NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on the Lamont-Doherty Earth Observatory's Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the Western Gulf of Alaska and National Marine Fisheries Service Permits and Conservation Division's Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Action Agency: National Science Foundation-Division of Ocean Sciences and the National Oceanic Atmospheric Administration National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division

Publisher: Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved: Donna S. Wieting

Donna S. Wieting
Director, Office of Protected Resources

Date: MAY 3 1 2019

Consultation Tracking number: OPR-2018-00010

Digital Object Identifier (DOI): https://doi.org/10.25923/vvja-kn52

This page left blank intentionally

Table of Contents

Page

List of Tables

Page

LIST OF FIGURES

1 INTRODUCTION

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

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

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

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

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

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

1.1 Background

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

1.2 Consultation History

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

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

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

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

2 The Assessment Framework

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 DESCRIPTION OF THE PROPOSED ACTION

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

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

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

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

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

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

3.1.1 Seismic Survey Overview and Objectives

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

The proposed survey would take advantage of passive seismic equipment already deployed in support of the Alaska Amphibious Community Seismic Experiment (AACSE). The survey would employ active sources (airguns), and data collected would supplement the overall project

goals of AACSE, which involve imaging the architecture of the subduction zone and understanding variability in slip behavior of the Alaska Peninsula subduction zone. The proposed activity, however, has independent utility from the AACSE and would provide unique higher resolution imaging of the subduction zone that is not possible with the AACSE data alone. Data collected would be in support of research that meets NSF program priorities and NSF's critical need to foster an understanding of Earth processes.

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

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

The project consists of a number of tracklines that cross the trench onto the Pacific plate and shorter connecting tracklines. The representative tracklines shown in Figure 1 have a total length of 4,400 kilometers (km) (2,375.8 nautical miles [nmi]). There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. In the calculations for all areas, 25 percent has been added in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed. During the survey, approximately 13 percent of the line km would take place in shallow water (<100 m; <328 ft), 27 percent would occur in intermediate water depths (100–1,000 m; 328-3,281 ft), and the rest (60 percent) would occur in deep water (>1,000 m; >3,280.8 ft).

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

asset, NSF and L-DEO strive to schedule its operations in the most efficient manner possible; schedule efficiencies are achieved when regionally occurring research projects are scheduled consecutively and non-operational transits are minimized.

3.1.2 Source Vessel Specifications

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

3.1.3 Airgun-Array and Acoustic Receivers Description

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

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

Table 1. Source array specifications for the proposed survey.

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

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

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

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

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the seismic survey from the *Langseth*. The Kongsberg EM 122 multi-beam echosounder and Knudsen Chirp 3260 sub-bottom profiler will map the ocean floor during the seismic survey. The Teledyne RDI 75 kiloHz (kHz) Ocean Surveyor acoustic Doppler current profiler will measure water current velocities. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound sources will operate continuously from the *Langseth*,

including simultaneously with the airgun array, but not during transit to and from the seismic survey areas.

3.1.3.2 Multi-Beam Echosounder

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

3.1.3.3 Sub-Bottom Profiler

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

3.1.3.4 Acoustic Doppler Current Profiler

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

3.1.4 Mitigation and Monitoring

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

The NMFS Permits and Conservation Division will require and the NSF and L-DEO will implement the mitigation and monitoring measures listed below. These mitigation and

monitoring measures are required during the seismic surveys to reduce potential for injury or harassment to marine mammals and sea turtles. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this opinion:

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

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

3.1.4.1 Proposed Exclusion and Buffer Zones

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

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

For deep and intermediate water depths, the field measurements in the Gulf of Mexico cannot be easily used to derive radii for proposed exclusion and buffer zones used for purposes of mitigation and monitoring. This is due to the fact that, at those sites, the calibration hydrophone for the 36 airgun acoustic calibration study was located at a roughly constant depth of 350 to 500 m (1,148.3 to 1,640.4 ft), which may not interect all the sound pressure level (SPL) isopleths at

their widest point from the sea surface down to the maximum relevant water depth for marine mammals of approximately 2,000 m (6,561.7 ft). At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model, constructed from the maximum SPL through the entire water column at varying distances from the airgun array, is the most relevant.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same airgun array tow depth are in good agreement. Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating radii for mitigation purposes. In shallow water (less than 100 m [328.1 ft]), the depth of the calibration hydrophone (18 m [59.1 ft]) used during the Gulf of Mexico calibration study was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Tolstoy et al. (2009) for the 36 airgun array at a tow depth of 6 m can be used to derive radii for mitigation. The proposed action will not be conducted in water depths less than 100 m (328.1 ft).

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

The NSF and L-DEO applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals are "harassed" based on definitions provide in the MMPA (16 U.S.C. §1362(18)(a)). The NSF and L-DEO concluded that ESA-listed marine mammals would be exposed to the airgun array during the proposed seismic survey activities. These acoustic thresholds were also used to develop radii for buffer and exclusion zones around the sound source to determine appropriate mitigation measures. Table 2 shows the distances at which rms sound levels are expected to be received from the airgun array. These thresholds are used to develop radii for exclusion zones around a sound source and the necessary power-down or shut-

down criteria to limit marine mammals and sea turtles' exposure to harmful levels of sound (NOAA, 2016). The 160 dB re 1 μPa (rms) distance is the safety criteria as specified by NMFS (1995) for cetaceans, as required by the NMFS during other L-DEO seismic projects (Holst & Smultea, 2008; Holst et al., 2005; Holst, 2008; Smultea et al., 2004). It is also the threshold at which the NMFS' Permits and Conservation Division is proposing to issue authorization for incidental take of marine mammals. The 175 dB rms isopleth represents our best understanding of the threshold at which sea turtles exhibit significant behavioral responses to seismic airguns (McCauley et al., 2000a); Popper et al. (2014).

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

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

An exclusion zone is a defined area within which occurrence of a marine mammal triggers mitigation action in order to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). Protected species observers (PSO) will establish a default (minimum) exclusion zone with a 500 m radius for visual monitoring for the 36 airgun arrays. The 500 m exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described in the IHA), if a marine mammal appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut-down, depending on the circumstance. In addition to the 500 m exclusion zone for the 36 airgun array, a 100 m (328.1 ft) exclusion zone will be established for the single 40 in^3 airgun. A power-down occurs when a marine mammal is detected outside the exclusion zone and appears likely to enter (or is already within the exclusion zone when first detected), and the airgun array is reduced from 36 airguns to a single airgun. A shut-down occurs when a marine mammal is detected outside the exclusion zone and appears likely to enter (or is already within the exclusion zone when first detected), and the single airgun array is turned off entirely. Additionally, a power-down of the 36 airgun arrays

will last no more than a maximum of 30 minutes at any given time; thus, the airgun array will be shut-down entirely if, after 30 minutes of power-down, a marine mammal remains inside the 500-m exclusion zone.

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

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

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

3.1.5 Additional Mitigation

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

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

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

away from acoustic sources, NMFS expects that there would be, at worst, minimal impacts to animals and habitat within the designated BIAs.

3.2 National Marine Fisheries Service's Proposed Activities

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

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

4 ACTION AREA

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

The proposed survey would occur within the area of ~52–58°N, ~150–162°W, within the Economic Exclusive Zone of Alaska in water depths ranging from ~15 to ~6,184 m (~49.2 to 20,288.7 ft). The project consists of a number of tracklines that cross the trench onto the Pacific plate and shorter connecting tracklines. Representative survey tracklines are shown in Figure 1. The representative tracklines shown in Figure 1 have a total length of 4,400 km (2,375.8 nmi). There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. Deviation in actual track lines,

including order of survey operations, could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Thus, within the constraints of any federal authorizations issued for the activity, tracklines may shift from those shown in Figure 1 and could occur anywhere within the coordinates noted above and illustrated by the box in the inset map on Figure 1. Tentative sail dates are June 1-19, 2019.

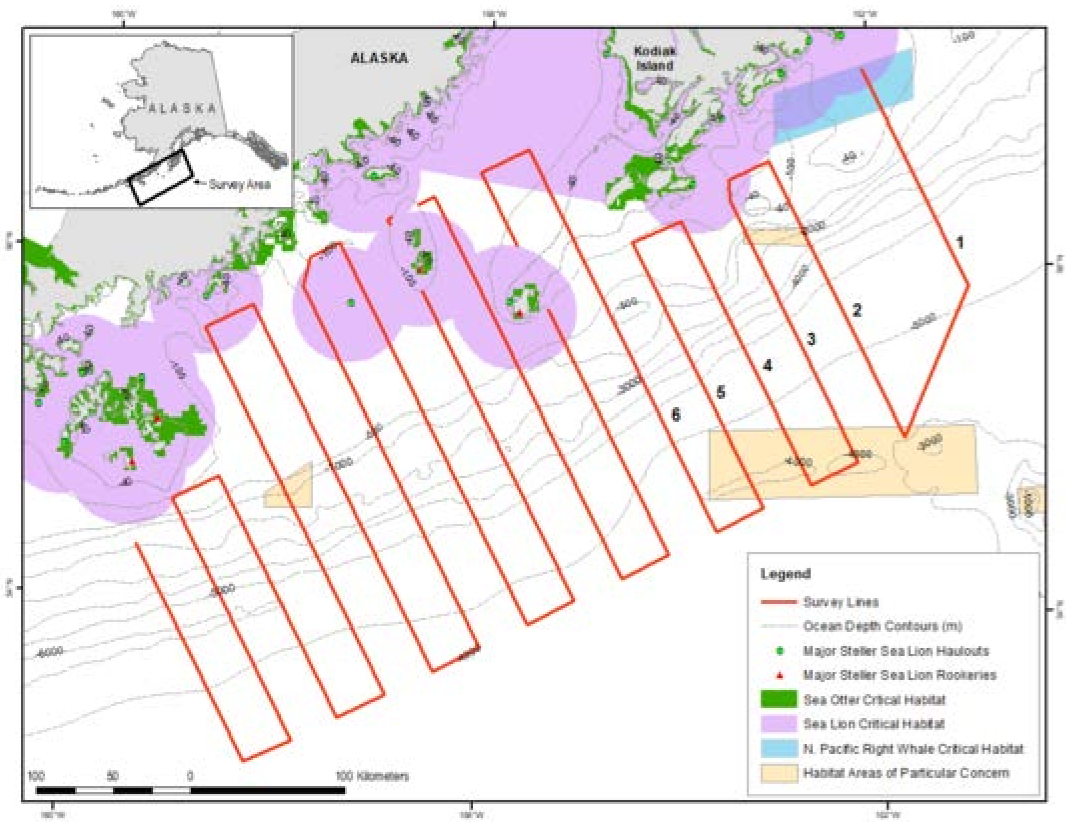

Figure 1. Map of the National Science Foundation's Western Gulf of Alaska seismic survey for this consultation.

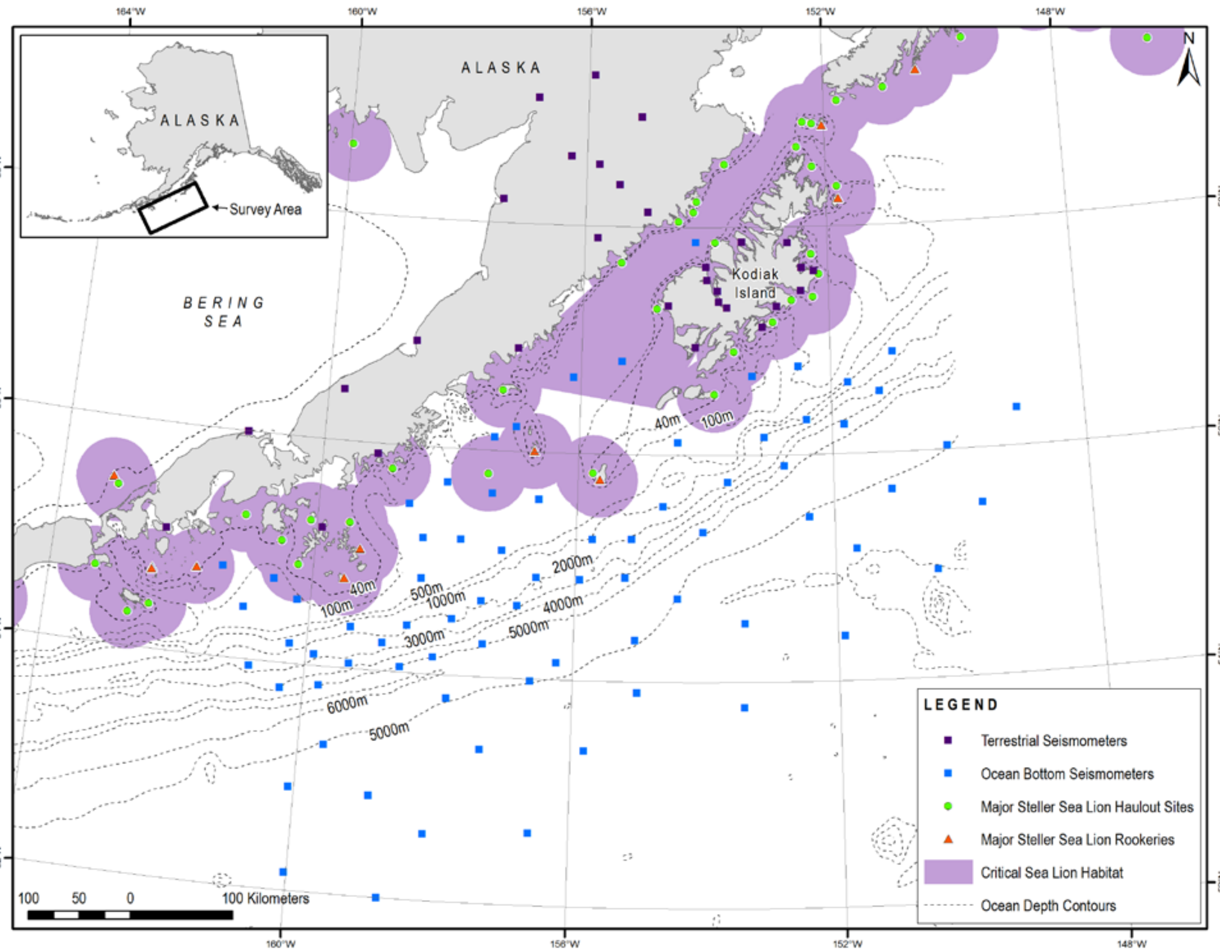

Figure 2. Map of previously deployed seismic receiver locations along the Alaskan Peninsula, including both terrestrial and ocean bottom seismometers.

5 Interrelated and Interdependent Actions

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

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

6 Potential Stressors

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

6.1 Pollution

The operation of the *Langeth* as a result of the proposed action may result in pollution from exhaust, fuel, oil, trash, and other debris. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Chance et al., 2015; Duce et al., 1991). Emissions also cause increased greenhouse gases (carbon dioxide, methane, nitrous oxide, and other fluorinated gases) that can deplete the ozone, affect natural earth cycles, and ultimately contribute to climate

change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species most commonly through entanglement or ingestion (Gall & Thompson, 2015).While lethal and non-lethal effects to air breathing marine animals such sea turtles, birds, and marine mammals are well documented, marine debris also adversely affects marine fish (Gall & Thompson, 2015).

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

6.1.1 Pollution by Oil or Fuel Leakage

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

6.2 Vessel Strikes

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

Vessel traffic associated with the proposed action carries the risk of vessel strikes of marine mammals. In general, the probability of a vessel collision and the associated response depends, in part, on the size and speed of the vessel. The *Langseth* has a length of 72 m (235 ft) and the operating speed during seismic data acquisition is typically approximately 9.3 km per hour (5 kts). When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km per hour (10 kts). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 km per hour (10 kts), with faster travel, especially of large

vessels (80 m [262.5 ft] or greater), being more likely to cause serious injury or death (Conn & Silber, 2013; Jensen & Silber, 2004; Laist et al., 2001; Vanderlaan & Taggart, 2007).

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

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

6.3 Acoustic Noise, Vessel Noise, and Visual Disturbance

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

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

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

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

6.3.1 Vessel Noise

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

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

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

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

6.4 Gear Entanglement

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

towing gear for long periods may prevent a whale from being able to feed, migrate, or reproduce (Lysiak et al., 2018; Van der Hoop et al., 2017).

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

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

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

7 Species and Critical Habitat Not Likely to be Adversely Affected

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

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

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

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

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

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

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

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

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

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

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

7.1 Endangered Species Act-Listed Cetaceans

7.1.1 Beluga Whale – Cook Inlet Distinct Population Segment

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

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

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

7.1.2 Gray Whale – Western North Pacific Population

The Eastern and Western North Pacific populations of gray whales were once considered geographically separated along either side of the ocean basin, but recent photo-identification, genetic, and satellite tracking data refute this. Two individuals from the Western North Pacific population of gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the GOA, and south to the Washington and Oregon coasts in one case (Mate et al., 2011), and to the southern tips of Baja California and back to Sakhalin Island in

another (IWC, 2012a). Comparisons of catalogues of Eastern and Western North Pacific populations of gray whales have thus far identified 24 individuals from the Western North Pacific population of gray whales occurring on the eastern side of the basin during winter and spring (Burdin et al., 2011; Weller et al., 2013). During one field season off Vancouver Island, individuals from the Western North Pacific population of gray whales were found to constitute six of 74 (8.1 percent) of photo-identifications (Weller et al., 2012). In addition, two genetic matches with the Western North Pacific population of gray whales off Santa Barbara, California have been made (Lang et al., 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al., 2012).

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

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

7.2 Endangered Species Act-Listed Sea Turtles

7.2.1 Green Turtle, Loggerhead Turtle, and Olive Ridley Turtle

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

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

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

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

7.2.2 Leatherback Sea Turtle

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

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

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

7.3 Endangered Species Act-Listed Fishes

7.3.1 Criteria and Thresholds to Predict Impacts to Fishes

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

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

7.3.2 Impulsive Sound Source Criteria (Airguns) – Fishes

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

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

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

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

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

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

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

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

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

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

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

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

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

7.3.3 Salmonids

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

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

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

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

7.3.4 Green Sturgeon – Southern Distinct Population Segment

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

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

The precise expected response of ESA-listed sturgeon to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for this taxon. Given the signal type and level of exposure to the low frequency sounds produced during the seismic survey activities (from the airgun array or the multi-beam echosounder, sub-bottom

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

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

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

7.4 Designated Critical Habitat Not Likely to be Adversely Affected

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

7.4.1 North Pacific Right Whales

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

processes, certain species of zooplankton (copepods), and a long photoperiod due to the high latitude (73 FR 19000).

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

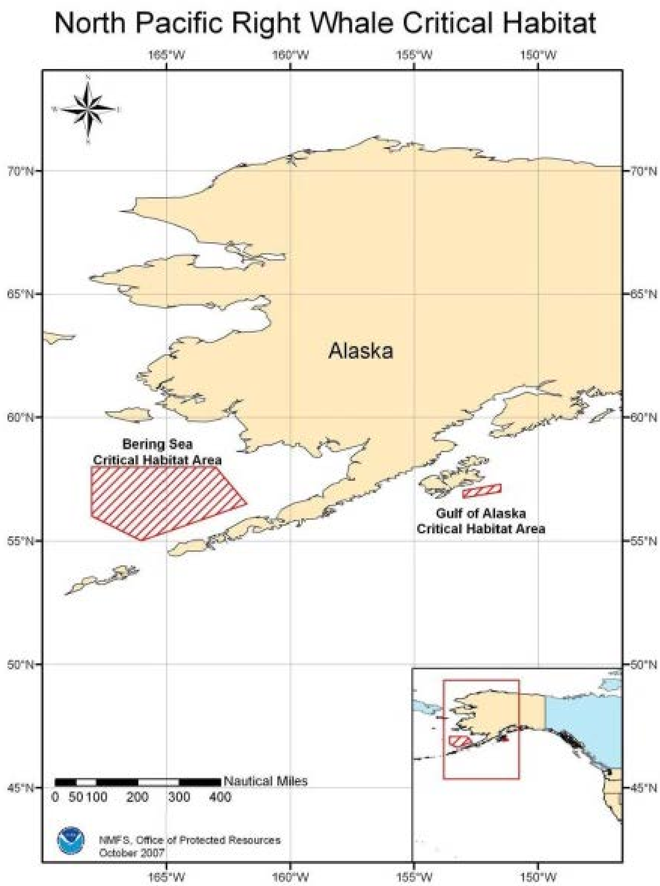

Figure 3. Map identifying designated critical habitat for the endangered North Pacific right whale in the Southeast Bering Sea and south of Kodiak Island in the GOA.

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

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

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

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

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

7.4.2 Steller Sea Lion – Western Distinct Population Segment

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

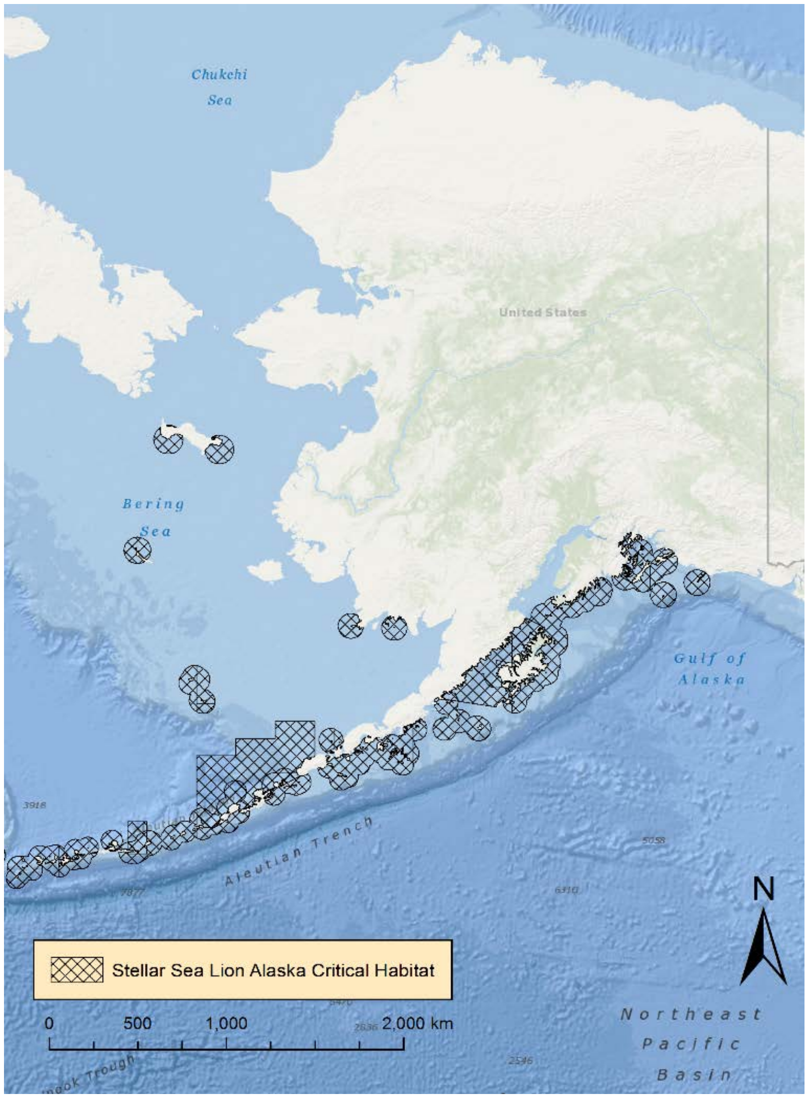

Figure 4: Map depicting Alaskan designated critical habitat for the Western distinct population segment of Steller sea lion.

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

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

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

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

7.4.3 Effects to Designated Critical Habitat

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

8 Species Likely to be Adversely Affected

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

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

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

E=Endangered
T=Threatened
DPS=Distinct Population Segment

9 Status of Species Likely to be Adversely Affected

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

recovery plans, and on these NMFS Web sites: http://www.nmfs.noaa.gov/pr/species/index.htm, among others.

9.1.1 Blue Whale

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

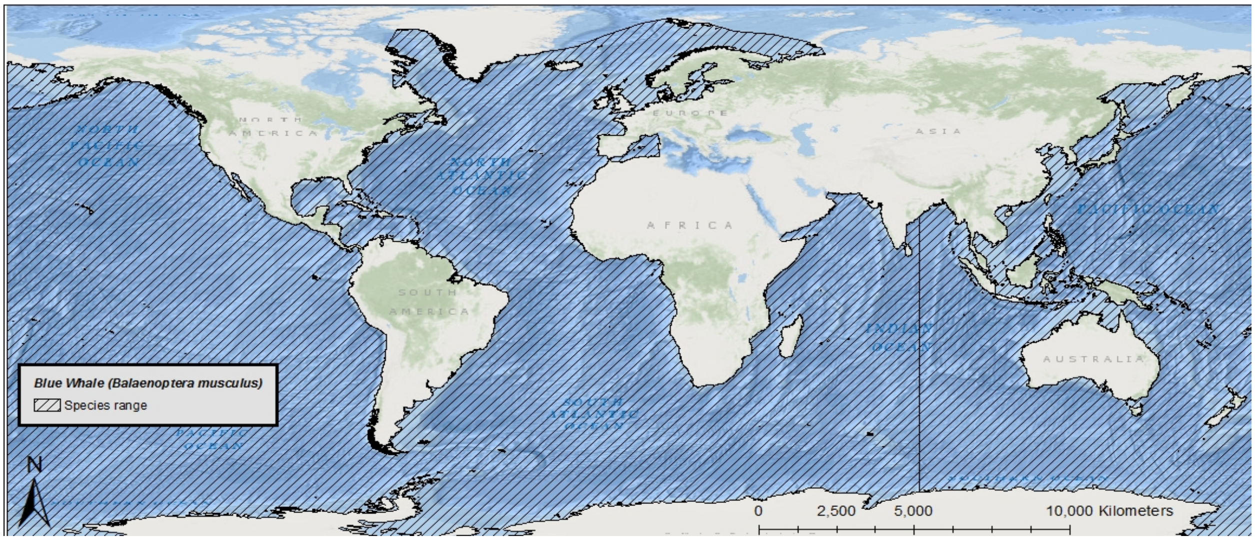

Figure 5. Map identifying the range of the endangered blue whale.

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

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

Life History

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

edge, where upwelling produces concentrations of krill at depths of 90 to 120 m (295.3 to 393.7 ft).

Population Dynamics

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

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

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

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

and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

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

Vocalization and Hearing

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

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

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson & Richardson, 1995), with a range of 12 to 400 Hz and dominant energy

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

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

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

In Southern California, blue whales produce two predominant call types: Type B and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al., 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al., 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. Blue whale D calls are down-swept in frequency (100 to 40 Hz) with duration of several seconds. These calls are similar

worldwide and are associated with feeding animals; they may be produced as call-counter-call between multiple animals (Oleson et al., 2007b). In the SOCAL Range Complex region, D call are produced in highest numbers during the late spring and early summer, and in diminished numbers during the fall, when A-B song dominates blue whale calling (Hildebrand et al., 2011; Hildebrand et al., 2012; Oleson et al., 2007c).

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

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

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

Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were taken from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are affected by anthropogenic noise, threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and

reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

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

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

9.1.2 Fin Whale

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

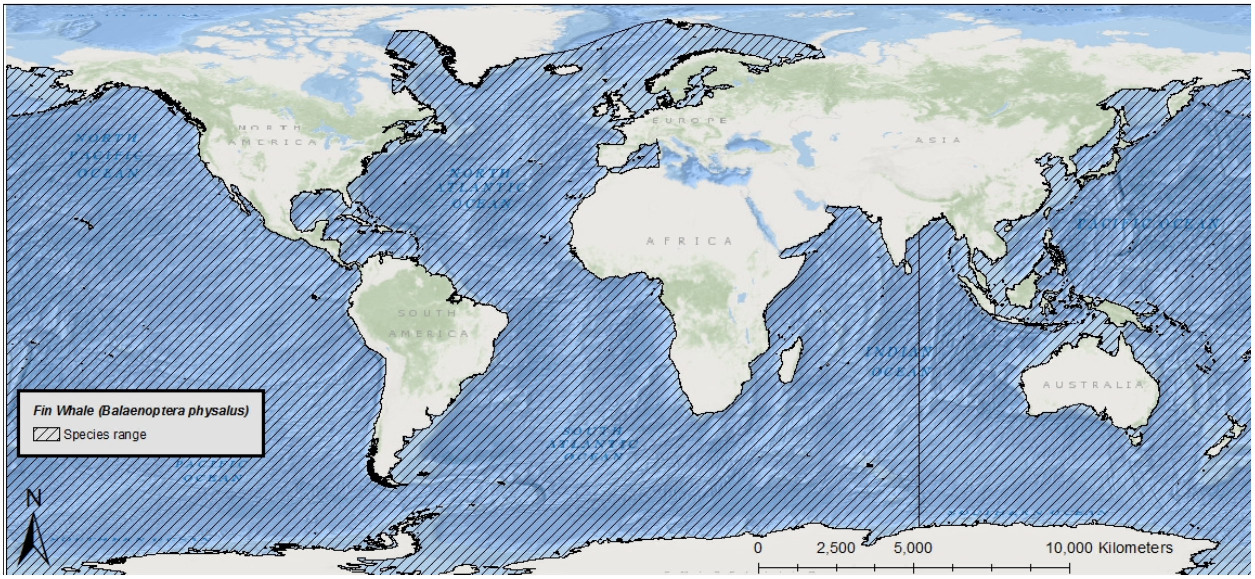

Figure 6. Map identifying the range of the endangered fin whale.

