8] N_{min}= Minimum population abundance.

'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. Data from satellite telemetry research indicate that blue whales in U.S. West Coast waters spend about five months outside the U.S. EEZ, from November to March (Hazen et al. 2017). 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.

8.1.3 Vocalization and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson and Richardson 1995), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten 1998; Mcdonald et al. 2001; McDonald et al. 1995; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls.

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 sweep down in frequency (20 to 80 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 µPa at 1 meter (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971; Ketten 1998; Mcdonald et al. 2001; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, 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). 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. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 m [98.4 ft] whales), while deeper diving whales (greater than 50 m [154 ft]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Mcdonald et al. 2001; Mellinger and 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 and Clark 2003; Samaran et al. 2010). 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 and Moore 2005). In Southern California, blue whales produce three known call types:

Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006) 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. D calls are produced in highest numbers during the late spring and early summer and in diminished numbers during the fall, when A-B songs dominate blue whale calling (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and 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 and Clark 2003; Payne and McVay 1971). Songs can be detected for hundreds, and even thousands of km (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 recordings from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island, California. 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. 2006). McDonald et al. (2009) observed a 31 percent 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.

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; Oleson et al. 2007b; Payne and Webb. 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while whales are 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 and Webb. 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Ketten 1997b; Richardson et al. 1995b). 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 and 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 (NOAA 2018).

8.1.4 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 killed 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, and 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.

8.1.5 Critical Habitat

No critical habitat has been designated for the blue whale.

8.1.6 Recovery Goals

In response to the current threats facing the species, which are discussed in further detail in the *Environmental Baseline* section (Section xx) of this opinion for those occurring in the action area, NMFS developed goals to recover blue whale populations. See the 1998 Final Recovery Plan for the blue whale (citation) for complete down listing/delisting criteria for each of the following recovery goals:

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

8.2 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 4).

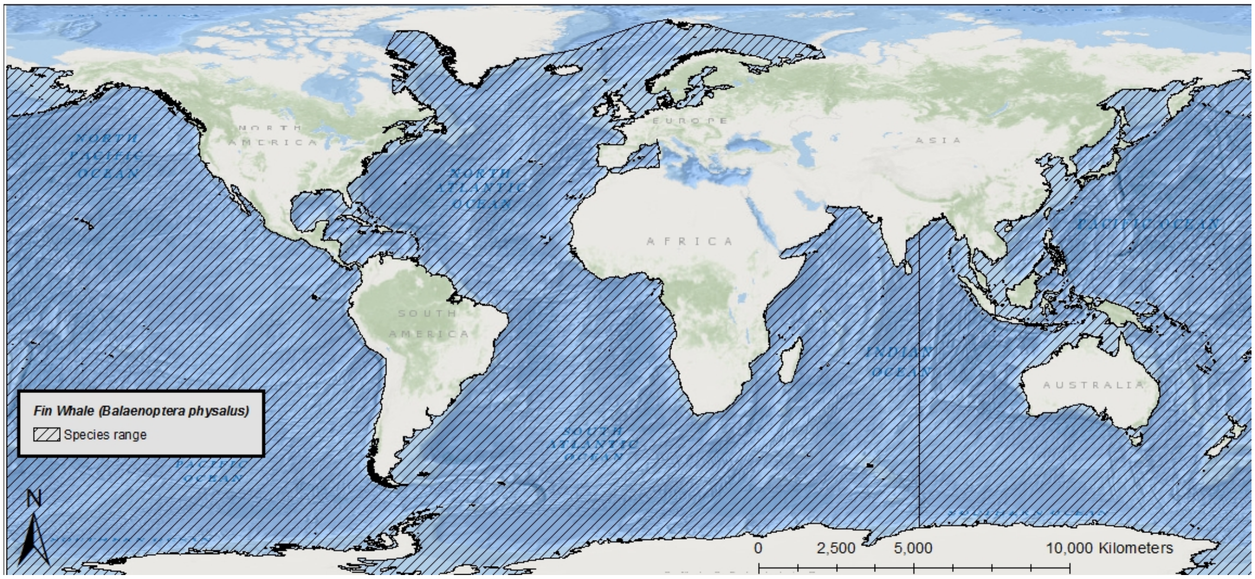

Figure 4. Map identifying the range of the endangered fin whale.

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. 2017a; Muto et al. 2017), and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

8.2.1 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 residents of certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lance.

8.2.2 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 and 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: California/Oregon/Washington (approximately 9,029 individuals, N_{min}=8,127) (Carretta et al. 2019), Hawaii (approximately 154 individuals, N_{min}=75) and Northeast Pacific (no current reliable abundance estimate)(Muto et al. 2019b). 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 an annual growth rate of 4.8 percent in the Northeast Pacific stock (Muto et al. 2019b) and a stable population abundance in the California/Oregon/Washington stock (Carretta et al. 2019). 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.

8.2.3 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 and 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 μPa at 1 meter (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson et al. 1995b;

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 and Charif 1998). Richardson et al. (1995b) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotypical 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 (U.S. Navy 2010; U.S. Navy 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 20 Hz fin whale calls in the eastern Pacific Ocean has been reported as 189 ± 5.8 dB re: 1 µPa at 1 meter (Weirathmueller et al. 2013b). 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 and Thompson 1994; Edds 1988; Watkins 1981).

In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 µPa at 1 meter (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (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 and Webb. 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of 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 1997b; Richardson et al. 1995b). 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 1997b). 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 kilohertz 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).

8.2.4 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 commercial whaling program, and under Iceland’s formal objection to the International Whaling Commission’s ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species’ overall large population size may provide some resilience to current threats, but population trends are largely unknown.

8.2.5 Critical Habitat

No critical habitat has been designated for the fin whale.

8.2.6 Recovery Goals

In response to the current threats facing the species, which will be discussed in further detail in the *Environmental Baseline* (Section xx) of this opinion, NMFS developed goals to recover fin whale populations. See the 2010 Final Recovery Plan for the fin whale (citation) 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.

8.3 Gray Whale

The gray whale is a baleen whale and the only species in the family Eschrichtiidae. There are two isolated geographic distributions of gray whales in the North Pacific Ocean: the Eastern North Pacific stock, found along the west coast of North America, and the Western North Pacific or “Korean” stock, found along the coast of eastern Asia (Figure 5).

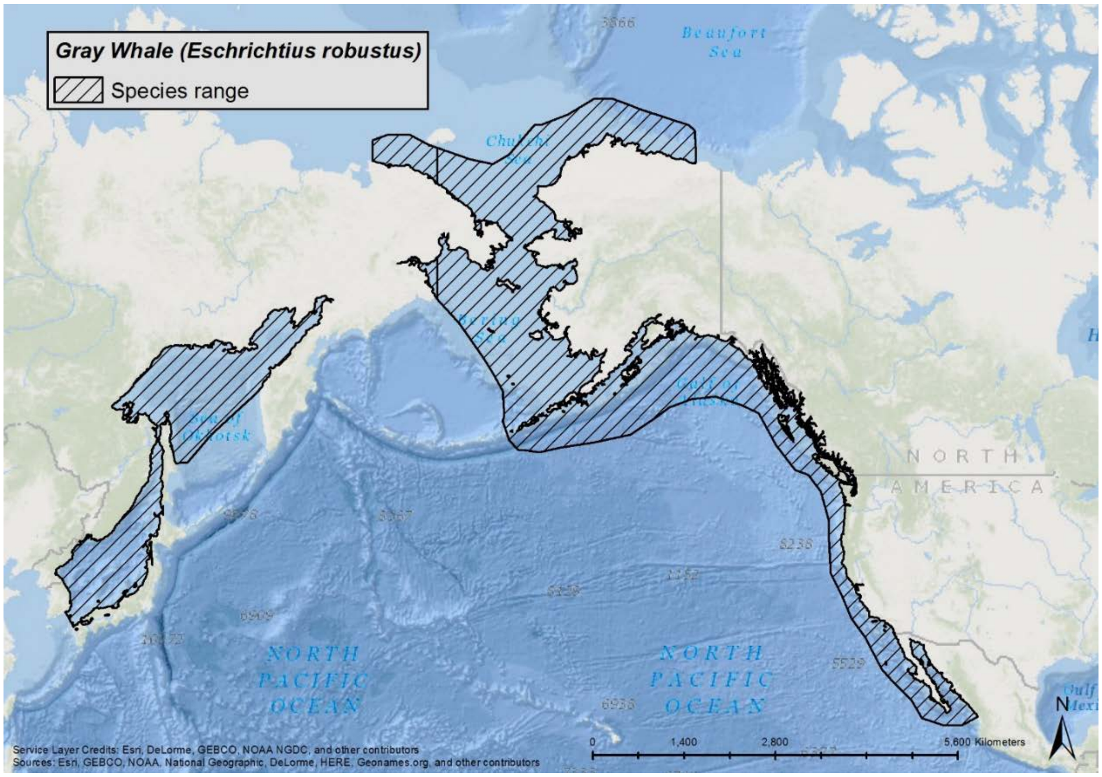

Figure 5. Map identifying the range of the gray whales.

Gray whales are distinguishable from other whales by a mottled gray body, small eyes located near the corners of their mouth, no dorsal fin, broad, paddle-shaped pectoral fins, and a dorsal hump with a series of eight to fourteen small bumps known as "knuckles." The gray whale was originally listed as endangered on December 2, 1970 (35 FR 18319). The Eastern North Pacific stock was officially delisted on June 16, 1994 (58 FR 3121) when it reached pre-exploitation numbers. The Western North Pacific population of gray whales remained listed as endangered. Western North Pacific gray whales could occur in the the Bering sea summer feeding area of which is relevant to the action area, although the probability is low (Table 3).

Table 3. Probability of encountering gray whales from the Eastern North Pacific and Western North Pacific populations in the North Pacific Ocean in various summer feeding areas (Caretta et al., 2019)

Summer Feeding Areas	Eastern North Pacific Population	Western North Pacific Population
Chukchi Sea	100%	0%
Beaufort Sea	100%	0%

Western North America (Kodiak Island, Alaska and Northern California)	99.9%	0.1%
Bering Sea	98.9%	1.1%
Okhotsk Sea	0%	100%

8.3.1 Life History

The average life span of gray whales is unknown but it is thought to be as long as eighty years. They have a gestation period of twelve to thirteen months, and calves nurse for seven to eight months. Sexual maturity is reached between six and twelve years of age with an average calving interval of two to four years (Weller et al. 2009). Gray whales mostly inhabit shallow coastal waters in the North Pacific Ocean. Some Western North Pacific gray whales winter on the west coast of North America while others migrate south to winter in waters off Japan and China, and summer in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Burdin et al. 2013). Gray whales travel alone or in small, unstable groups and are known as bottom feeders that eat "benthic" amphipods.

8.3.2 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 gray whale.

The global, pre-exploitation estimate for abundance of the Western North Pacific DPS of gray whales is unknown. By 1910, after some commercial exploitation had already occurred, it is estimated that only 1,000 to 1,500 gray whales remained in the Western North Pacific population (Berzin and Vladimirov 1981). By the 1930s, it was speculated that gray whales in the Western North Pacific could be extinct (Mizue 1951{Bowen, 1974 #190). Estimated population size from photo-ID data in 2016 was estimated at 290 whales (N_{min}=271) (Cooke et al. 2017). The combined Sakhalin Island and Kamchatka populations were estimated to be increasing from 2005 through 2016 at an average rate between two and five percent annually (Cooke et al. 2017).

There are often observed movements between individuals from the Eastern North Pacific stock and Western North Pacific stock; however, genetic comparisons show significant mitochondrial and nuclear genetic differences between whales sampled from each stock, indicating genetically distinct populations (Leduc et al. 2002). A study conducted between 1995 and 1999 using biopsy samples found that Western North Pacific gray whales have retained a relatively high number of mitochondrial DNA haplotypes for such a small population. Although the number of haplotypes currently found in the Western North Pacific stock is higher than might be expected, this pattern may not persist into the future. Populations reduced to small sizes, such as the Western North

Pacific stock, can suffer from a loss of genetic diversity, which in turn may compromise their ability to respond to changing environmental conditions (Willi et al. 2006) and negatively influence long-term viability (Frankham 2005; Spielman et al. 2004).

Gray whales in the Western North Pacific population are thought to feed in the summer and fall in the Okhotsk Sea, primarily off Sakhalin Island, Russia and the Kamchatka peninsula in the Bering Sea, and winter in the South China Sea (Figure 5). However, tagging, photo-identification, and genetic studies have shown that some whales identified as members of the Western North Pacific stock have been observed in the Eastern North Pacific, which may indicate that not all gray whales share the same migratory patterns.

8.3.3 Status

The Western North Pacific gray whale is endangered as a result of past commercial whaling and may still be hunted under "aboriginal subsistence whaling" provisions of the International Whaling Commission. Current threats include ship strikes, fisheries interactions (including entanglement), habitat degradation, harassment from whale watching, illegal whaling or resumed legal whaling, and noise.

8.3.4 Critical Habitat

No critical habitat has been designated for the Western North Pacific gray whale because NMFS cannot designate critical habitat in foreign waters.

8.3.5 Recovery Goals

There is no Recovery Plan for the Western North Pacific gray whale because listed species that are outside U.S. jurisdiction are not likely to benefit from such planning efforts (55 FR 24296; June 15, 1990).