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

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

Life History

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

Population Dynamics

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

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi & Wada, 1974). In the North Atlantic Ocean, at least 55,000 fin whales were

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

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

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

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

Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds, 1988; Thompson et al., 1992; Watkins, 1981; Watkins et al., 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hz range, but only males are known to produce these (Clark et al., 2002; Patterson & Hamilton, 1964). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ± 4 dB re 1 microPascal (μPa) at 1 m (Charif et al., 2002; Clark et al., 2002; Edds, 1988; Richardson et

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

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

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

belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA, 2018).

Status

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

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

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

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

9.1.3 Humpback Whale – Mexico Distinct Population Segment

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

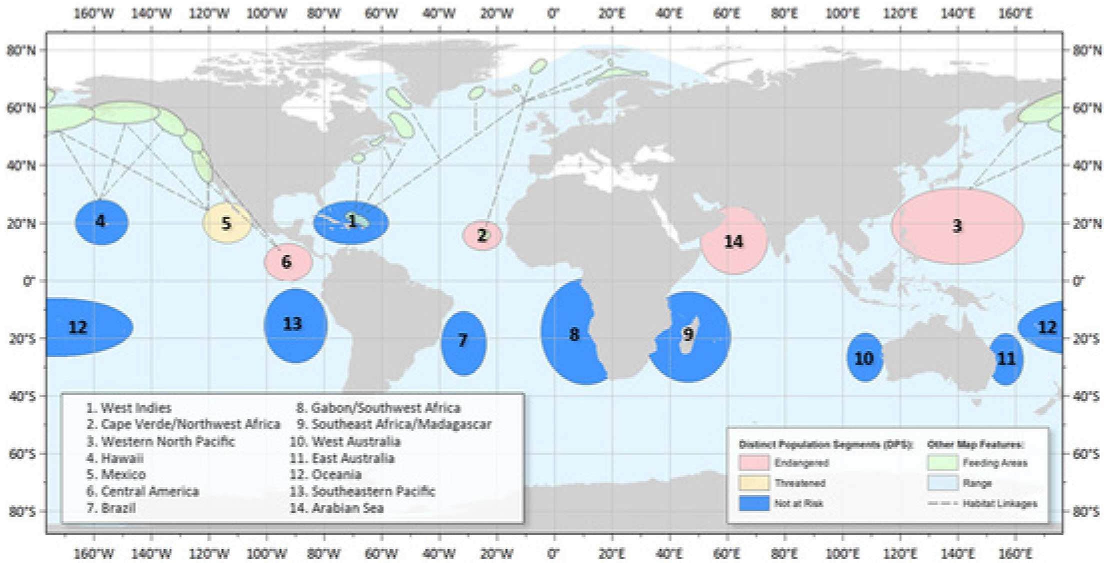

Figure 7. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al., 2015).

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

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

Life History

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

Population Dynamics

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

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

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

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

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

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

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

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

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

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

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

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al., 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144 to 174 dB (Au & Green, 2000; Frazer & Mercado, 2000; Richardson et al., 1995; Winn et al., 1970). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz to 10 kHz with most energy below 3 kHz (Silber, 1986; Tyack, 1983). Such sounds can be heard up to 9 km (4.9 nautical miles) away (Tyack, 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al., 1995; Tyack, 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89 Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 μPa at 1 m) (Au & Green, 2000; Erbe, 2002a; Payne, 1985; Richardson et al., 1995; Thompson et al., 1986). However, humpback whales tend

to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al., 1995). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hz (NOAA, 2013). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz.

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

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

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

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

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

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

Status

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

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

Critical Habitat

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

Recovery Goals

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

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

9.1.4 Humpback Whale – Western North Pacific Distinct Population Segment

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

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

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

Life History

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

Population Dynamics

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

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

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

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

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

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

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

Vocalization and Hearing

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

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

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

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

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

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

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

Status

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

Critical Habitat

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

Recovery Goals

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

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

9.1.5 North Pacific Right Whale

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

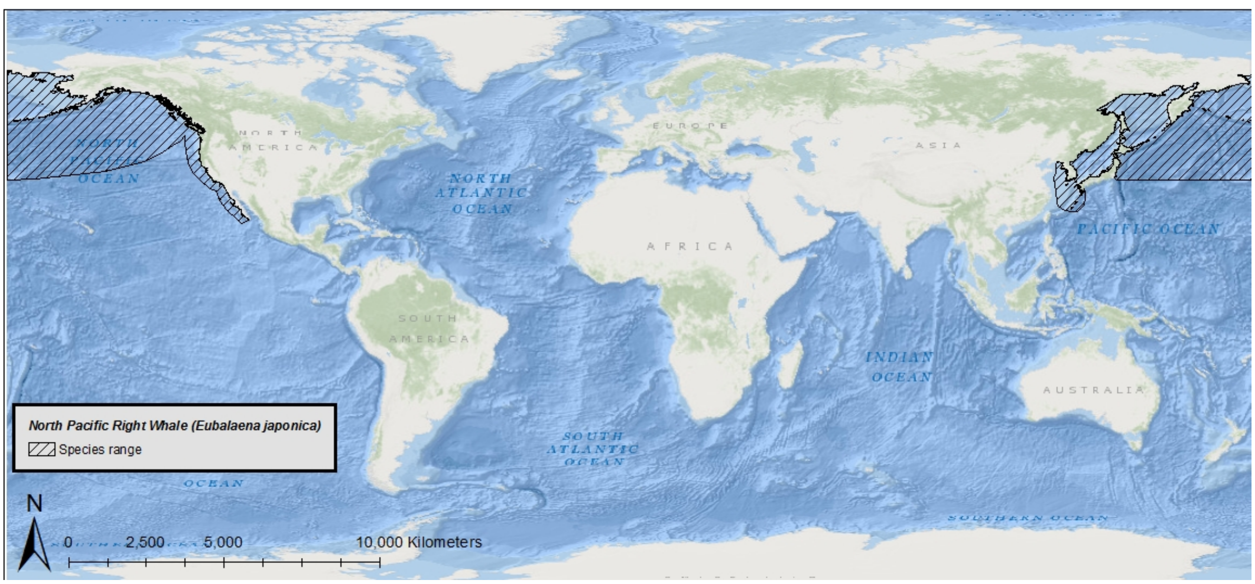

Figure 8. Map identifying the range of the endangered North Pacific right whale.

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

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

Life History

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

Population Dynamics

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

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

As a result of past commercial whaling, the remnant population of North Pacific right whales has been left vulnerable to genetic drift and inbreeding due to low genetic variability. This low

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

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

Vocalization and Hearing

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

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

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

Status

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

Critical Habitat

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

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

Recovery Goals

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

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

9.1.6 Sei Whale

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

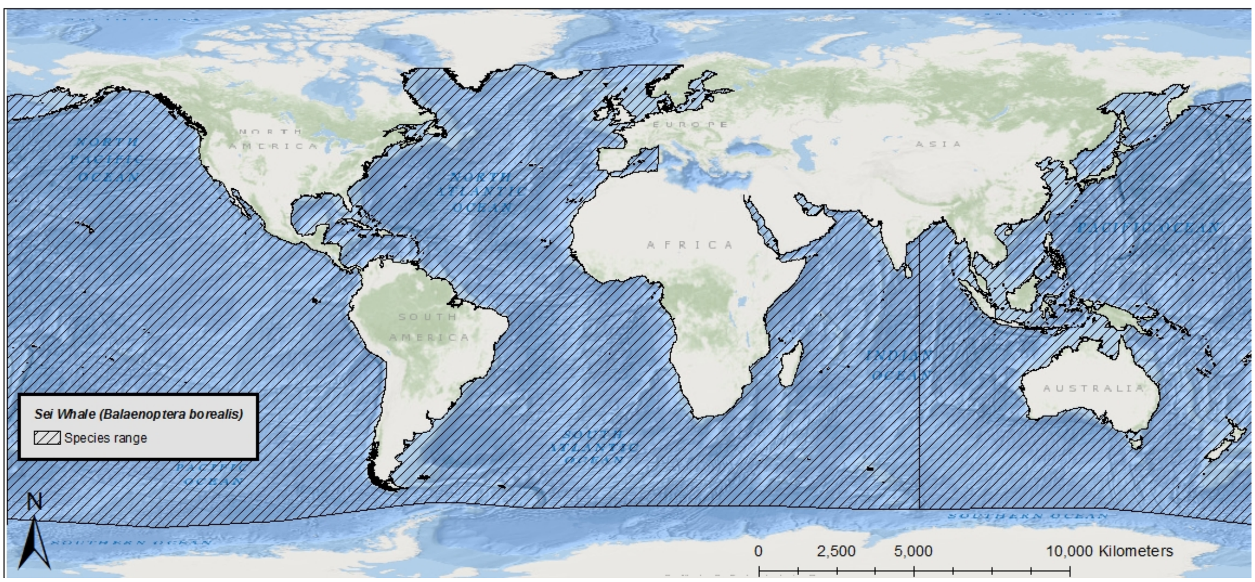

Figure 9. Map identifying the range of the endangered sei whale.

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

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

Life History

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

Population Dynamics

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

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

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

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

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hz range of one to three second durations (McDonald et al., 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 seconds,

separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson & Richardson, 1995). Source levels of 189 ±5.8 dB re: 1 µPa at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al., 2013).

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

Status

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

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

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

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

9.1.7 Sperm Whale

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

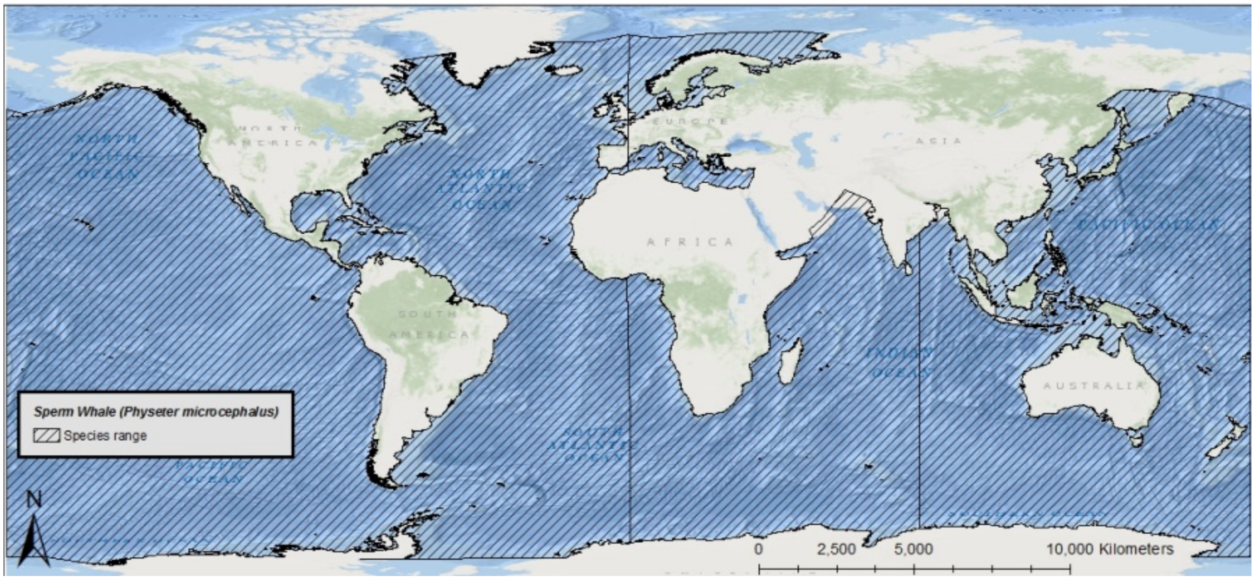

Figure 10. Map identifying the range of the endangered sperm whale.

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

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

Life History

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

Population Dynamics

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

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of

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

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

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold, 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins, 1977) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. Another class of sound, “squeals,” are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al., 2007). The source levels of clicks can reach 236 dB re: 1 μPa at 1 m, although lower source level energy has been suggested at around 171 dB re 1 μPa at 1 m (Goold & Jones,

1995; Mohl et al., 2003; Weilgart & Whitehead, 1993; Weilgart & Whitehead, 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold & Jones, 1995; Weilgart & Whitehead, 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re 1 µPa at 1 m (Madsen et al., 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris & Harvey, 1972).

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

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder & Ridgway, 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten, 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten, 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al., 1985; Watkins & Schevill, 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and

left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al., 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al., 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and one kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold & Jones, 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al., 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA, 2018).

Status

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

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

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

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

9.1.8 Steller Sea Lion – Western Distinct Population Segment

The Steller sea lion ranges from Japan, through the Okhotsk and Bering Seas, to central California. It consists of two morphologically, ecologically, and behaviorally separate DPSs: the Eastern, which includes sea lions in Southeast Alaska, British Columbia, Washington, Oregon,

and California; and the Western, which includes sea lions in all other regions of Alaska, as well as Russia and Japan (Figure 11).

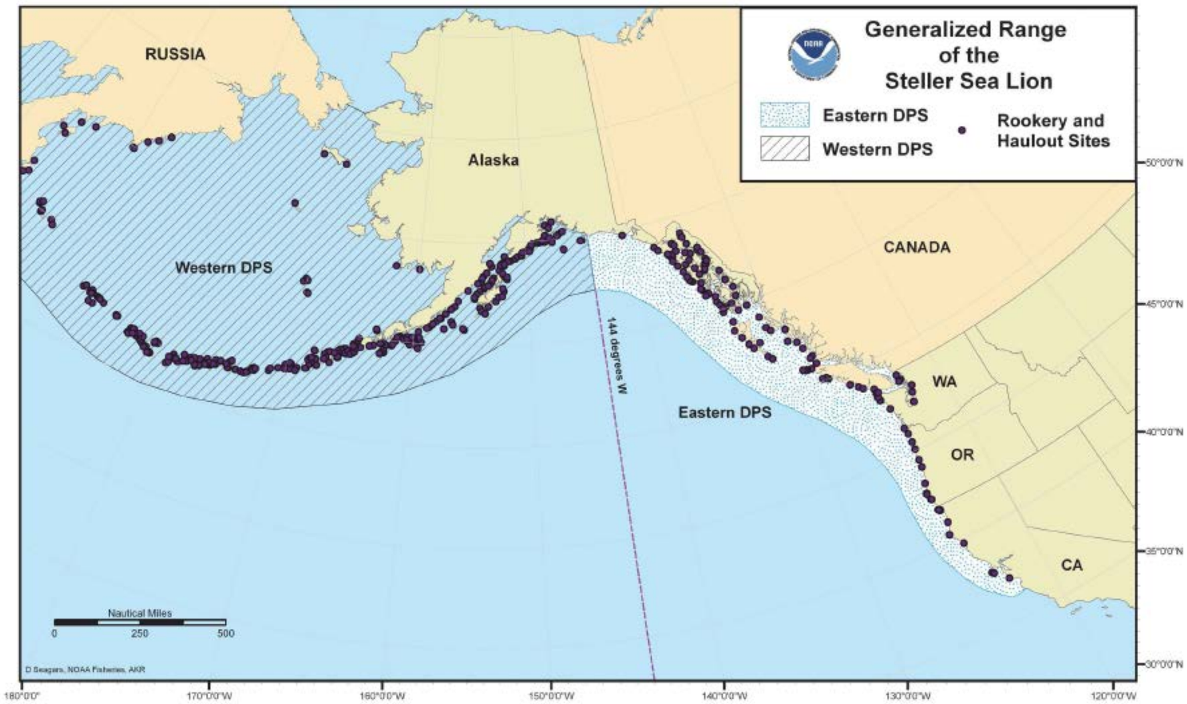

Figure 11. Map identifying the range of the endangered Western distinct population segment of Steller sea lion.

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

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

Life History

Within the Western DPS of Steller sea lions, pupping and breeding occurs at numerous major rookeries from late May to early July. Male Steller sea lions become sexually mature at three to seven years of age. They are polygynous, competing for territories and females by age ten or eleven. Female Steller sea lions become sexually mature at three to six years of age and reproduce into their early 20’s. Most females breed annually, giving birth to a single pup. Pups are usually weaned in one to two years. Females and their pups disperse from rookeries by August to October. Juveniles and adults disperse widely, especially males. Their large aquatic

ranges are used for foraging, resting, and traveling. Steller sea lions forage on a wide variety of demersal, semi-demersal, and pelagic prey, including fish and cephalopods. Some prey species form large seasonal aggregations, including endangered salmon and eulachon species. Others are available year round.

Population Dynamics

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

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

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

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

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

Vocalization and Hearing

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

(best sensitivity at the low end of the range) and females hearing from 16 to 25 kHz (best hearing at the upper end of the range) (Kastelein et al., 2005).

Status

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

Critical Habitat

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

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

Recovery Goals

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

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

10 Environmental Baseline

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

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

10.1 Climate Change

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

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

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as

representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC, 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

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

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

Several of the most important threats contributing to the extinction risk of ESA-listed species are related to impacts to prey availability due to changes in ocean temperatures, ocean currents and ocean acidification. The main concerns regarding impacts of global climate change are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean [ocean acidification; (IPCC, 2014)]. As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution,

ocean acidification has already occurred throughout the world's oceans, including in the Caribbean, and is predicted to increase considerably between now and 2100 (IPCC, 2014). These impacts are particularly concerning for those animals which serve as prey for ESA-listed species.

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

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

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

the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al., 2006); (Baker et al., 2006).

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

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

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

10.2 Oceanic Temperature Regimes

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

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

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

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

10.3 Whaling and Subsistence Harvesting

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

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

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

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

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

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

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

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

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al., 2014). Additionally, despite the moratorium on large-scale commercial whaling, catch of

some of these species still occurs in the Atlantic, Pacific, and Southern Oceans whether it be under objection of the International Whaling Commission, for aboriginal subsistence purposes, or under International Whaling Commission scientific permit 1985 through 2013. Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

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

10.4 Vessel Strike

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

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales). This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al., 1993; Wiley et al., 1995). As vessels to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. All sizes and types of vessels can hit whales, but most lethal and sever injuries are caused by vessels 80 m (262.5 ft) or longer (Laist et al., 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 km per hour (14 kts) (Laist et al., 2001). Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al., 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported and most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff et al., 2011). Kraus et al. (2005) estimated that 17 percent of

vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al., 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of five and 17 percent and conservatively estimated that vessel strike mortality may be as high as 7.8, 2.0, and 2.7 times the recommended limit for blue, humpback, and fin whale stocks in this area, respectively.

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

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

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

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

DPS=Distinct Population Segment
NA=Not Applicable

10.5 Whale Watching

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

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

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

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

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

10.6 Fisheries Interactions

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

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

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

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

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

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

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

DPS=Distinct Population Segment
NA=Not Applicable

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

10.7 Pollution

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

10.7.1 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al., 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al., 2010). Marine debris has been discovered to be accumulating in gyres throughout the oceans. Marine mammals often become entangled in marine debris, including fishing gear (Baird et al., 2015). Despite

debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (NRC, 2008) and continues to accumulate in the ocean and along shorelines within the action area.

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

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

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

the 22 dissected specimens, nine had marine debris in their gastro-intestinal tracts. Most of it (78 percent) was fishing-related debris (e.g., nets, monofilament line) and the remainder (22 percent) was general debris (plastic bags, plastic buckets, agricultural foils) (Unger et al., 2016).

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

10.7.2 Pesticides and Contaminants

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

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

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

10.7.3 Hydrocarbons

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

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

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

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

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

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

10.8 Aquatic Nuisance Species

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

10.9 Anthropogenic Sound

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

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

irritating sounds, changes in in diving behavior, or (for cetaceans) changes in vocalization patterns (MMC, 2007).

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

10.9.1 Vessel Sound and Commercial Shipping

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

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

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

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

10.9.2 Aircraft

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

10.9.3 Seismic Surveys

There are seismic survey activities involving towed airgun arrays that may occur within the action area. They are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. These activities may produce noise that could impact ESA-listed cetaceans within the action area. These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of ten to 20 seconds for extended periods (NRC, 2003c). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB at dominant frequencies of five to 300 Hz (NRC, 2003a). Most of the sound energy is at frequencies below 500 Hz, which is within the hearing range of baleen whales (Nowacek et al., 2007). In the U.S., all seismic surveys

involving the use of airguns with the potential to take marine mammals are covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic waters as well as the NSF and U.S. Geological Survey funds and/or conducts these activities in domestic and foreign waters, and in doing so, consults with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including authorized takes, can be found in recent biological opinions.

10.10 Marine Construction

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

10.11 Military Activities

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

The U.S. Navy’s activities produce sound and visual disturbance to marine mammals throughout the action area (NMFS, 2011a, 2017a). Anticipated impacts from harassment due to the U.S. Navy’s activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals. The U.S. Navy’s activities constitute a federal action and take

of ESA-listed marine mammals considered for these activities have previously undergone separate ESA Section 7 consultation. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from activities on ESA-listed resources in the GOA Training area.

10.12 Scientific Research Activities

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

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

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

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

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

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

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

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

11 Effects of the Action

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

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

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

11.1 Stressors Associated with the Proposed Action

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

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

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

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

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

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

11.2 Mitigation to Minimize or Avoid Exposure

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

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

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

Kodiak Island, and Chirikof Island generally define the portion of the BIA NSFis expected to transit through.

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

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

11.3 Exposure and Response Analysis

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

11.3.1 Exposure Analysis

Although there are multiple acoustic and non-acoustic stressors associated with the proposed action, the stressor of primary concern is the acoustic impacts of the airgun arrays. Airguns contribute a massive amount of anthropogenic energy to the world's oceans ($3.9x10^{13}$ Joules cumulatively), second only to nuclear explosions (Moore & Angliss, 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold & Coates, 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al., 2004).

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

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

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

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

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

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

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

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

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

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

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

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

11.3.1.1 Exposure Estimates of Endangered Species Act-Listed Marine Mammals

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

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

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

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

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

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

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

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

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

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

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

Acoustic Thresholds

To determine at what point during exposure to airgun arrays (and other active acoustic sources) marine mammals are considered "harassed" under the MMPA and ESA, NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for exclusion zones around a sound source and the necessary mitigation requirements necessary to limit marine

mammal exposure to harmful levels of sound (NOAA, 2018). For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 µPa (rms). This value is based on observations of behavioral responses of mysticetes, but is used for all marine mammal species. For the proposed action, the NMFS Permits and Conservation Division continued to rely on this historic NMFS acoustic threshold to estimate the number of takes by MMPA Level B harassment, and accordingly, take of ESA-listed marine mammals that are proposed in the incidental harassment authorization.

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

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

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

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

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
LF=Low-Frequency
MF=Mid-Frequency
*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al., 2007) (approximation).
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
Note: Peak sound pressure (Lpk) has a reference value of 1 µPa, and cumulative sound exposure level (LE) has a reference value of 1 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.

Exposure Estimates

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

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

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

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

Table 10. Modeled sound source levels (dB) modified farfield signature for the R/V *Marcus G. Langseth*'s 6,600 in^3 36 airguns array, and single-bolt 40 in^3 airgun.

	Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	**Mid frequency cetaceans** ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB	**High frequency cetaceans** ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	**Otariid Pinnipeds (Underwater)** ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)
6,600 in^3 airgun array (Peak SPL_{flat})	252.06	252.65	253.24	252.52
6,600 in^3 airgun array (SEL_{cum})	232.98	232.84	233.10	232.08

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

NA=Not Available

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

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

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

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

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

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

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

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

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

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

All densities were corrected for perception bias [$f(0)$] as described by the respective authors. There is some uncertainty related to the estimated density data and the assumptions used in their calculations, as with all density data estimates. However, the approach used here is based on the best available data that are stratified by the water depth (habitat) zones present within the survey area. Alternative density estimates available for species in this region are not stratified by water depth and therefore do not reflect the known variability in species distribution relative to habitat

features. The calculated exposures that are based on these densities are best estimates for the proposed survey.

The estimated numbers of individuals potentially exposed are based on the 160 dB re 1 μPa_{rms} criterion for all marine mammals. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the proposed seismic survey in GOA if no animals moved away from the survey vessel are shown in Table 13. The authorized takes requested by the NMFS Permit and Conservation Division and NSF are given in the right-most column (*Requested Take Authorization*) Table 13. The NSF requested takes for North Pacific right whale was one Level B harassment and one Level A harrasment. However, the NMFS Permit and Conservation Division and the Interagency and Cooperation Division increased the Level B takes based on the density-based calculations to mean group size per of 11 takes (Shelden et al., 2005), (Waite et al., 2003) and (Wade et al., 2011b). No MMPA Level A takes or ESA harm of North Pacific rights will be authorized.

For all species, including those for which densities were not available or expected to be low, the *Requested Take Authorization* was for at least the mean group size for species where that number was higher than the calculated take. Exposure estimates provided by NSF assume that the proposed survey would be fully completed. The calculated takes were increased by 25 percent by assuming additional survey operations would take place (see below). Thus, the following estimates of the numbers of marine mammals potentially exposed to sounds ≥160 dB re 1 μPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved during the proposed activities.

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 µPa (rms) for marine mammals on one or more occasions were estimated assuming that the marine area that would be within the 160 dB re 1 µPa (rms) isopleth around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involved selecting a seismic trackline(s) that could be surveyed on one day (~222 km) with a proportion occurring in the marine mammal density zones (inshore, slope, offshore, and seamount) that is roughly similar to that of the entire survey. The area expected to be ensonified on a specific day was determined by entering the planned survey lines into a Map-Info GIS, using GIS to identify the relevant areas by "drawing" the applicable 160 dB re 1 µPa (rms) TTS and PTS threshold buffers around each line. The ensonified areas, increased by 25 percent, were then multiplied by the number of survey days (18 days). This is equivalent to adding an additional 25 percent to the proposed line km. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the *Langseth* approaches.

Take estimates of the numbers of ESA-listed cetaceans and pinnipeds that could be exposed to seismic sounds with received levels equal to injurious thresholds (e.g., MMPA Level A) thresholds for various hearing groups Table 13 if there were no mitigation measures (power downs or shut downs when PSOs observered animals approaching or are inside the esonification zones), are also given in Table 13. Those numbers likely overestimate actual MMPA Level A takes and ESA take because the predicted Level A esonification zones are small and mitigation measures would further reduce the chances of, if not eliminate, any such takes.

The resulting estimates of the number of marine mammals that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the GOA survey area includes 4,699 ESA-listed cetaceans: 49 blue whales, 3,913 fin whales, 631 humpback whales (2 DPS's), 11 North Pacific right whale, 9 sei whales, 86 sperm whales, and 2,168 Steller sea lions (Table 13). In terms of the ESA, this represents: 2 blue whales harmed and 47 harrassed; 16 fin whales harmed and 3,897 harmed; 4 humpback whales (2 DPS's) harmed and 627 harrassed; 11 North Pacific right whales harassed; 2 sei whales harmed and 7 harrassed; 86 sperm whales harassed; and 3 Steller sea lions harmed and 2,196 harmed (Table 13).

Table 13. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation and National Marine Fisheries Service NMFS Permits and Conservation Divisionduring National Science Foundation's seismic survey in the Western Gulf of Alaska.