8.4 Humpback Whale – Mexico and Western North Pacific Distinct Population Segments

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 6). Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white.

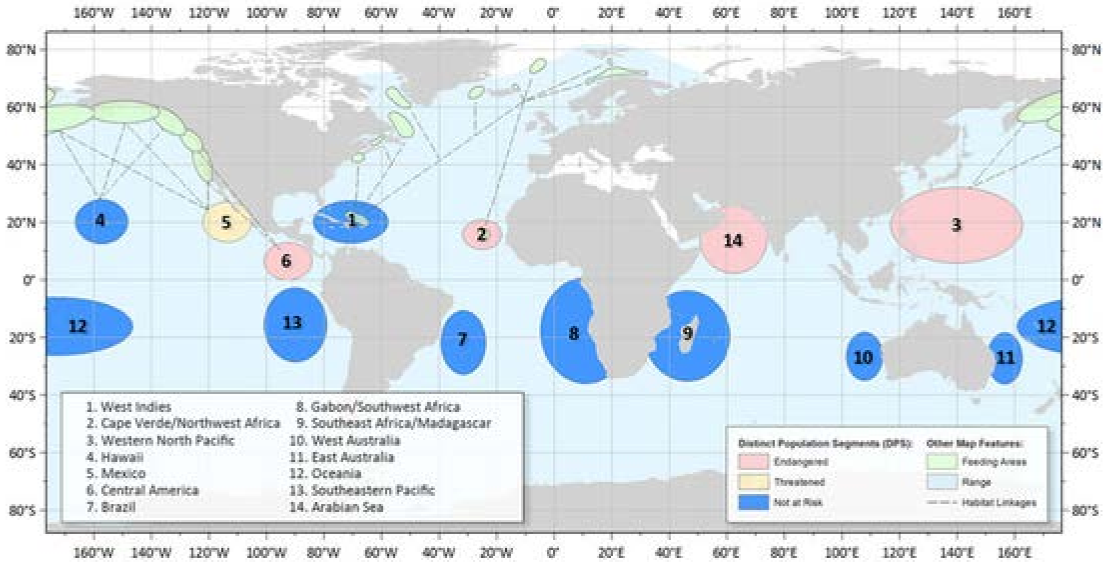

Figure 6. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015a).

The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). A global status review of humpback whales by NMFS resulted in 14 DPSs of humpback whales being recognized worldwide under the ESA (81 FR 62260; September 8, 2016) with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico). The proposed action area is within the Aleutian Islands and Bering Sea summer feeding area, with an estimated abundance of 14,693 humpback whales, which includes humpbacks from the non-ESA-listed Hawaii DPS (87 percent), threatened Mexico DPS (11 percent), and endangered Western North Pacific DPS (2.1 percent)(Wade 2017).

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 (81 FR 62259).

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 coast of Russia.

8.4.1 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. 2015a).

8.4.2 Population Dynamics

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

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). Prior to 1905, whaling records indicate that the humpback whale population in the North Pacific was 15,000 whales. By 1966, whaling had reduced the North Pacific population to about 1,200.

The California/Oregon/Washington stock of humpback whales is considered by NMFS to include two separate feeding groups containing individuals from the Central America DPS and the Mexico DPS (as well as humpback whales from the non-ESA-listed Hawaii DPS); the abundance estimate for the California/Oregon/Washington stock is approximately 2,900 individuals (N_{min}=2,784) (Carretta 2019b). This estimate is considered to include virtually the entire Central American DPS, which is estimated to include 411 whales that is based on 2004-2006 photographic mark-recapture data (Wade et al. 2016) that are greater than 8 years old and not considered a very reliable estimate of current abundance (NOAA 2016).

The current abundance estimate for the Mexico DPS of humpback whales is 3,264 individuals (81 FR 62259). A population growth rate is currently unavailable for the Mexico DPS. 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 (Bettridge et al. 2015b).

The current abundance of the Western North Pacific DPS is an estimated 1,107, with a minimum population size estimate of 865 (Muto et al. 2019a). A population growth rate is currently unavailable for the Western North Pacific humpback whale DPS. 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. This low abundance may be able to maintain some genetic diversity but could be vulnerable to risks of extinction from substantial environmental variances and catastrophes (Bettridge et al. 2015a).

8.4.3 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 songs 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 and Green 2000; Frazer and Mercado 2000; Richardson et al. 1995a; 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 nm) 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. 1995a; 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 with dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 µPa at 1 m) (Au and Green 2000; Erbe 2002a; Payne 1985; Richardson et al. 1995a; Thompson et al. 1986). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995a). 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 and 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 and Clapham 2004; Gabriele and 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 and Clapham 2004; Gabriele and Frankel. 2002; McSweeney et al. 1989). Humpback whales off Hawaii have been observed to sing louder at night compared to the day (Au et al. 2006). 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 and 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). Female vocalizations are noted as having less complexity Simao and Moreira (2005).

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 and Moreira 2005). “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[9] (DTAGs) (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple 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.

The generalized hearing range of humpback whales is in the low-frequency cetacean hearing group category, 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 and 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. 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.

8.4.4 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).

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[9] 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 recording is synchronous so the relative timing of sounds and motion can be determined precisely Johnson, M. P., and P. L. Tyack. 2003. A digital acoustic recording tag for measuring the response of wild marine mammals to sound. IEEE Journal of Oceanic Engineering 28(1):3-12.

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 Mexico DPS still faces a risk of becoming endangered within the foreseeable future and the Western North Pacific DPS still faces a risk of extinction.

8.4.5 Critical Habitat

No critical habitat has been designated yet for humpback whales, but there are areas that have been proposed in Alaskan waters (84 FR 54354) for the Mexico and Western North Pacific Distinct Population Segments, but none are in or near the action area of this consultation.

8.4.6 Recovery Goals

In response to the current threats facing the species, which will be discussed in further detail in the *Environmental Baseline* (Section 9) of this opinion for threats in the action area, NMFS developed goals to recover humpback whale populations. See the 1991 Final Recovery Plan for the humpback whale (citation) 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.

8.5 North Pacific Right Whale

North Pacific right whales are found in temperate and sub-polar waters of the North Pacific Ocean (Figure 7).

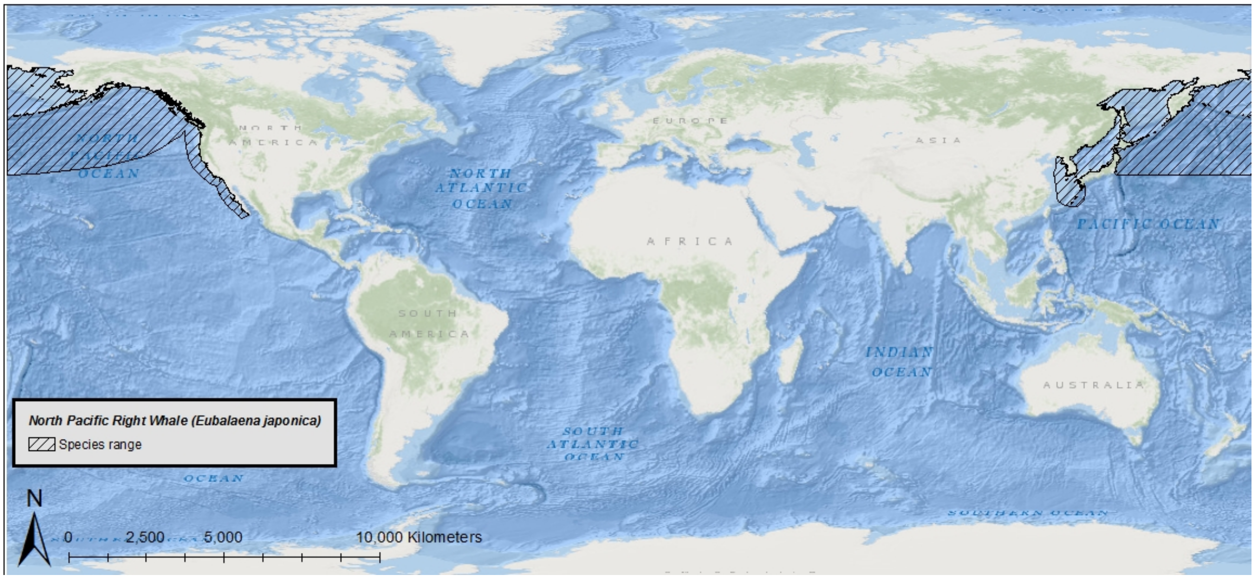

Figure 7. Map identifying the range of the endangered North Pacific right whale.

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.

8.5.1 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 filteri through their baleen while moving through a patch of zooplankton.

8.5.2 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. 2011b) 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). 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 Gulf of Alaska, 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.

8.5.3 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 and 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 and Moore 2002; Parks and 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 And 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). Gunshots appear to be largely or exclusively male vocalization (Parks et al. 2005b). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100 to 400 Hz (Gillespie and Leaper 2001).

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 almost year-round in Massachusetts Bay, except July and August, and peaked 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 to their mothers' screams (Parks et al. 2003; Parks and 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 and 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 and 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).

8.5.4 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.

8.5.5 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 Gulf of Alaska that are not within the action area of this consultation.

8.5.6 Recovery Goals

In response to the current threats facing the species, which will be discussed in further detail in the *Environmental Baseline* (Section 9) of this opinion for threats occurring in the action area, NMFS developed goals to recover North Pacific right whale populations. See the 2013 Final Recovery Plan for the North Pacific right whale (citation) 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.

8.6 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 8).

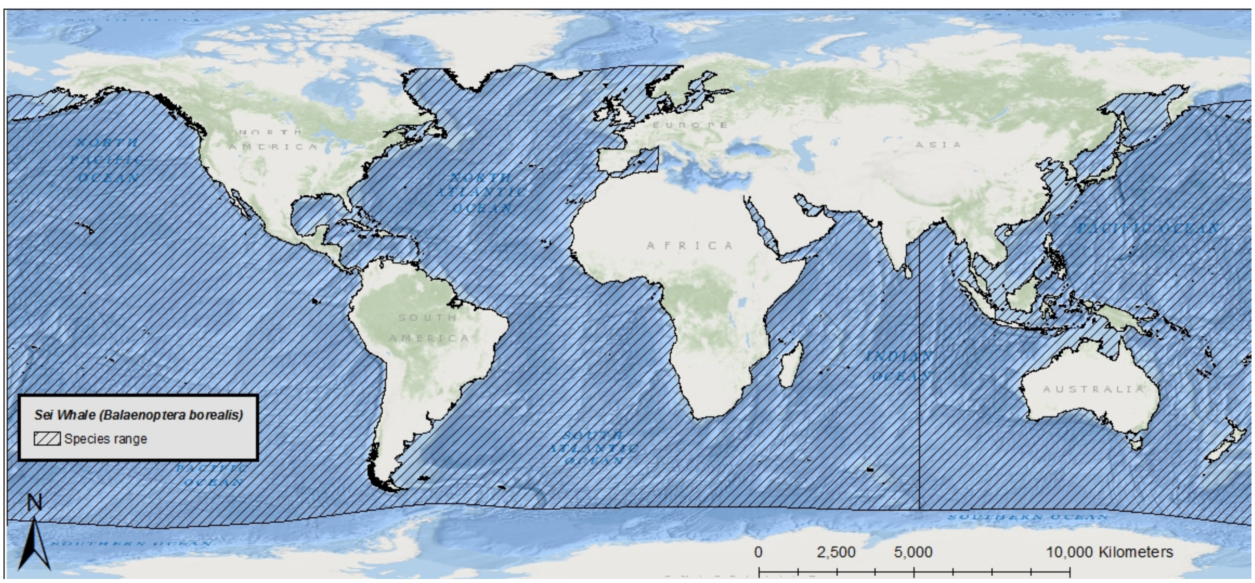

Figure 8. Map identifying the range of the endangered sei whale.

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.

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Hayes et al. 2017b{Carretta, 2019 #176), and status review (NMFS 2012) were used to summarize the life history, population dynamics and status of the species as follows.

8.6.1 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.

8.6.2 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) (Hayes et al. 2017a), Hawaii (N=391, N_{min}=204) and Eastern North Pacific (N=519, N_{min}=374)(Carretta et al. 2019). 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 and 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 and 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).

8.6.3 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 and 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. 2013a).

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 1997a; Richardson et al. 1995a). 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 1997a). 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).

8.6.4 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.

8.6.5 Critical Habitat

No critical habitat has been designated for the sei whale.

8.6.6 Recovery Goals

In response to the current threats facing the species, which will be discussed in further detail in the *Environmental Baseline* (Section 9) of this opinion for those threats occurring in the action area, NMFS developed goals to recover sei whale populations. See the 2011 Final Recovery Plan for the sei whale (citation) 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.