Species	Potential Permanent Threshold Shift and Harm	Potential Temporary Threshold Shift and Behavioral Harassment	Total
Blue Whale	2	47	49
Fin Whale	16	3,897	3,913
Humpback Whale – Mexico DPS	3	599	602
Humpback Whale – Western Pacific DPS	1	28	29
North Pacific Right Whale	0	11	11
Sei Whale	2	7	9
Sperm Whale	0	86	86
Cetaceans Total	**24**	**4,4675**	**4,699**
Steller Sea Lion	3	2,165	2,168

North Pacific Right Whales. Note that for North Pacific right whales the NMFS Permits and Conservation Division proposed to authorize a larger number of incidental takes than the number of incidental takes requested by NSF. This is based on evidence of a much higher density of this species within the critical habitat south of Kodiak Island. The density value of 0.0053 animals/km^2 is based on detections from the GOALS II survey (4 individuals) (Rone et al., 2014), the assumed use of the critical habitat by all right whales in the GOA (Wade et al., 2011b), and a conservative correction factor (4), all divided by the area of the critical habitat (3,042.2 km^2). To account for this habitat, NMFS used the Alaska Protected Resources Division Species Distribution Mapper (*https://www.fisheries.noaa.gov/resource/data/alaska-endangered-species-and-critical-habitat-mapper-web-application*) to determine a conservative approximation of NSF's survey path through the critical habitat based on the representative tracks in Figure 1 of the IHA Application. This measured distance was 35 km. Because the majority of this habitat is inside of the 100 m isopleth, the predicted distance to the 160 dB received sound level would be ~25.5 km. This resulted in a portion of the North Pacific righ whale critical habitat 35 km long by 51 km wide (25.5 km on each side of the survey track), or 1,785 km^2 being ensonified. Applying the higher density of 0.0053 animals/km^2 to this area, results in an estimate of 9.46 North Pacific right whales exposed to Level B harassment in the critical habitat. No further correction, such as the 25 percent operation day increase, is needed for the estimate in the critical habitat, because the density of 0.0053 animals/ km^2 has already been corrected to be highly conservative. To account for the rest of the survey occurring outside of the critical habitat, the minimal density presented in (DON, 2014), 0.00001 individuals/km^2, was used for the remainder of the survey. The expected take in the rest of the survey is 1.10 individuals. Summing these two estimates for take, in both the critical habitat and remainder of survey, results in an expected take of 10.56 individuals (rounded to 11 individuals). With ESA-listed marine mammals one calculated take was conservatively assumed to be a take by ESA (Table 13), however no takes by Level A harassment or harm under the ESA are proposed for authorization for North Pacific right whale given the low density of the species and NMFS evaluation of the effectiveness of mitigation and monitoring measures.

The estimated instances of take for North Pacific right whales appears high compared to stock abundance (35.5 percent), but realistically 11 right whales are not likely to experience harassment. Given the higher assumed density of whales in the critical habitat area off of Kodiak Island, the vast majority of estimated takes would occur in that area. Overall, right whales are very rarely detected (visual or acoustic) in the GOA, and most evidence of the region's importance for the species is based historic whaling records (Muto et al., 2018) . North Pacific right whales are much more commonly detected in their Bering Sea critical habitat (73 FR 19000, April 8, 2008; (Muto et al., 2018). Given this evidence, only a small portion of the North Pacific right whale population is expected to be present in the GOA and the Kodiak Island critical habitat. As such, it is more realistic to believe there will be multiple takes of the few individuals present, comprising less than a third of the overall population. Additionally, NSF proposed survey will only impact the North Pacific right whale critical habitat for a very short

portion of their survey and there are additional mitigation measures in place to further minimize any acoustic impacts on North Pacific right whales.

Blue Whale. The expected instances of take of the Central North Pacific stock of blue whales appears high when compared to the overall abundance of the stock. However, in reality 49 blue whales are not likely to be harmed (2) or harassed (47) given the mitigation measures in place. However, based on the numbers there is the potential that there will be 2 instances of harm and 47 instances of harassment under the ESA. Blue whales belonging to this stock appear to feed in summer in waters southwest of Kamchatka, south of the Aleutians, and in the GOA (Stafford, 2003); (Watkins et al., 2000). Because of this large summer range of this species compared to the size of NSF's action area, it is more likely that there will be multiple takes of a smaller number of individuals that would occur within the action area, and the percentage of the stock taken will be less than a third of the individuals.

Fin Whales. While the expected take of Northeast Pacific stock of fin whales appears to impact a high percentage of the population (123.5 percent), in reality 3,913 fin whales are not likely to be harmed (16) or harassed (3,897). The range of the Northeast Pacific fin whale stock extends through much of the north Pacific (Muto et al., 2018), and NSF's actions are located in a small portion of this range in the GOA and will occur within a period of less than a month. Given the range of the species and the comparatively small action area, combined with the short duration of the survey, it is more likely that there will be multiple takes of a few individuals rather than limited takes of a larger number of animals that are in the action area during the proposed survey and entirely unlikely that more than a third of the stock would be exposed to the seismic survey.

Humpback Whales. For humpback whales, takes are apportioned between the different stocks or DPSs present based on Wade et al. (2016b). With this apportionment, the expected instances of take of the Central North Pacific stock's Mexico DPS appears high (18.44 percent of the estimated DPS abundance). In reality, 631 humpback whales (regardless of DPS) are not likely to be harmed (4) or harassed (627), as it is more likely that a smaller number of individuals will experience multiple takes. The GOA is an important center of humpback whale abundance, and NSF's survey affects a portion of the GOA. The highest densities of humpback whales in the GOA are observed between July and August (Ferguson et al., 2015), while NSF's survey is planned for June, so the survey should not overlap with peak abundance. Additionally, there are other areas of high humpback whale density in the Aleutian Islands and Bering Sea (Muto et al., 2018). This evidence, plus the Central North Pacific stock's large range relative to NSF's action area, along with the short duration of the survey, mean that it is more likely that there will be multiple takes of a few individuals that occur in NSF's action area, and fewer than a third of the individuals in the stock will be taken.

Steller Sea Lion. NSF modeling predicts that the western DPS of Steller sea lion could be exposed to sound from seismic airguns that may result in 2,168 exposures that could result in 3 instances of harm and 2,165 instances of harassment. Most harassment will be in the form of some behavioral responses of Steller sea lions and given the level of mitigation in place during

the surveys harm is not likely to be realized. Ranges to some behavioral impacts could take place at distances exceeding 100 km (54 nmi), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Harassment of Steller sea lions would be short term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely.

11.3.1.3 Exposure of Endangered Species Act-Listed Marine Mammals to Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler

The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are the three additional active acoustic systems that will operate during the proposed seismic surveys on the. *Langseth*. The multi-beam echosounder system, sub-bottom profiler, and acoustic Doppler current profiler have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: 1 µPa (rms) threshold. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler systems operate at generally higher frequencies than airgun array operations (10 to 13.5 kHz for the multi-beam echosounder, 3.5 kHz for the sub-bottom profiler, and 75 kHz for the acoustic Doppler current profiler). As such, the frequencies will attenuate more rapidly than those from airgun array sound sources. For these reasons ESA-listed marine mammals would likely experience higher levels of sound from the airgun array well before the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound of equal amplitude since these other sound sources would drop off faster than the airgun arrays.

While the airgun array is not operational, visual protected species observers will remain on duty to collect sighting data. If ESA-listed marine mammals or sea turtles closely approach the vessel, the *Langseth* will take evasive actions to avoid a ship-strike and simultaneously avoid exposure to very high source levels. Ship strike has already been ruled out as a discountable effect. We also rule out high-level ensonification of ESA-listed marine mammals (multi-beam echosounder sound source level equals 242 dB re: 1 µPa [rms], sub-bottom profiler sound source level equals 222 dB re: 1 µPa [rms], and acoustic Doppler current profiler sound source level equals 224 dB re: 1 µPa [rms]), because it presents a low risk for auditory or other damage to occur. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multi-beam echosounders, sub-bottom profilers, and acoustic Doppler current profilers similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury. To be susceptible to TTS, a marine mammal will have to pass at very close range and match the vessel's speed and direction; we expect a very small probability of this during the proposed seismic surveys. An individual will have to be located well within 100 m (328.1 ft) of the vessel to experience a single multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler pulse that could result in TTS (LGL Ltd., 2008). It is possible, however, that some small number of ESA-listed marine mammals (fewer than those exposed to the airgun array) could experience low-level exposure to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. We are unable to quantify the level of exposure from the

secondary sound sources, but do not expect any exposure at levels sufficient to cause more than behavioral responses (e.g. avoidance of the sound source) in some species capable of hearing frequencies produced by the multi-beam echosounder system, sub-bottom profiler, and acoustic Doppler current profiler.

11.3.2 Response Analysis

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

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed marine mammals and sea turtles in the action area.

As discussed in *The Assessment Framework* (Section 2) of this opinion, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on the environment or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

11.3.2.1 Potential Response of Marine Mammals to Acoustic Sources

Marine Mammals and Hearing Threshold Shifts

Exposure of marine mammals to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. A TTS results in a temporary change to hearing sensitivity (Finneran & Schlundt, 2013), and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing, has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa & Liberman, 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case

each pulse need not be as loud as a single pulse to have the same accumulated effect. A TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action (Kastak, 2005; Ketten, 2012; Schlundt et al., 2000).

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue, fin, humpback, North Pacific right, and sei) have an estimated functional hearing frequency range of 7 Hz to 35 kHz (Southall et al., 2007). Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB SEL or approximately 196 to 201 dB re: 1 μPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al., 2007). A PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al., 2007). In terms of exposure to the *Langseth*'s airgun array, an individual will need to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re: 1 μPa (peak) (Caldwell & Dragoset, 2000). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, or 202 dB for high-frequency cetaceans, PTS could occur. A marine mammal will have to be within 38.9 m (127.3 ft) for low-frequency cetaceans or 13.6 m (45.3 ft) for mid-frequency cetaceans of the *Langseth*'s 36 airgun array to be within the MMPA Level A harassment threshold isopleth and risk PTS (Table 12).

Research and observations show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If sea lions are exposed to active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sea lions may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003; Götz and Janik 2011; Kvadsheim et al. 2010). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

NSF modeling predicts that the western DPS of Steller sea lion (western U.S. stock) could be exposed to sound from seismic sources that may result in 2,165 instances of harassment and 3 instances of harm, but no mortality of Steller sea lions given the level of mitigation in place during the surveys. Ranges to some behavioral impacts could take place at distances exceeding 100 km (54 nmi), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Behavioral reactions would be short term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely.

Overall, we do not expect TTS to result in long-term affects to any ESA-listed marine mammals as a result of exposure to the airgun array for several reasons. We expect that most individuals will move away from the airgun array as it approaches; however, a few individuals may be exposed to sound levels that may result in TTS or PTS, but we expect the probability to be low. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the vessel and sound source and thus avoid exposures that will induce TTS or PTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons, as acoustic energy accumulates to higher levels animals would be expected to move away and therefore unlikely to accumulate more injurious levels. Furthermore, mitigation measures will be in place to initiate a power-down if individuals enter or are about to enter the 500 m (1,640.4 ft) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. As stated in the *Exposure Analysis*, each individual is expected to potentially be exposed to 160 dB re: 1 μPa (rms) levels. We do not expect this to produce a cumulative TTS or other physical injury for several reasons. We expect that individuals will recover from TTS between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals, to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS or PTS.

Marine Mammals and Auditory Interference (Masking)

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Francis & Barber, 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson, 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis & Barber, 2013).

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales and South Island Hector's dolphins. The proposed seismic surveys could mask whale calls at some of the lower frequencies for these species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans, 1998; NMFS, 2006h). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz , and though the findings by Madsen et al. (2006) suggest frequencies of

pulses from airgun arrays can overlap this range, the strongest spectrum levels of airguns are below 200 Hz (2 to 188 Hz for the *Langseth*'s airgun array).

Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS, 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls will be expected to pose a somewhat greater risk of masking. The *Langseth*'s airguns will emit a 0.1 second pulse when fired approximately every 16 to 60 seconds. Therefore, pulses will not "cover up" the vocalizations of ESA-listed marine mammals to a significant extent (Madsen et al., 2002). We address the response of ESA-listed marine mammals stopping vocalizations as a result of airgun sound in the *Marine Mammals and Behavioral Responses* section below.

Although sound pulses from airguns begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as in shallow water environments, airgun sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add significantly to acoustic background (Guerra et al., 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

The sound localization abilities of marine mammals suggest that, if signal and sound come from different directions, masking will not be as severe as the usual types of masking studies might suggest (Richardson, 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain & Dahlheim, 1994; Bain et al., 1993; Dubrovskiy & Giro, 2004). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au, 1975; Au et al., 1974; Lesage et al., 1999; Moore & Pawloski, 1990; Romanenko & Kitain, 1992; Thomas et al., 1990). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Au, 1993; Dahlheim, 1987; Foote et al., 2004; Holt et al., 2009; Lesage et al., 1993; Lesage et al., 1999; Parks, 2009; Terhune, 1999).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine

mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency as 18 kHz, in contrast to the pronounced effect at higher frequencies. Studies have noted direction hearing at frequencies as low as 0.5 to 2 kHz in several marine mammals, including killer whales (Richardson et al., 1995). This ability may be useful in reducing masking at these frequencies. In summary, high levels of sound generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects, such as that used in echolocation by toothed whales.

Marine Mammals and Behavioral Responses

We expect the greatest response of marine mammals to airgun sounds in terms of number of responses and overall impact to be in the form of changes in behavior. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case some of these repsonses could equate to harassment of individuals but are unlikely to result in meaningful behavioral responses at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al., 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al., 2012); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Francis & Barber, 2013). Although some studies are available which address responses of ESA-listed marine mammals considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-ESA-listed or species outside the action area are also considered here. Animals generally respond to anthropogenic perturbations as they will predators, increasing vigilance, and altering habitat selection (Reep et al., 2011). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis & Barber, 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect it possible for marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus.

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds for airguns. Whales continue calling while seismic surveys are operating locally (Greene Jr et al., 1999; Jochens et al., 2006; Madsen et al., 2002; McDonald et al., 1993; McDonald et al., 1995; Nieukirk et al., 2004; Richardson et al., 1986; Smultea et al.,

2004; Tyack et al., 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio et al., 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al., 1994; Clark & Gagnon, 2006; McDonald et al., 1995). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al., 2012). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates and found no evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re: 1 µPa (rms) (Wilcock et al., 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio & Clark, 2009). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al., 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re: 1 µPa (peak-to-peak) (Madsen et al., 2002; McCall Howard, 1999). For the species considered in this consultation, some exposed individuals may cease calling in response to the *Langseth*'s airgun array. If individuals ceased calling in response to the *Langseth*'s airgun array during the course of the proposed seismic surveys, the effect is expected to be temporary and brief given the ship is constantly moving when seismic airguns are active. Animals may resume or modify calling at a later time or location once the acoustic stressor has diminished..

There are numerous studies of the responses of some baleen whales to airguns. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re: 1 µPa (rms) (the level used in this Opinion to determine the extent of acoustic effects for marine mammals) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al., 1995). Activity of individuals seems to influence response (Robertson et al., 2013), as feeding individuals respond less than mother and calf pairs and migrating individuals (Harris et al., 2007; Malme & Miles, 1985; Malme et al., 1984; Miller et al., 1999; Miller et al., 2005; Richardson et al., 1995; Richardson et al., 1999). Surface duration decreased markedly during exposure to airgun sounds, especially while individuals were engaged in traveling or non-calf social interactions (Robertson et al., 2013). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re: 1 µPa (rms) exposures at distances of 20 to 30 km (10.8 to 16.2 nmi), but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152 to 178 dB re: 1 µPa [rms]) (Harris et al., 2007; Ljungblad et al., 1988; Miller et al., 1999; Miller et al., 2005; Richardson et al., 1995; Richardson et al., 1999; Richardson et al., 1986). Responses such as stress may occur and the threshold for displacement may simply be higher while feeding. Bowhead whale calling rate was found to decrease during migration in the Beaufort Sea as well as temporary displacement from seismic sources (Nations et al., 2009). Calling rates decreased when exposed to seismic airguns at received levels of 116 to 129 dB re: 1 µPa (possibly but not

knowingly due to whale movement away from the airguns), but did not change at received levels of 99 to 108 dB re: 1 µPa (Blackwell et al., 2013). Despite the above information and exposure to repeated seismic surveys, bowhead whales continue to return to summer feeding areas and when displaced, appear to re-occupy within a day (Richardson et al., 1986). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether though they tolerate repeat exposures, they may still experience a stress response.

Gray whales respond similarly. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 µPa (rms) (Bain & Williams, 2006; Gailey et al., 2007; Johnson et al., 2007; Malme & Miles, 1985; Malme et al., 1984; Malme et al., 1986; Malme et al., 1988; Würsig et al., 1999; Yazvenko et al., 2007a; Yazvenko et al., 2007b). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re: 1 µPa (rms) and slight behavioral changes at 140 to 160 re: 1 µPa (rms) (Malme & Miles, 1985; Malme et al., 1984). As with bowhead whales, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al., 1984). (Johnson et al., 2007) reported that gray whales exposed to airgun sounds during seismic surveys off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002 through 2005.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: 1 µPa (rms) when females with calves were present, or 7 to 12 km (3.8 to 6.5 nmi) from the acoustic source (McCauley et al., 2000a; McCauley et al., 1998). A startle response occurred as low as 112 dB re: 1 µPa (rms). Closest approaches were generally limited to 3 to 4 km (1.6 to 2.2 nmi), although some individuals (mainly males) approached to within 100 m (328.1 ft) on occasion where sound levels were 179 dB re: 1 µPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 µPa (rms).

Natural sources of sound also influence humpback whale behavior. Migrating humpback whales showed evidence of a Lombard effect in Australia, increasing vocalization in response to wind-dependent background noise (Dunlop et al., 2014a). Since natural resources of noise alone can influence whale behavior, additional anthropogenic sources could also add to these effects.

Multiple factors may contribute to the degree of response exhibited by migrating humpback whales. In a preliminary study examining the responses by migrating humpback whales of exposure to a 20 in^3 airgun, researchers found that the humpback whales' behavior seemed to be influenced by social effects; "whale groups decreased dive time slightly and decreased speed towards the source, but there were similar responses to the control" (i.e., towed airgun, not in operation) (Dunlop et al., 2014b). Whales in groups may pick up responses by other individuals in the group and react. The results of this continued study are still pending, and will examine the effects of a full size commercial airgun array on humpback whale behavior (Dunlop et al., 2014b).

Feeding humpback whales appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150 to 169 dB re: 1 µPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 µPa (rms) (Malme et al., 1984; Malme et al., 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airguns. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir, 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone, 2003; Stone & Tasker, 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities) as well as whales being more distant during seismic operations (Moulton et al., 2006a; Moulton et al., 2006b; Moulton & Miller, 2005). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1 µPa (rms) (Moulton & Miller, 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al., 2000; Madsen et al., 2006; Miller et al., 2009; Moulton et al., 2006a; Moulton & Miller, 2005; Stone, 2003; Stone & Tasker, 2006; Weir, 2008). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1 µPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al., 2006; Gordon et al., 2004; Jochens et al., 2006; Madsen et al., 2006; Winsor & Mate, 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens & Biggs, 2003; Jochens & Biggs, 2004; Mate et al., 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 µPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold, 1999; Watkins et al., 1985; Watkins & Schevill, 1975). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a non-random distribution of satellite-tagged sperm whales at and beyond 5 km (2.7 nmi) from airgun arrays, suggesting individuals were not displaced or move away from the airgun array at and beyond these distances in the Gulf of Mexico (Winsor & Mate, 2013). However, no tagged whales within 5 km (2.7 nmi) were available to assess potential displacement (Winsor & Mate, 2013). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 188 Hz) pulses produced by seismic airguns (Richardson et al., 1995). Sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold & Fish, 1998), so

even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 µPa lower at 1 kHz and 60 dB re: 1 µPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude, 2013). Reactions to impulse noise likely vary depending on the activity at time of exposure, for example, in the presence of abundant food or during breeding encounters toothed whales sometimes are extremely tolerant of noise pulses (NMFS, 2006b).

For whales exposed to airguns during the proposed seismic survey activities, behavioral changes stemming from exposure to the airgun array may result in loss of feeding opportunities. Similar to the species behavioral responses described above, we expect ESA-listed whales exposed to sound from the airgun array considered in this consultation will also exhibit an avoidance reaction, displacing individuals from the action area at least temporarily. However, we expect secondary foraging areas to be available that will allow whales to continue feeding even when displaced from some foraging areas in the action area. Although breeding may be occurring, we are unaware of any habitat features that whales will be displaced from that is essential for breeding if whales depart an area as a consequence of the *Langseth*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect these temporary disruptions to result in the loss of any breeding opportunities. Other essential behaviors such as travel or migration are also expected to continue by indivduals transiting through the area during these activities.

Steller sea lions may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003; Götz and Janik 2011; Kvadsheim et al. 2010). These behavioral changes are expected to be temporary and not persist, and significant behavioral reactions would not be expected in most cases, thus long-term consequences for individuals or the population are unlikely.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress, that can significantly affect life history. Other effects like neurological effects, bubble formation, and other types of organ or tissue damage could occur, but similar to stress.

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Busch, 2009; Gregory & Schmid, 2001; Gulland et al., 1999; St. Aubin & Geraci, 1988; St. Aubin et al., 1996; Thomson & Geraci, 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose

into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch, 2009; Cattet et al., 2003; Dickens et al., 2010; Dierauf & Gulland, 2001; Elftman et al., 2007; Fonfara et al., 2007; Kaufman & Kaufman, 1994; Mancia, 2008; Noda et al., 2007; Thomson & Geraci, 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al., 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan & Curry, 1998, 2002; Cowan, 2008; Herraez et al., 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf & Gulland, 2001). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner & Hall, 1997; Hunt et al., 2006; Keay, 2006; Romero et al., 2008; St. Aubin et al., 1996). For example, stress is lower in immature North Atlantic right whales (*Eubalaena glacialis*) than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al., 2006; Keay, 2006).

Loud noises generally increase stress indicators in mammals (Kight, 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic watergun (up to 228 dB re: 1 µPa m peak-to-peak and single pure tones (up to 201 dB re: 1 µPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S.; this decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al., 2012). These levels returned to baseline after 24 hours of traffic resuming. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities will be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS, 2006g). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are also expected to be accompanied by physiological stress responses (NMFS, 2006g; NRC, 2003b). As we do not expect individuals to experience any long-term affects from TTS , (see *Marine Mammals and Threshold Shifts*), we also do not expect any ESA-listed individual to experience a stress response at high levels. Although we assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, and these stress responses can exert deleterious effects on individuals if chronic or of long duration, the stressor (sounds associated with the airgun array or multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler) will dissipate in a short period as the vessel (and stressors) transits away without significant or long-term harm to the individual via the stress response.

Exposure to loud noise (e.g., airguns) can also adversely affect reproductive and metabolic physiology (Kight, 2011). Premature birth and indicators of developmental instability (possibly

due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. In fish eggs and embryos exposed to sound levels only 15 dB greater than background, increased mortality was found and surviving fry had slower growth rates (a similar effect was observed in shrimp), although the opposite trends have also been found in sea bream. Dogs exposed to loud music took longer to digest food. The small intestine of rats leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). Exposure to 12 hours of loud noise can alter elements of cardiac tissue. In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight, 2011).

It is possible that a marine animal's prior exposure to sounds from seismic surveys influence its future response. Although we have little information available to us as to what response individuals will have to future exposures to sources from seismic surveys compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response will likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (André et al., 1997; Gordon et al., 2006). We do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to sounds from seismic surveys that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis*).

Marine Mammals and Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (Iagc, 2004; IWC, 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20 airgun array (139,126.2 cm^3[8,490 in^3]) 22 km (11.9 nmi) offshore the general area at the time that stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al., 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al., 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an

animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Creel, 2005; Fair & Becker, 2000; Kerby et al., 2004; Moberg, 2000; Romano et al., 2004). At present, the factors of airgun arrays from seismic surveys that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings. We therefore do not expect ESA-listed marine mammals to strand as a result of the proposed seismic survey.

Responses of Marine Mammal Prey

Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed marine mammals. Unfortunately, species-specific information on the prey of ESA-listed marine mammals is not generally available. Until more specific information is available, we expect that teleost, cephalopod, and krill prey of ESA-listed marine mammals to react in manners similar to those fish and invertebrates described herein.

Some support has been found for fish or invertebrate mortality resulting from exposure to airguns, and this is limited to close-range exposure to high amplitudes (Bjarti, 2002; Falk & Lawrence, 1973; Hassel et al., 2003; Holliday et al., 1987; Kostyuchenko, 1973; La Bella et al., 1996; McCauley et al., 2000a; McCauley et al., 2000b; McCauley et al., 2003; Popper et al., 2005; Santulli et al., 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al., 2004; Dalen & Knutsen, 1986). We expect that if fish detect the sound and perceive it as a threat or some other signal that induces them to leave the area since they are capable of moving away from the sound source (e.g., airgun array) and will return to the area and available as prey for marine mammals.

There are reports showing sub-lethal effects to some fish species. Several fish species (various life stages) have been exposed to high-intensity sound sources (220 to 242 dB re: 1 µPa) at close distances, with some cases of injury and are presented below (Booman et al., 1996; McCauley et al., 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 $\mu Pa^2 s$, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al., 2005). Caged pink snapper (*Pelates spp.*) have experienced PTS when exposed over 600 times to received sound levels of 165 to 209 dB re: 1 µPa peak-to-peak. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen & Knutsen, 1986). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne et al., 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 µPa (Falk & Lawrence, 1973).

By far the most common response by fishes is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column. Although received sound levels were not reported, caged

Pelates spp., pink snapper, and trevally (*Caranx ignobilis*) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (McCauley & Fewtrell, 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (McCauley & Fewtrell, 2013a).

Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1 µPa 0-to-peak and alarm responses at greater than 177 dB re: 1 µPa 0-to-peak (Pearson et al., 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 re: 1 µPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski et al., 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 km (1.3 nmi) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re: 1 µPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 dB re: 1 µPa) despite airgun activity (Chapman & Hawkins, 1969). Whiting may also flee from sounds from airguns (Dalen & Knutsen, 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al., 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al., 2003; Hassel et al., 2004).

McCauley et al. (2000; 2000a) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 dB re: 1 µPa (rms), but responses tended to decrease over time, suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195 to 218 dB re: 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al., 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 m (65.6 to 164 ft) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al., 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 µPa peak-to-peak sound levels from an airgun (Bjarti, 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 µPa 0-to-peak (Dalen & Knutsen, 1986; Engås et al., 1996; Engås et al., 1993; Løkkeborg, 1991; Løkkeborg & Soldal, 1993; Turnpenny et al., 1994).

Increased swimming activity in response to airgun exposure on fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate

during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1 µPa 0-to-peak (Turnpenny & Nedwell, 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al., 1994). La Bella (La Bella et al., 1996) found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

Squid are know to be important prey for sperm whales. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 µPa (rms) by first ejecting ink and then moving rapidly away from the area (McCauley & Fewtrell, 2013b; McCauley et al., 2000a; McCauley et al., 2000b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 dB re: 1 µPa (rms). Norris and Mohl (1983, summarized in(Moriyasu et al., 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after three to 11 minutes. (Andre et al., 2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 Hz at 157 ±5 dB re: 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received SPL was 157 ±5 dB re: 1 µPa, with peak levels at 175 dB re: 1 µPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. Another laboratory story observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al., 2013).

Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Payne et al., 2013). However, feeding did increase in exposed individuals (Payne et al., 2013). Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed seismic surveys. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: 1 µPa (rms) isopleths could vacate the area and/or dive to greater depths.

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We are not aware of any specific studies regarding sound effects on and the detection ability of other invertebrates such as krill (*Euphausiacea* spp.), the primary prey of most ESA-listed baleen whales. However, we do not expect krill populations to experience long-term effects from seismic sounds of airguns. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales. We do not expect indirect effects from airgun array operations

through reduced feeding opportunities for ESA-listed whales to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, these cetaceans and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

Marine Mammal Response to Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler

We expect ESA-listed whales to experience exposure to acoustic stressors from not only the airgun array, but also from the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler used during these seismic survey operate at a frequencies of 10.5 to 13 (usually 12) kHz, 3.5 kHz, and 75 kHz. These frequencies are within the functional hearing range of baleen whales, such as the ESA-listed blue, fin, humpback, North Pacific right, and sei whales, as well as sperm whales (NOAA, 2016). We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng et al., 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80 to 90 dB re: 1 µPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kHz mid-frequency sonar at received levels below 90 dB re: 1 µPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen et al., 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler systems (Ketten, 1997; Richardson et al., 1995).

Assumptions for humpback and sperm whale hearing are much different than for ESA-listed baleen whales. Humpback and sperm whales vocalize between 3.5 to 12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au, 2000; Carder & Ridgway, 1990; Erbe, 2002a; Frazer & Mercado, 2000; Goold & Jones, 1995; Levenson, 1974; Payne & Payne, 1985; Payne, 1970; Richardson et al., 1995; Silber, 1986; Thompson et al., 1986; Tyack, 1983; Tyack & Whitehead, 1983; Weilgart & Whitehead, 1993; Weilgart & Whitehead, 1997; Weir et al., 2007; Winn et al., 1970). The response of a blue whale to 3.5 kHz sonar supports this species' ability to hear this signal as well (Goldbogen et al., 2013). Maybaum (1990; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kHz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal will have to pass at close range and be swimming at speeds similar to the vessel. The animal will have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient

exposure to cause TTS. Sperm whales have stopped vocalizing in response to 6 to 13 kHz pingers, but did not respond to 12 kHz echosounders (Backus & Schevill, 1966; Watkins, 1977; Watkins & Schevill, 1975). Sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding, but not while traveling (Andre & Jurado, 1997; André et al., 1997).