8.7 Sperm Whale

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

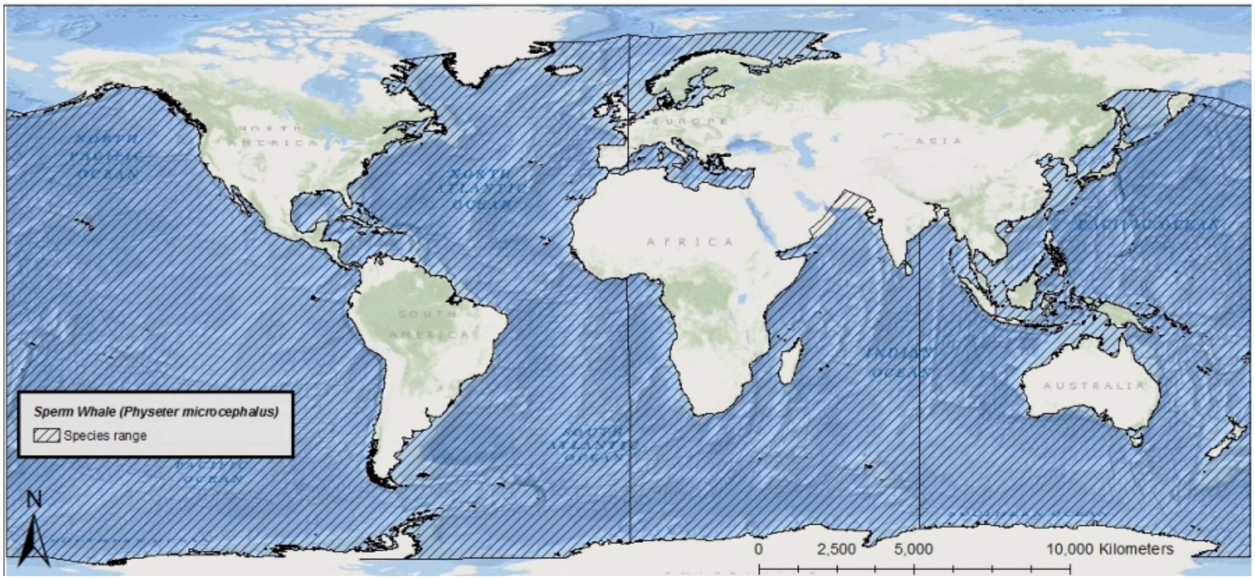

Figure 9. Map identifying the range of the endangered sperm whale.

Sperm whales are the largest of the toothed whales and distinguishable from other whales by their extremely large head, which takes up to 25 to 35 percent of the 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. 2017a; 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.

8.7.1 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 of four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 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).

8.7.2 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.

Population estimates are available for two of three recognized stocks in the U.S. Atlantic Ocean; the Northern Gulf of Mexico stock, estimated to consist of 763 individuals (N_{min}=560) and the North Atlantic stock, estimated to consist of 2,288 individuals (N_{min}=1,815) (Hayes et al., 2017). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock.

Population estimates are available for two of three recognized U.S. stocks that occur in the Pacific Ocean: the California/Oregon/Washington stock, estimated to consist of 1,997 individuals (N_{min}=1,270), and the Hawaii stock, estimated to consist of 4,559 individuals (N_{min}=3,478) (Carretta 2019). 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 are insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific 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 of 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.

8.7.3 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 and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold and Jones 1995; Weilgart and 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 and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Whitehead and 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 and 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 and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and 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 and 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 and 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 and 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 and 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 sounds (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 and 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. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa2-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 and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). 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).

8.7.4 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.

8.7.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.7.6 Recovery Goals

In response to the current threats facing the species, which will be discussed in further detail in the *Environmental Baseline* (Section 9) of this opinion for those threats occurring in the action area, NMFS developed goals to recover sperm whale populations. See the 2010 Final Recovery Plan for the sperm whale (citation) 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.

8.8 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 10).

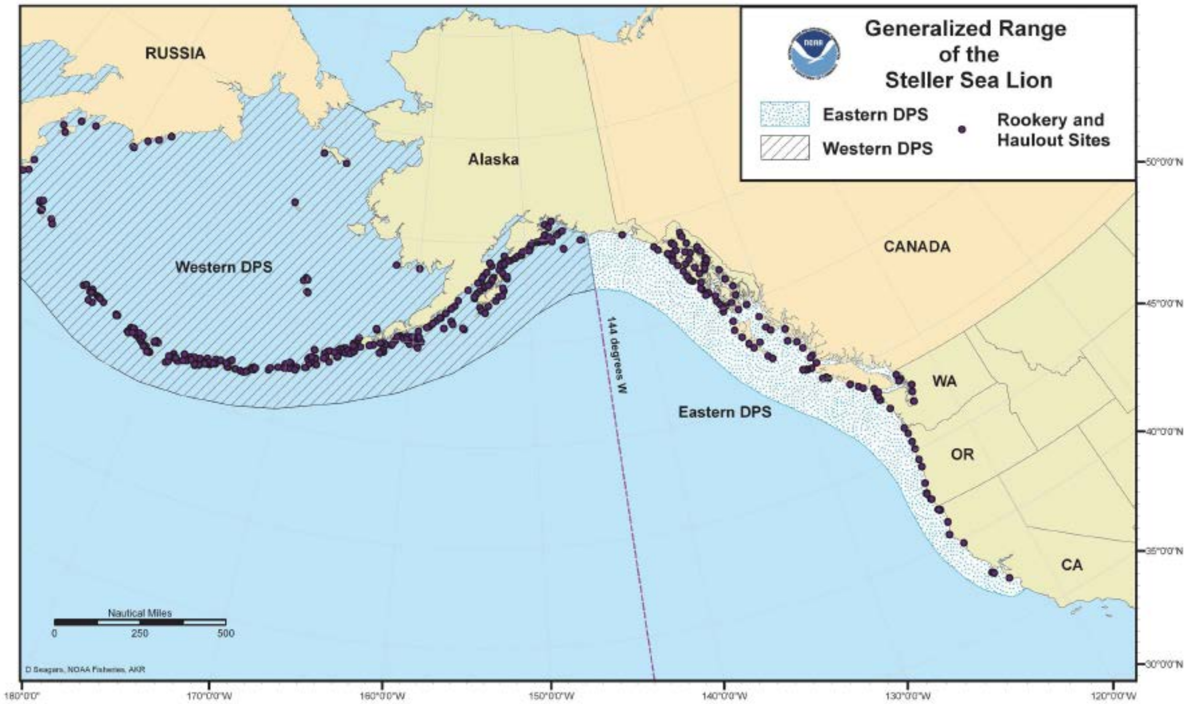

Figure 10. Map identifying the range of the endangered Western distinct population segment of Steller sea lion.

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).

We used information available in the final listing, the revised Recovery Plan (NMFS 2008), and the most recent stock assessment report (Muto et al. 2018) to summarize the status of the Western DPS of Steller sea lions, as follows.

8.8.1 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.

8.8.2 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 by 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 (approximately 170°W) and generally negative trends to the west in the Aleutian Islands (Muto et al. 2018). Non-pup trends from 2002 to 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 (Muto et al. 2018).

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 10). The Western DPS includes Steller sea lions that reside in the central and western GOA, and Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia).

8.8.3 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).

8.8.4 Status

The species was ESA-listed as threatened in 1990 because of significant declines in population sizes (55 FR 49204). 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 3 nautical miles (5.6 km) of listed rookeries, within one-half statutory miles (0.8 km) on land, and within sight of 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 additional protections the Western DPS of Steller sea lions is still in declining in 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.

8.8.5 Critical Habitat

In 1997, NMFS designated critical habitat for the Steller sea lion (58 FR 45269). The designated critical habitat includes specific rookeries, haulouts, 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 2).

As described in Section 7.3.1, the physical and biological features for the Western DPS Steller sea lion designated critical habitat include three special aquatic foraging areas in Alaska. Two of them are in the Aleutians, Bogoslof Island and Seaguam Pass, and Shelikof Strait is in the Gulf of Alaska. These important foraging areas are located near Steller sea lion abundance centers and concentrations of prey, which also attract commercial fisheries.

8.8.6 Recovery Goals

See the 2008 Revised Recovery Plan for the Steller sea lion (citation) 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.

9 Environmental Baseline

The “environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02; 84 FR 44976 published August 27, 2019).

The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of (write out all the marine mammals you are considering as LAA here) in the action area. The following discussion summarizes the impacts, which include climate change, oceanic temperature regimes, unusual mortality events, whaling and subsistence harvesting, vessel strike, whale watching, fisheries, pollution (marine debris, contaminants, and hydrocarbons), anthropogenic sound (vessels, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities.

9.1 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. Climate change effects include, changes in air and water temperatures, changes in precipitation and drought patterns, increased frequency and magnitude of severe weather events, and sea level rise; all of which are likely to impact ESA resources. Annual average temperatures have increased by 1.8 degrees Celsius 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). Globally, there more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov).

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); (Kintisch 2006; Robinson et al. 2005); (Learmonth et al. 2006); (McMahon and Hays 2006); (Evans and Bjørge 2013); (IPCC 2014). 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. 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).

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. 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 (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990). 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 that are dependent on squid, such as sperm whales, and possibly for Steller sea lions whose broader diet includes cephalopods. For ESA-listed species that undergo long migrations, such as the cetaceans in this consultation, if either prey availability or habitat suitability is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

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 in the atmosphere since the Industrial Revolution, ocean acidity has increased by 26 percent since the beginning of the industrial era and is predicted to increase considerably between now and 2100 throughout the world's oceans (IPCC 2014). 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. 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.

While it is difficult to accurately predict the precise consequences of climate change to a particular species or habitat, especially highly mobile marine species (Simmonds and Isaac 2007a), a range of consequences are expected that are likely to change the status of the species and the condition of their habitats in the action area. It is also likely these consequences will overlap and result in synergistic impacts.

9.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns (of high and low pressure systems) 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 north Pacific (Beamish 1993; Benson and Trites 2002; Hare and Mantua 2001; Mantua et al. 1997; Mundy and Cooney 2005; Stabeno et al. 2004).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific Ocean and operates over longer periods than the Southern Oscillation events of El Niño, or La Niña, and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and 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). El Niño periods can influence reproductive success by altering prey availability, probably linked to a decline in primary productivity in coastal areas. Data suggest that sperm whale females have lower rates of conception following these periods of warmer surface temperatures (Whitehead et al. 1997).

These periodic shifts in oceanic conditions are complex and the resultant changes in habitat and productivity can be difficult to predict especially when trying to incorporate the longer-term anthropogenic-related changes in climate (Kintisch 2006; Simmonds and Isaac 2007b). Vulnerable populations of listed species are going to be sensitive to climatic variability that impacts the resources they need. Climate change may be driving the natural oscillation in environmental conditions to greater extremes, which poses more risk to the stability of a vulnerable population.

9.3 Unusual Mortality Event

Since January 1, 2019, elevated gray whale strandings have occurred along the west coast of North America, from Mexico up into the Artic coast of Alaska, and it has been declared an Unusual Mortality Event (UME)[10]. Several dead whales were emaciated with moderate to heavy whale lice (cyamid) loads. Full or partial necropsy examinations conducted on a subset of whales found evidence of vessel strike in three whales and entanglement in one whale. Findings are preliminary and investigations are ongoing, with more research needed to understand the cause of the strandings and if any of the dead gray whales are from the western population.

9.4 Whaling, Harvesting and Subsistence

Prior to current prohibitions on whaling, most large whale species were depleted to the extent that they were listed as endangered under the Endangered Species Preservation Act of 1966. The International Whaling Commission (IWC) issued a moratorium on commercial whaling beginning in 1986 and currently there is no legal commercial whaling by IWC Member Nations party to the moratorium; however, whales are still killed commercially by countries that lodged objections to the moratorium (i.e., Iceland and Norway) and by Japan which has withdrawn from the IWC[11]. 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

[10] https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2020-gray-whale-unusual-mortality-event-along-west-coast (Accessed 3/26/20)

[11] https://iwc.int/statement-on-government-of-japan-withdrawal-from-t (Accessed 8/28/20)

commercial whaling can be found on the International Whaling Commission's website at: https://iwc.int/whaling.

9.4.1 Subsistence Harvest of Steller Sea Lions

Historically, Steller sea lions were an important subsistence resource for Alaska Natives that hunted them for their meat, hides, oil, and other products. They are still an important subsistence resource for Alaskan communities, including in the Aleutian Islands, which harvest a combined annual mean of 203 Western U.S. Steller sea lions (Muto et al. 2019b).

9.5 Vessel Strike

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 from which 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 severe 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 mortalities 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, 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; however, all whale species have the potential to be affected by vessel strikes (Laist et al. 2001; Vanderlaan and 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). The potential lethal effects of vessel strikes are particularly profound on species with low abundance. Vessel traffic can come from both private (e.g., commercial, recreational) and federal vessel (e.g., military, research) traffic, but traffic that is most likely to result in vessel strikes comes from commercial shipping. There are shipping transit corridors to the north and south of the Aleutian Islands (Sullender 2017).

9.6 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 per year global industry (Lambert et al. 2010). Private vessels may partake in this activity as well. NMFS has issued certain regulations and guidelines relevant to whale watching. Many of the cetaceans considered in this opinion are highly migratory and 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 and 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.

Whale watching is a popular activity in Alaska although it is generally difficult to precisely quantify and or estimate the magnitude of the risks posed to the marine mammals subject to these activities. The amount of whale watching activity across Alaska is likely to be significantly reduced because of restrictions due to the COVID-19 pandemic in 2020, such as social distancing requirements and restrictions on non-essential activities.

9.7 Fisheries Interactions

Fisheries constitute an important and widespread use of the ocean resources throughout the action area. Fisheries can adversely affect targeted fish populations, other species, and habitats. Direct effects of fisheries interactions on marine mammals and sea turtles include entanglement and entrapment, which can lead to fitness consequences or mortality resulting from injury or drowning. Indirect effects include reduced prey availability, including overfishing of targeted species, and destruction of habitat.

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox, Heathcote et al. 2015). Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich, Cornish 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 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, Moore et al. 2013). In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014).

Marine mammals can 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, Massey 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, Kenney et al. 2016). Nevertheless, all marine mammals may face threats from derelict fishing gear.

In addition to these direct impacts, marine mammals may also be subject to indirect impacts from fisheries that have a profound influence on fish populations. In a study of retrospective 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. 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). Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Thus, competition with humans for prey is a potential concern. Even species that do not directly compete with human fisheries could be indirectly affected, by changes in ecosystem dynamics through fishing activities. However, the effects of fisheries on marine mammals through changes in prey abundance in the action area is not well understood.

9.8 Pollution

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

9.8.1 Marine Debris

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and 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 such as mammals.

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). 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 is accumulating in oceanic gyres (Law et al. 2010). Despite debris removal and outreach to heighten public awareness, marine debris has not been reduced in the environment (NRC 2008) and continues to accumulate in the ocean and along shorelines within the action area.

The ingestion of marine debris can result in blockage or obstruction of the mouth, stomach lining and digestive tract of various species and lead to serious internal injury or mortality (Derraik 2002). 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 and Perry 2014). 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. Gastric impactions were suspected as 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).

Marine mammals are expected to be exposed to marine debris in the action area through the duration of the project and we assume similar effects from marine debris documented within other regions could occur. The lack of detailed marine debris data specific to the action area makes it difficult to conclude the level of risk and degree of impacts on the ESA-listed species' populations considered in this consultation.

9.8.2 Contaminants

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

The accumulation of persistent organic pollutants, including polychlorinated-biphenyls (better known as PCBs), 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 declines in levels of monitored pesticide, although the persistent chemicals are still detected and expected to endure for years (Grant and Ross 2002; Mearns 2001).

Plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik 2002). Plastic waste chemically attracts hydrocarbon pollutants such as PCBs and dichlorodiphenyltrichloroethane. Marine animals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. Fin whales are exposed to high densities of microplastics on the feeding grounds in the Mediterranean Sea, and in turn exposed to a higher oxidative stress because of the presence of plasticizers, an additive in plastics (Fossi et al. 2016).

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 can pass on contaminants to offspring during pregnancy and lactation (Addison and Brodie 1987; Borrell et al. 1995). Pollutants can be transferred from mothers to offspring 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 contaminants is likely to continue for marine mammals, the level of risk and degree of impact remains unknown due to the lack of data for potential contaminants specific to the action area.

9.9 Anthropogenic Sound

The ESA-listed species that occur in the action area can be impacted by increased levels of anthropogenic-induced background sound or high intensity, short-term 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).

Many researchers have described behavioral responses of marine mammals to sounds produced by vessels, aircraft, and construction or dredging (reviewed in Gomez et al. 2016; and Nowacek et al. 2007). Most observations are short-term behavioral responses, which include avoidance behavior and temporary cessation of feeding, resting, or social interactions.

9.9.1 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 2003b). Commercial shipping is a major source of low-frequency sound in the ocean and the majority of vessel traffic occurs in the Northern Hemisphere. 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; Ross 1993; Ross 2005). Most data indicate vessel sound is likely still increasing (Hildebrand 2009a). 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.

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. 2012a).. 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, Ross 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 possible commercial and recreational vessels that also operate within the action area may produce similar sounds, although to a lesser extent given their much smaller size.

Vessels produce acoustic signatures that can change with vessel speed, vessel load, and activities 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: µPa2-s at 1 m for fast-moving (greater than 37 km per hour [20 kts]) supertankers to 140 dB re: μPa2-s at 1 m for small fishing vessels (NRC 2003). 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 and Gabriele 2004). Typically, sound levels are higher for the larger vessels and increased vessel speeds result in higher sound levels.

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 relatively 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 9.11.

9.9.2 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).

9.9.3 Seismic Surveys

All seismic surveys involving the use of airguns with the potential to take marine mammals in the U.S. should obtain incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. Consultation with NMFS is also needed when Federal entities authorize seismic surveys in domestic waters (such as Bureau of Ocean Energy Management for oil and gas activities) or fund and/or conduct these activities in domestic and foreign waters, 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.

9.10 Marine Construction

Marine construction 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). The Andreanof portion of the Aleutian Islands are remote and sparsely populated and therefore not likely to have significant amounts of major construction.

9.11 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. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. 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.

To the east of the NSF's seismic survey action area in the Aleutian Island's there is a U.S. Navy Training and Testing range complex in the Gulf of Alaska which is a considerable distance away and unlikely to create any significant additional acoustic impacts for consideration in this consultation.

9.12 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. The field research studies are often monitoring populations over decades or gathering data for behavioral and ecological studies. NMFS issues dozens of permits on an annual basis for various forms of "take" of marine mammals and sea turtles from a variety of biological research activities that include sampling and aerial or vessel based surveys. The consultations on the issuance of these permits found the authorized research activities should have no more than short-term effects and were not determined to result in jeopardy to the species or adverse modification of designated critical habitat.

Scientific research permits issued by NMFS authorize studies of ESA-listed species in the North Pacific Ocean, including Alaska, some of which have extend into portions of the action area for the proposed action. Considering the large ranges of the marine mammals being considered, we do not expect many of the authorized "takes" in those studies to involve the same individuals that will be subject to the actions of the proposed seismic research survey.

9.13 Impact of the Environmental Baseline on Endangered Species Act-Listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on blue, fin, gray, humpback, North Pacific right, sei, and sperm whales, and Steller sea lions within the action area. 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., scientific research permits) 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 species to be the status and trends of those species. As noted in Section 8, 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 activities described in 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 limiting 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 for which NMFS has found the action is likely to cause adverse effects is discussed in the *Species and Critical Habitat Likely to be Adversely Affected* (Section 8)of this opinion.

10 EFFECTS OF THE ACTION

Section 7 regulations were revised in August 2019 to define "effects of the action" as all consequences to ESA-listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur (50 C.F.R. §402.02). Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.17). Section 7 regulations (50 C.F.R. §402.17) elaborate on this definition as follows:

- *Activities that are reasonably certain to occur* – A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Factors to consider when evaluating whether activities caused by the proposed action (but not part of the proposed action) or activities reviewed under cumulative effects are reasonably certain to occur include, but are not limited to: (1) past experiences with activities that have resulted from actions that are similar in scope, nature, and magnitude to the proposed action; (2) existing plans for the activity; and (3) any remaining economic, administrative, and legal requirements necessary for the activity to go forward.
- *Consequences caused by the proposed action* – To be considered an effect of a proposed action, a consequence must be caused by the proposed action (i.e., the consequence would not occur but for the proposed action and is reasonably certain to occur). A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Considerations for determining that a consequence to the species or critical habitat is not caused by the

> proposed action include, but are not limited to: (1) the consequence is so remote in time from the action under consultation that it is not reasonably certain to occur; or (2) the consequence is so geographically remote from the immediate area involved in the action that is not reasonably certain to occur; or (3) the consequence is only reached through a lengthy causal chain that involves so many steps as to make the consequence not reasonably certain to occur.

This section follows the stressor, exposure, response, and risk assessment framework described in Section 2. The effects analyses describe the potential stressors associated with the proposed action, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in Section 10.3, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment will consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses could have population-level consequences.

10.1 Effects that are Insignificant or Extremely Unlikely to Occur

As discussed in Section 5, we determined that the following stressors may result from the NSF seismic survey and associated NMFS IHA authorization:

1. Vessel strike.
2. Vessel noise.
3. Sound fields produced by the MBES, SBP and ADCP.
4. Sound fields produced by the airgun array.

Based on a review of available information, during consultation we determined which of these possible stressors will be extremely unlikely to occur or insignificant in terms of their effects to blue, fin, Western North Pacific gray, humpback (Mexico and Western North Pacific DPSs) , North Pacific right, sei, and sperm whales, and Western DPS Steller sea lions. These stressors are vessel strike, vessel noise, and sound fields produced by the MBES, SBP, and ADCP. We have determined that the effects of these stressors on these ESA-listed marine mammals may affect, but are not likely to adversely affect these species in part because of the required monitoring and mitigation measures (Section 3) that include the use visual monitoring with NMFS-approved PSOs, vessel strike avoidance measures, and additional mitigation measures considered in the presence of ESA-listed species to minimize or avoid exposure to stressors.

While the airgun array is not operational, visual PSOs will remain on duty to collect sighting data. If ESA-listed marine mammals or sea turtles closely approach the vessel, the R/V *Langseth* will take evasive actions to avoid a ship-strike and simultaneously avoid exposure to very high source levels. Ship strikes are extremely unlikely to occur due in part to the avoidance and minimization measures that will be implemented as part of the proposed action (Section 3).

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. The MBES, SBP, and ADCP 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. 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 only from the airgun array.

The MBES, SBP, ADCP, and acoustic release transponder are four additional active acoustic system that will operate during the proposed seismic survey on the R/V Marcus G. Langseth. These systems have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: 1 µPa (rms) threshold, but generally operate at higher frequencies than airgun array operations (10 to 13.5 [usually 12] kHz for the MBES, 3.5 kHz for the SBP, 75 kHz for the ADCP, and eight to 13 kHz for the acoustic release transponder). As such, the frequencies will attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed marine mammals will likely experience higher levels of sound from the airgun array well before these other acoustic sources of equal amplitude because these other sounds will drop off faster than those from the airgun arrays.

We rule out high-level ensonification of ESA-listed marine mammals (approximate sound source levels: 242 dB re: 1 µPa [rms] for MBES, 222 dB re: 1 µPa [rms] for SBP, 224 dB re: 1 µPa [rms] for ADCP, 93 dB re: 1 µPa [rms] for acoustic release transponder), because it presents a low risk for auditory or other damage to occur, which is similarly concluded by Boebel et al. (2006) and Lurton and DeRuiter (2011). 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 would have to be located well within 100 m (328.1 ft) of the vessel to experience a pulse from these acoustic sources that could result in TTS (LGL Ltd. 2008). It is possible that a small number of ESA-listed marine mammals could experience low-level exposure to the MBES, SBP, ADCP, and acoustic release transponder. However, we do not expect any exposure at levels sufficient to cause more than behavioral responses (e.g. avoidance of the sound source) and would therefore have insignificant effects to ESA-listed marine mammals.

10.2 Exposure and Response Analysis

In the previous sections, we described the stressors resulting from the action and determined that noise from the airgun array is likely to adversely affect ESA-listed blue, fin, Western North Pacific gray, humpback (Mexico and Western North Pacific DPSs), North Pacific right, sei, and sperm whales, and Western DPS Steller sea lions.

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. The response analysis also considers information on the potential stranding and the potential effects on the prey of ESA-listed marine mammals in the action area.

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 and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold and 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.

10.2.1 Definition of Take, Harm, and Harass

Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. We categorize two forms of take, lethal and sublethal take. Lethal take is expected to result in immediate, imminent, or delayed but likely mortality. Sublethal take is when effects of the action are below the level expected to cause death, but are still expected to cause injury, harm, or harassment. Harm, as defined by regulation (50 C.F.R. §222.102), includes acts that actually kill or injure wildlife and acts that may cause significant habitat modification or degradation that actually kill or injure fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering. Thus, for sublethal take we are concerned with harm that does not result in mortality but is still likely to injure an animal.

NMFS has not defined "harass" under the ESA by regulation. However, on October 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 this consultation, we rely on this definition of harass when assessing effects to all ESA-listed species, with the qualifications noted below.

NMFS guidance issued on October 21, 2016, states that our "interim ESA harass interpretation does not specifically equate to MMPA Level A or Level B harassment, but shares some similarities with both levels in the use of the terms 'injury/injure' and a focus on a disruption of behavior patterns. NMFS has not defined 'injure' for purposes of interpreting Level A and Level B harassment but in practice has applied a physical test for Level A harassment." Under the MMPA, harassment is defined 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).

NSF and NMFS Permits and Conservation Division estimate the 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. Because our ESA analysis relies on NMFS interim guidance on the ESA term harass, our conclusions may differ from those reached by the NMFS Permits and Conservation Division in their MMPA analysis. Given the differences between the MMPA and ESA standards for harassment, there may be circumstances in which an act is considered harassment, and thus take under the MMPA, but not the ESA.

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 of ESA-listed species that may be adversely affected by sound from the survey. . This is a conservative approach, because not all harassment under the MMPA constitutes take under the ESA. Accordingly, the number of takes under the ESA will likely be lower than the number of takes authorized under the MMPA.

Harassment under the ESA is expected to occur during the seismic survey activities and may involve a wide range of behavioral responses for ESA-listed marine mammals including but not limited to avoidance, and disruption or changes in: vocalizations, dive patterns, feeding, migration 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 estimate exposure of ESA-listed species and determine the likely nature of their behavioral responses and the potential fitness consequences in accordance with the definitions of "take" related to harm or harass under the ESA.

10.2.2 Exposure and Response Estimates for Endangered Species Act-Listed Marine Mammals

As discussed in the *Status of Species and Critical Habitat Likely to be Adversely Affected* section, there are eight ESA-listed marine mammal species that are likely to be affected by the proposed action: blue, fin, humpback (Mexico and Western North Pacific DPSs), Western North Pacific gray, North Pacific right, sei, and sperm whales and Western DPS Steller sea lions. 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 (i.e., acoustic thresholds) 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 as harm or harassment. In many cases, estimating the potential 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.