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kHz multi-beam echosounder, similar in operating characteristics as that proposed for use aboard the *Langseth*, played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall et al., 2013). Although pathological data suggest a direct physical effect are lacking and the authors acknowledge that while the use of this type of sonar is widespread and commonplace globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multi-beam echosounder (Southall et al., 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Langseth*'s multi-beam echosounder. Although effects such as this have not been documented for ESA-listed species, the combination of exposure of this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than will otherwise be anticipated or has been documented to date (Ellison et al., 2012; Francis & Barber, 2013).

Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have not been correlated to use of these sonars. Stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by the *Langseth* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multi-beam echosounder. The sound energy received by any individuals exposed to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sources during the proposed seismic survey activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, fin, humpback, North Pacific right, sei, or sperm whales communication to appreciably occur due to the multi-beam echosounder's, sub-bottom profiler's, and acoustic Doppler current profiler's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multi-beam echosounder was less than three percent that of ship strike. Behavioral responses to the multi-beam echosounder, sub-bottom profiler, and

acoustic Doppler current profiler are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. Also, we do not expect hearing impairment such as TTS and other physical effects if the animal is in the area, as it would have to pass the transducers at close range in order to be subjected to sound levels that could cause these effect.

11.4 Risk Analysis

In this section, we assess the consequences of the responses to the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. For designated critical habitat, we assess the consequences of these responses on the value of the critical habitat for the conservation of the species for which the habitat had been designated.

We measure risks to individuals of endangered or threatened species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success.

We expect that up to 49 blue, 3,913 fin, 631 humpback, 11 North Pacific right, 9 sei, 86 sperm whales as well as 2,168 Steller sea lions (see Table 13), to be exposed to the airgun array within 160 dB re: 1 µPa (rms) ensonified areas during the seismic survey. When we do not expect individual ESA-listed marine mammals exposed to an action's effects to experience reductions in fitness, we will not expect the action to have adverse consequences on the viability of the populations those individuals belong or the species those populations comprise. As a result, if we conclude that ESA-listed animals are not likely to experience reductions in their fitness, we will conclude our assessment. If, however, we conclude that individual animals are likely to experience reductions in fitness, we will assess the consequences of those fitness reductions on the population(s) to which those individual belong.

Because of the mitigation measures in the incidental harassment authorization, and the nature of the seismic surveys, as described above, we do not expect any mortality to occur from the exposure to the acoustic sources that result from the proposed action. As described above, the proposed action will result in temporary harassment and potential harm to the exposed marine mammals. Harassment is not expected to have more than short-term effects on individual ESA-listed species (blue, fin, humpback, North Pacific right, sei, sperm whales, or Steller sea lions). While permited, harm under the ESA is not expected to occur with high probability given the mitigation measures in place for the proposed activity to protect ESA-listed species.. As such we do not expect ESA-listed marine mammals exposed to this action's effects to experience reductions in fitness, nor do we expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise. No critical habitat for these species will be adversely affected by activities associated with the proposed action.

12 Integration and Synthesis

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 11) to the *Environmental Baseline* (Section 10) and the *Cumulative Effects* (Section 13) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species Likely to be Adversely Affected* (Section 9).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion.

12.1 Blue Whale

No reduction in the distribution of blue whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

There are three stocks of blue whales designated in United States (U.S.) waters: the Eastern North Pacific Ocean (current best estimate N=1,647, N_{min}=1,551;) (Payne et al., 1990), Central North Pacific Ocean (N=81, N_{min}=38), and Western North Atlantic Ocean (N=400 to 600, N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95 percent confidence intervals 1,160 to 4,500 (Branch, 2007).

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

The effects of seismic survey activities considered in this opinion are not expected to result in lethal take of any individual blue whale. The anticipated take in the form of non-lethal harm resulting to 2 individuals (PTS) and 47 individuals harassed as a result of TTS (behavioral responses, etc.) is not anticipated to result in a reduction in numbers for this species. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the abundance, distribution and reproduction of blue whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for blue whales. In conclusion, we believe the non-lethal effects associated with the proposed actions are not expected to appreciably reduce the likelihood of survival and recovery of blue whales in the wild.

12.2 Fin Whale

No reduction in the distribution of fin whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization. There are expected to be 16 individual harmed and 3,897 individual fin harassed as a result of the proposed seismic surveys.

There are three fin whale stocks in U.S. Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al., 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al., 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al., 2016).

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

The effects of seismic survey activities considered in this opinion are not expected to result in lethal take of any individual fin whale. The anticipated take in the form of non-lethal harm resulting to 16 individuals (PTS) and 3,897 individuals being harassed as a result of TTS (behavioral responses, etc.) is not anticipated to result in a reduction in numbers for this species. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the fin whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for fin whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of fin whales in the wild.

12.3 Humpback Whale – Mexico Distinct Population Segment

No reduction in the distribution of the Mexico DPS of humpback whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

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

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be 3 individuals harmed and 599 individual humpback whales (Mexico DPS) harassed as a result of the proposed seismic surveys. Because we do not anticipate a reduction in numbers or reproduction of Mexico DPS of humpback whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the distribution of the Mexico DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Mexico DPS of humpback whales in the wild.

12.4 Humpback Whale – Western Pacific Population Segment

No reduction in the distribution of Western Pacific DPS of humpback whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

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

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be 1

individual harmed and 28 individuals humpback whales (Western Pacific DPS) harassed as a result of the proposed seismic surveys.

Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the distribution of Western Pacific DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for Western Pacific DPS of humpback whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Western Pacific DPS of humpback whales in the wild.

12.5 North Pacific Right Whale

No reduction in the distribution of North Pacific right whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization. There are expected to be no instances of harm and 11 instances of harassment of North Pacific right whales as a result of the proposed seismic surveys.The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals. There are two currently recognized stocks of North Pacific right whales, a Western North Pacific stock that feeds primarily in the Sea of Okhotsk, and an Eastern North Pacific stock that feeds in eastern North Pacific Ocean waters off Alaska, Canada, and Russia. Several lines of evidence indicate a total population size of less than 100 for the Eastern North Pacific stock. Based on photo-identification from 1998 to 2013 (Wade et al., 2011a) estimated 31 individuals, with a minimum population estimate of 26 individuals (Muto et al., 2017). Genetic data have identified 23 individuals based on samples collected between 1997 and 2011 (Leduc et al., 2012). The Western North Pacific stock is likely more abundant and was estimated to consist of 922 whales (95 percent confidence intervals 404 to 2,108) based on data collected in 1989, 1990, and 1992 (IWC, 2001; Thomas et al., 2016). The population estimate for the Western North Pacific stock is likely in the low hundreds (Brownell Jr. et al., 2001). While there have been several sightings of Western North Pacific right whales in recent years, with one sighting identifying at least 77 individuals, these data have yet to be compiled to provide a more recent abundance estimate (Thomas et al., 2016). There is currently no information on the population trend of North Pacific right whales.

The effects of seismic survey activities considered in this opinion are not expected to result in lethal take of any individual blue whale. The anticipated take in the form of 11 individuals being harassed as a result of TTS (behavioral responses, etc.) is not anticipated to result in a reduction in numbers for this species. There are no anticipated takes in the form of harm to this species. Because we do not anticipate a reduction in numbers or reproduction of North Pacific right

whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2013 Final Recovery Plan for the North Pacific right whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of North Pacific right whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for North Pacific right whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of North Pacific right whales in the wild.

12.6 Sei Whale

No reduction in the distribution of sei whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

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

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be two individuals harmed and seven sei whales harassed as a result of the proposed seismic surveys. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2001 Final Recovery Plan for the sei whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of sei whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sei whales in the wild.

12.7 Sperm Whale

No reduction in the distribution of sperm whales from the Pacific Ocean are expected because of the NSF's seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization.

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

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be zero individuals harmed and 86 individual sperm whales harassed as a result of the proposed seismic surveys. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the sperm whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of sperm whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits

and Conservation Division's issuance of an IHA will impede the recovery objectives for sperm whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sperm whales in the wild.

12.8 Steller Sea Lion – Western Distinct Population Segment

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

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

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

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

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be 3 individuals harmed and 2,165 individual Steller sea lions harassed as a result of the proposed seismic surveys. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Steller sea lions as a result of the proposed seismic survey activities and the Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2008 Final Recovery Plan for the Steller sea lion lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of Steller sea lions are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits and Conservation Division's issuance of an IHA will impede the recovery objectives for Steller sea lions. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Steller sea lions in the wild.

13 Cumulative Effects

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

We expect that those aspects described in the *Environmental Baseline* (Section 10) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, harvesting, vessel strikes, whale watching, fisheries interactions, pollution, aquatic nuisance species, disease, oil spills, anthropogenic sound, military activities, and scientific research activities to continue into the future for marine mammals.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. We conducted electronic searches of *Google* and other electronic search engines for other potential future state or private activities that are likely to occur in the action area. We are not aware of any state or private activities that are likely to occur in the action area during the foreseeable future that were not considered in the *Environmental Baseline* section of this opinion.

14 Conclusion

After reviewing the current status of the ESA-listed species, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of blue whales, fin whales, Mexico DPS of humpback whales, Western North Pacific DPS of humpback whales, North Pacific right whales, sei whales, sperm whales, and Steller sea lions or to destroy or adversely modify any of their designated critical habitat.

15 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" (16 U.S.C. §1532(19)). "Harm" is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102).

Incidental take is take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. NMFS had not yet defined "harass" under the ESA in regulation. On December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering."

For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed marine mammals and the ESA interim definition of harassment to estimate the number of instances of harassment for ESA species.

ESA section 7(b)(4) states that take of ESA-listed marine mammals must be authorized under MMPA section 101(a)(5) before the Secretary can issue an incidental take statement for ESA-listed marine mammals. NMFS' implementing regulations for MMPA section 101(a)(5)(D) specify that an IHA is required to conduct activities pursuant to any incidental take authorization for a specific activity that will "take" marine mammals. Once NMFS has authorized the incidental take of marine mammals under an IHA for the period of August 8, 2018, through August 7, 2019, under the MMPA, the incidental take of ESA-listed marine mammals is exempt from the ESA take prohibitions as stated in this incidental take statement pursuant to section 7(b)(4) and 7(o)(2).

Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

15.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent, of such incidental taking on the species and may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take for marine mammals may be exceeded. As such, if more tracklines are conducted during the seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation will be necessary.

15.1.1 Marine Mammals

We and the NMFS Permits and Conservation Division anticipate the proposed seismic survey in the GOA are likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 14). Behavioral (MMPA Level B) harassment is expected to occur at received levels at or above 160 dB re: 1 μPa (rms) for ESA-listed marine mammals. For all species of ESA-listed marine mammals, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form of MMPA Level B harassment, and is not expected to result in the death or injury of any ESA-listed individuals that will be exposed. It is believed that any PTS incurred in these marine mammals as a result of the proposed activity would be in the form of only a small degree of PTS, not total deafness, and would be unlikely to affect the fitness of any individuals, because of the constant movement of both the *Langseth* and of the marine mammals in the project areas, as well as the fact that the vessel is not expected to remain in any one area in which individual marine mammals would be expected to concentrate for an extended period of time (*i.e.*, since the duration of exposure to loud sounds will be relatively short). Also, as described above, we expect that marine mammals would be likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in PTS, given sufficient notice of the *Langseth's* approach due to the vessel's relatively low speed when conducting seismic surveys.

Table 14. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Gulf of Alaska by the incidental take statement.

Species	Potential Temporary Threshold Shift and Behavioral Harassment	Potential Permanent Threshold Shift and Harm
Blue Whale	47	2
Fin Whale	3,897	16
Humpback Whale – Mexico DPS	599	3
Humpback Whale – Western Pacific DPS	28	1
North Pacific Right Whale	11	0
Sei Whale	7	2
Sperm Whale	86	0

Steller Sea Lion – Western DPS	2,165	3

DPS=Distinct Population Segment

15.2 Effects of the Take

In this Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

15.3 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by NSF and the NMFS Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS Permits and Conservation Division must ensure that the NSF implements a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed IHA for the incidental taking of blue, fin, humpack (Mexico and Western Pacific DPSs), North Pacific right, sei, and sperm whales, and Steller sea lions pursuant to section 101(a)(5)(D) of the MMPA. In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and to inform the NMFS ESA Interagency Cooperation Division if take is exceeded.
- The NMFS Permits and Conservation Division must ensure that the NSF implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of marine mammals.

15.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the NSF and NMFS Permits and Conservation Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These include the take minimization,

monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the NSF and NMFS Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the reasonable and prudent measures, the NSF, and the NMFS Permits and Conservation Division shall implement the following terms and conditions.

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the incidental harassment authorization, whichever comes sooner.
2. Any reports of injured or dead ESA-listed species must be provided to the ESA Interagency Cooperation Division immediately to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by email at cathy.tortorici@noaa.gov.

16 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We recommend the following conservation recommendations, which will provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect ESA-listed species as well as reduce harassment related to the authorized seismic survey activities.

1. We recommend that the NSF develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
2. We recommend that the NMFS Permits and Conservation Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future incidental harassment authorizations for seismic surveys.
3. We recommend the NSF use (and NMFS Permits and Conservation require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting threatened and endangered species.
4. We recommend the NSF and NMFS Permits and Conservation Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across protected species observer reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us

understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.

5. We recommend the NSF notify NMFS Permits and Conservation Division of any sightings of North Pacific right whales and provide sighting information within 48 hours.
6. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the *Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to protected species observers.

In order for NMFS' Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat the NMFS Permits and Conservation Division should notify the NMFS Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

17 Reinitiation Notice

This concludes formal consultation for

National Science Foundation and Lamont-Doherty Earth Observatory's Proposed Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the Western Gulf of Alaska and National Marine Fisheries Service Permits and Conservation Division's Issuance of an IHA pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the incidental take statement is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then (3) above may be met and reinitiation of consultation may be necessary.

18 REFERENCES

Aburto, A., Rountry, D. J., & Danzer, J. L. (1997). *Behavioral responses of blue whales to active signals* (Technical Report 1746). Retrieved from San Diego, CA:

Ackerman, R. A. (1997). The nest environment and the embryonic development of sea turtles. In M. J. Kennish & P. L. Lutz (Eds.), *The Biology of Sea Turtles* (pp. 83-106). Boca Raton: CRC Press.

Addison, R. F., & Brodie, P. F. (1987). Transfer of organochlorine residues from blubber through the circulatory system to milk in the lactating grey seal Halichoerus grypus. *Canadian Journal of Fisheries and Aquatic Sciences, 44*, 782-786.

Amaral, K., & Carlson, C. (2005). *Summary of non-lethal research techniques for the study of cetaceans.* Retrieved from

Anderwald, P., Evans, P. G. H., & Hoelzel, A. R. (2006). *Interannual differences in minke whale foraging behaviour around the small isles, West Scotland*. Paper presented at the Twentieth Annual Conference of the European Cetacean Society, Gdynia, Poland.

Andre, M., & Jurado, L. F. L. (1997). *Sperm whale (Physeter macrocephalus) behavioural response after the playback of artificial sounds*. Paper presented at the Tenth Annual Conference of the European Cetacean Society, Lisbon, Portugal.

Andre, M., Sole, M., Lenoir, M., Durfort, M., Quero, C., Mas, A., Lombarte, A., van der Schaar, M., Lopez-Bejar, M., Morell, M., Zaugg, S., & Houegnigan, L. (2011). Low-frequency sounds induce acoustic trauma in cephalopods. *Frontiers in Ecology and the Environment, 9*(9), 489-493. doi:10.1890/100124

André, M., Terada, M., & Watanabe, Y. (1997). *Sperm whale (Physeter macrocephalus) behavioural responses after the playback of artificial sounds* (SC/48/NA13). Retrieved from

Antonelis, G. A., Baker, J. D., Johanos, T. C., Braun, R. C., & Harting, A. L. (2006). Hawaiian monk seal (Monachus schauinslandi): status and conservation issues. *Atoll Research Bulletin, 543*, 75-101.

Archer, F. I., Morin, P. A., Hancock-Hanser, B. L., Robertson, K. M., Leslie, M. S., Berube, M., Panigada, S., & Taylor, B. L. (2013). Mitogenomic phylogenetics of fin whales (Balaenoptera physalus spp.): genetic evidence for revision of subspecies. *PLoS One, 8*(5), e63396. doi:10.1371/journal.pone.0063396

Attard, C. R. M., Beheregaray, L. B., Jenner, C., Gill, P., Jenner, M., Morrice, M., Bannister, J., LeDuc, R., & Möller, L. (2010). Genetic diversity and structure of blue whales (*Balaenoptera musculus*) in Australian feeding aggregations. *Conservation Genetics, 11*(6), 2437–2441. doi:10.1007/s10592-010-0121-9

Au, W., Darling, J., & Andrews, K. (2001). High-frequency harmonics and source level of humpback whale songs. *Journal of the Acoustical Society of America, 110*(5 Part 2), 2770.

Au, W. W. L. (1975). *Propagation of dolphin echolocation signals*. Paper presented at the Conference on the Biology and Conservation of Marine Mammals, University of California, Santa Cruz.

Au, W. W. L. (1993). *The Sonar of Dolphins*. New York, New York: Springer-Verlag.

Au, W. W. L. (2000). Hearing in whales and dolphins: an overview. In W. W. L. Au, A. N. Popper, & R. R. Fay (Eds.), *Hearing by Whales and Dolphins* (pp. 1-42). New York: Springer-Verlag.

Au, W. W. L., Floyd, R. W., Penner, R. H., & Murchison, A. E. (1974). Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu in open waters. *Journal of the Acoustical Society of America, 56*(4), 1280-1290.

Au, W. W. L., & Green, M. (2000). Acoustic interaction of humpback whales and whale-watching boats. *Marine Environmental Research, 49*(5), 469-481.

Au, W. W. L., Mobley, J., Burgess, W. C., Lammers, M. O., & Nachtigall, P. E. (2000a). Seasonal and diurnal trends of chorusing humpback whales wintering in waters off western Maui. *Marine Mammal Science, 16*(3), 15.

Au, W. W. L., Pack, A. A., Lammers, M. O., Herman, L. M., Deakos, M. H., & Andrews, K. (2006). Acoustic properties of humpback whale songs. *Journal of the Acoustical Society of America, 120*(2), 1103-1110. doi:10.1121/1.2211547

Au, W. W. L., Popper, A. N., & Fay, R. R. (2000b). *Hearing by whales and dolphins*. New York: Springer-Verlag.

Backus, R. H., & Schevill, W. E. (1966). Physeter clicks. In K. S. Norris (Ed.), *Whales, dolphins, and porpoises* (pp. 510-528). Berkeley, California: University of California Press.

Bain, D. E., & Dahlheim, M. E. (1994). Effects of masking noise on detection thresholds of killer whales. In T. R. Loughlin (Ed.), *Marine Mammals and the Exxon Valdez* (pp. 243-256). San Diego: Academic Press.

Bain, D. E., Kriete, B., & Dahlheim, M. E. (1993). Hearing abilities of killer whales (*Orcinus orca*). *Journal of the Acoustical Society of America, 94*(3 part 2), 1829.

Bain, D. E., Lusseau, D., Williams, R., & Smith, J. C. (2006). *Vessel traffic disrupts the foraging behavior of southern resident killer whales (Orcinus spp.)*. Retrieved from

Bain, D. E., & Williams, R. (2006). Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. *International Whaling Commission Working Paper SC/58/E35.*

Baird, R. W., Mahaffy, S. D., Gorgone, A. M., Cullins, T., Mcsweeney, D. J., Oleson, E. M., Bradford, A. L., Barlow, J., & Webster, D. L. (2015). False killer whales and fisheries interactions in Hawaiian waters: Evidence for sex bias and variation among populations and social groups. *Marine Mammal Science, 31*(2), 579-590.

Baker, C. S., & Clapham, P. J. (2004). Modelling the past and future of whales and whaling. *Trends in Ecology and Evolution, 19*(7), 365-371.

Baker, J. D., Littnan, C. L., & Johnston, D. W. (2006). Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. *Endangered Species Research, 2*, 21-30.

Barber, J. R., Crooks, K. R., & Fristrup, K. M. (2010). The costs of chronic noise exposure for terrestrial organisms. *Trends in Ecology and Evolution, 25*(3), 180–189. doi:10.1016/j.tree.2009.08.002

Bauer, G. B. (1986). *The behavior of humpback whales in Hawaii and modifications of behavior induced by human interventions. (Megaptera novaeangliae).* (Ph.D. dissertation), University of Hawaii. 314p.,

Baulch, S., & Perry, C. (2014). Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin, 80*(1-2), 210-221.

Beamish, R. J. (1993). Climate and exceptional fish production off the west coast of North American. *Canadian Journal of Fisheries and Aquatic Sciences, 50*(10), 2270-2291.

Bejder, L., Dawson, S. M., & Harraway, J. A. (1999). Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. *Marine Mammal Science, 15*(3), 738-750.

Bejder, L., & Lusseau., D. (2008). Valuable lessons from studies evaluating impacts of cetacean-watch tourism. *Bioacoustics, 17-Jan*(3-Jan), 158-161. Special Issue on the International Conference on the Effects of Noise on Aquatic Life. Edited By A. Hawkins, A. N. Popper & M. Wahlberg.

Bejder, L., Samuels, A., Whitehead, H., Finn, H., & Allen, S. (2009). Impact assessment research: Use and misuse of habituation, sensitisation and tolerance to describe wildlife responses to anthropogenic stimuli. *Marine Ecology Progress Series, 395*, 177-185.

Benson, A., & Trites, A. W. (2002). Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. *Fish and Fisheries, 3*(2), 95-113.

Berchok, C. L., Bradley, D. L., & Gabrielson, T. B. (2006). St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. *Journal of the Acoustical Society of America, 120*(4), 2340–2354.

Bettridge, S., Baker, C. S., Barlow, J., Clapham, P. J., Ford, M., Gouveia, D., Mattila, D. K., Pace Iii, R. M., Rosel, P. E., Silber, G. K., & Wade, P. R. (2015). *Status review of the humpback whale (Megaptera novaeangliae) under the Endangered Species Act*. Retrieved from

Bickham, J. W., Loughlin, T. R., Wickliffe, J. K., & Burkanov, V. N. (1998). Geographic variation in the mitochondrial DNA of Steller sea lions: Haplotype diversity and endemism in the Kuril Islands. *Biosphere Conservation, 1*(2), 107-117.

Biedron, I. S., Clark, C. W., & Wenzel, F. (2005). *Counter-calling in North Atlantic right whales (Eubalaena glacialis)*. Paper presented at the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Bjarti, T. (2002). *An experiment on how seismic shooting affects caged fish.* University of Aberdeen, Aberdeen, Scotland.

Blackwell, S. B., Nations, C. S., McDonald, T. L., Greene Jr., C. R., Thode, A. M., Guerra, M., & Macrander, A. M. (2013). Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science, 29*(4), E342-E365.

Blair, H. B., Merchant, N. D., Friedlaender, A. S., Wiley, D. N., & Parks, S. E. (2016). Evidence for ship noise impacts on humpback whale foraging behaviour. *Biol Lett, 12*(8). doi:10.1098/rsbl.2016.0005

Blane, J. M., & Jaakson, R. (1994a). The impact of ecotourism boats on the St. Lawrence beluga whales. *Environmental Conservation, 21*(3), 267–269.

Blane, J. M., & Jaakson, R. (1994b). The impact of ecotourism boats on the St. Lawrence beluga whales (*Delphinapterus leucas*). *Environmental Conservation, 21*(3), 267-269.

Boebel, O., Burkhardt, E., & Bornemann, H. (2006). Risk assessment of Atlas hydrosweep and Parasound scientific echosounders. *EOS, Transactions, American Geophysical Union, 87*(36).

Booman, C., Dalen, J., Leivestad, H., Levsen, A., Meeren, T. v. d., & Toklum, K. (1996). Effecter av luftkanonskyting på egg, larver og yngel. *Fisken Og Havet, 1996*(3), 1-83.

Boren, L. J., Gemmell, N. J., & Barton., K. J. (2001). *Controlled approaches as an indicator of tourist disturbance on New Zealand fur seals (Arctocephalus forsteri).* Paper presented at the Fourteen Biennial Conference on the Biology of Marine Mammals, 28 November-3 December Vancouver Canada. p.30.

Borrell, A., Bloch, D., & Desportes, G. (1995). Age trends and reproductive transfer of organochlorine compounds in long-finned pilot whales from the Faroe Islands. *Environmental Pollution, 88*(3), 283-292.

Bort, J. E., Todd, S., Stevick, P., Van Parijs, S., & Summers, E. (2011). *North Atlantic right whale (Eubalaena glacialis) acoustic activity on a potential wintering ground in the Central Gulf of Maine*. Paper presented at the 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Bowles, A. E., Smultea, M., Würsig, B., DeMaster, D. P., & Palka, D. (1994). Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *Journal of the Acoustic Society of America*, *96*(4), 2469–2484.

Branch, T. A. (2007). Abundance of Antarctic blue whales south of 60 S from three complete circumpolar sets of surveys.

Breitzke, M., Boebel, O., El Naggar, S., Jokat, W., & Werner, B. (2008). Broad-band calibration of marine seismic sources used by R/V *Polarstern* for academic research in polar regions. *Geophysical Journal International, 174*, 505-524.

Brown, J. J., & Murphy, G. W. (2010). Atlantic sturgeon vessel-strike mortalities in the Delaware Estuary. *Fisheries, 35*(2), 72-83. doi:10.1577/1548-8446-35.2.72

Brownell Jr., R. L., Clapham, P. J., Miyashita, T., & Kasuya, T. (2001). Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management*(Special Issue 2), 269-286.

Bryant, P. J., Lafferty, C. M., & Lafferty., S. K. (1984). Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. (*Eschrichtius robustus*). In M. L. Jones, S. L. Swartz, & S. Leatherwood (Eds.), *The Gray Whale, Eschrichtius robustus*. New York: Academic Press.

Buchanan, R. A., Christian, J. R., Dufault, S., & Moulton, V. D. (2004). *Impacts of underwater noise on threatened or endangered species in United States waters* (LGL Report SA791). Retrieved from Washington, D.C.:

Burdin, A. M., Bradford, A. L., Tsidulko, G. A., & Sidorenko, M. (2011). *Status of western gray whales off northeastern Sakhalin Island and eastern Kamchatka, Russia in 2010*. Retrieved from Tromso, Norway:

Burkhardt, E., Boebel, O., Bornemann, H., & Ruholl, C. (2013). Risk assessment of scientific sonars. *Bioacoustics, 17*, 235-237.

Burtenshaw, J. C., Oleson, E. M., Hildebrand, J. A., McDonald, M. A., Andrew, R. K., Howe, B. M., & Mercer, J. A. (2004). Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. *Deep-Sea Research II, 51*, 967-986.

Busch, D. S. H., Lisa S. (2009). Stress in a conservation context: A discussion of glucocorticoid actions and how levels change with conservation-relevant variables. *Biological Conservation, 142*(12), 2844-2853.

Calambokidis, J., Falcone, E., Douglas, A., Schlender, L., & Jessie Huggins, J. (2009). *Photographic identification of humpback and blue whales off the US West Coast: Results and updated abundance estimates from 2008 field season*. Retrieved from Olympia, Washington:

Caldwell, J., & Dragoset, W. (2000). A brief overview of seismic air-gun arrays. *The Leading Edge, 19*(8), 898-902.

Carder, D. A., & Ridgway, S. (1990). Auditory brainstem response in a neonatal sperm whale. *Journal of the Acoustic Society of America, 88*(Supplement 1), S4.

Carretta, J. V., Forney, K. A., Oleson, E. M., Weller, D. W., Lang, A. R., Baker, J., Muto, M. M., Hanson, B., Orr, A. J., Huber, H., Lowry, M. S., Barlow, J., Moore, J. E., Lynch, D.,

Carswell, L., & Jr., R. L. B. (2017). *U.S. Pacific marine mammal stock assessments: 2016* (NOAA-TM-NMFS-SWFSC-577). Retrieved from

Carretta, J. V., Oleson, E. M., Baker, J., Weller, D. W., Lang, A. R., Forney, K. A., Muto, M. M., Hanson, B., Orr, A. J., Huber, H., Lowry, M. S., Barlow, J., Moore, J. E., Lynch, D., Carswell, L., & Brownell Jr., R. L. (2016). U.S. Pacific marine mammal stock assessments: 2015. doi:10.7289/V5/TM-SWFSC-561

Casper, B. M., Popper, A. N., Matthews, F., Carlson, T. J., & Halvorsen, M. B. (2012). Recovery of barotrauma injuries in Chinook salmon, Oncorhynchus tshawytscha from exposure to pile driving sound. *PLoS One, 7*(6), e39593. doi:10.1371/journal.pone.0039593

Cassoff, R. M., Moore, K. M., McLellan, W. A., Barco, S. G., Rotstein, D. S., & Moore, M. J. (2011). Lethal entanglement in baleen whales. *Diseases of Aquatic Organisms, 96*(3), 175-185.