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) from the airgun array. Our exposure estimates stem from the best available information on marine mammal densities (Table 7) and a predicted radial distance based on isopleths corresponding to harm (Table 6) and harassment (Table 5) thresholds 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.

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 use the same values to determine the extent of take for ESA-listed marine mammals, while recognizing that harassment under the ESA and the MMPA are not synonymous and acknowledging that some of the takes calculated by NSF and the NMFS Permits and Conservation Division would not constitute takes under the ESA.

The NSF and NMFS Permits and Conservation Division did not provide any take estimates from sound sources other than the airgun array because this is the only sound source that was determined to result in likely adverse effects to marine mammals. The NSF and NMFS Permits and Conservation Division estimated the number of ESA-listed marine mammal species that might be exposed to the sound field and experience an adverse response. This estimation relied on acoustic thresholds to determine when marine mammals are expected to exhibit a response that may be considered take under the ESA, such as harm or harassment. The thresholds are then utilized to calculate ensonified areas and 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 generated by the airgun array.

During the development of the IHA, the NMFS Permits and Conservation Division conducted an independent exposure analysis that was informed by comments received during the required public comment period for the proposed IHA. The exposure analysis 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.

For our ESA section 7 consultation, we conducted an evaluation of both the NSF and the NMFS Permit and Conservation Division's estimates of ESA-listed marine mammals that will be exposed to acoustic levels that may cause harassment under the ESA. In this opinion, we adopted the Permits and Conservation Division's exposure analysis because it utilized the best available information and methods to evaluate exposure of ESA-listed marine mammals. Below we describe the exposure analysis for ESA-listed marine mammals.

10.2.2.1 Acoustic Thresholds

To determine at what point during exposure to active acoustic sources (e.g., airgun arrays) 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 mitigation requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA 2018). The references, analysis, and methodology used in the development of these thresholds are described in *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018), which is available online at https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance. For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold of 160 dB re: 1 µPa (rms) for impulsive sound sources and 120 dB re: 1 µPa (rms) for non-impulsive sound sources. These values are based on observations of behavioral responses of mysticetes, but are used for all marine mammals 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 that are proposed in the IHA, and accordingly, take of ESA-listed marine mammals.

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 or PTS), these TTS and PTS auditory thresholds differ by species hearing group. Furthermore, these acoustic thresholds are a dual metric for impulsive sounds, with one threshold based on peak SPL (0-pk SPL) that does not include duration of exposure. The other metric, the cumulative sound exposure criteria, incorporates 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, because it is the more precautionary criteria.

The NMFS Permits and Conservation Division classify any exposure equal to or above the acoustic threshold for the onset of PTS (see Table 6) as auditory injury, and thus MMPA Level A harassment. Level A harassment under the MMPA roughly corresponds to 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) threshold for impulsive acoustic sources is classified as MMPA Level B harassment. Some MMPA Level B harassment would correspond to ESA harassment. Among harassment (MMPA Level B) exposures, the NMFS Permits and Conservation Division does not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response.

Table 4. 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 Hz 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 Hz 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 Hz 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 Hours
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. 2007a) (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 μPa^2s. 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.

10.2.2.2 Modeled Sound Fields of the Airgun Array

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. If we find that exposures above the thresholds are likely, we then estimate the number of marine mammal exposures based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methods used by the NSF and NMFS Permits and Conservation Division for estimating the number of ESA-listed species that might be exposed to the sound field 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. The area estimated to be ensonified in a single day of the seismic survey activities is then calculated, based on the predicted ensonified area around the airgun array and the estimated trackline distance to be traveled by the R/V *Marcus G. Langseth* per day. Compensating for possible delays during the seismic survey (e.g., weather, equipment malfunction) and accounting for additional seismic survey activities (e.g., turns, airgun array testing, and repeat coverage for any areas where initial data quality is sub-standard), a 25 percent contingency 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 and NMFS Permits and Conservation Division, we have determined that listed marine mammals are likely to be exposed to sound levels at or above the threshold at which TTS and behavioral harassment will occur. The predicted and modeled radial distances for the R/V *Langseth*'s airgun arrays configurations and water depth can be found in Table 6 and Table 5 according to the various MMPA Level A and the 160 dB re: 1 µPa (rms) Level B thresholds for ESA-listed marine mammals.

Table 5. Predicted distances to which sound levels ≥160 dB re 1 μPa rms could be received from the single and 36-airgun array towed at 9 m.

Airgun Configuration	Water Depth (m)	Predicted rms radii (m)
		160 dB
18 airguns (3,300-in^3)	>1,000-m	3,562[1]
	100-1,000-m	3,939[2]
	<100	5,263[2]
36 airguns (6,600-in^3)	>1,000-m	5,629[1]
	100-1,000-m	8,233[3]
	<100	11,000[3]

[1] Distance is based on NSF/L-DEO model results. [2] Based on empirical data from Crone et al. (2014) with scaling factor based on deep-water modeling applied to account for differences in array size; see Appendix A for details. [3] Based on empirical data from Crone et al. (2014).

Table 6. Modeled threshold distances in m from the R/V Marcus G. Langseth's four string, 36 airgun, array and a shot interval of 50 m[1], 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	LF Cetaceans	MF Cetaceans	HF Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/Otters
PTS SEL_{cum}[2]	**376.0**	0	0.9	9.9	0
Peak SPL_{flat}	38.8	**13.8**	**229.2**	**42.1**	**10.9**

[1] Using the 50-m shot interval provides more conservative distances than the 278-m shot interval. [2] Results from NMFS user spreadsheet tool (NMFS 2018), based on modeled source levels and survey parameters.

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.

10.2.2.3 Marine Mammal Occurrence – Density Estimates

The best available scientific information for ESA-listed marine mammal species that occur within the Aleutian survey action area is provided by habitat-based stratified density estimates developed by the U.S. Navy (DON 2014) for the GOA. Rone et al. (2014) defined four strata in the GOA study area: 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.

Compared to Rone et al. (2014), the proposed Aleutian survey area does not have the same habitat bathymetry, such as a gradual "slope" habitat, instead, water depths decrease rapidly to the north and south of the Aleutian Islands. To compensate for the area differences, NSF uses the Rone et al. (2014) marine mammal densities, for inshore (which was for all waters <1000 m) in both shallow (<100 m) and intermediate (100–1000 m) water depths, while offshore densities were used for all deep water areas >1000 m. For the Aleutian survey, approximately one percent of the track line is in shallow (<100 m) water depths, 26 percent in intermediate depths (100–1000 m), and the remaining 73 percent is in deep water (>1000 m).

Density data always have some uncertainty related to the estimates and the assumptions used in their calculations; however, the approach used here is based on the best available data stratified by the water depth (habitat) zones most relevant to the proposed seismic survey area. Density data estimates used to calculate exposure for ESA-listed marine mammal species are found in Table 7 and are described in more detail in Appendix B of the NSF's EA for the Aleutian Arc Geophysical Survey. DON (2014) derived gray whale densities in two zones, nearshore (0–2.25 nm from shore) and offshore (from 2.25–20 nm from shore). L–DEO used the nearshore density to represent shallow water (<100 m deep), and the offshore density for intermediate and deep water. It was assumed that 1.1 percent of gray whales that occur in the Bering Sea are from the Western North Pacific DPS (Carretta et al. 2019), and that 2.1 percent, 86.8 percent, and 11percent of humpbacks in the Aleutian Islands are from the Western Pacific DPS, Hawaii DPS, and Mexico DPS, respectively (Wade 2017). The Steller sea lion density from DoN (2014) had applied a correction factor to calculate for an area that did not contain waters close to shore, that factor was removed for waters <1000 m in the proposed survey area to more accurately reflect the densities expected to occur in the nearshore.

Table 7. Densities used for calculating exposure of ESA-listed cetaceans.

Species	Density (#/1000 km^2) in Shallow Water (< 100 meters)	Density (#/1000 km^2) in Intermediate Water (100 to 1,000 meters)	Density (#/1000 km^2) in Deep Water (> 1,000 meters)	Source (i.e. reference)

Blue Whale	0.5	0.5	0.5	Rone et al. 2014
Fin Whale	71.0	71.0	21.0	Rone et al. 2014
Gray Whale	48.57	0	0	DON 2014
Humpback Whale	129.0	129.0	1.0	Rone et al. 2014
North Pacific Right Whale	0.01	0.01	0.01	DON 2014
Sei Whale	0.10	0.10	0.10	DON 2014
Sperm whale	0.00	0.00	1.3	DON 2014
Steller Sea Lion	39.2	39.2	9.8	DON 2014

Take estimates of the of ESA-listed cetaceans and pinnipeds that could be exposed to seismic sounds with received levels equal to harm (e.g., MMPA Level A) and harassment (MMPA Level B) thresholds calculated as if there were no mitigation measures (e.g, shutdowns when PSOs observe animals approaching or that are inside the esonification zones) are given in Table 8. Exposures were estimated by NSF through calculation of 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. The area expected to be ensonified on a given day was determined by entering the planned survey lines into GIS and "drawing" the applicable 160 dB re 1 µPa (rms) TTS and PTS threshold buffers around each line. The ensonified areas, were then multiplied by the number of survey days (16.3 days). The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels as the R/V *Langseth* approaches.

The calculated takes include the assumed 25 percent additional survey operations that may take place associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard. Therefore, these estimates are precautionary, probably overestimating the actual numbers of marine mammals that could be affected by the proposed activities. Actual MMPA Level A takes are likely to be even less because the predicted Level A ensonification zones are small and mitigation measures would further reduce the chances of, if not eliminate, any such takes. Additionally, marine mammals are expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures considered harm under ESA (MMPA Level A harassment). However, the extent to which marine mammals will move away from the sound source is difficult to quantify; therefore, it is not accounted for in the exposure estimates. The Requested Take Authorization in the NSF request for an IHA was for at least the mean group size for all species when that number was higher than the calculated take.

Table 8. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation, and proposed by the National Marine Fisheries Service NMFS Permits and Conservation Division, during the Aleutian Islands seismic survey.

	NSF/L-DEO			NMFS Permits and Conservation Division		
Species	**Potential Temporary Threshold Shift and Behavioral Harassment**	**Potential Permanent Threshold Shift and Harm**	**Total**	**Potential Temporary Threshold Shift and Behavioral Harassment**	**Potential Permanent Threshold Shift and Harm**	**Total**
Blue Whale	23	2	25	23	2	25
Fin Whale	1,650	104	1,754	1,650	104	1,754
Gray Whale – Western North Pacific DPS	1	0	1	1	0	1
Humpback Whale – Mexico DPS	203	12	215	NA[1]	NA[1]	
Humpback Whale – Western North Pacific DPS	39	2	41	NA[1]	NA[1]	
North Pacific Right Whale	0	0	2	2	0	2
Sei Whale	5	0	5	5	0	5
Sperm Whale	43	0	43	43	0	43
Steller Sea Lion	907	2	909	909	0	909

[1] The proposed IHA does not separate humpback whales into DPSs.

The total estimates of exposed individuals for each endangered species by NSF and NMFS Permits and Conservation Division are the same. There is a difference between the two sets of estimates for Steller sea lions. The Permits and Conservation Division considers auditory injury as unlikely to occur for pinnipeds; therefore, NMFS Permits and Conservation Division does not expect there to be a reasonable potential for take by Level A harassment. The modeled zones of injury (Table 6) for otariid pinnipeds is very small (<12 m) and because the airgun sound source is arranged in a spatial array, the near-field sound levels are not the same as those in the far-field (see *Ensonified Area* in Appendix A for more detail). The estimated exposures above MMPA Level A harassment thresholds for Steller sea lions have been added to the estimated exposures above the MMPA Level B harassment threshold proposed for authorization. The low density of North Pacific right whales results in calculated take estimate that is less than one for either threshold. In order to account for the possibility of encountering a North Pacific right whale, NSF requested take authorization for the mean group size of 2, based on Shelden et al. (2005) Wade et al. (2011a), which NMFS Permits and Conservation Division agreed with.

Given that the proposed seismic survey will be conducted in September-October 2020, whales are expected to be feeding, traveling, or migrating in the action area and some females could have young-of-the-year accompanying them. These individuals could be exposed to the proposed seismic survey activities while they are transiting through the action area. We assume that sex distribution is even for the animals that could be exposed, except sperm whales are more likely to be males. Adult male sperm whales are generally more solitary and more likely to migrate toward the northern portion of their range, poleward of about 40 to 50° latitude (Muto et al. 2019b).

10.2.2.4 Estimated percentages of populations exposed

Blue Whale. There are 25 total expected instances of exposure e for blue whales, which is less than two percent of the Eastern North Pacific stock (current best estimate N=1,647) (Carretta et al. 2019).

Fin Whales. There are 1,754 total expected instances of exposure for fin whales. There is no current reliable estimate for the entire Northeast Pacific stock.

Western North Pacific Gray Whale. There is one potential instance of take by harassment under the ESA for the Western North Pacific DPS of gray whales, which is less than percent of the abundance estimate for that gray whale population (approximately 290) (Cooke et al. 2017). There are no expected instances of harm under the ESA.