Castellote, M., Clark, C. W., & Lammers, M. O. (2012). Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. *Biological Conservation*. doi:10.1016/j.biocon.2011.12.021

Cattet, M. R. L., Christison, K., Caulkett, N. A., & Stenhouse, G. B. (2003). Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases, 39*(3), 649-654.

Cerchio, S., Strindberg, S., Collins, T., Bennett, C., & Rosenbaum, H. (2014). Seismic surveys negatively affect humpback whale singing activity off northern Angola. *PLoS One, 9*(3), e86464.

Chance, R., Jickells, T. D., & Baker, A. R. (2015). Atmospheric trace metal concentrations, solubility and deposition fluxes in remote marine air over the south-east Atlantic. *Marine Chemistry, 177*, 45-56. doi:10.1016/j.marchem.2015.06.028

Chapman, C. J., & Hawkins, A. D. (1969). The importance of sound in fish behaviour in relation to capture by trawls. *FAO Fisheries Report, 62*(3), 717-729.

Chapman, N. R., & Price, A. (2011). Low frequency deep ocean ambient noise trend in the Northeast Pacific Ocean. *Journal of the Acoustical Society of America, 129*(5), EL161-EL165.

Charif, R. A., Mellinger, D. K., Dunsmore, K. J., Fristrup, K. M., & Clark, C. W. (2002). Estimated source levels of fin whale (Balaenoptera physalus) vocalizations: Adjustments for surface interference. *Marine Mammal Science*, *18*(1), 81-98.

Childers, A. R., Whitledge, T. E., & Stockwell, D. A. (2005). Seasonal and interannual variability in the distribution of nutrients and chlorophyll a across the Gulf of Alaska shelf: 1998-2000. *Deep-Sea Research II, 52*, 193-216.

Christiansen, F., Rasmussen, M. H., & Lusseau, D. (2014). Inferring energy expenditure from respiration rates in minke whales to measure the effects of whale watching boat interactions. *Journal of Experimental Marine Biology and Ecology, 459*, 96-104. doi:10.1016/j.jembe.2014.05.014

Clapham, P. J., Young, S. B., & Brownell Jr., R. L. (1999). Baleen whales: Conservation issues and the status of the most endangered populations. *Mammal Review, 29*(1), 35-60.

Clark, C. W., Borsani, J. F., & Notarbartolo-Di-Sciara, G. (2002). Vocal activity of fin whales, Balaenoptera physalus, in the Ligurian Sea. *Marine Mammal Science, 18*(1), 286-295.

Clark, C. W., & Charif, R. A. (1998). *Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997* (JNCC Report No. 281). Retrieved from

Clark, C. W., & Clapham, P. J. (2004). Acoustic monitoring on a humpback whale (Megaptera novaeangliae) feeding ground shows continual singing into late spring. *Proceedings of the Royal Society of London Series B Biological Sciences, 271*(1543), 1051-1057.

Clark, C. W., & Gagnon, G. C. (2004). Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. *Journal of Underwater Acoustics (USN), 52*(3), 609–640.

Clark, C. W., & Gagnon, G. C. (2006). *Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales*. Retrieved from

Cohen, A. N. F., Brent. (2000). The regulation of biological pollution: Preventing exotic species invasions from ballast water discharged into California coastal waters. *Golden Gate University Law Review, 30*(4), 787-773.

Conn, P. B., & Silber, G. K. (2013). Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. *Ecosphere, 4*(4), 43. doi:10.1890/es13-00004.1

Constantine, R. (2001). Increased avoidance of swimmers by wild bottlenose dolphins (Tursiops truncatus) due to long-term exposure to swim-with-dolphin tourism. *Marine Mammal Science, 17*(4), 689-702.

Corkeron, P. J. (1995). Humpback whales (Megaptera novaeangliae) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. *Canadian Journal of Zoology, 73*(7), 1290-1299.

COSEWIC. (2002). COSEWIC assessment and update status report on the blue whale Balaenoptera musculus (Atlantic population, Pacific population) in Canada. vi + 32.

Cowan, D. E., & Curry, B. E. (1998). *Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical pacific ocean: Research planning* (NOAA-TM-NMFS-SWFSC-254). Retrieved from

Cowan, D. E., & Curry, B. E. (2002). *Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery* (NMFS SWFSC administrative report LJ-02-24C). Retrieved from

Cowan, D. E. C., B. E. (2008). Histopathology of the alarm reaction in small odontocetes. *Journal of Comparative Pathology, 139*(1), 24-33. doi:10.1016/j.jcpa.2007.11.009

Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T. W., Crum, L., D'amico, A., D'spain, G., Fernandez, A., Finneran, J. J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J. A., Houser, D. S., Hullar, T., Jepson, P. D., Ketten, D., Macleod, C. D., Miller, P., Moore, S., Mountain, D. C., Palka, D., Ponganis, P. J., Rommel, S. A., Rowles, T., Taylor, B. L., Tyack, P., Wartzok, D., Gisiner, R., Mead, J. G., & Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management, 7*(3), 177-187.

Cranford, T. W., & Krysl, P. (2015). Fin whale sound reception mechanisms: Skull vibration enables low-frequency hearing. *PLoS One, 10*(1), e116222.

Creel, S. (2005). Dominance, aggression, and glucocorticoid levels in social carnivores. *Journal of Mammalogy, 86*(2), 255-246.

Croll, D. A., Clark, C. W., Acevedo, A., Tershy, B., Flores, S., Gedamke, J., & Urban, J. (2002). Only male fin whales sing loud songs. *Nature, 417*, 809.

Croll, D. A., Clark, C. W., Calambokidis, J., Ellison, W. T., & Tershy, B. R. (2001). Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. *Animal Conservation, 4*(1), 13-27.

Croll, D. A., Tershy, B. R., Acevedo, A., & Levin, P. (1999). *Marine vertebrates and low frequency sound* (Technical report for LFA EIS). Retrieved from

Cummings, W. C., & Thompson, P. O. (1971). Underwater sounds from the blue whale, *Balaenoptera musculus*. *Journal of the Acoustical Society of America, 50*(4B), 1193-1198.

Cummings, W. C., & Thompson, P. O. (1994). Characteristics and seasons of blue and finback whale sounds along the U.S. west coast as recorded at SOSUS stations. *Journal of the Acoustical Society of America, 95*, 2853.

Czech, B., & Krausman, P. R. (1997). Distribution and causation of species endangerment in the United States. *Science, 277*(5329), 1116-1117.

D'Vincent, C. G., Nilson, R. M., & Hanna, R. E. (1985). Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. *Scientific Reports of the Whales Research Institute, 36*, 41-47.

Dahlheim, M. E. (1987). *Bio-acoustics of the gray whale (Eschrichtius robustus).* (Ph.D.), University of British Columbia,

Dalen, J., & Knutsen, G. M. (1986). Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. *Pp.93-102 In: H.M. Merklinger (Ed), Progress in Underwater Acoustics. Plenum, New York. 839p.*

Dalton, T., & Jin, D. (2010). Extent and frequency of vessel oil spills in US marine protected areas. *Marine Pollution Bulletin, 60*(11), 1939-1945. doi:http://dx.doi.org/10.1016/j.marpolbul.2010.07.036

Danielsdottir, A. K., Duke, E. J., Joyce, P., & Arnason, A. (1991). Preliminary studies on genetic variation at enzyme loci in fin whales (Balaenoptera physalus) and sei whales (Balaenoptera borealis) form the North Atlantic. *Report of the International Whaling Commission, Special Issue 13*, 115-124.

Davenport, J. (1997). Temperature and the life-history strategies of sea turtles. *Journal of Thermal Biology, 22*(6), 479-488. doi:Doi: 10.1016/s0306-4565(97)00066-1

Davis, R. W., Evans, W. E., & Würsig, B. (2000). Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume II: Technical Report. *Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-03. 364p.*

de Soto, N. A., Delorme, N., Atkins, J., Howard, S., Williams, J., & Johnson, M. (2013). Anthropogenic noise causes body malformations and delays development in marine larvae. *Scientific Reports, 3*(2831), 1-5. doi:10.1038/srep02831

Deepwater Horizon NRDA Trustees. (2016). *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement*. Retrieved from http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan

Deepwater Horizon Trustees. (2016). *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement*. Retrieved from

Deng, Z. D., Southall, B. L., Carlson, T. J., Xu, J., Martinez, J. J., Weiland, M. A., & Ingraham, J. M. (2014). 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. *PLoS One, 9*(4), e95315.

Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin, 44*(9), 842-852. doi:10.1016/s0025-326x(02)00220-5

Dickens, M. J., Delehanty, D. J., & Romero, L. M. (2010). Stress: An inevitable component of animal translocation. *Biological Conservation, 143*(6), 1329-1341. doi:10.1016/j.biocon.2010.02.032

Diebold, J. B., Tolstoy, M., Doermann, L., Nooner, S. L., Webb, S. C., & Crone, T. J. (2010). *R/V Marcus G. Langseth* seismic source: Modeling and calibration. *Geochemistry Geophysics Geosystems, 10*(12), Q12012.

Dierauf, L. A., & Gulland, F. M. D. (2001). *CRC Handbook of Marine Mammal Medicine* (Second Edition ed.). Boca Raton, Florida: CRC Press.

Dietrich, K. S., Cornish, V. R., Rivera, K. S., & Conant., T. A. (2007). *Best practices for the collection of longline data to facilitate research and analysis to reduce bycatch of protected species.* Retrieved from

DON. (2006). *Marine Resources Assessment for the Gulf of Alaska Operating Area* (Contract # N62470-02-D-9997. CTO 0029). Retrieved from Plano, Texas:

DON. (2010). *Annual Range Complex Exercise Report 2 August 2009 to 1 August 2010 U.S. Navy Southern California (SOCAL) Range Complex and Hawaii Range Complex (HRC).* Retrieved from

DON. (2012). *Marine Species Monitoring for the U.S. Navy's Southern California Range Complex- Annual Report 2012*. Retrieved from Pearl Harbor, HI:

DON. (2014). *Navy marine species density database technical report*. Retrieved from

Doney, S. C., Ruckelshaus, M., Duffy, J. E., Barry, J. P., Chan, F., English, C. A., Galindo, H. M., Grebmeier, J. M., Hollowed, A. B., & Knowlton, N. (2012). Climate change impacts on marine ecosystems. *Marine Science, 4*.

Dubrovskiy, N. A., & Giro, L. R. (2004). Modeling of the click-production mechanism in the dolphin. In J. A. Thomas, C. F. Moss, & M. Vater (Eds.), *Echolocation in Bats and Dolphins* (pp. 59-64): University of Chicago Press.

Duce, R. A., Liss, P. S., Merrill, J. T., Atlas, E. L., Buat-Menard, P., Hicks, B. B., Miller, J. M., Prospero, J. M., Arimoto, R., Church, T. M., Ellis, W., Galloway, J. N., Hansen, L., Jickells, T. D., Knap, A. H., Reinhardt, K. H., Schneider, B., Soudine, A., Tokos, J. J., Tsunogai, S., Wollast, R., & Zhou, M. (1991). The atmospheric input of trace species to the world ocean. *Global Biogeochemical Cycles, 5*(3), 193-259. doi:10.1029/91gb01778

Duncan, E. M., Botterell, Z. L. R., Broderick, A. C., Galloway, T. S., Lindeque, P. K., Nuno, A., & Godley, B. J. (2017). A global review of marine turtle entanglement in anthropogenic debris: A baseline for further action. *Endangered Species Research, 34*, 431-448. doi:10.3354/esr00865

Dunlop, R. A., Cato, D. H., & Noad, M. J. (2008). Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). *Marine Mammal Science, 24*(3), 613-629. doi:doi:10.1111/j.1748-7692.2008.00208.x

Dunlop, R. A., Cato, D. H., & Noad, M. J. (2014a). Evidence of a Lombard response in migrating humpback whales (*Megaptera novaeangliae*). *Journal of the Acoustical Society of America, 136*(1), 430-437.

Dunlop, R. A., Noad, M. J., McCauley, R., Kruest, E., & Cato, D. H. (2014b). *The behavioural response of humpback whales (Megaptera novaeangliae) to a small seismic air gun*. Paper presented at the Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014), Amsterdam, The Netherlands.

Edds-Walton, P. L. (1997). Acoustic communication signals of mysticete whales. *Bioacoustics-the International Journal of Animal Sound and Its Recording, 8*, 47–60.

Edds, P. L. (1988). Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence estuary. *Bioacoustics, 1*, 131–149.

Elftman, M. D., Norbury, C. C., Bonneau, R. H., & Truckenmiller, M. E. (2007). Corticosterone impairs dendritic cell maturation and function. *Immunology, 122*(2), 279-290. doi:10.1111/j.1365-2567.2007.02637.x

Ellison, W. T., Southall, B. L., Clark, C. W., & Frankel, A. S. (2012). A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conservation Biology, 26*(1), 21–28. doi:10.1111/j.1523-1739.2011.01803.x

Engås, A., Løkkeborg, S., Ona, E., & Vold Soldal, A. (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences, 53*, 2238-2249.

Engås, A., Løkkeborg, S., Soldal, A. V., & Ona, E. (1993). Comparative trials for cod and haddock using commercial trawl and longline at two different stock levels. *Journal of Northwest Atlantic Fisheries Science, 19*, 83-90.

Engel, M. H., Marcondes, M. C. C., Martins, C. C. A., Luna, F. O., Lima, R. P., & Campos, A. (2004). *Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil*. Retrieved from

Engelhaupt, D., Hoelzel, A. R., Nicholson, C., Frantzis, A., Mesnick, S., Gero, S., Whitehead, H., Rendell, L., Miller, P., De Stefanis, R., Canadas, A., Airoldi, S., & Mignucci-Giannoni, A. A. (2009). Female philopatry in coastal basins and male dispersion across the North Atlantic in a highly mobile marine species, the sperm whale (*Physeter macrocephalus*). *Mol Ecol, 18*(20), 4193-4205. doi:10.1111/j.1365-294X.2009.04355.x

Erbe, C. (2002a). *Hearing abilities of baleen whales.* Retrieved from

Erbe, C. (2002b). Underwater noise of whale-watching boats and potential effects on killer whales (Orcinus orca), based on an acoustic impact model. *Marine Mammal Science, 18*(2), 394-418.

Evans, P. G. H. (1998). Biology of cetaceans of the North-east Atlantic (in relation to seismic energy). Chapter 5 *In:* Tasker, M.L. and C. Weir (eds), Proceedings of the Seismic and Marine Mammals Workshop, London 23-25 June 1998. Sponsored by the Atlantic Margin Joint Industry Group (AMJIG) and endorsed by the UK Department of Trade and Industry and the UK's Joint Nature Conservation Committee (JNCC).

Evans, P. G. H., & Bjørge, A. (2013). Impacts of climate change on marine mammals. *Marine Climate Change Impacts Parternship: Science Review*, 134-148. doi:10.14465/2013.arc15.134-148

Evans, P. G. H., Canwell, P. J., & Lewis, E. (1992). An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. *European Research on Cetaceans, 6*, 43–46.

Evans, P. G. H., Carson, Q., Fisher, P., Jordan, W., Limer, R., & Rees, I. (1994). A study of the reactions of harbour porpoises to various boats in the coastal waters of southeast Shetland. *European Research on Cetaceans, 8*, 60–64.

Fair, P. A., & Becker, P. R. (2000). Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery, 7*(4), 335-354.

Falk, M. R., & Lawrence, M. J. (1973). *Seismic exploration: Its nature and effects on fish*. Retrieved from Winnipeg, Canada:

Felix, F. (2001, November 28-December 3, 2001). *Observed changes of behavior in humphack whales during whalewatching encounters off Ecuador.* Paper presented at the 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Félix, F. (2001, 28 November - 3 December 2001). *Observed changes of behavior in humpback whales during whalewatching encounters off Ecuador.* Paper presented at the 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Ferguson, M. C., Curtice, C., & Harrison, J. (2015). Biologically important areas for cetaceans within U.S. waters – Gulf of Alaska region. *Aquatic Mammals, 41*(1), 65-78.

Fewtrell, J. L., & McCauley, R. D. (2012). Impact of air gun noise on the behaviour of marine fish and squid. *Marine Pollution Bulletin, 64*(5), 984-993. doi:10.1016/j.marpolbul.2012.02.009

Finneran, J. J., & Schlundt, C. E. (2013). Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America, 133*(3), 1819-1826.

Fonfara, S., Siebert, U., Prange, A., & Colijn, F. (2007). The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). *Journal of the Marine Biological Association of the United Kingdom, 87*(1), 305-311.

Foote, A. D., Osborne, R. W., & Hoelzel, A. R. (2004). Whale-call response to masking boat noise. *Nature, 428*, 910.

Fossi, M. C., Marsili, L., Baini, M., Giannetti, M., Coppola, D., Guerranti, C., Caliani, I., Minutoli, R., Lauriano, G., & Finoia, M. G. (2016). Fin whales and microplastics: The Mediterranean Sea and the Sea of Cortez scenarios. *Environmental Pollution, 209*, 68-78.

Francis, C. D., & Barber, J. R. (2013). A framework for understanding noise impacts on wildlife: An urgent conservation priority. *Frontiers in Ecology and the Environment, 11*(6), 305-313.

Frantzis, A., & Alexiadou, P. (2008). Male sperm whale (Physeter macrocephalus) coda production and coda-type usage depend on the presence of conspecifics and the behavioural context. *Canadian Journal of Zoology, 86*(1), 62-75.

Frazer, L. N., & Mercado, I., Eduardo. (2000). A sonar model for humpback whale song. *IEEE Journal of Oceanic Engineering, 25*(1), 160-182.

Fromentin, J.-M., & Planque, B. (1996). *Calanus* and environment in the eastern North Atlantic. II. Influence of the North Atlantic Oscillation on *C. finmarchicus* and *C. helgolandicus*. *Marine Ecology Progress Series, 134*, 111-118.

Gabriele, C., Kipple, B., & Erbe, C. (2003). *Underwater acoustic monitoring and estimated effects of vessel noise on humpback whales in Glacier Bay, Alaska*. Paper presented at the Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Gabriele, C. M., & Frankel., A. S. (2002). Surprising humpback whale songs in Glacier Bay National Park. In *Alaska Park Science: Connections to Natural and Cultural Resource Studies in Alaska's National Parks. p.17-21.*

Gailey, G., Würsig, B., & McDonald, T. L. (2007). Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. *Environmental Monitoring and Assessment., Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9812-1. 17p.*

Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin, 92*(1-2), 170–179. doi:10.1016/j.marpolbul.2014.12.041

Gallo, F., Fossi, C., Weber, R., Santillo, D., Sousa, J., Ingram, I., Nadal, A., & Romano, D. (2018). Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. *Environmental Sciences Europe, 30*(1). doi:10.1186/s12302-018-0139-z

Gambell, R. (1999). The International Whaling Commission and the contemporary whaling debate. In J. R. T. Jr. (Ed.), *Conservation and Management of Marine Mammals* (pp. 179-198). Washington: Smithsonian Institution Press.

Gardiner, K. J., & Hall, A. J. (1997). Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). *Canadian Journal of Zoology, 75*(11), 1773-1780.

Garrett, C. (2004). *Priority Substances of Interest in the Georgia Basin - Profiles and background information on current toxics issues* (GBAP Publication No. EC/GB/04/79). Retrieved from

Gattuso, J. P., Magnan, A., Bille, R., Cheung, W. W., Howes, E. L., Joos, F., Allemand, D., Bopp, L., Cooley, S. R., Eakin, C. M., Hoegh-Guldberg, O., Kelly, R. P., Portner, H. O., Rogers, A. D., Baxter, J. M., Laffoley, D., Osborn, D., Rankovic, A., Rochette, J., Sumaila, U. R., Treyer, S., & Turley, C. (2015). Contrasting futures for ocean and society from different anthropogenic CO(2) emissions scenarios. *Science, 349*(6243), aac4722. doi:10.1126/science.aac4722

Geraci, J. R. (1990). Physiological and toxic effects on cetaceans. Pp. 167-197 *In:* Geraci, J.R. and D.J. St. Aubin (eds), Sea Mammals and Oil: Confronting the Risks. Academic Press, Inc.

Gillespie, D., & Leaper, R. (2001). *Report of the Workshop on Right Whale Acoustics: Practical Applications in Conservation, Woods Hole, 8-9 March 2001*. Retrieved from London:

Glass, A. H., Cole, T. V. N., & Garron, M. (2010). *Mortality and serious injury determinations for baleen whale stocks along the United States and Canadian Eastern Seaboards, 2004-2008*. Retrieved from

Goldbogen, J. A., Southall, B. L., Deruiter, S. L., Calambokidis, J., Friedlaender, A. S., Hazen, E. L., Falcone, E. A., Schorr, G. S., Douglas, A., Moretti, D. J., Kyburg, C., McKenna, M. F., & Tyack, P. L. (2013). Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society of London Series B Biological Sciences, 280*(1765), Article 20130657.

Gomez, C., Lawson, J., Wright, A. J., Buren, A., Tollit, D., & Lesage, V. (2016). A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. *Canadian Journal of Zoology, 94*(12), 801–819. doi:10.1139/cjz-2016-0098

Goodwin, L., & Cotton, P. A. (2004). Effects of boat traffic on the behaviour of bottlenose dolphins (Tursiops truncatus). *Aquatic Mammals, 30*(2), 279-283.

Goold, J. C. (1999). Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. *Journal of the Marine Biological Association of the United Kingdom, 79*(3), 541-550.

Goold, J. C., & Coates, R. F. W. (2006). Near source, high frequency air-gun signatures. *Paper SC/58/E30, prepared for the International Whaling Commmission (IWC) Seismic Workshop, St. Kitts, 24-25 May 2006. 7p.*

Goold, J. C., & Fish, P. J. (1998). Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. *Journal of the Acoustical Society of America, 103*(4), 2177-2184.

Goold, J. C., & Jones, S. E. (1995). Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America, 98*(3), 1279–1291.

Gordon, J., Antunes, R., Jaquet, N., & Wursig., B. (2006). *An investigation of sperm whale headings and surface behaviour before, during and after seismic line changes in the Gulf of Mexico. [Pre-meeting]*. Retrieved from

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2004). A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal, 37*(4), 16-34.

Grant, S. C. H., & Ross, P. S. (2002). *Southern Resident killer whales at risk: toxic chemicals in the British Columbia and Washington environment*. Retrieved from Sidney, B.C.:

Greene Jr, C. R., Altman, N. S., & Richardson, W. J. (1999). *Bowhead whale calls*. Retrieved from

Greer, A. W., Stankiewicz, M., Jay, N. P., McAnulty, R. W., & Sykes, A. R. (2005). The effect of concurrent corticosteroid induced immuno-suppression and infection with the intestinal parasite *Trichostrongylus colubriformis* on food intake and utilization in both immunologically naive and competent sheep. *Animal Science, 80*, 89-99.

Gregory, L. F., & Schmid, J. R. (2001). Stress responses and sexing of wild Kemp's ridley sea turtles (*Lepidochelys kempii*) in the northwestern Gulf of Mexico. *General and Comparative Endocrinology, 124*, 66-74.

Guerra, A., Gonzalez, A. F., & Rocha, F. (2004). *A review of the records of giant squid in the north-eastern Atlantic and severe injuries in Architeuthis dux stranded after acoustic explorations*. Paper presented at the ICES Annual Science Conference, Vigo, Spain.

Guerra, M., Thode, A. M., Blackwell, S. B., & Macrander., A. M. (2011). Quantifying seismic survey reverberation off the Alaskan North Slope. *Journal of the Acoustical Society of America, 130*(5), 3046-3058.

Gulland, F. M. D., Haulena, M., Lowenstine, L. J., Munro, C., Graham, P. A., & Bauman, J. H., J. (1999). Adrenal function in wild and rehabilitated Pacific harbor seals (*Phoca vitulina richardii*) and in seals with phocine herpesvirus-associated adrenal necrosis. *Marine Mammal Science, 15*(3), 810-827.

Halvorsen, M. B., Casper, B. M., Matthews, F., Carlson, T. J., & Popper, A. N. (2012a). Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia and hogchoker. *Proceedings of Biological Sciences, 279*(1748), 4705–4714. doi:10.1098/rspb.2012.1544

Halvorsen, M. B., Casper, B. M., Woodley, C. M., Carlson, T. J., & Popper, A. N. (2011). *Predicting and mitigating hydroacoustic impacts on fish from pile installations*. Retrieved from Washington, DC:

Halvorsen, M. B., Casper, B. M., Woodley, C. M., Carlson, T. J., & Popper, A. N. (2012b). Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds. *PLoS One, 7*(6), e38968. doi:10.1371/journal.pone.0038968

Hansen, D. J., & Hubbard, J. D. (1999). *Distribution of Cook Inlet beluga whales (Delphinapterus leucas) in winter.* . Retrieved from Anchorage, Alaska:

Hare, S. R., & Mantua, N. J. (2001). *An historical narrative on the Pacific Decadal Oscillation, interdecadal climate variability and ecosystem impacts*. Retrieved from

Hare, S. R., Mantua, N. J., & Francis, R. C. (1999). Inverse production regimes: Alaska and West Coast Pacific salmon. *Fisheries, 24*(1), 6-14.

Harris, R. E., Elliott, T., & Davis, R. A. (2007). *Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006*. Retrieved from Houston, Texas:

Hartwell, S. I. (2004). Distribution of DDT in sediments off the central California coast. *Marine Pollution Bulletin, 49*(4), 299-305.

Hassel, A., Knutsen, T., Dalen, J., Løkkeborg, S., Skaar, K., Østensen, Ø., Haugland, E. K., Fonn, M., Høines, Å., & Misund, O. A. (2003). *Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study*. Retrieved from Bergen, Norway:

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Ostensen, O., Fonn, M., & Haugland, E. K. (2004). Influence of seismic shooting on the lesser sandeel (Ammodytes marinus). *ICES Journal of Marine Science, 61*, 1165-1173.

Hastings, M. C. (1990). *Effects of underwater sound on fish*. Retrieved from

Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M., & Wiley, D. (2008). Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. *Environmental Management, 42*(5), 735-752. doi:10.1007/s00267-008-9169-4

Hauser, D. W., & Holst, M. (2009). *Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Gulf of Alaska, Septmerb-October 2008* Retrieved from King City, Canada:

Haver, S. M., Gedamke, J., Hatch, L. T., Dziak, R. P., Van Parijs, S., McKenna, M. F., Barlow, J., Berchok, C., DiDonato, E., Hanson, B., Haxel, J., Holt, M., Lipski, D., Matsumoto, H., Meinig, C., Mellinger, D. K., Moore, S. E., Oleson, E. M., Soldevilla, M. S., & Klinck, H. (2018). Monitoring long-term soundscape trends in U.S. Waters: The NOAA/NPS Ocean Noise Reference Station Network. *Marine Policy, 90*, 6–13. doi:10.1016/j.marpol.2018.01.023

Hawkins, A. D., & Johnstone, A. D. F. (1978). The hearing of the Atlantic salmon, *Salmo salar*. *Journal of Fish Biology, 13*(6), 655-673.

Hawkins, A. D., Pembroke, A. E., & Popper, A. N. (2014). Information gaps in understanding the effects of noise on fishes and invertebrates. *Reviews in Fish Biology and Fisheries*. doi:10.1007/s11160-014-9369-3

Hayes, S. A., Josephson, E., Maze-Foley, K., & Rosel, P. E. (2017). *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2016* (NMFS-NE-241). Retrieved from Woods Hole, Massachusetts:

Hayhoe, K., Doherty, S., Kossin, J. P., Sweet, W. V., Vose, R. S., Wehner, M. F., & Wuebbles, D. J. (2018). In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (Reidmiller, D.R., et al. [eds.]). *U.S. Global Change Research Program, Washington, DC, USA*. doi:10.7930/NC4.2018.CH2

Hazel, J., Lawler, I. R., Marsh, H., & Robson, S. (2007). Vessel speed increases collision risk for the green turtle Chelonia mydas. *Endangered Species Research, 3*, 105-113.

Hazen, E. L., Jorgensen, S., Rykaczewski, R. R., Bograd, S. J., Foley, D. G., Jonsen, I. D., Shaffer, S. A., Dunne, J. P., Costa, D. P., Crowder, L. B., & Block, B. A. (2012). Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change, 3*(3), 234-238. doi:10.1038/nclimate1686

Helweg, D. A., Frankel, A. S., Joseph R. Mobley, J., & Herman, L. M. (1992). Humpback whale song: Our current understanding. In J. A. Thomas, R. A. Kastelein, & A. Y. Supin (Eds.), *Marine Mammal Sensory Systems* (pp. 459-483). New York: Plenum Press.