Mexico and Western North Pacific Humpback Whale. There are 215 total expected instances of exposure for the Mexico DPS of humpback whales, which is about seven percent of the current abundance estimate of approximately 3,264 individuals for that population segment of humpbacks (81 FR 62259).

There are 41 total expected instances of exposure for the Western North Pacific DPS of humpback whales, which is about four percent of the current abundance estimate of approximately 1,107 individuals for that population segment of humpbacks(Muto et al. 2019b).

North Pacific Right Whales. There are two total expected instances of exposure for North Pacific right whales, which is about six percent of the estimated 31 individuals in the Eastern North Pacific stock (Muto et al. 2017). The two exposures are not expected to be harm under the ESA.

Sei Whale. There are five total expected instances of exposure for sei whales, which is about one percent of the estimated 519 individuals in the Eastern North Pacific stock (Carretta et al. 2019). None of the exposures are expected to be harm under the ESA.

Sperm Whale. There are 43 total expected instances of exposure for sperm whales. There is not sufficient data to estimate the population abundance of the North Pacific stock. None of the exposures are harm under the ESA.

Steller Sea Lion. There are 909 total expected instances of exposure for Steller Sea Lions, which is less than 2% of the estimated 54,267 individuals in the Western DPS of Steller sea lions in Alaska (Muto et al. 2018). None of the exposures are harm under the ESA.

10.2.3 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 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. Assessments during our consultation try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Response analyses consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

10.2.3.1 Marine Mammals and Hearing Threshold Shifts

Exposure of marine mammals to very strong impulsive sound sources from the 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 and 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 following TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either TTS or PTS is 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, although it is less evident in broadband noise sound sources that are associated with the proposed action (Kastak 2005; Ketten 2012; Schlundt et al. 2000). Both TTS and PTS 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 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. 2007a). Threshold distances from full operation of the airgun array for this survey that place marine mammals within risk of TTS and PTS can be found in Table 5 and Table 6, respectively.

A few individuals could be exposed to sound levels that may result in TTS, but we expect the probability to be low and there are several reasons we do not expect long-term effects to any ESA-listed marine mammals. Most individuals are expected to move away from the airgun array as it approaches. Sound intensity received by ESA-listed individuals increases as the seismic survey approaches and the conditions they experience (stress, loss of prey, discomfort, etc.) prompt them to move away from the sound source, thus avoiding more intense exposure that could 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 would therefore be unlikely to be exposed to more injurious sound levels. Furthermore, mitigation measures will be in place to initiate a shutdown 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 to result in any of the ESA-listed marine mammals as described above.

As stated previously, potential exposure to 160 dB re: 1 µPa (rms) is not expected to produce a cumulative TTS or other physical injury for several reasons. We expect that individuals will recover from TTS between each potential exposure. Monitoring is expected to produce some degree of mitigation such that exposures will be reduced. When individuals generally move away from the sound source, at least a short distance, the likelihood of consequences from exposure is reduced. 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.

10.2.3.2 Marine Mammals and Auditory Interference (Masking)

As discussed in other sections of this opinion, 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 (Clark et al. 2009; Erbe et al. 2016). 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 and 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. The proposed seismic surveys could mask whale calls at some of the lower frequencies for these species. This could affect their communication, ability to perceive their environment, and affect echolocation for sperm whales (Evans 1998; NMFS 2006h). Findings by Madsen et al. (2006) suggest airgun array pulses can overlap with frequencies of sperm whale clicks, which are concentrated at 2 to 4 kHz and 10 to 16 kHz , although the strongest airgun spectrum levels are below 200 Hz (2 to 188 Hz for the R/V *Langseth*'s airgun array). Given the disparity between sperm whale echolocation and communication-related sound frequencies and the dominant frequencies for the seismic survey, masking is not likely to be significant for sperm whales (NMFS 2006h). Any masking that might occur will likely be temporary because acoustic sources from the seismic surveys are not continuous and the research vessel continues to transit through the area.

Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls could pose a somewhat greater risk of masking. The R/V *Langseth*'s airguns will emit an approximate 0.1 second pulse when fired at intervals of approximately every 22 or every 120 seconds. Therefore, pulses are not expected to "cover up" the vocalizations of ESA-listed baleen whales 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. Studies of how impulsive sound deforms from short bursts to lengthened waveforms in the marine environment are limited, but evidence suggests it can add considerably to the acoustic background (Guerra et al. 2011). Therefore, it has the potential to interfere with an animal's ability to detect sounds in its environment.

The sound localization abilities of marine mammals suggest that masking will not be as severe as the usual types of masking studies might suggest if signal and sound come from different directions (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 and Dahlheim 1994; Bain et al. 1993; Dubrovskiy and 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 and Pawloski 1990; Romanenko and 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 is 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. 1995a). 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 is expected to be more prominent for lower frequencies, such those used by baleen whales for communication. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects.

10.2.3.3 Marine Mammals and Behavioral Responses

We expect the greatest response of marine mammals to airgun sounds, in terms of the number of responses and overall impact, to be in the form of behavioral changes. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance from the sound source. Some of these responses could equate to harassment of individuals under the ESA but are unlikely to result in meaningful 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. However, given the short duration of the proposed seismic survey, this will not be the case for this action.

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; Harris et al. 2018). This is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Costa et al. 2016; Fleishman et al. 2016; Francis and Barber 2013; New et al. 2014; NRC 2005). Studies from non-ESA-listed species and from outside the action area can provide relevance in determining the responses expected by the species for which adverse effects of the proposed action are likely to occur. Animals generally respond to anthropogenic perturbations as they do to predators, by increasing vigilance and altering habitat selection (Reep et al. 2011). There is increasing support that this prey-like response is true for animals' responses to anthropogenic sound (Harris et al. 2018). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect that it is 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 airgun sounds. Whales have continued 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 and 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. 2012a). 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 or evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of 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 and Clark 2009). Sperm whales may be sensitive to airgun sounds, at least under some conditions, 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 whale species considered in this consultation, some exposed individuals may cease calling in response to the airgun array, but the effect is expected to be temporary and brief given the constant movement of the vessel when seismic airguns are active and the short duration of the survey. 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 to marine mammals) as the received sound level that causes behavioral responses other than vocalization changes (Richardson et al. 1995a). Available data indicate that most, if not all, baleen whale species exhibit avoidance of active seismic airguns (Barkaszi et al. 2012; Castellote et al. 2012a; Castellote et al. 2012b; Gordon et al. 2003; NAS 2017; Potter et al. 2007; Southall et al. 2007a; Southall et al. 2007b; Stone et al. 2017; Stone and Tasker 2006). The activity in which individuals are engaged seems to influence response (Robertson et al. 2013), and feeding individuals respond less than mother and calf pairs or migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984a; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995a; Richardson et al. 1999).

Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 µPa (rms) (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984b; Malme et al. 1987; Malme et al. 1986; Meier et al. 2007; Würsig et al. 1999; Yazvenko et al. 2007). 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 and Miles 1985; Malme et al. 1984b; Malme et al. 1984a). Habitat continues to be used despite frequent seismic survey activity and long-term effects have not been identified, (Malme et al. 1984a). Johnson et al. (2007b) 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. When strict mitigation measures, such as those proposed by the NMFS Permits and Conservation Division, are taken to avoid conducting seismic surveys during certain times of the year when most gray whales are expected to be present and to closely monitor operations, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016).

Humpback whales exhibit lower tolerances 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 nm) 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). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 km (1.6 nm) at levels of 140 dB re: 1 μPa^2-second.

Feeding humpback whales have displayed higher levels of tolerance. Humpback whales off the coast of 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. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. 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).

Multiple factors may contribute to the degree of response exhibited by migrating humpback whales. Researchers found responses by migrating humpback whales to exposure to sound from a 20-in^3 airgun 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. A recent study examining the response of migrating humpback whales to a full 51,291.5 cm^3 (3,130 in^3) airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array, and while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017). While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). 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).

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 et al. 2017; Stone and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities), as well as whales being more distant during seismic operations (Moulton et al. 2006a; Moulton et al. 2006b; Moulton and Miller 2005). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1 µPa (rms) (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior), or no reaction. Several studies have found 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 and Miller 2005; Stone 2003; Stone and 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 and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2003; Jochens and Biggs 2004; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 µPa. 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 any patterns in the distribution of satellite-tagged sperm whales, at and beyond 5 km (2.7 nm) from airgun arrays in the Gulf of Mexico, to suggest individuals were displaced or moved away from the airgun noise (Winsor and Mate 2013). No tagged whales occurred within 5 km (2.7 nm) during the study, but marine mammal observer data from other seismic operations, during the same years and areas used by tagged subjects, recorded 12 occurrences of sperm whales at less than 1.15 km away (Winsor and Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 km (27 nm).

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. 1995a). Sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 µPa lower at 1 kHz and 60 dB re: 1 µPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975).

Reactions to impulse noise (airguns are an impulsive sound source) likely vary depending on the activity at time of exposure. Toothed whales sometimes are extremely tolerant of noise pulses, such as in the presence of abundant food or during breeding encounters (NMFS 2006b).

We expect ESA-listed whales exposed to sound from the airgun array considered in this consultation to exhibit avoidance reactions similar to the behavioral responses described for different species above. Individuals could be displaced from the action area, at least temporarily. Secondary foraging areas are expected to be available, allowing whales to continue feeding. Breeding is not expected to be occurring during the time period of the action, but other essential behaviors such as travel or migration are also expected to continue on the part of individuals transiting through the area during the proposed activities.

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. Ranges to some behavioral impacts could take place at distances exceeding 100 km (54 nm), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. 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).

In summary, ESA-listed marine mammals are expected to exhibit a wide range of behavioral responses when exposed to sound fields from the airgun array. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Toothed whales (i.e., sperm whales) are expected to exhibit less overt behavioral changes but may alter foraging behavior, including echolocation vocalizations. Behavioral reactions for Steller sea lions would be short-term, likely lasting the duration of the exposure to the sound source as it continuously transits, and behavioral reactions are typically not expected to be significant. In general, long-term consequences for individuals or populations are unlikely.

10.2.3.4 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 (Romano et al. 2002), that may have adverse effects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007b; Tal et al. 2015; Zimmer and Tyack 2007), but, similar to stress, these effects are not readily observable. Importantly, these more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, not seismic airguns. We do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses as a result of the proposed seismic survey activities.

Stress is an adaptive response and does not normally place an animal at risk. 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 and Schmid 2001; Gulland et al. 1999; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and 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 and Gulland 2001; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia 2008; Noda et al. 2007; Thomson and 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 and Curry 1998; Cowan and Curry 2002; Cowan 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner and 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 sounds 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 can 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 sound 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. 2012a; Rolland et al. 2012b). These levels returned to baseline after 24 hours of vessel traffic returning to pre-9/11 levels.

Because whales use hearing as a primary way to communicate and gather information about their environment, we assume that limiting these abilities will be stressful. Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the ESA harassment (MMPA Level B harassment) 160 dB re: 1 µPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, because exposure to sounds from airgun arrays operated as part of the proposed action are expected to be temporary, we expect any such stress responses to be short-term. Given the available data, animals are expected to return to baseline state (e.g., baseline cortisol level pre-airgun array operation) within hours to days, with the duration of the stress response depending on the severity of the exposure. Although we do not have a way to determine the health of the animal at the time of exposure, we assume that the stress responses resulting from these exposures could be more significant or exacerbate other factors if an animal is already in a compromised state.

Data regarding other non-auditory physical and physiological responses to sound specific to cetaceans is generally lacking. In studies of other vertebrates, exposure to loud sound may adversely affect reproductive and metabolic physiology (reviewed in Kight and Swaddle 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. Fish eggs and embryos exposed to sound levels only 15 dB greater than background showed increased mortality and surviving fry and slower growth rates, although the opposite trends have also been found in sea bream. Studies of rats have shown that their small intestine 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). In addition, exposure to 12 hours of loud sound may alter cardiac tissue in rats. In a variety of response categories, including behavioral and physiological responses, female animals appear to be more sensitive or respond more strongly than males. It is noteworthy that although various exposures to loud sound appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa. Clearly, the impacts of even loud sounds are complex and not universally negative (Kight and Swaddle 2011). Given the available data and the short duration of exposure to sounds generated by airgun arrays associated with the proposed action, we do not anticipate any effects to the reproductive and metabolic physiology of ESA-listed marine mammals.

It is possible that an animal's prior exposure to sounds from seismic surveys influences its future response. There is little information available to understand what responses an individual may have to future seismic survey exposures as compared to prior experience. If prior exposure produces a learned response, it will likely be similar to or less than prior responses to other novel stimulus stressors with behavioral consequences, such as moving away and reduced time budget for activities otherwise undertaken (Andre 1997; André 1997; Gordon et al. 2006). We do not believe sensitization, more intense, and/or earlier response to subsequent exposures will occur based upon the lack of severe responses previously observed in marine mammals exposed to seismic survey sounds. There is potential for cetaceans to habituate to airgun array sounds which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015), The short-term, transient nature of this survey should minimize the likelihood that sensitization or habituation will occur.

10.2.3.5 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 nm) offshore in 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 and 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. Therefore, we do not expect ESA-listed marine mammals to strand as a result of the proposed seismic survey.