Henry, A. G., Cole, T. V., Garron, M., Ledwell, W., Morin, D., & Reid, A. (2017). *Serious Injury and Mortality Determinations for Baleen Whale Stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2011-2015* (Reference Document 17-19). Retrieved from Woods Hole, Massachusetts:

Herraez, P., Sierra, E., Arbelo, M., Jaber, J. R., de los Monteros, A. E., & Fernandez, A. (2007). Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. *Journal of Wildlife Diseases, 43*(4), 770–774.

Hildebrand, J. A. (2009a). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series, 395*, 20-May. doi:10.3354/meps08353

Hildebrand, J. A. (2009b). Metrics for characterizing the sources of ocean anthropogenic noise. *Journal of the Acoustical Society of America, 125*(4), 2517.

Hildebrand, J. A., Baumann-Pickering, S., Bassett, A. S. H., Cummins, A., Kerosky, S., Roche, L., Simonis, A., & Wiggins, S. M. (2011). *Passive acoustic monitoring for marine mammals in the SOCAL Naval Training Area 2010-2011*. Retrieved from

Hildebrand, J. A., Baumann-Pickering, S., Sirovic, A., Buccowich, J., Debich, A., Johnson, S., Kerosky, S., Roche, L., Berga, A. S., & Wiggins, S. M. (2012). *Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training Area 2011-2012*. Retrieved from Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego: http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/212/

Hodge, R. P., & Wing, B. L. (2000). Occurrences of marine turtles in Alaska Waters: 1960-1998. *Herpetological Review, 31*(3), 148-151.

Holliday, D. V., Piper, R. E., Clarke, M. E., & Greenlaw, C. F. (1987). *The effects of airgun energy release on the eggs, larvae, and adults of the northern anchovy (Engraulis mordax)*. Retrieved from Washington, D.C.:

Holst, M. (2010). *Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's ETOMO marine seismic program in the northeast Pacific Ocean August-September 2009* Retrieved from King City, Canada:

Holst, M., & Smultea, M. A. (2008). *Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off Central America, Feburary-April 2008*. Retrieved from Palisades, New York:

Holst, M., Smultea, M. A., Koski, W. R., & Haley, B. (2005). Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific Ocean off Central America, November–December 2004. *Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. Report TA2822-30. 125 p.*

Holst, M. J. B. (2008). *Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's seismic testing and calibration study in the northern Gulf of Mexico, November 2007-February 2008*. Retrieved from Palisades, New York:

Holt, M. M. (2008). *Sound exposure and Southern Resident killer whales (Orcinus orca): A review of current knowledge and data gaps* (NMFS-NWFSC-89). Retrieved from

Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K., & Veirs, S. (2009). Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *Journal of the Acoustical Society of America, 125*(1), El27-El32.

Hotchkin, C. F., Parks, S. E., & Clark, C. W. (2011). *Source level and propagation of gunshot sounds produced by North Atlantic right whales (Eubalanea glacialis) in the Bay of Fundy during August 2004 and 2005*. Paper presented at the Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Houser, D. S., Helweg, D. A., & Moore, P. W. B. (2001). A bandpass filter-bank model of auditory sensitivity in the humpback whale. *Aquatic Mammals, 27*(2), 82-91.

Hoyt, E. (2001). *Whale Watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits*. Retrieved from Yarmouth Port, MA, USA:

Huijser, L. A. E., Bérubé, M., Cabrera, A. A., Prieto, R., Silva, M. A., Robbins, J., Kanda, N., Pastene, L. A., Goto, M., Yoshida, H., Víkingsson, G. A., & Palsbøll, P. J. (2018). Population structure of North Atlantic and North Pacific sei whales (Balaenoptera borealis) inferred from mitochondrial control region DNA sequences and microsatellite genotypes. *Conservation Genetics*. doi:10.1007/s10592-018-1076-5

Hunt, K. E., Rolland, R. M., Kraus, S. D., & Wasser, S. K. (2006). Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). *General and Comparative Endocrinology, 148*(2), 260-272.

Hurrell, J. W. (1995). Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. *Science, 269*, 676-679.

Iagc. (2004). *Further analysis of 2002 Abrolhos Bank, Brazil humpback whale stradings coincident with seismic surveys*. Retrieved from Houston, Texas:

Iorio, L. D., & Clark, C. W. (2009). Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters, in press*(in press), in press.

IPCC. (2014). *Climate change 2014: Impacts, adaptation, and vulnerability. IPCC Working Group II contribution to AR5*. Retrieved from http://www.ipcc.ch/report/ar5/wg2/

IPCC. (2018). Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland*, 32pp.

IUCN. (2012). The IUCN red list of threatened species. Version 2012.2. Retrieved from http://www.iucnredlist.org

Ivashchenko, Y. V., Brownell Jr., R. L., & Clapham, P. J. (2014). Distribution of Soviet catches of sperm whales Physeter macrocephalus in the North Pacific. *Endangered Species Research, 25*(3), 249-263.

Iwata, H., S. Tanabe, N. Sakai, and R. Tatsukawa. (1993). Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of ocean on their global transport and fate. *Environmental Science and Technology, 27*, 1080-1098.

IWC. (2001). Report of the workshop on the comprehensive assessment of right whales. *Journal of Cetacean Research and Management (Special Issue), 2*, 1-60.

IWC. (2007a). *Annex K: Report of the standing working group on environmental concerns*. Retrieved from

IWC. (2007b). Whale population estimates. Retrieved from http://www.iwcoffice.org/conservation/estimate.htm Accessed 3/06/09

IWC. (2012a). *Extracts from the IWC64 Scientific Committee report relevant to the WGWAP*. Retrieved from

IWC. (2012b). International Whaling Commission: Whaling. Retrieved from http://www.iwcoffice.org/whaling

IWC. (2016). Report of the Scientific Committee. *Journal of Cetacean Research and Management (Supplement), 17*.

IWC. (2017a). *Aboriginal subsistence whaling catches since 1985*. Retrieved from http://iwc.int/table_aboriginal

IWC. (2017b). *Catches under objection or under reservation since 1985*. Retrieved from http://iwc.int/table_objection

IWC. (2017c). *Special permit catches since 1985*. Retrieved from http://iwc.int/table_permit

Jackson, J., Kirby, M., Berger, W., Bjorndal, K., Botsford, L., Bourque, B., Bradbury, R., Cooke, R., Erlandson, J., Estes, J., Hughes, T., Kidwell, S., Lange, C., Lenihan, H., Pandolfi, J., Peterson, C., Steneck, R., Tegner, M., & Warner, R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science, 293*(5530), 629-638.

Jacobsen, J. K., Massey, L., & Gulland, F. (2010). Fatal ingestion of floating net debris by two sperm whales (Physeter macrocephalus). *Marine Pollution Bulletin, 60*(5), 765-767. doi:10.1016/j.marpolbul.2010.03.008

Jay, A., Reidmiller, D. R., Avery, C. W., Barrie, D., DeAngelo, B. J., Dave, A., Dzaugis, M., Kolian, M., Lewis, K. L. M., Reeves, K., & Winner, D. (2018). In: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. *U.S. Global Change Research Program, Washington, DC, USA*, 33-71. doi:10.7930/NCA4.2018.CH1

Jenner, C., Jenner, M., Burton, C., Sturrock, V., Kent, C. S., Morrice, M., Attard, C., Moller, L., & Double, M. C. (2008). *Mark recapture analysis of pygmy blue whales from the Perth Canyon, Western Australia 2000-2005*. Retrieved from Santiago, Chile:

Jensen, A. S., & Silber, G. K. (2004). *Large whale ship strike database*. Retrieved from http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/lwssdata.pdf

Jochens, A., Biggs, D. C., Engelhaupt, D., Gordon, J., Jaquet, N., Johnson, M., Leben, R., Mate, B., Miller, P., Ortega-Ortiz, J., Thode, A. M., Tyack, P., Wormuth, J., & Würsig, B. (2006). Sperm whale seismic study in the Gulf of Mexico; Summary Report 2002-2004. *U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-034. 352p.*

Jochens, A. E., & Biggs, D. C. (2003). *Sperm whale seismic study in the Gulf of Mexico* (OCS MMS 2003-069). Retrieved from New Orleans:

Jochens, A. E., & Biggs, D. C. (2004). Sperm whale seismic study in the Gulf of Mexico: Annual report: Year 2. *U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-067, 167p.*

Johnson, M., & Miller, P. (2002). *Sperm whale diving and vocalization patterns from digital acoustic recording tags and assessing responses of whales to seismic exploration*. Paper presented at the MMS Information Transfer Meeting, Kenner, LA.

Johnson, M. P., & Tyack, P. L. (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.

Johnson, S. R., Richardson, W. J., Yazvenko, S. B., Blokhin, S. A., Gailey, G., Jenkerson, M. R., Meier, S. K., Melton, H. R., Newcomer, M. W., Perlov, A. S., Rutenko, S. A., Würsig, B., Martin, C. R., & Egging, D. E. (2007). A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment, Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9813-0. 19p.*

Kanda, N., Goto, M., Matsuoka, K., Yoshida, H., & Pastene, L. A. (2011). *Stock identity of sei whales in the central North Pacific based on microsatellite analysis of biopsy samples obtained from IWC/Japan joint cetacean sighting survey in 2010*. Retrieved from Tromso, Norway:

Kanda, N., Goto, M., & Pastene, L. A. (2006). Genetic characteristics of western North Pacific sei whales, Balaenoptera borealis, as revealed by microsatellites. *Marine Biotechnology, 8*(1), 86-93.

Kanda, N., Matsuoka, K., Goto, M., & Pastene, L. A. (2015). *Genetic study on JARPNII and IWC-POWER samples of sei whales collected widely from the North Pacific at the same time of the year*. Retrieved from San Diego, California:

Kanda, N., Matsuoka, K., Yoshida, H., & Pastene, L. A. (2013). *Microsatellite DNA analysis of sei whales obtained from the 2010-2012 IWC-POWER*. Retrieved from Jeju, Korea:

Kastak, D. S., Brandon L.; Schusterman, Ronald J.; Kastak, Colleen Reichmuth. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. *Journal of the Acoustical Society of America, 118*(5), 3154-3163.

Kastelein, R. A., van Schie, R., Verboom, W. C., & de Haan, D. (2005). Underwater hearing sensitivity of a male and a female Steller sea lion (*Eumetopias jubatus*). *Journal of the Acoustical Society of America, 118*(3), 1820-1829.

Kaufman, G. A., & Kaufman, D. W. (1994). Changes in body-mass related to capture in the prairie deer mouse (*Peromyscus maniculatus*). *Journal of Mammalogy, 75*(3), 681-691.

Keay, J. M. S., Jatinder; Gaunt, Matthew C.; Kaur, Taranjit. (2006). Fecal glucocorticoids and their metabolites as indicators of stress in various mammalian species: A literature review. *Journal of Zoo and Wildlife Medicine, 37*(3), 234-244. doi:10.1638/05-050.1

Kenney, R. D., Hyman, M. A. M., & Winn., H. E. (1985). *Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States Outer Continental Shelf.* Retrieved from

Kerby, A. S., Bell, A. M., & L., J. (2004). Two stressors are far deadlier than one. *Trends in Ecology and Evolution, 19*(6), 274-276.

Ketten, D. R. (1992). The cetacean ear: Form, frequency, and evolution. In J. A. Supin (Ed.), *Marine Mammal Sensory Systems* (pp. 53-75). New York: Plenum Press.

Ketten, D. R. (1997). Structure and function in whale ears. *Bioacoustics, 8*, 103–135.

Ketten, D. R. (1998). *Marine Mammal Auditory Systems: A Summary of Audiometroc and Anatomical Data and its Implications for Underwater Acoustic Impacts* (NOAA-TM-NMFS-SWFSC-256). Retrieved from

Ketten, D. R. (2012). Marine mammal auditory system noise impacts: Evidence and incidence. In A. N. P. A. Hawkings (Ed.), *The Effects of Noise on Aquatic Life* (pp. 6): Springer Science.

Ketten, D. R., & Mountain, D. C. (2014). *Inner ear frequency maps: First stage audiograms of low to infrasonic hearing in mysticetes*. Paper presented at the Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014), Amsterdam, The Netherlands.

Kight, C. R. S., John P. (2011). How and why environmental noise impacts animals: An integrative, mechanistic review. *Ecology Letters*. doi:10.1111/j.1461-0248.2011.01664.x

Kintisch, E. (2006). As the seas warm: Researchers have a long way to go before they can pinpoint climate-change effects on oceangoing species. *Science, 313*, 776-779.

Kipple, B., & Gabriele, C. (2004). *Underwater noise from skiffs to ships*. Paper presented at the Fourth Glacier Bay Science Symposium.

Kipple, B., & Gabriele, C. (2007). *Underwater noise from skiffs to ships*. Paper presented at the Fourth Glacier Bay Science Symposium.

Kite-Powell, H. L., Knowlton, A., & Brown, M. (2007). *Modeling the effect of vessel speed on right whale ship strike risk*. Retrieved from

Knudsen, F. R., Enger, P. S., & Sand, O. (1992). Awareness Reactions And Avoidance Responses To Sound In Juvenile Atlantic Salmon, *Salmo-Salar*. *Journal of Fish Biology, 40*(4), 523-534.

Knudsen, F. R., Enger, P. S., & Sand, O. (1994). Avoidance responses to low-frequency sound in downstream migrating Atlantic salmon smolt, *Salmo-salar*. *Journal of Fish Biology, 45*(2), 227-233.

Kostyuchenko, L. P. (1973). Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. *Hydrobiological Journal, 9*(5), 45-48.

Krahn, M. M., Hanson, M. B., Baird, R. W., Boyer, R. H., Burrows, D. G., Emmons, C. K., Ford, J. K. B., Jones, L. L., Noren, D. P., Ross, P. S., Schorr, G. S., & Collier, T. K. (2007). Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales (*Orcinus orca*). *Marine Pollution Bulletin, 54*(12), 1903–1911.

Krahn, M. M., Hanson, M. B., Schorr, G. S., Emmons, C. K., Burrows, D. G., Bolton, J. L., Baird, R. W., & Ylitalo, G. M. (2009). Effects of age, sex and reproductive status on persistent organic pollutant concentrations in ‘‘Southern Resident” killer whales. *Marine Pollution Bulletin*.

Kraus, S. D., Brown, M. W., Caswell, H., Clark, C. W., Fujiwara, M., Hamilton, P. K., Kenney, R. D., Knowlton, A. R., Landry, S., Mayo, C. A., Mcmellan, W. A., Moore, M. J., Nowacek, D. P., Pabst, D. A., Read, A. J., & Rolland, R. M. (2005). North Atlantic right whales in crisis. *Science, 309*(5734), 561-562.

Kraus, S. D., Kenney, R. D., Mayo, C. A., McLellan, W. A., Moore, M. J., & Nowacek, D. P. (2016). Recent Scientific Publications Cast Doubt on North Atlantic Right Whale Future. *Frontiers in Marine Science*. doi:10.3389/fmars.2016.00137

Kremser, U., Klemm, P., & Kötz, W. D. (2005). Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. *Antarctic Science, 17*(1), 3-10.

Kujawa, S. G., & Liberman, M. C. (2009). Adding insult to injury: Cochlear nerve degeneration after "temporary" noise-induced hearing loss. *The Journal of Neuroscience, 29*(45), 14077–14085.

Kuznetsov, M. Y. (2009). Traits of acoustic signalization and generation of sounds by some schooling physostomous fish. *Acoustical Physics, 55*(6), 866-875. doi:10.1134/s1063771009060219

La Bella, G., Cannata, S., Froglia, C., Modica, A., Ratti, S., & Rivas, G. (1996). *First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea*. Paper presented at the Society of Petroleum Engineers, International Conference on Health, Safety and Environment, New Orleans, Louisiana.

Lacy, R. C. (1997). Importance of Genetic Variation to the Viability of Mammalian Populations. *Journal of Mammalogy, 78*(2), 320-335.

Laidre, K. L., Shelden, K. E. W., Rugh, D. J., & Mahoney, B. (2000). Beluga, Delphinapterus leucas, distribution and survey effort in the Gulf of Alaska. . *Marine Fisheries Review, 62*(3), 27-36.

Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S., & Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science, 17*(1), 35-75.

Lambert, E., Hunter, C., Pierce, G. J., & MacLeod, C. D. (2010). Sustainable whale-watching tourism and climate change: Towards a framework of resilience. *Journal of Sustainable Tourism, 18*(3), 409–427.

Lande, R. (1991). Applications of genetics to management and conservation of cetaceans. *Report of the International Whaling Commission, Special Issue 13*, 301-311.

Lang, A. R., Weller, D. W., LeDuc, R., Burdin, A. M., Pease, V. L., Litovka, D., Burkanov, V., & R. L. Brownell, J. (2011). *Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific*. Retrieved from

Laplanche, C., Adam, O., Lopatka, M., & Motsch, J. F. (2005). *Sperm whales click focussing: Towards an understanding of single sperm whale foraging strategies*. Paper presented at the Nineteenth Annual Conference of the European Cetacean Society, La Rochelle, France.

Law, K. L., Moret-Ferguson, S., Maximenko, N. A., Proskurowski, G., Peacock, E. E., Hafner, J., & Reddy, C. M. (2010). Plastic accumulation in the North Atlantic subtropical gyre. *Science, 329*(5996), 1185-1188. doi:10.1126/science.1192321

Learmonth, J. A., Macleod, C. D., Santos, M. B., Pierce, G. J., Crick, H. Q. P., & Robinson, R. A. (2006). Potential effects of climate change on marine mammals. *Oceanography and Marine Biology: an Annual Review, 44*, 431-464.

Leduc, R. G., Taylor, B. L., Martien, K. K., Robertson, K. M., Pitman, R. L., Salinas, J. C., Burdin, A. M., Kennedy, A. S., Wade, P. R., Clapham, P. J., & Brownell Jr., R. L. (2012). Genetic analysis of right whales in the eastern North Pacific confirms severe extirpation risk. *Endangered Species Research, 18*(2), 163-167.

Lemon, M., Lynch, T. P., Cato, D. H., & Harcourt, R. G. (2006). Response of travelling bottlenose dolphins (Tursiops aduncus) to experimental approaches by a powerboat in Jervis Bay, New South Wales, Australia. *Biological Conservation, 127*(4), 363-372. doi:10.1016/j.biocon.2005.08.016

Lesage, V., Barrette, C., & Kingsley, M. C. S. (1993). *The effect of noise from an outboard motor and a ferry on the vocal activity of beluga (Delphinapterus leucas) in the St. Lawrence Estuary, Canada*. Paper presented at the Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.

Lesage, V., Barrette, C., Kingsley, M. C. S., & Sjare, B. (1999). The effect of vessel noise on the vocal behavior of Belugas in the St. Lawrence River estuary, Canada. *Marine Mammal Science, 15*(1), 65-84.

Levenson, C. (1974). Source level and bistatic target strength of the sperm whale (Physeter catodon) measured from an oceanographic aircraft. *Journal of the Acoustic Society of America, 55*(5), 1100-1103.

LGL Ltd. (2008). Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Gulf of Alaska, September 2008. *Prepared by LGL Ltd., environmental research associates, King City, Ontario for the Lamont-Doherty Earth Observatory, Palisades, New York, and the National Science Foundation, Arlington, Virginia. LGL Report TA4412-1. 204p.*

Li, W. C., Tse, H. F., & Fok, L. (2016). Plastic waste in the marine environment: A review of sources, occurrence and effects. *Sci Total Environ, 566-567*, 333-349. doi:10.1016/j.scitotenv.2016.05.084

Ljungblad, D. K., Würsig, B., Swartz, S. L., & Keene, J. M. (1988). Observations on the behavioral responses of bowhead whales (Balaena mysticetus) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic, 41*(3), 183-194.

Løkkeborg, S. (1991). *Effects of geophysical survey on catching success in longline fishing*. Paper presented at the International Council for the Exploration of the Sea (ICES) Annual Science Conference.

Løkkeborg, S., & Soldal, A. V. (1993). The influence of seismic explorations on cod (Gadus morhua) behaviour and catch rates. *ICES Marine Science Symposium, 196*, 62-67.

Løkkeborg, S. O., Egil; Vold, Aud; Salthaug, Are; Jech, Josef Michael. (2012). Sounds from seismic air guns: Gear- and species-specific effects on catch rates and fish distribution. *Canadian Journal of Fisheries and Aquatic Sciences, 69*(8), 1278-1291. doi:10.1139/f2012-059

Lombarte, A., Yan, H. Y., Popper, A. N., Chang, J. C., & Platt, C. (1993). Damage and regeneration of hair cell ciliary bundles in a fish ear following treatment with gentamicin. *Hearing Research, 66*, 166-174.

Lovell, J. M., Findlay, M. M., Moate, R. M., Nedwell, J. R., & Pegg, M. A. (2005). The inner ear morphology and hearing abilities of the paddlefish (Polyodon spathula) and the lake sturgeon (Acipenser fulvescens). *Comparative Biochemistry and Physiology. Part A, Molecular and Integrative Physiology, 142*(3), 286-296. doi:10.1016/j.cbpa.2005.07.018

Luksenburg, J., & Parsons, E. (2009). *The effects of aircraft on cetaceans: implications for aerial whalewatching* (SC/61/WW2). Retrieved from

Lurton, X., & DeRuiter, S. (2011). Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. *International Hydrographic Review, November*, 7-17.

Lusseau, D. (2003). Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. *Conservation Biology, 17*(6), 1785-1793.

Lusseau, D. (2006). The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. *Marine Mammal Science, 22*(4), 802-818.

Lyrholm, T., & Gyllensten, U. (1998). Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. *Proceedings of the Royal Society B-Biological Sciences, 265*(1406), 1679-1684.

Lysiak, N. S. J., Trumble, S. J., Knowlton, A. R., & Moore, M. J. (2018). Characterizing the Duration and Severity of Fishing Gear Entanglement on a North Atlantic Right Whale (*Eubalaena glacialis*) Using Stable Isotopes, Steroid and Thyroid Hormones in Baleen. *Frontiers in Marine Science, 5*, 168. doi:10.3389/fmars.2018.00168

Macleod, C. D. (2009). Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. *Endangered Species Research, 7*(2), 125-136. doi:10.3354/esr00197

Macleod, C. D., Bannon, S. M., Pierce, G. J., Schweder, C., Learmonth, J. A., Herman, J. S., & Reid, R. J. (2005). Climate change and the cetacean community of north-west Scotland. *Biological Conservation, 124*(4), 477-483.

Madsen, P. T., Carder, D. A., Au, W. W. L., Nachtigall, P. E., Møhl, B., & Ridgway, S. H. (2003). Sound production in neonate sperm whales. *Journal of the Acoustical Society of America, 113*(6), 2988–2991.

Madsen, P. T., Johnson, M., Miller, P. J. O., Aguilar Soto, N., Lynch, J., & Tyack, P. (2006). Quantitative measurements of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *Journal of the Acoustical Society of America, 120*(4), 2366–2379.

Madsen, P. T., Møhl, B., Nielsen, B. K., & Wahlberg, M. (2002). Male sperm whale behaviour during seismic survey pulses. *Aquatic Mammals, 28*(3), 231-240.

Magalhaes, S., Prieto, R., Silva, M. A., Goncalves, J., Afonso-Dias, M., & Santos, R. S. (2002). Short-term reactions of sperm whales (Physeter macrocephalus) to whale-watching vessels in the Azores. *Aquatic Mammals, 28*(3), 267-274.

Malme, C. I., & Miles, P. R. (1985). *Behavioral responses of marine mammals (gray whales) to seismic discharges*. Paper presented at the Proc. Workshop on Effects of Explosives Use in the Marine Environment, Ottawa, Canada.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. (1984). Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration. Report prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Office under Contract No. 14-12-0001-29033. 29357p.

Malme, C. I., Miles, P. R., Tyack, P., Clark, C. W., & Bird, J. E. (1985). *Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior*. Retrieved from Anchorage, Alaska:

Malme, C. I., Würsig, B., Bird, J. E., & Tyack, P. (1986). *Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling*. Retrieved from

Malme, C. I. B., Würsig, B., Bird, J. E., & Tyack, P. (1988). *Observations of feeding gray whale responses to controlled industrial noise exposure*. Paper presented at the Port and Ocean Engineering Under Arctic Conditions: Symposium on noise and marine mammals, University of Alaska at Fairbanks.

Mancia, A. W., W.; Chapman, R. W. (2008). A transcriptomic analysis of the stress induced by capture-release health assessment studies in wild dolphins (*Tursiops truncatus*). *Molecular Ecology, 17*(11), 2581-2589. doi:10.1111/j.1365-294X.2008.03784.x

Mann, J., Connor, R. C., Barre, L. M., & Heithaus., M. R. (2000). Female reproductive success in bottlenose dolphins (Tursiops sp.): Life history, habitat, provisioning, and group-size effects. *Behavioral Ecology, 11*(2), 210-219.

Mantua, N. J., & Hare, S. R. (2002). The Pacific decadal oscillation. *Journal of Oceanography, 58*(1), 35-44.

Mantua, N. J., Hare, S. R., Zhang, Y., Wallace, J. M., & Francis, R. C. (1997). A Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society, 78*(6), 1069-1079.

Marcoux, M., Whitehead, H., & Rendell, L. (2006). Coda vocalizations recorded in breeding areas are almost entirely produced by mature female sperm whales (Physeter macrocephalus). *Canadian Journal of Zoology, 84*(4), 609-614.

Markon, C., Gray, S., Berman, L., Eerkes-Medrano, T., Huntington, H., Littell, J., McCammon, M., Thoman, R., & Trainor, S. (2018). Alaska. In D. R. Reidmiller, C. W. Avery, D. R. Easterling, et al. (Eds.), *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment* (Vol. II, pp. 1185-1241). Washington, DC, USA: U.S. Global Change Research Program.

Marques, T. A., Munger, L., Thomas, L., Wiggins, S., & Hildebrand, J. A. (2011). Estimating North Pacific right whale Eubalaena japonica density using passive acoustic cue counting. *Endangered Species Research, 13*(3), 163-172. doi:10.3354/esr00325

Mate, B., Bradford, A., Tsidulko, G., Vertyankin, V., & Ilyashenko, V. (2011). *Late-feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the eastern North Pacific*. Retrieved from Tromso, Norway:

Mate, B. R., Stafford, K. M., & Ljungblad, D. K. (1994). A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. *Journal of the Acoustic Society of America, 96*(5 part 2), 3268–3269.

Matkin, C. O., & Saulitis, E. (1997). Restoration notebook: killer whale (*Orcinus orca*). *Exxon Valdez Oil Spill Trustee Council, Anchorage, Alaska.*

Matthews, J. N., Brown, S., Gillespie, D., Johnson, M., McManaghan, R., Moscrop, A., Nowacek, D., Leaper, R., Lewis, T., & Tyack, P. (2001). Vocalisation rates of the North Atlantic right whale (Eubalaena glacialis). *Journal of Cetacean Research and Management, 3*(3), 271-282.

Maybaum, H. L. (1990). Effects of 3.3 kHz sonar system on humpback whales, Megaptera novaeangliae, in Hawaiian waters. *EOS Transactions of the American Geophysical Union, 71*(2), 92.

Maybaum, H. L. (1993). Responses of humpback whales to sonar sounds. *Journal of the Acoustical Society of America, 94*(3 Pt. 2), 1848–1849.

McAlpine, D. F., Orchard, S. A., & Sendall, K. A. (2002). Recent occurrences of the green turtle from British Columbia waters. *Northwest Science, 76*(2), 185-188.

McCall Howard, M. P. (1999). *Sperm whales Physeter macrocephalus in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying.* (Bachelors Thesis), Dalhousie University, Halifax, Nova Scotia.

McCauley, R., & Jenner, C. (2010). Migratory patterns and estimated population size of pygmy blue whales (Balaenoptera musculus brevicauda) traversing the Western Australian coast based on passive acoustics. *IWC SC/62/SH26.*

McCauley, R. D., Day, R. D., Swadling, K. M., Fitzgibbon, Q. P., Watson, R. A., & Semmens, J. M. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology and Evolution, 1*(7), 195. doi:10.1038/s41559-017-0195

McCauley, R. D., & Fewtrell, J. (2013a). Experiments and observations of fish exposed to seismic survey pulses. *Bioacoustics, 17*, 205-207.

McCauley, R. D., & Fewtrell, J. (2013b). Marine invertebrates, intense anthropogenic noise, and squid response to seismic survey pulses. *Bioacoustics, 17*, 315-318.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J., & Mccabe, K. (2000a). *Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid*. Retrieved from Western Australia:

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdock, J., & McCabe, K. (2000b). Marine seismic surveys - a study of environmental implications. *Australian Petroleum Production & Exploration Association (APPEA) Journal, 40*, 692-708.