10.2.3.6 Responses of Marine Mammal Prey

Seismic surveys may also have adverse effects on ESA-listed marine mammals by affecting their prey (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Potential prey that may be affected by exposure to sound from the airgun array include fishes, zooplankton, cephalopods, and other invertebrates such as crustaceans, molluscs, and jellyfish. Carroll et al. (2017) summarized an extensive review of information available on the impact seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals is not available. Until more specific information becomes available, we expect that the prey of ESA-listed marine mammals will respond to sound associated with the proposed action in a similar manner to those fishes and invertebrates described below (information derived from Carroll et al. (2017) unless otherwise noted).

Seismic surveys can cause physical and physiological responses in fishes and invertebrates, including direct mortality. Responses appear to be highly variable in fishes and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Data indicate that possible responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. Research is more limited for invertebrates, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality in some cases. In crustaceans and bivalves, there are mixed results with some studies suggesting that seismic surveys do not result in meaningful physiological and/or physical effects, while others indicate such effects may be possible under certain circumstances. There can be differing results even within studies, depending on what aspect of physiology one examines (e.g., Fitzgibbon et al. 2017). Discrepancies can occur between observational field studies and more controlled experimental studies. A relatively uncontrolled field study did not find significant differences in mortality between oysters that were exposed to a full seismic airgun array and those that were not (Parry et al. 2002). A more controlled study found significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure (Day et al. 2017), although the increased mortality was not significantly different from expected natural mortality. Another laboratory study observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013). All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, we assume that some fishes and invertebrates may experience physical and physiological effects, including mortality, but in most cases, such effects are only expected at relatively close distances to the sound source.

Cases of fish or invertebrate mortality resulting from exposure to airguns are limited to close-range exposure to high amplitudes (Bjarti 2002; D'Amelio 1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000b; McCauley et al. 2000c; 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 and Knutsen 1986).

There are reports showing sub-lethal effects to some fish species. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: 1 µPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 μPa^2-second, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al. 2005). 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 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 µPa (Falk and Lawrence 1973).

Recently there has been research suggesting that 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 (approximately 150 in^3) 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. Effects were found up to 1.2 km (0.6 nm) out, which is the maximum distance the sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic survey 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, largely due to the fast turnover rate of zooplankton. Three-dimensional seismic surveys that involve multiple overlapping tracklines for intensive surveys are of particular concern (McCauley et al. 2017). However, data from Fields et al. (2019) showed limited effects on the mortality or escape response of *Calanus finmarchicus* within 10 m (32.8 ft) of seismic blasts from two airguns (260 in^3) and no measurable impact at greater distances. Fields et al. (2019) concluded that the impacts to *C. finmarchicus* observed from their series of control experiments were much less than reported by McCauley et al. (2017).

Results of McCauley et al. (2017) excluded analyses of zooplankton at the surface where the majority of copepod prey (available to baleen whales or fishes that are prey of these whales) is expected to be (Witherington et al. 2012). Airguns primarily transmit sound downward and the array in the proposed action will be towed at depths of nine m (29.5 ft). Sounds from this array should be relatively low at the surface. The proposed seismic survey may temporarily alter copepod or crustacean abundance in the action area, but when considering sound from the airgun array is expected to be relatively low near the surface and the high turnover rate of zooplankton combined with ocean circulation, we expect such effects to be extremely localized. We are not aware of specific studies regarding sound effects on krill (*Euphausiacea* spp.), an important prey of most ESA-listed baleen whales, but we expect the effects would be similar to other zooplankton crustaceans.

The prey of ESA-listed marine mammals may also exhibit behavioral responses if exposed to active seismic airgun arrays. As reviewed by Carroll et al. (2017), considerable variation exists in how fishes behaviorally respond to seismic survey activities, with some studies indicating no response and others noting startle or alarm responses and/or avoidance behavior. However, no effects to foraging or reproduction have been documented. Data on the behavioral response of invertebrates similarly suggest that some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. Charifi et al. (2017) found that oysters appear to close their valves in response to low frequency sinusoidal sounds and Day et al. (2017) found that scallops exhibit behavioral responses such as flinching, when exposed to seismic airgun array sounds but none of the observed behavioral responses were considered to be energetically costly. As with marine mammals, behavioral responses by fishes and invertebrates may also be associated with a stress response.

A common response by fishes to airgun sound 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 (Davidsen et al. 2019; Fewtrell 2013a). During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) to generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). In addition, Davidsen et al. (2019) performed controlled exposure experiments on Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) to test their response to airgun noise. Davidsen et al. (2019) noted the cod exhibited reduced heart rate (bradycardia) in response to the particle motion component of the sound from the airgun, indicative of an initial flight response; however, no behavioral startle response to the airgun was observed. Both the Atlantic cod and saithe changed both swimming depth and horizontal position more frequently during airgun sound production (Davidsen et al. 2019).

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 dB 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 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 km (1.3 nm) 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 and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and 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; 2000b) 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 (Thomsen 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 and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994).

Increased swimming activity in response to airgun exposure in fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate the survey area during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1 μPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five-month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no difference in trawl catch data before and after seismic survey activities, and echosurveys of fish occurrence did not reveal differences in pelagic biomass.

Squid are known 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 (Fewtrell 2013b; McCauley et al. 2000b; McCauley et al. 2000c). 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). 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 sound pressure level 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, which has implications for loss of prey for sperm whales.

Available data indicate seismic survey activities could result in temporary and minor reduction in the availability of prey for ESA-listed species near the active airgun array. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. We expect that if fish or squid detect the sound and perceive it as a threat or some other signal, they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort and will return to the area and return to being available as prey for marine mammals. We do not expect any temporary movement of prey species out of the action area to have a meaningful immediate impact on ESA-listed marine mammals, because we believe that those mammals will mostly avoid closely approaching the airgun array when it is active; therefore, the animals will not be in areas where prey have been affected. We do not expect effects from airgun array operations through temporary reduced feeding opportunities for ESA-listed marine mammals in the action area to reach a significant level. Effects are likely to be temporary and, if displaced, both marine mammals and their prey will re-distribute back into the action area once seismic survey activities have concluded.

10.3 Risk Analysis

In this section, we assess the consequences of the responses to the individuals that have been exposed to sounds from the use of airgun arrays, the populations those individuals represent, and the species those populations comprise. 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 affect the viability of the populations to which those individuals belong, or the species those populations comprise. As a result, if 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.

We expect that up to 25 blue, 1,754 fin, 1 Western North Pacific gray, 215 Mexico DPS humpback, 41 Western North Pacific DPS humpback, 2 North Pacific right, 5 sei, 43 sperm whales as well as 909 Western DPS Steller sea lions (see Table 8), to be exposed to the airgun array within 160 dB re: 1 µPa (rms) ensonified areas during the seismic survey. Because of the mitigation measures developed by NSF and those required by the IHA, 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, gray, humpback, North Pacific right, sei, sperm whales, or Steller sea lions). 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. Any reductions in fitness experienced by the ESA-listed marine mammals exposed to this action's effects are not expected to have any severity that would have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise.

Estimates of take provided by NSF and NMFS Permits and Conservation Division are considered conservative, that is they are likely higher than the actual exposures and the mitigation measures that will be implemented will further reduce exposure of marine mammals to acoustic stressors resulting from operation of the airgun array. Conservative take estimates can lead to overestimating the potential exposure of ESA-listed populations. It is also likely that take may occur more than once within the action area for an individual animal, resulting in a smaller total number of individuals exposed. The seismic survey activities will be relatively short in duration and the ESA-listed species being considered here have large ranges, especially the cetaceans, compared to the relatively small size of the NSF's action area.

11 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During the writing of this opinion, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. Based on our search of electronic media, including state agency information, we did not find information regarding additional 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* of this opinion. Similarly, we are not aware of any proposed or anticipated changes in these activities that would substantially change their impacts on ESA-listed blue, fin, Western North Pacific gray, Mexico DPS humpback, Western North Pacific DPS humpback, North Pacific right, sei, and sperm whales, and Western DPS Steller sea lions.

12 Integration and Synthesis

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 9) to the *Environmental Baseline* (Section 10) and the *Cumulative Effects* (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to 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. This assessment is made in full consideration of the *Endangered Species Act Resources that may be Affected* (Section 6).

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the contined existence of a listed species," which is "to engage in an action that would be expected to, directly or indirectly, 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 following discussions separately summarize the probable risks the proposed action poses to blue, fin, Western North Pacific gray, Mexico DPS humpback, Western North Pacific DPS humpback, North Pacific right, sei, and sperm whales, and Western DPS Steller sea lions.

These summaries integrate the exposure profiles presented previously with the results of our response analyses for the use of the airgun array, which was considered further in this opinion.

12.1 Blue Whale

No reduction in the distribution or geographic range of blue whales in the Pacific Ocean is expected because of the NSF’s seismic survey activities and the NMFS Permits and Conservation Division’s issuance of an IHA.

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), Central North Pacific Ocean (N=133, N_{min}=63) (Carretta et al. 2019), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440)(Waring et al. 2010). 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 whales. Therefore, no reduction in numbers or reproduction is anticipated as part of the proposed actions. The estimated harm is anticipated to be two individuals in the form of non-lethal PTS and 23 individuals may experience harassment primarily in the form of behavioral disturbance, but some TTS may also occur to these individuals. Because we do not anticipate a significant reduction in numbers or population-level reproduction of blue whales as a result of the proposed seismic survey activities and the Permits and Conservation Division’s issuance of an IHA, a reduction in the species’ likelihood of survival is not expected.

The 1998 Final Recovery Plan for the blue whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Reduce or eliminate human-caused injury and mortality of blue whales.

- Minimize detrimental effects of directed vessel interactions with blue whales.

Because no significant changes in 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. Therefore, we conclude that the proposed action will not jeopardize the continued existence of blue whales.

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 three fin whale stocks designated under the MMPA in U.S. Pacific Ocean waters: California/Oregon/Washington (approximately 9,029 individuals, N_{min}=8,127)(Carretta et al. 2019), Hawaii (approximately 154 individuals, N_{min}=75) and Northeast Pacific (no current reliable abundance estimate)(Muto et al. 2019b).

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 an annual growth rate of 4.8 percent in the Northeast Pacific stock (Muto et al. 2019b) and a stable population abundance in the California/Oregon/Washington stock (Carretta et al. 2019). 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 estimated harm is anticipated to be 104 individuals in the form of non-lethal (PTS) and 1,650 individuals being harassed as a result of TTS (behavioral responses, etc.). Because we do not anticipate a reduction in numbers or population-level 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 Gray Whale – Western North Pacific Distinct Population Segment

No reduction in the distribution of Western North Pacific DPS of gray whales 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 abundance of the Western North Pacific DPS of gray whales is unknown. By 1910, after some commercial exploitation had already occurred, it is estimated that only 1,000 to 1,500 gray whales remained in the Western North Pacific population (Berzin and Vladimirov 1981). By the 1930s it was speculated that gray whales in the Western North Pacific could be extinct (Bowen 1974; Mizue 1951). Estimated population size from photo-ID data in 2016 was estimated at 290 whales (N_{min}=271) (Cooke et al. 2017). The combined Sakhalin Island and Kamchatka populations were estimated to be increasing from 2005 through 2016 at an average rate between 2-5% annually (Cooke et al. 2017).

It is estimated there could be one Western North Pacific DPS gray whale harassed as a result of the proposed seismic surveys and no occurrence of harm expected. No reduction in numbers is anticipated as part of the proposed actions, therefore, no reduction in reproduction is expected. 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 the Western North Pacific DPS of gray whales in the wild.

There is no Recovery Plan for the Western North Pacific gray whale because listed species that reside mostly outside of U.S. jurisdiction are considered not likely to benefit from recovery planning efforts.

12.4 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 and Palumbi 2003). The current abundance estimate for the Mexico DPS of humpback whales is 3,264 individuals (81 FR 62259). 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 is estimated to be 12 individuals harmed and 203 individual humpback whales (Mexico DPS) harassed as a result of the proposed seismic surveys. Because we do not anticipate a reduction in numbers or population-level 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.

The 1991 Final Recovery Plan for the Humpback whale lists the following objective relevant to the impacts of the proposed actions:

- Identify and reduce direct human-related injury and mortality.

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 objective for this 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 Mexico DPS of humpback whales in the wild.

12.5 Humpback Whale – Western North 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 and Palumbi 2003). The current abundance of the Western North Pacific DPS is 1,107 (Muto et al. 2019b). 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 estimated to be 2 individual harmed and 39 individuals humpback whales (Western North Pacific DPS) harassed as a result of the proposed seismic surveys.

Because we do not anticipate a reduction in numbers or population-level reproduction of the Western North Pacific 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.

The 1991 Final Recovery Plan for the Humpback whale lists the following objective relevant to the impacts of the proposed actions:

- Identify and reduce direct human-related injury and mortality.

Because no mortalities or effects on the distribution of Western North 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 objective for Western North 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 North Pacific DPS of humpback whales in the wild.

12.6 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 only two potential occurrences 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. 2011b) 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 right whale. The estimated 2 individuals 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 anticipation 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.

12.7 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. Two relatively small stocks occur in U.S. waters of the Pacific ocean: Hawaii (N=391, N_{min}=204), and Eastern North Pacific (N=519, N_{min}=374) (Carretta et al. 2019). 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 estimated to be 5 sei whales harassed as a result of the proposed seismic surveys and no occurrence of harm to any sei whales. 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.