McCauley, R. D., Fewtrell, J., & Popper, A. N. (2003). High intensity anthropogenic sound damages fish ears. *Journal of the Acoustical Society of America, 113*, 5.

McCauley, R. D., Jenner, M.-N., Jenner, C., McCabe, K. A., & Murdoch, J. (1998). The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal, 38*, 692-707.

McDonald, M. A., Calambokidis, J., Teranishi, A. M., & Hildebrand, J. A. (2001). The acoustic calls of blue whales off California with gender data. *Journal of the Acoustical Society of America, 109*(4), 1728–1735.

McDonald, M. A., Hildebrand, J. A., & Mesnick., S. (2009). Worldwide decline in tonal frequencies of blue whale songs. *Endangered Species Research, 9*(1), 13-21.

McDonald, M. A., Hildebrand, J. A., Webb, S., Dorman, L., & Fox, C. G. (1993). Vocalizations of blue and fin whales during a midocean ridge airgun experiment. *Journal of the Acoustic Society of America, 94*(3 part 2), 1849.

McDonald, M. A., Hildebrand, J. A., & Webb, S. C. (1995). Blue and fin whales observed on a seafloor array in the northeast Pacific. *Journal of the Acoustical Society of America, 98*(2 Part 1), 712-721.

McDonald, M. A., Hildebrand, J. A., & Wiggins, S. M. (2006a). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal of the Acoustical Society of America, 120*(2), 711-718.

McDonald, M. A., Hildebrand, J. A., Wiggins, S. M., Thiele, D., Glasgow, D., & Moore, S. E. (2005). Sei whale sounds recorded in the Antarctic. *Journal of the Acoustical Society of America, 118*(6), 3941–3945.

McDonald, M. A., Mesnick, S. L., & Hildebrand, J. A. (2006b). Biogeographic characterisation of blue whale song worldwide: Using song to identify populations. *Journal of Cetacean Research and Management, 8*(1), 55-65.

McDonald, M. A., & Moore, S. E. (2002). Calls recorded from North Pacific right whales (Eubalaena japonica) in the eastern Bering Sea. *Journal of Cetacean Research and Management, 4*(3), 261-266.

McKenna, M. F., Ross, D., Wiggins, S. M., & Hildebrand, J. A. (2012). Underwater radiated noise from modern commercial ships. *Journal of the Acoustical Society of America, 131*(2), 92-103.

McKenna, M. F., Ross, D., Wiggins, S. M., & Hildebrand, J. A. (2013). Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. *Scientific Reports, 3*, 1760.

McMahon, C. R., & Burton, H. R. (2005). Climate change and seal survival: Evidence for environmentally mediated changes in elephant seal, Mirounga leonina, pup survival. *Proceedings of the Royal Society of London Series B Biological Sciences, 272*(1566), 923-928.

McMahon, C. R., & Hays, G. C. (2006). Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. *Global Change Biology, 12*(7), 1330-1338. doi:10.1111/j.1365-2486.2006.01174.x

McSweeney, D. J., Chu, K. C., Dolphin, W. F., & Guinee, L. N. (1989). North Pacific humpback whale songs - a comparison of southeast Alaskan feeding ground songs with Hawaiian wintering ground songs. *Marine Mammal Science, 5*(2), 139-148.

Mearns, A. J. (2001). *Long-term contaminant trends and patterns in Puget Sound, the Straits of Juan de Fuca, and the Pacific Coast*. Paper presented at the 2001 Puget Sound Research Conference, Olympia, Washington.

Mellinger, D. K., & Clark, C. W. (2003). Blue whale (Balaenoptera musculus) sounds from the North Atlantic. *Journal of the Acoustical Society of America, 114*(2), 1108-1119.

Mesnick, S. L., Taylor, B. L., Archer, F. I., Martien, K. K., Trevino, S. E., Hancock-Hanser, B. L., Moreno Medina, S. C., Pease, V. L., Robertson, K. M., Straley, J. M., Baird, R. W., Calambokidis, J., Schorr, G. S., Wade, P., Burkanov, V., Lunsford, C. R., Rendell, L., & Morin, P. A. (2011). Sperm whale population structure in the eastern and central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. *Mol Ecol Resour, 11 Suppl 1*, 278-298. doi:10.1111/j.1755-0998.2010.02973.x

Meyer, M., & Popper, A. N. (2002). Hearing in "primitive" fish: Brainstem responses to pure tone stimuli in the lake sturgeon, *Acipenser fulvescens*. *Abstracts of the Association for Research in Otolaryngology, 25*, 11–12.

Miksis-Olds, J. L., & Nichols, S. M. (2016). Is low frequency ocean sound increasing globally? *Journal of the Acoustical Society of America, 139*(1), 501–511. doi:10.1121/1.4938237

Miller, G. W., Elliot, R. E., Koski, W. R., Moulton, V. D., & Richardson, W. J. (1999). Whales. In R. W.J. (Ed.), *Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998*.

Miller, G. W., Moulton, V. D., Davis, R. A., Holst, M., Millman, P., MacGillivray, A., & Hannay, D. (2005). Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. In S. L. Armsworthy, P. J. Cranford, & K. Lee (Eds.), *Offshore Oil and Gas Environmental Effects Monitor-ing/Approaches and Technologies* (pp. 511-542). Columbus, Ohio: Battelle Press.

Miller, P. J. O., Johnson, M. P., & Tyack, P. L. (2004). Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. *Proceedings of the Royal Society of London Series B Biological Sciences, 271*(1554), 2239-2247.

Miller, P. J. O., M.P.Johnson, P.T.Madsen, N.Biassoni, M.Quero, & P.L.Tyack. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep-Sea Research, in press*.

Milton, S. L., & Lutz, P. L. (2003). Physiological and Genetic Responses to Environmental Stress. In P. L. Lutz, J. A. Musick, & J. Wyneken (Eds.), *The Biology of Sea Turtles Volume II* (pp. 455). Washington, D.C.: CRC Press.

MMC. (2007). *Marine mammals and noise: A sound approach to research and management*. Retrieved from

Moberg, G. P. (2000). Biological response to stress: Implications for animal welfare. In G. P. Moberg & J. A. Mench (Eds.), *The Biology of Animal Stress* (pp. 21-Jan). Oxford, United Kingdom: Oxford University Press.

Mohl, B., Wahlberg, M., Madsen, P. T., Heerfordt, A., & Lund, A. (2003). The monopulsed nature of sperm whale clicks. *Journal of the Acoustical Society of America, 114*(2), 1143–1154.

Moncheva, S. P., & Kamburska, L. T. (2002). *Plankton stowaways in the Black Sea - Impacts on biodiversity and ecosystem health*. Paper presented at the Alien marine organisms introduced by ships in the Mediterranean and Black seas, Istanbul, Turkey.

Mongillo, T. M., Holmes, E. E., Noren, D. P., VanBlaricom, G. R., Punt, A. E., O'Neill, S. M., Ylitalo, G. M., Hanson, M. B., & Ross, P. S. (2012). Predicted polybrominated diphenyl ether (PBDE) and polychlorinated biphenyl (PCB) accumulation in southern resident killer whales. *Marine Ecology Progress Series, 453*, 263-277. doi:10.3354/meps09658

Moore, E., Lyday, S., Roletto, J., Litle, K., Parrish, J. K., Nevins, H., Harvey, J., Mortenson, J., Greig, D., Piazza, M., Hermance, A., Lee, D., Adams, D., Allen, S., & Kell, S. (2009). Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001-2005. *Marine Pollution Bulletin, 58*(7), 1045–1051.

Moore, P. W. B., & Pawloski, D. A. (1990). Investigations on the control of echolocation pulses in the dolphin (*Tursiops truncatus*). In J. A. T. R. A. Kastelein (Ed.), *Sensory Abilities of Cetaceans: Laboratory and Field Evidence* (pp. 305-316). New York: Plenum Press.

Moore, S. E., & Angliss, R. P. (2006). *Overview of planned seismic surveys offshore northern Alaska, July-October 2006*. Paper presented at the Paper SC/58/E6 presented to IWC Scientific Committee, St Kitts and Nevis.

Morano, J. L., Rice, A. N., Tielens, J. T., Estabrook, B. J., Murray, A., Roberts, B. L., & Clark, C. W. (2012). Acoustically detected year-round presence of right whales in an urbanized migration corridor. *Conservation Biology, 26*(4), 698-707.

Moriyasu, M., Allain, R., Benhalima, K., & Claytor, R. (2004). *Effects of seismic and marine noise on invertebrates: A literature review*. Retrieved from

Moulton, V. D., Mactavish, B. D., & Buchanan, R. A. (2006a). *Marine mammal and seabird monitoring of Conoco-Phillips' 3-D seismic program in the Laurentian Sub-basin, 2005*. Retrieved from

Moulton, V. D., Mactavish, B. D., Harris, R. E., & Buchanan, R. A. (2006b). *Marine mammal and seabird monitoring of Chevron Canada Limited's 3-D seismic program on the Orphan Basin, 2005*. Retrieved from

Moulton, V. D., & Miller, G. W. (2005). *Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003*. Retrieved from

Mundy, P. R. (2005). *The Gulf of Alaska: Biology and Oceanography*. Fairbanks: Alaska Sea Grant College Program, University of Alaska.

Mundy, P. R., & Cooney, R. T. (2005). Physical and biological background. In P. R. Mundy (Ed.), *The Gulf of Alaska: Biology and oceanography* (pp. 15-23). Fairbanks, Alaska: Alaska Sea Grant College Program, University of Alaska.

Mussoline, S. E., Risch, D., Hatch, L. T., Weinrich, M. T., Wiley, D. N., Thompson, M. A., Corkeron, P. J., & Parijs, S. M. V. (2012). Seasonal and diel variation in North Atlantic right whale up-calls: Implications for management and conservation in the northwestern Atlantic Ocean. *Endangered Species Research, 17*(1-Jan), 17-26.

Muto, M. M., Helker, V. T., Angliss, R. P., Allen, B. A., Boveng, P. L., Breiwick, J. M., Cameron, M. F., Clapham, P. J., Dahle, S. P., Dahlheim, M. E., Fadely, B. S., Ferguson, M. C., Fritz, L. W., Hobbs, R. C., Ivashchenko, Y. V., Kennedy, A. S., London, J. M., Mizroch, S. A., Ream, R. R., Richmond, E. L., Shelden, K. E. W., Towell, R. G., Wade, P. R., Waite, J. M., & Zerbini, A. N. (2016). Alaska Marine Mammal Stock Assessments, 2015. doi:10.7289/V5/TM-AFSC-323

Muto, M. M., Helker, V. T., Angliss, R. P., Allen, B. A., Boveng, P. L., Breiwick, J. M., Cameron, M. F., Clapham, P. J., Dahle, S. P., Dahlheim, M. E., Fadely, B. S., Ferguson, M. C., Fritz, L. W., Hobbs, R. C., Ivashchenko, Y. V., Kennedy, A. S., London, J. M., Mizroch, S. A., Ream, R. R., Richmond, E. L., Shelden, K. E. W., Towell, R. G., Wade, P. R., Waite, J. M., & Zerbini, A. N. (2017). *Alaska Marine Mammal Stock Assessments, 2016* (NMFS-AFSC-355). Retrieved from Seattle, Washington:

Muto, M. M., Helker, V. T., Angliss, R. P., Allen, B. A., Boveng, P. L., Breiwick, J. M., Cameron, M. F., Clapham, P. J., Dahle, S. P., Dahlheim, M. E., Fadely, B. S., Ferguson, M. C., Fritz, L. W., Hobbs, R. C., Ivashchenko, Y. V., Kennedy, A. S., London, J. M., Mizroch, S. A., Ream, R. R., Richmond, E. L., Shelden, K. E. W., Towell, R. G., Wade, P. R., Waite, J. M., & Zerbini, A. N. (2018). *Alaska Marine Mammal Stock Assessments, 2017* (NMFS-AFSC-378). Retrieved from Seattle, Washington:

Nadeem, K., Moore, J. E., Zhang, Y., & Chipman, H. (2016). Integrating population dynamics models and distance sampling data: A spatial hierarchical state-space approach. *Ecology, 97*(7), 1735-1745. doi:10.1890/15-1406.1

Nations, C. S., Blackwell, S. B., Kim, K. H., Thode, A. M., Charles R. Greene, J., & Mcdonald., T. L. (2009). Effects of seismic exploration in the Beaufort Sea on bowhead whale call distributions. *Journal of the Acoustical Society of America, 126*(4), 2230.

Nelms, S. E., Piniak, W. E. D., Weir, C. R., & Godley, B. J. (2016). Seismic surveys and marine turtles: An underestimated global threat? *Biological Conservation, 193*, 49-65. doi:10.1016/j.biocon.2015.10.020

Neproshin, A., & Kulikova, W. (1975). Sound production organs in salmonids. *J. Ichthyiol, 15*, 481-485.

Neproshin, Y. (1972). Some physical characteristics of sound in Pacific salmon. *Zoologicheskii Zhurnal, 51*, 1025-1030.

Nieukirk, S. L., Stafford, K. M., Mellinger, D. k., Dziak, R. P., & Fox, C. G. (2004). Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean *Journal of the Acoustical Society of America, 115*, 1832-1843.

NMFS. (1991). *Final recovery plan for the humpback whale (Megaptera novaeangliae)*. Retrieved from Silver Spring, Maryland:

NMFS. (1995). Small takes of marine mammals incidental to specified activities; offshore seismic activities in southern California: Notice of issuance of an incidental harassment authorization. *Federal Register, 60*(200), 53753-53760.

NMFS. (1998). *Recovery plan for the blue whale (Balaenoptera musculus)*. Retrieved from Silver Spring, Maryland:

NMFS. (2006). *Biological Opinion on the issuance of Section 10(a)(1)(A) permits to conduct scientific research on the southern resident killer whale (Orcinus orca) distinct population segment and other endangered or threatened species* (NWR-2006-470). Retrieved from Seattle, Washington:

NMFS. (2006b). Draft Recovery Plan for the Sperm Whale (*Physeter Macrocephalus*). *National Marine Fisheries Service, Silver Spring, Maryland. 92p.*

NMFS. (2006g). Biological Opinion on the 2006 Rim-of-the-Pacific Joint Training Exercises (RIMPAC). *National Marine Fisheries Service, Silver Spring, Maryland. 123p.*

NMFS. (2006h). Biological Opinion on the Funding and Permitting of Seismic Surveys by the National Science Foundation and the National Marine Fisheries Service in the Eastern Tropical Pacific Ocean from March to April 2006. *National Marine Fisheries Service, Silver Spring, Maryland. 76p.*

NMFS. (2008). *Recovery Plan for the Steller Sea Lion (Eumetopias jubatus). Revision.* Silver Spring, MD.

NMFS. (2010a). *Final recovery plan for the sperm whale (Physeter macrocephalus)*. Retrieved from Silver Spring, Maryland:

NMFS. (2010b). *Recovery plan for the fin whale (Balaenoptera physalus)*. Retrieved from Silver Spring, Maryland:

NMFS. (2011a). *Endangered Species Act consultation biological opinion on U.S. Navy Pacifictraining activities on the Gulf ofAlaska Temporary Maritime Training Area and promulgation of regulations to authorize the Navy to take marine mammals incidental to training on the Gulf ofAlaska Temporary Maritime Training Area from April 2011 to April 2016*. Retrieved from Silver Spring, Maryland:

NMFS. (2011b). Fin whale (*Balaenoptera physalus*) 5-Year Review: Evaluation and Summary.

NMFS. (2011c). *Final recovery plan for the sei whale (Balaenoptera borealis)*. Retrieved from Silver Spring, Maryland:

NMFS. (2012a). 5-Year Review North Pacific Right Whale (*Eubalaena japonica*).

NMFS. (2012b). *Sei whale (Balaenoptera borealis). 5-year review: Summary and evaluation*. Retrieved from

NMFS. (2013). *Draft recovery plan for the North Pacific right whale (Eubalaena japonica)*. Retrieved from Silver Spring, Maryland:

NMFS. (2015). *Sperm whale (Physeter macrocephalus) 5-year review: Summary and evaluation*. Retrieved from

NMFS. (2016). *Occurrence of Distinct Population Segments (DPSs) of Humpback Whales off Alaska. National Marine Fisheries Service, Alaska Region. Revised December 12, 2016*.

NMFS. (2017a). *Biological Opinion on the US Navy's Gulf of Alaska Training Activities and Associated NMFS Regulations and Letter of Authorization (April 2017 - April 2022)* (FPR-2015-9118). Retrieved from Silver Spring, Maryland:

NMFS. (2017b). *Letter of concurrence on the issuance of Permit No. 20527 to Ann Pabst for vessel and aerial surveys of blue, fin, North Atlantic right, sei, and sperm whales* (FPR-2017-9199). Retrieved from Silver Spring, Maryland: https://repository.library.noaa.gov/view/noaa/14654 https://repository.library.noaa.gov/view/noaa/14654/noaa_14654_DS1.pdf

NMFS. (2017c). North Pacific Right Whale (*Eubalaena japonica*) Five Yar Review: Summary and Evaluation. 39.

NMFS. (2018). *Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.*

NMFS, & USFWS. (2007a). *5-year review: Summary and evaluation, green sea turtle (Chelonia mydas)*. Retrieved from

NMFS, & USFWS. (2007b). *Loggerhead sea turtle (Caretta caretta) 5-year review: Summary and evaluation*. Retrieved from Silver Spring, Maryland:

NMFS, & USFWS. (2008). *Recovery plan for the northwest Atlantic population of the loggerhead sea turtle (Caretta caretta), second revision.* Retrieved from Silver Spring, Maryland:

NMFS, & USFWS. (2013a). *Hawksbill sea turtle (Eretmochelys imbricata) 5-year review: Summary and evaluation* Retrieved from Silver Spring, Maryland:

NMFS, & USFWS. (2013b). *Leatherback sea turtle (Dermochelys coriacea) 5-year review: Summary and evaluation*. Retrieved from Silver Spring, Maryland:

NMFS, & USFWS. (2015). *Kemp's ridley sea turtle (Lepidochelys kempii) 5-year review: Summary and evaluation*. Retrieved from Silver Spring, Maryland:

NOAA. (2013). *Draft guidance for assessing the effects of anthropogenic sound on marine mammals: acoustic threshold levels for onset of permanent and temporary threshold shifts*. Retrieved from http://www.nmfs.noaa.gov/pr/acoustics/draft_acoustic_guidance_2013.pdf

NOAA. (2016). *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing*. Retrieved from Silver Spring, Maryland:

NOAA. (2018). *Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. Retrieved from Silver Spring, Maryland:

Noda, K., Akiyoshi, H., Aoki, M., Shimada, T., & Ohashi, F. (2007). Relationship between transportation stress and polymorphonuclear cell functions of bottlenose dolphins, *Tursiops truncatus*. *Journal of Veterinary Medical Science, 69*(4), 379-383.

Noren, D. P., Johnson, A. H., Rehder, D., & Larson, A. (2009). Close approaches by vessels elicit surface active behaviors by southern resident killer whales. *Endangered Species Research, 8*(3), 179–192.

Norris, K. S., & Harvey, G. W. (1972). A theory for the function of the spermaceti organ of the sperm whale. In S. R. Galler (Ed.), *Animal Orientation and Navigation* (pp. 393–417).

Nowacek, D., Tyack, P., & Johnson, M. (2003). *North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alarm signal*. Paper presented at the Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, Texas.

Nowacek, D. P., Johnson, M. P., & Tyack, P. L. (2004). North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London Series B Biological Sciences, 271*(1536), 227-231.

Nowacek, D. P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review, 37*(2), 81-115.

Nowacek, S. M., Wells, R. S., & Solow, A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science, 17*(4), 673-688.

NRC. (2003a). *National Research Council: Ocean noise and marine mammals.* Washington, D.C.: National Academies Press.

NRC. (2003b). Ocean Noise and Marine Mammals. National Research Council: Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals.

NRC. (2003c). *Ocean Noise and Marine Mammals*. Retrieved from Washington, District of Columbia:

NRC. (2005). *Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects*. Retrieved from Washington, District of Columbia:

NRC. (2008). *Tackling marine debris in the 21st Century*. Retrieved from Washington, District of Columbia:

O'Connor, S., Campbell, R., Cortez, H., & Knowles, T. (2009). *Whale Watching Worldwide: Tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare*. Retrieved from Yarmouth, Massachusetts:

Ohsumi, S., & Wada, S. (1974). Status of whale stocks in the North Pacific, 1972. *Report of the International Whaling Commission, 24*, 114-126.

Oleson, E. M., Calambokidis, J., Barlow, J., & Hildebrand, J. A. (2007a). Blue whale visual and acoustic encounter rates in the southern California bight. *Marine Mammal Science, 23*(3), 574-597. doi:doi:10.1111/j.1748-7692.2007.02303.x

Oleson, E. M., Calambokidis, J., Burgess, W. C., McDonald, M. A., Leduc, C. A., & Hildebrand, J. A. (2007b). Behavioral context of call production by eastern North Pacific blue whales. *Marine Ecology Progress Series, 330*, 269-284.

Oleson, E. M., Wiggins, S. M., & Hildebrand, J. A. (2007c). Temporal separation of blue whale call types on a southern California feeding ground. *Animal Behaviour, 74*(4), 881-894.

Overland, J. E., & Wang, M. Y. (2007). Future regional Arctic sea ice declines. *Geophysical Research Letters, 34*(17), L17705. doi:Artn L17705; Doi 10.1029/2007gl030808

Palka, D. (2012). Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2011 line transect survey.

Parente, C. L., Araujo, J. P., & Araujo, M. E. (2007). Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. *Biota Neotropica, 7*(1).

Parks, S. E. (2003). Response of North Atlantic right whales (Eubalaena glacialis) to playback of calls recorded from surface active groups in both the North and South Atlantic. *Marine Mammal Science, 19*(3), 563-580.

Parks, S. E. (2009). *Assessment of acoustic adaptations for noise compensation in marine mammals*. Retrieved from

Parks, S. E., & Clark, C. W. (2007). Acoustic communication: Social sounds and the potential impacts of noise. In S. D. K. R. Rolland (Ed.), *The Urban Whale: North Atlantic Right Whales at the Crossroads* (pp. 310-332). Cambridge, Massahusetts: Harvard University Press.

Parks, S. E., Clark, C. W., & Tyack, P. (2007a). Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America, 122*(6), 3725-3731.

Parks, S. E., Clark, C. W., & Tyack, P. L. (2005a). *North Atlantic right whales shift their frequency of calling in response to vessel noise*. Paper presented at the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Parks, S. E., Hamilton, P. K., Kraus, S. D., & Tyack, P. L. (2005b). The gunshot sound produced by male North Atlantic right whales (Eubalaena glacialis) and its potential function in reproductive advertisement. *Marine Mammal Science, 21*(3), 458-475.

Parks, S. E., Hotchkin, C. F., Cortopassi, K. A., & Clark, C. W. (2012a). Characteristics of gunshot sound displays by North Atlantic right whales in the Bay of Fundy. *Journal of the Acoustical Society of America, 131*(4), 3173-3179.

Parks, S. E., Johnson, M., Nowacek, D., & Tyack, P. L. (2011). Individual right whales call louder in increased environmental noise. *Biology Letters, 7*(1), 33-35.

Parks, S. E., Johnson, M., & Tyack., P. (2010). Changes in vocal behavior of individual North Atlantic right whales in increased noise. *Journal of the Acoustical Society of America, 127*(3 Pt 2), 1726.

Parks, S. E., Johnson, M. P., Nowacek, D. P., & Tyack, P. L. (2012b). Changes in vocal behavior of North Atlantic right whales in increased noise. In A. N. P. A. Hawkings (Ed.), *The Effects of Noise on Aquatic Life* (pp. 4): Springer Science.

Parks, S. E., Ketten, D. R., O'malley, J. T., & Arruda, J. (2007b). Anatomical predictions of hearing in the North Atlantic right whale. *Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology, 290*(6), 734-744.

Parks, S. E., Kristrup, K. M., Kraus, S. D., & Tyack, P. L. (2003). *Sound production by North Atlantic right whales in surface active groups*. Paper presented at the Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Parks, S. E., Parks, S. E., Clark, C. W., & Tyack, P. L. (2006). Acoustic Communication in the North Atlantic Right Whale (*Eubalaena glacialis*) and Potential Impacts of Noise. *EOS, Transactions, American Geophysical Union, 87*(36), Ocean Sci. Meet. Suppl., Abstract OS53G-03.

Parks, S. E., & Tyack, P. L. (2005). Sound production by North Atlantic right whales (Eubalaena glacialis) in surface active groups. *Journal of the Acoustical Society of America, 117*(5), 3297-3306.

Parsons, E. C. M. (2012). The Negative Impacts of Whale-Watching. *Journal of Marine Biology, 2012*, 1-9. doi:10.1155/2012/807294

Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Wursig, B., & Greene, C. R. (2002). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science, 18*(2), 309-335.

Patterson, B., & Hamilton, G. R. (1964). Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. In W. N. Tavolga (Ed.), *Marine Bio-acoustics* (pp. 125–145). Oxford, United Kingdom: Pergamon Press.

Pavan, G., Hayward, T. J., Borsani, J. F., Priano, M., Manghi, M., Fossati, C., & Gordon, J. (2000). Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. *Journal of the Acoustical Society of America, 107*(6), 3487-3495.

Payne, J. F., Andrews, C. D., Fancey, L. L., Guiney, J., Cook, A., & Christian, J. R. (2013). Are seismic surveys an important risk factor for fish and shellfish? *Bioacoustics, 17*, 262-265.

Payne, J. F., Coady, J., & White, D. (2009). *Potential effects of seismic airgun discharges on monkfish eggs (Lophius americanus) and larvae.* Retrieved from St. John's, Newfoundland:

Payne, K. (1985). Singing in humpback whales. *Whalewatcher, 19*(1), 3-6.

Payne, K., & Payne, R. (1985). Large scale changes over 19 years in songs of humpback whales in Bermuda. *Zeitschrift fur Tierpsychologie, 68*, 89-114.

Payne, K., Tyack, P., & Payne, R. (1983). Progressive changes in the songs of humpback whales (*Megaptera novaeangliae*): A detailed analysis of two seasons in Hawaii. In R. Payne (Ed.), *Communication and Behavior of Whales* (pp. 9-57). Boulder, CO: Westview Press.

Payne, P. M., Nicolas, J. R., O'brien, L., & Powers, K. D. (1986). The distribution of the humpback whale, Megaptera novaeangliae, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, Ammodytes americanus. *Fishery Bulletin, 84*(2), 271-277.

Payne, P. M., Wiley, D. N., Young, S. B., Pittman, S., Clapham, P. J., & Jossi, J. W. (1990). Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in prey abundance. *Fishery Bulletin, 88*(4), 687-696.

Payne, R., & Webb, D. (1971). Orientation by means of long range acoustic signaling in baleen whales. *Annals of the New York Academy of Sciences, 188*(1), 110–141.

Payne, R. S. (1970). Songs of the humpback whale [Phonograph record]. Hollywood: Capital Records.

Payne, R. S., & McVay, S. (1971). Songs of humpback whales. Humpbacks emit sounds in long, predictable patterns ranging over frequencies audible to humans. *Science, 173*(3997), 585-597.

Pearson, W. H., Skalski, J. R., & Malme, C. I. (1992). Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences, 49*, 1343-1356.

Pecl, G. T., & Jackson, G. D. (2008). The potential impacts of climate change on inshore squid: Biology, ecology and fisheries. *Reviews in Fish Biology and Fisheries, 18*, 373-385.

Pickett, G. D., Eaton, D. R., Seaby, R. M. H., & Arnold, G. P. (1994). Results of bass tagging in Poole Bay during 1992. In. Lowestoft, Endland: MAFF Direct. Fish. Res.

Polefka, S. (2004). *Anthropogenic noise and the Channel Islands National Marine Sanctuary: How noise affects sanctuary resources, and what we can do about it.* Retrieved from

Poloczanska, E. S., Limpus, C. J., & Hays, G. C. (2009). Vulnerability of marine turtles in climate change. In *Advances in MArine Biology* (Vol. 56, pp. 151-211). New York: Academic Press.

Popper, A. N. (1977). Comparative structure of the fish ear. *Journal of the Acoustical Society of America, 61*(S1), S76-S76. doi:10.1121/1.2015886

Popper, A. N. (2005). *A review of hearing by sturgeon and lamprey*. Retrieved from

Popper, A. N., Halvorsen, M. B., Kane, A., Miller, D. L., Smith, M. E., Song, J., Stein, P., & Wysocki, L. E. (2007). The effects of high-intensity, low-frequency active sonar on rainbow trout. *Journal of the Acoustical Society of America, 122*(1), 623-635.

Popper, A. N., & Hastings, M. C. (2009). The effects of human-generated sound on fish. *Integrative Zoology, 4*, 43-52.