12.8 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 of the three U.S. stocks that occur in the Pacific, the California/Oregon/Washington stock, estimated to consist of 1,997 individuals (N_{min}=1,270), and the Hawaii stock, estimated to consist of 4,559 individuals (N_{min}=3,478)(Carretta et al. 2019). 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. 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 action. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are estimated to be 43 individual sperm whales harassed as a result of the proposed seismic surveys and no individuals harmed. Because we do not anticipate a reduction in numbers or population-level 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.

12.9 Steller Sea Lion – Western Distinct Population Segment

No reduction in the distribution of Steller sea lions from the Western DPS are expected because of the NSF’s seismic survey activities and the Permits and Conservation Division’s issuance of an incidental harassment authorization.

Estimated population size for the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups in 2017 (total N_{min}= 54,267) (Muto et al. 2018). This less than half of the historical 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 (approximately 170°W) and generally negative trends to the west in the Aleutian Islands (Muto et al. 2018). 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 (Muto et al. 2018).

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 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).

There are estimated to be 909 individual Steller sea lions harassed as a result of the proposed seismic survey and no individuals harmed. No reduction in numbers is anticipated from the proposed actions, therefore no reduction in population-level reproduction is 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:

- Insure adequate habitat and range for recovery
- Protect from over-utilization for commercial, recreational, scientific, or educational purposes.
- Protect from other natural or anthropogenic actions and administer the recovery program.

No mortalities or effects on the distribution of Steller sea lions are expected as a result of the proposed actions, we therefore 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 Conclusion

After reviewing the current status of the ESA-listed species, the effects of the proposed action, and cumulative effects, it is NMFS biological opinion that the proposed action is not likely to jeopardize the continued existence of North Pacific right whales, Western North Pacific DPS of gray whales, Western North Pacific DPS of humpback whales, Mexico DPS of humpback whales, blue whales, fin whales, sei whales, sperm whales, and Western DPS of Steller sea lions.

It is also NMFS biological opinion, that the action is not likely to adversely affect the following ESA-listed species: Central North Pacific distinct population segment (DPS) and East Pacific DPS of green turtle (*Chelonia mydas*); leatherback turtle (*Dermochelys coriacea*); North Pacific Ocean DPS of loggerhead turtle (*Caretta caretta*); Mexico's Pacific Coast breeding colonies and all other areas of olive ridley turtle (*Lepidochelys olivacea*); lower Columbia River evolutionary significant unit (ESU), upper Columbia River spring-run ESU, Puget Sound ESU, Snake River fall-run ESU, Snake River spring/summer ESU, and Upper Willamette River ESU of chinook salmon (*Oncorhynchus tshawytscha)*; Hood Canal summer-run ESU of chum salmon (*Oncorhynchus keta*); lower Columbia River ESU of coho salmon (*Oncorhynchus kisutch*); Snake River ESU of sockeye salmon (*Oncorhynchus nerka*); lower Columbia River DPS, middle Columbia River DPS, Snake River Basin DPS, upper Columbia River DPS, and upper Willamette River DPS of steelhead trout (*Oncorhynchus mykiss*); and Southern DPS of green sturgeon (*Acipenser medirostris*).

It is also NMFS biological opinion, that the action is not likely to adversely affect designated critical habitat for the Western DPS of Steller sea lions (*Eumetopias jubatus*).

14 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. Section 7(o)(2) provides 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.

ESA section 7(b)(4)(C) provides that take of ESA-listed marine mammals may be included in the ITS of a biological opinion only if the taking is authorized under MMPA section 101(a)(5). 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.

14.1 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. The extent of take specifies the impact,, which 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).

We anticipate the proposed seismic survey in the Andreanof Islands of the Aleutian Arc is likely to result in the incidental take of ESA-listed marine mammals from exposure to acoustic energy during airgun array operations. The impacts of the incidental take are limited to the numerical exposures described in Table 8 of this biological opinion by the NMFS Permits and Conservation Division. Table 8 describes the number of takes under the MMPA and delineates the maximum extent of the incidental takes we anticipate under the ESA. Not all the exposures described in Table 8 will necessarily constitute takes under the ESA.

No death or injury of any ESA-listed individuals exposed to sound from the airgun array is expected. It is believed that any PTS resulting from the proposed activity would not result in total deafness, and would be unlikely to affect the longer-term fitness of any individuals. Therefore, PTS, TTS, and behavioral harassment are anticipated to result in non-lethal take.

14.2 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 RPMs, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions 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 blue, fin, Western North Pacific gray, Mexico DPS humpback, Western North Pacific DPS humpback, North Pacific right, sei and sperm whales, and Western DPS Steller sea lions:

- The NMFS Permits and Conservation Division must ensure that the NSF implement a program to mitigate, monitor, 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, gray (Western North Pacific DPS), humpack (Mexico DPS and Western North Pacific DPS), North Pacific right, sei, and sperm whales, and Steller sea lions (Western DPS). In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and inform the NMFS ESA Interagency Cooperation Division immediately upon determining that a planned activity may exceed or has exceeded the expected levels of take in this ITS.

- 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 blue, fin, gray (Western North Pacific DPS), humpack (Mexico DPS and Western North Pacific DPS), North Pacific right, sei, and sperm whales, and Steller sea lions (Western DPS) that may rise to the level of take.

14.3 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 RPMs 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 to implement the associated RPMS, the protective coverage of section 7(o)(2) may lapse.

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 IHA, 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.

15 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 IHAs that are consistent with the ESA section 7(a)(1) obligation and therefore should be carried out by NSF and NMFS Permits and Conservation Division:

1. We recommend that the NSF promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle, fish, and invertebrate species.

2. 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.
3. We recommend that the NSF seek information and high quality data to refine current models, and/or use other relevant models, of potential impacts to ESA-listed species from seismic surveys and validate assumptions used in effects analyses.
4. We recommend that the NSF conduct sound source verification in study areas (and future locations) to validate predicted and modeled isopleth distances to ESA harm and harassment thresholds. These utilize results can be used to improve estimates of received sound levels and guide subsequent needs for mitigation for future seismic survey activities.
5. 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 IHAs for seismic surveys.
6. We recommend the NSF use (and NMFS Permits and Conservation require in MMPA incidental take authorizations and IHAs) 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 versus the binocular and naked eye methods.
7. We recommend the NSF use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys for post-seismic survey activities take analysis and use in monitoring reports.
8. We recommend the NSF and NMFS Permits and Conservation Division collaborate 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 PSO reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only aid in understanding 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.
9. We recommend the NSF utilize real-time cetacean sighting services such as the WhaleAlert application (http://www.whalealert.org/). We recognize that the research vessel may not have reliable internet access during operations far offshore and in remote locations, but access may be better in some nearshore locations where many of the cetaceans considered in this opinion are likely found in greater numbers. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed cetacean sightings, and may also be valuable for alerting others of ESA-listed cetaceans in the area to aid avoidance.
10. We recommend the NSF submit their monitoring data (i.e., visual sightings) from PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of

Megavertebrate Populations online database (http://seamap.env.duke.edu/) so that it can be added to the aggregate global marine mammal, seabird, sea turtle, and fish observation data.

11. 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.
12. 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 to aid avoidance and relay information to PSOs.

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 NSF and 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.

16 Reinitiation Notice

This concludes formal consultation for the NSF proposed marine geophysical survey by the R/V *Marcus G. Langseth* in the Andreanof Islands portion of the Aleutian Arc in Alaska and the NMFS Permits and Conservation Division's issuance of an IHA pursuant to Section 101(a)(5)(D) of the MMPA. Consistent with 50 C.F.R. §402.16 (a), reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(1) The 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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18 APPENDICES

18.1 Appendix A – Proposed Incidental Harassment Authorization

The text below was taken directly from the final incidental harassment authorization provided to us from the NMFS Permits and Conservation Division.

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 geophysical survey in the Aleutian Islands, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for marine geophysical survey activity, as specified in L-DEO's IHA application.

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. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

   (c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (d) During use of the acoustic source, if any marine mammal species that are not listed in Table 1 appear within or enter the Level B harassment zone (Table 3) the acoustic source must be shut down.

   (e) L-DEO must ensure that relevant vessel personnel and PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Measures

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

(a) L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, 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 must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

(b) At least one visual and two acoustic PSOs 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 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 of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(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. Estimated harassment zones are provided in Tables 2-3 for reference.

(iii) Visual PSOs must immediately communicate all 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) When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

(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.

(e) Exclusion zone and buffer zone

(i) Except as provided below in 4(e)(ii), the PSOs must establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1,000 m). The 1,000-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the exclusion zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

(ii) An extended 1,500-m exclusion zone must be established for all beaked whales. No buffer zone is required.

(f) Pre-start 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-start 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 all other odontocetes, including sperm whales, beaked whales, killer whales, and Risso’s dolphins).

(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 visual observation or acoustic detection 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, but such observation must be communicated to the operator to prepare for the potential shutdown.

(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 (*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-start 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-start clearance watch 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-start clearance watch.

(g) Shutdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source.

(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 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 (1) a marine mammal (excluding delphinids of the genera described in 4(g)(v)) 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 dispute regarding a PSO shutdown must be resolved after deactivation.

(iv) The airgun array must be shut down if any of the following are detected at any distance:

1. North Pacific right whale.

2. Large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).

3. Aggregation of six or more large whales.

(v) The shutdown requirement shall be waived for Pacific white-sided dolphins and northern right whale dolphins.

a. If a small delphinid (individual of the Family Delphinidae, which includes the aforementioned dolphin species), is visually and/or acoustically detected and localized within the exclusion zone, no shutdown is required unless the acoustic PSO or a visual PSO confirms the individual to be of a genera other than those listed above, in which case a shutdown is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shutdown.

(vi) 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 all other odontocetes, including sperm whales, beaked whales, killer whales, and Risso’s dolphins) with no further observation of the marine mammal(s).

(h) Vessel strike avoidance:

(i) Vessel operator and crew 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 mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

(ii) Vessel speeds must also be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

(iii) The vessel must maintain a minimum separation distance of 500 m from right whales. If a whale is observed but cannot be confirmed as a species other than a right whale, the vessel operator must assume that it is a right whale and take appropriate action.

(iv) The vessel must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

(v) The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

(vi) When marine mammals are sighted while a vessel is underway, the vessel shall take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). 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 does not apply to any vessel towing gear or any vessel that is navigationally constrained.

(vii) These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring must be conducted in accordance with the following requirements:

(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 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 an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

(iii) Global Positioning Unit (GPS) (plus backup).

(iv) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

(v) Compass (plus backup).

(vi) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

(vii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must have successfully completed an acceptable 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.

(ii) NMFS must review and approve PSO resumes.

(iii) 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.

(iv) 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. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) 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.

(v) 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.

(vi) 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.

(vii) 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 name and call sign;

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-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any marine mammal, 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 must 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. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

(ii) Summary of all data required to be collected (see 5(d));

(iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iii) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal 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; and

(vi) Raw observational data.

(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), NMFS and the NMFS Alaska Regional Stranding Coordinator as soon as feasible. The report must include the following information:

a. 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 the Alaska Regional Stranding Coordinator 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).

7. 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:

(a) 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 L-DEO that the shutdown around the animals' location is no longer needed.

(b) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

(c) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with L-DEO 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.

(d) 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, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO 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.

(i) 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

(ii) 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.

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.

8. 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.

9. Renewals - On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

   (a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (recognizing that the Renewal IHA expiration date cannot extend beyond one year from expiration of the initial IHA).

   (b) The request for renewal must include the following:

      (i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

      (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 will remain the same and appropriate, and the findings in the initial IHA remain valid.

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

Table 1. Numbers of Incidental Take of Marine Mammals Authorized.

Species	Authorized Take	
	Level B	Level A
North Pacific right whale	2	0
Humpback whale	1,842	106
Blue whale	23	2
Fin whale	1,650	104
Sei whale	5	0
Minke whale	27	2
Gray whale (ENP)	61	1
Gray whale (WNP)	1	0
Sperm whale	43	0
Baird's beaked whale	24	0
Sato’s beaked whale	9	0
Cuvier’s beaked whale	106	0
Stejneger’s beaked whale	47	0
Pacific white-sided dolphin	1,002	0
Northern right-whale dolphin	58	0
Risso’s dolphin	22	0
Killer whale	141	0
Dall's porpoise	4,312	157
Harbor porpoise	679	23
Northern fur seal	789	0
Steller sea lion	909	0
Northern elephant seal	106	0
Harbor seal	149	0
Spotted seal	5	0
Ribbon seal	5	0

Table 2. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds.

Airgun Configuration	Threshold	Level A harassment zone (m)				
		LF cetaceans	MF cetaceans	HF cetaceans	Phocids	Otariids
36-airgun array (6,600 in^3)	SEL_{cum}	376	0	1	10	0
	Peak	39	14	229	42	11
18-airgun array (3,300 in^3)	SEL_{cum}	55	0	0	2	0
	Peak	23	11	119	25	10

Table 3. Modeled Radial Distances (m) to Isopleths Corresponding to Level B Harassment Threshold.

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
18-airgun array (3,300 in^3)	>1,000	3,562
	100-1,000	3,939
	<100	5,263
36-airgun array (6,600 in^3)	>1,000	5,629
	100-1,000	8,233
	<100	11,000