Popper, A. N., & Hawkins, A. D. (2014). Assessing the impact of underwater sounds on fishes and other forms of marine life. *Acoustics Today, 10*(2), 30-41.

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Løkkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, D. G., & Tavolga, W. N. (2014). Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. In *ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI* (pp. 33-51).

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. Macgillivray, M. E. Austin, & Mann, D. A. (2005). Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America, 117*(6), 3958-3971.

Potter, J. R., Thillet, M., Douglas, C., Chitre, M. A., Doborzynski, Z., & Seekings, P. J. (2007). Visual and passive acoustic marine mammal observations and high-frenquency seismic source characteristics recorded during a seismic survey. *IEEE Journal of Oceanic Engineering, 32*(2), 469-483.

Pughiuc, D. (2010). Invasive species: Ballast water battles. *Seaways, March*, 5–7.

Putnam, N. F., Lohmannm, K. J., Putnam, E. M., Quinn, T. P., Klimley, A. P., & Noakes, D. L. G. (2013). Evidence for geomagnetic imprinting as a homing mechanism in Pacific salmon. *Current Biology, 23*, 312-316.

Raaymakers, S. (2003). The GEF/UNDP/IMO global ballast water management programme integrating science, shipping and society to save our seas. *Proceedings of the Institute of Marine Engineering, Science and Technology Part B: Journal of Design and Operations, 4*(7), 2–10.

Raaymakers, S., & Hilliard, R. (2002). *Harmful aquatic organisms in ships' ballast water - Ballast water risk assessment*. Paper presented at the Alien marine organisms introduced by ships in the Mediterranean and Black seas, Istanbul, Turkey.

Ramajo, L., Pérez-León, E., Hendriks, I. E., Marbà, N., Krause-Jensen, D., Sejr, M. K., Blicher, M. E., Lagos, N. A., Olsen, Y. S., & Duarte, C. M. (2016). Food supply confers calcifiers resistance to ocean acidification. *Scientific Reports, 6*, 19374. doi:10.1038/srep19374

https://www.nature.com/articles/srep19374#supplementary-information

Rankin, S., Ljungblad, D., Clark, C., & Kato, H. (2005). Vocalisations of Antarctic blue whales, *Balaenoptera musculus intermedia*, recorded during the 2001/2002 and 2002/2003 IWC/SOWER circumpolar cruises, Area V, Antarctica. *Journal of Cetacean Research and Management, 7*(1), 13-20.

Reep, R. L., Joseph C. Gaspard, I., Sarko, D., Rice, F. L., Mann, D. A., & Bauer, G. B. (2011). Manatee vibrissae: Evidence for a lateral line function. *Annals of the New York Academy of Sciences, 1225*(1), 101-109.

Reilly, S. B., Bannister, J. L., Best, P. B., Brown, M., Brownell Jr., R. L., Butterworth, D. S., Clapham, P. J., Cooke, J., Donovan, G. P., Urbán, J., & Zerbini, A. N. (2013). *Balaenoptera physalus*. The IUCN Red List of Threatened Species. *The IUCN Red List of Threatened Species 2013*, e.T2478A44210520. doi:http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T2478A44210520.en

Rendell, L., Mesnick, S. L., Dalebout, M. L., Burtenshaw, J., & Whitehead, H. (2012). Can genetic differences explain vocal dialect variation in sperm whales, Physeter macrocephalus? *Behav Genet, 42*(2), 332-343. doi:10.1007/s10519-011-9513-y

Rendell, L., & Whitehead, H. (2004). Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. *Animal Behaviour, 67*(5), 865-874.

Richardson, A. J., Matear, R. J., & Lenton, A. (2017). *Potential impacts on zooplankton of seismic surveys*. Retrieved from Australia:

Richardson, W. J. (1995). Marine mammal hearing. In C. R. W. J. G. J. Richardson, C. I. Malme, & D. H. Thomson (Eds.), *Marine Mammals and Noise* (pp. 205-240). San Diego, California: Academic Press.

Richardson, W. J., Greene, C. R., Malme, C. I., & Thomson, D. H. (1995). *Marine Mammals and Noise*. San Diego, California: Academic Press, Inc.

Richardson, W. J., Miller, G. W., & C.R. Greene, J. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. *Journal of the Acoustical Society of America*, *106*(4-2), 2281.

Richardson, W. J., Würsig, B., & Greene, C. R., Jr. (1986). Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America*, *79*(4), 1117-1128.

Richter, C. F., Dawson, S. M., & Slooten, E. (2003). Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. *Science for Conservation, 219*.

Rivers, J. A. (1997). Blue whale, Balaenoptera musculus, vocalizations from the waters off central California. *Marine Mammal Science*, *13*(2), 186-195.

Robertson, F. C., Koski, W. R., Thomas, T. A., Richardson, W. J., Wursig, B., & Trites, A. W. (2013). Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. *Endangered Species Research*, *21*(2), 143-160.

Robinson, R. A., Learmonth, J. A., Hutson, A. M., Macleod, C. D., Sparks, T. H., Leech, D. I., Pierce, G. J., Rehfisch, M. M., & Crick, H. Q. P. (2005). *Climate change and migratory species*. Retrieved from Norfolk, U.K. :

Rockwood, R. C., Calambokidis, J., & Jahncke, J. (2017). High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. *PLoS One*, *12*(8), e0183052. doi:10.1371/journal.pone.0183052

Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., Wasser, S. K., & Kraus, S. D. (2012). Evidence that ship noise increases stress in right whales. *Proc Biol Sci*, *279*(1737), 2363-2368. doi:10.1098/rspb.2011.2429

Roman, J., & Palumbi, S. R. (2003). Whales before whaling in the North Atlantic. *Science, 301*(5632), 508-510.

Romanenko, E. V., & Kitain, V. Y. (1992). The functioning of the echolocation system of *Tursiops truncatus* during noise masking. In J. A. T. R. A. K. A. Y. Supin (Ed.), *Marine Mammal Sensory Systems* (pp. 415-419). New York: Plenum Press.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. R., Carder, D. A., & Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences, 61*, 1124-1134.

Romero, L. M., Meister, C. J., Cyr, N. E., Kenagy, G. J., & Wingfield, J. C. (2008). Seasonal glucocorticoid responses to capture in wild free-living mammals. *American Journal of Physiology-Regulatory Integrative and Comparative Physiology, 294*(2), R614-R622. doi:10.1152/ajpregu.00752.2007

Rone, B. K., Douglas, A. B., Yack, T. M., Zerbini, A. N., Norris, T. N., Ferguson, E., & Calambokidis, J. (2014). *Report for the Gulf of Alaska Line-Transect Survey (GOALS) II:*

Marine Mammal Occurrence in the Temporary Maritime Activities Area (TMAA). Retrieved from

Rosenbaum, H. C., Brownell, R. L., Brown, M., Schaeff, C., Portway, V., White, B., Malik, S., Pastene, L., Patenaude, N., Baker, C. S., Goto, M., Best, P. B., Clapham, P. J., Hamilton, P., Moore, M., Payne, R., Rowntree, V., Tynan, C., Bannister, J., & Desalle, R. (2000). World-wide genetic differentiation of Eubalaena: Questioning the number of right whale species. *Molecular Ecology, 9*(11), 1793-1802.

Ross, D. (1976). *Mechanics of Underwater Noise*. New York: Pergamon Press.

Ross, D. (1993). On ocean underwater ambient noise. *Acoustics Bulletin, 18*, 8-May.

Ross, D. (2005). Ship Sources of Ambient Noise. *IEEE Journal of Oceanic Engineering, 30*(2), 257-261. doi:10.1109/joe.2005.850879

Ross, P. S. (2002). The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. *Human and Ecological Risk Assessment*, *8*(2), 277-292.

Royer, T. C. (2005). Hydrographic responses at a coastal site in the northern Gulf of Alaska to seasonal and interannual forcing. *Deep-Sea Research Part Ii-Topical Studies in Oceanography, 52*(1-2), 267-288. doi:10.1016/j.dsr2.2004.09.022

Rugh, D. J., Shelden, K. E. W., & Hobbs, R. C. (2010). Range contraction in a beluga whale population. *Endangered Species Research, 12*, 69-75.

Samaran, F., Guinet, C., Adam, O., Motsch, J. F., & Cansi, Y. (2010). Source level estimation of two blue whale subspecies in southwestern Indian Ocean. *Journal of the Acoustical Society of America*, *127*(6), 3800–3808. doi:10.1121/1.3409479

Samuels, A., Bejder, L., & Heinrich., S. (2000). *A review of the literature pertaining to swimming with wild dolphins*. Retrieved from

Santulli, A., Modica, A., Messina, C., Ceffa, L., Curatolo, A., Fabi, G. R. G., & D'Amelio, V. (1999). Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by offshore experimental seismic prospecting. *Marine Pollution Bulletin, 38*(12), 1105-1114.

Scheidat, M., Castro, C., Gonzalez, J., & Williams, R. (2004). Behavioural responses of humpback whales (Megaptera novaeangliae) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. *Journal of Cetacean Research and Management, 6*(1), 63-68.

Schevill, W. E., Watkins, W. A., & Backus, R. H. (1964). *The 20-cycle signals and Balaenoptera (fin whales)*. Paper presented at the Marine Bio-acoustics, Lerner Marine Laboratory, Bimini, Bahamas.

Schlundt, C. E., Finneran, J. J., Carder, D. A., & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. *Journal of the Acoustical Society of America, 107*(6), 3496-3508.

Shelden, K. E. W., Moore, S., Waite, J. M., Wade, P. R., & Rugh, D. J. (2005). Historic and current habitat use by North Pacific right whales Eubalaena japonica in the Bering Sea and Guylf of Alaska. *Mammal Review, 35*, 129-155.

Silber, G. K. (1986). The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). *Canadian Journal of Zoology, 64*(10), 2075-2080.

Simao, S. M., & Moreira, S. C. (2005). Vocalizations of a female humpback whale in Arraial do Cabo (Rj, Brazil). *Marine Mammal Science, 21*(1), 150-153.

Simmonds, M. P. (2005). *Whale watching and monitoring: some considerations* (SC/57/WW5). Retrieved from Cambridge, United Kingdom:

Simmonds, M. P., & Eliott, W. J. (2009). Climate change and cetaceans: Concerns and recent developments. *Journal of the Marine Biological Association of the United Kingdom, 89*(1), 203-210.

Simmonds, M. P., & Isaac, S. J. (2007). The impacts of climate change on marine mammals: Early signs of significant problems. *Oryx, 41*(1), 19-26.

Sirovic, A., Hildebrand, J. A., & Wiggins, S. M. (2007). Blue and fin whale call source levels and propagation range in the Southern Ocean. *Journal of the Acoustical Society of America, 122*(2), 1208–1215.

Sirovic, A., Williams, L. N., Kerosky, S. M., Wiggins, S. M., & Hildebrand, J. A. (2012). Temporal separation of two fin whale call types across the eastern North Pacific. *Marine Biology, 160*(1), 47-57.

Skalski, J. R., Pearson, W. H., & Malme, C. I. (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences, 49*, 1357-1365.

Slotte, A., Hansen, K., Dalen, J., & Ona, E. (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research, 67*, 143-150.

Smith, J. N., Goldizen, A. W., Dunlop, R. A., & Noad., M. J. (2008). Songs of male humpback whales, Megaptera novaeangliae, are involved in intersexual interactions. *Animal Behaviour, 76*(2), 467-477.

Smith, M. E., Coffin, A. B., Miller, D. L., & Popper, A. N. (2006). Anatomical and functional recovery of the goldfish (Carassius auratus) ear following noise exposure. *Journal of Experimental Biology, 209*(21), 4193-4202. doi:10.1242/jeb.02490

Smultea, M. A., Holst, M., Koski, W. R., & Stoltz, S. (2004). Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004. *LGL Rep. TA2822-26. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. 106 p.*

Smultea, M. A., Mobley, J. J. R., Fertl, D., & Fulling, G. L. (2008). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research, 20*, 75–80.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., & Tyack, P. L. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals, 33*(4), 411-521.

Southall, B. L., Nowacek, D. P., Miller, P. J. O., & Tyack, P. L. (2016). Experimental field studies to measure behavioral responses of cetaceans to sonar. *Endangered Species Research, 31*, 293-315. doi:10.3354/esr00764

Southall, B. L., Rowles, T., Gulland, F., Baird, R. W., & Jepson, P. D. (2013). *Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melonheaded whales (Peponocephala electra) in Antsohihy, Madagascar*. Retrieved from

Sremba, A. L., Hancock-Hanser, B., Branch, T. A., LeDuc, R. L., & Baker, C. S. (2012). Circumpolar diversity and geographic differentiation of mtDNA in the critically endangered Antarctic blue whale (*Balaenoptera musculus intermedia*). *PLoS One, 7*(3), e32579. doi:10.1371/journal.pone.0032579

St. Aubin, D. J., & Geraci, J. R. (1988). Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whale, *Delphinapterus leucas*. *Physiological Zoology, 61*(2), 170-175.

St. Aubin, D. J., Ridgway, S. H., Wells, R. S., & Rhinehart, H. (1996). Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *Tursiops truncatus,* and influence of sex, age, and season. *Marine Mammal Science, 12*(1), 1-13.

Stabeno, P. J., Bond, N. A., Hermann, A. J., Kachel, N. B., Mordy, C. W., & Overland., J. E. (2004). Meteorology and oceanography of the northern Gulf of Alaska. *Continental Shelf Research, 24-Jan*(8-Jul), 859-897.

Stafford, K. M. (2003). Two types of blue whale calls recorded in the Gulf of Alaska. *Marine Mammal Science, 19*(4), 12.

Stafford, K. M., Fox, C. G., & Clark, D. S. (1998). Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean. (Balaenoptera musculus). *Journal of the Acoustical Society of America, 104*(6), 3616-3625.

Stafford, K. M., & Moore, S. E. (2005). Atypical calling by a blue whale in the Gulf of Alaska (L). *Journal of the Acoustical Society of America, 117*(5), 2724-2727.

Stafford, K. M., Nieukirk, S. L., & Fox, C. G. (2001). Geographic and seasonal variation of blue whale calls in the North Pacific. (Balaenoptera musculus). *Journal of Cetacean Research and Management, 3*(1), 65-76.

Stimpert, A. K., Wiley, D. N., Au, W. W. L., Johnson, M. P., & Arsenault, R. (2007). 'Megapclicks': Acoustic click trains and buzzes produced during night-time foraging of humpback whales (Megaptera novaeangliae). *Biology Letters, 3*(5), 467-470.

Stone, C. J. (2003). *The effects of seismic activity on marine mammals in UK waters 1998-2000*. Retrieved from Aberdeen, Scotland:

Stone, C. J., & Tasker, M. L. (2006). The effects of seismic airguns on cetaceans in UK waters. *Journal of Cetacean Research and Management, 8*(3), 255-263.

Strayer, D. L. (2010). Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. *Freshwater Biology, 55*, 152-174. doi:DOI 10.1111/j.1365-2427.2009.02380.x

Sweeney, K., Helker, V. T., Perryman, W. L., LeRoi, D., Fritz, L., Gelatt, T., & Angliss, R. (2016). Flying beneath the clouds at the edge of the world: using a hexacopter to supplement abundance surveys of Steller sea lions (Eumetopias jubatus) in Alaska. *Journal of Unmanned Vehicle Systems, 4*(1), 70-81.

Swingle, W. M., Barco, S. G., Pitchford, T. D., Mclellan, W. A., & Pabst, D. A. (1993). Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. *Marine Mammal Science, 9*(3), 309-315.

Taylor, A. H., Jordon, M. B., & Stephens, J. A. (1998). Gulf Stream shifts following ENSO events. *Nature, 393*, 68.

Taylor, B., Barlow, J., Pitman, R., Ballance, L., Klinger, T., Demaster, D., Hildebrand, J., Urban, J., Palacios, D., & Mead, J. (2004). *A call for research to assess risk of acoustic impact on beaked whale populations*. Retrieved from

Terdalkar, S., Kulkarni, A. S., Kumbhar, S. N., & Matheickal, J. (2005). Bio-economic risks of ballast water carried in ships, with special reference to harmful algal blooms. *Nature, Environment and Pollution Technology, 4*(1), 43-47.

Terhune, J. M. (1999). Pitch separation as a possible jamming-avoidance mechanism in underwater calls of bearded seals (Erignathus barbatus). *Canadian Journal of Zoology, 77*(7), 1025-1034.

Thode, A., Straley, J., Tiemann, C. O., Folkert, K., & O'connell, V. (2007). Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. *Journal of the Acoustical Society of America, 122*(2), 1265-1277.

Thomas, J. A., Pawloski, J. L., & Au, W. W. L. (1990). Masked hearing abilities in a false killer whale (*Pseudorca crassidens*). In J. A. T. R. A. Kastelein (Ed.), *Sensory Abilities of Cetaceans: Laboratory and Field Evidence* (pp. 395-404). New York: Plenum Press.

Thomas, P. O., Reeves, R. R., & Brownell, R. L. (2016). Status of the world's baleen whales. *Marine Mammal Science, 32*(2), 682-734. doi:10.1111/mms.12281

Thompson, P. O., Cummings, W. C., & Ha., S. J. (1986). Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. *Journal of the Acoustical Society of America, 80*(3), 735-740.

Thompson, P. O., Findley, L. T., Vidal, O., & Cummings, W. C. (1996). Underwater sounds of blue whales, *Balaenoptera musculus*, in the Gulf of California, Mexico. *Marine Mammal Science, 12*(2), 288-293.

Thompson, P. O., T., F. L., & Vidal, O. (1992). 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. *Journal of the Acoustical Society of America, 92*(6), 3051–3057.

Thomson, C. A., & Geraci, J. R. (1986). Cortisol, aldosterone, and leukocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. *Canadian Journal of Fisheries and Aquatic Sciences, 43*(5), 1010-1016.

Thomson, D. H., & Richardson, W. J. (1995). Marine mammal sounds. In W. J. Richardson, C. R. Greene, C. I. Malme, & D. H. Thomson (Eds.), *Marine Mammals and Noise* (pp. 159–204). San Diego: Academic Press.

Todd, S., Lien, J., & Verhulst, A. (1992). Orientation of humpback whales (Megaptera novaengliae) and minke whales (Balaenoptera acutorostrata) to acoustic alarm devices designed to reduce entrapment in fishing gear. In J. A. Thomas, R. A. Kastelein, & A. Y. Supin (Eds.), *Marine mammal sensory systems*. New York, New York: Plenum Press.

Tolstoy, M., Diebold, J., Doermann, L., Nooner, S., Webb, S. C., Bohenstiehl, D. R., Crone, T. J., & Holmes, R. C. (2009). Broadband calibration of R/V Marcus G. Langseth four-string seismic sources. *Geochemistry Geophysics Geosystems, 10*.

Tolstoy, M., J. B. Diebold, S. C. Webb, D. R. Bohnenstiehl, E. Chapp, R. C. Holmes, & Rawson, M. (2004). Broadband calibration of *R/V Ewing* seismic sources. *Geophysical Research Letters, 31*(14), 4.

Trumble, S. J., Norman, S. A., Crain, D. D., Mansouri, F., Winfield, Z. C., Sabin, R., Potter, C. W., Gabriele, C. M., & Usenko, S. (2018). Baleen whale cortisol levels reveal a physiological response to 20th century whaling. *Nature Communications, 9*(1), 4587. doi:10.1038/s41467-018-07044-w

Turnpenny, A. W. H., & Nedwell, J. R. (1994). The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. *Consultancy Report, Fawley Aquatic Research Laboratories, Ltd. FCR 089/94. 50p.*

Turnpenny, A. W. H., Thatcher, K. P., & Nedwell, J. R. (1994). The effects on fish and other marine animals of high-level underwater sound. *Research Report for the Defence Research Agency, Fawley Aquatic Research Laboratories, Ltd., FRR 127/94. 34p.*

Tyack, P. (1983). Differential response of humpback whales, Megaptera novaeangliae, to playback of song or social sounds. *Behavioral Ecology and Sociobiology, 13*(1), 49-55.

Tyack, P., Johnson, M., & Miller, P. (2003). Tracking responses of sperm whales to experimental exposures of airguns. In A. E. Jochens & D. C. Biggs (Eds.), *Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1* (Vol. OCS Study MMS 2003-069, pp. 115-120). New Orleans, Louisiana: Texas A&M University and Minerals Management Service, Gulf of Mexico OCS Region.

Tyack, P., & Whitehead, H. (1983). Male competition in large groups of wintering humpback whales. *Behaviour, 83*, 132-153.

Tyack, P. L. (1999). Communication and cognition. In J. E. R. I. S. A. Rommel (Ed.), *Biology of Marine Mammals* (pp. 287-323). Washington: Smithsonian Institution Press.

Tyson, R. B., & Nowacek, D. P. (2005). *Nonlinear dynamics in North Atlantic right whale (Eubalaena glacialis) vocalizations*. Paper presented at the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Unger, B., Rebolledo, E. L. B., Deaville, R., Gröne, A., Ijsseldijk, L. L., Leopold, M. F., Siebert, U., Spitz, J., Wohlsein, P., & Herr, H. (2016). Large amounts of marine debris found in sperm whales stranded along the North Sea coast in early 2016. *Marine Pollution Bulletin, 112*(1), 134-141. doi:https://doi.org/10.1016/j.marpolbul.2016.08.027

Van der Hoop, J., Corkeron, P., & Moore, M. (2017). Entanglement is a costly life-history stage in large whales. *Ecology and Evolution, 7*(1), 92–106. doi:10.1002/ece3.2615

Van der Hoop, J. M., Moore, M. J., Barco, S. G., Cole, T. V., Daoust, P. Y., Henry, A. G., McAlpine, D. F., McLellan, W. A., Wimmer, T., & Solow, A. R. (2013). Assessment of management to mitigate anthropogenic effects on large whales. *Conservation Biology, 27*(1), 121-133. doi:10.1111/j.1523-1739.2012.01934.x

Vanderlaan, A. S., Hay, A. E., & Taggart, C. T. (2003). Characterization of North Atlantic right-whale (Eubalaena glacialis) sounds in the Bay of Fundy. *IEEE Journal of Oceanic Engineering, 28*(2), 164-173.

Vanderlaan, A. S., & Taggart, C. T. (2007). Vessel collisions with whales: The probability of lethal injury based on vessel speed. *Marine Mammal Science, 23*(1), 144-156.

Wada, S., & Numachi, K.-I. (1991). Allozyme analyses of genetic differentiation among the populations and species of the Balaenoptora. *Report of the International Whaling Commission, Special Issue 13*, 125-154.

Wade, P. R., Kennedy, A., Leduc, R., Barlow, J., Carretta, J., Shelden, K., Perryman, W., Pitman, R., Robertson, K., Rone, B., Salinas, J. C., Zerbini, A., Brownell Jr., R. L., & Clapham, P. J. (2011a). The world's smallest whale population? *Biology Letters, 7*(1), 83-85.

Wade, P. R., Quinn II, T. J., Barlow, J., Baker, C. S., Burdin, A. M., Calambokidis, J., Clapham, P. J., Falcone, E., Ford, J. K. B., Gabriele, C. M., Leduc, R., Mattila, D. K., Rojas-Bracho, L., Straley, J., Taylor, B. L., Urbán R., J., Weller, D., Witteveen, B. H., & Yamaguchi, M. (2016a). *Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas. Paper SC/66b/IA21 submitted to the Scientific Committee of the International Whaling Commission, June 2016, Bled, Slovenia.*

Wade, P. R., Quinn, T. J., Barlow, J., Baker, C. S., Burden, A. M., Calambokidis, J., Clapham, P. J., Falcone, E. A., Ford, J. K. B., Gabriele, C. M., Mattila, D. K., Rojas-Bracho, L., Straley, J. M., Taylor, B., Urbán, J., Weller, D., Witteveen, B. H., & Yamaguchi., M. (2016b). *Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas*. Paper presented at the International Whaling Commission Scientific Committee.

Wade, P. R., Robertis, A. D., Hough, K. R., Booth, R., Kennedy, A., Leduc, R. G., Munger, L., Napp, J., Shelden, K. E. W., Rankin, S., Vasquez, O., & Wilson, C. (2011b). Rare detections of North Pacific right whales in the Gulf of Alaska, with observations of their potential prey. *Endangered Species Research, 13*(2), 99-109.

Waite, J. M., Wynne, K., & Mellinger, D. K. (2003). Documented sighting of a North Pacific right whale in the Gulf of Alaska and post-sighting acoustic monitoring. *Northwestern Naturalist, 84*(1), 38-43.

Wardle, C. S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, Ziolkowski, A. M., Hampson, G., & Mackie, D. (2001). Effects of seismic air guns on marine fish. *Continental Shelf Research, 21*, 1005-1027.

Waring, G. T., Josephson, E., Fairfield, C. P., & Maze-Foley, K. (2008). *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2007* (NOAA Technical Memorandum NMFS-NE-205). Retrieved from Woods Hole, Massachusetts:

Waring, G. T., Josephson, E., Maze-Foley, K., & Rosel, P. E. (2016). *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2015* (NMFS-NE-238). Retrieved from Woods Hole, Massachusetts:

Watkins, W. A. (1977). Acoustic behavior of sperm whales. *Oceanus, 20*, 50-58.

Watkins, W. A. (1981). Activities and underwater sounds of fin whales (*Balaenoptera physalus*). *Scientific Reports of the Whales Research Institute Tokyo, 33*, 83–118.

Watkins, W. A. (1986). Whale Reactions to Human Activities in Cape-Cod Waters. *Marine Mammal Science, 2*(4), 251–262.

Watkins, W. A., Daher, M. A., Reppucci, G. M., George, J. E., Martin, D. L., Dimarzio, N. A., & Gannon, D. P. (2000). Seasonality and distribution of whale calls in the North Pacific. *Oceanography, 13*(1), 62-67.

Watkins, W. A., Moore, K. E., & Tyack, P. L. (1985). Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology, 49*, 1–15.

Watkins, W. A., & Schevill, W. E. (1975). Sperm whales (Physeter catodon) react to pingers. *Deep Sea Research and Oceanogaphic Abstracts, 22*(3), 123-129 +121pl.

Watkins, W. A., & Schevill, W. E. (1977). Spatial distribution of Physeter catodon (sperm whales) underwater. *Deep Sea Research, 24*(7), 693-699.

Watkins, W. A., Tyack, P., Moore, K. E., & Bird, J. E. (1987). The 20-Hz signals of finback whales (Balaenoptera physalus). *Journal of the Acoustical Society of America, 82*(6), 1901-1912.

Watters, D. L., Yoklavich, M. M., Love, M. S., & Schroeder, D. M. (2010). Assessing marine debris in deep seafloor habitats off California. *Marine Pollution Bulletin, 60*, 131–138.

Weilgart, L., & Whitehead, H. (1993). Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. *Canadian Journal of Zoology, 71*(4), 744–752.

Weilgart, L. S., & Whitehead, H. (1997). Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. *Behavioral Ecology and Sociobiology, 40*(5), 277-285.

Weir, C. R. (2008). Overt responses of humpback whales (Megaptera novaeangliae), sperm whales (Physeter macro-cephalus), and Atlantic spotted dolphins (Stenella frontalis) to seismic exploration off Angola. *Aquatic Mammals, 34*(1), 71-83.

Weir, C. R., Frantzis, A., Alexiadou, P., & Goold, J. C. (2007). The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). *Journal of the Marine Biological Association of the United Kingdom, 87*(1), 39–46.

Weirathmueller, M. J., Wilcock, W. S. D., & Soule, D. C. (2013). Source levels of fin whale 20 Hz pulses measured in the Northeast Pacific Ocean. *Journal of the Acoustical Society of America, 133*(2), 741–749.

Weller, D. W., Bettridge, S., Brownell Jr., R. L., Laake, J. L., Moore, J. E., Rosel, P. E., Taylor, B. L., & Wade, P. R. (2013). *Report of the National Marine Fisheries Service gray whale stock identification workshop.* Paper presented at the National Marine Fisheries Service Gray Whale Stock Identification Workshop.

Weller, D. W., Klimek, A., Bradford, A. L., Calambokidis, J., Lang, A. R., Gisborne, B., Burdin, A. M., Szaniszlo, W., Urban, J., Unzueta, A. G.-G., Swartz, S., & Robert L. Brownell, J. (2012). Movements of gray whales between the western and eastern North Pacific. *Endangered Species Research, 18*(3), 193-199. doi: 10.3354/esr00447

Whitehead, H. (2009). Sperm whale: Physeter macrocephalus. In W. F. P. B. W. J. G. M. Thewissen (Ed.), *Encyclopedia of Marine Mammals* (Second ed., pp. 1091-1097). San Diego: Academic Press.

Whitehead, H., Christal, J., & Dufault., S. (1997). Past and distant whaling and the rapid decline of sperm whales off the Galapagos Islands. (Physeter macrocephalus). *Conservation Biology, 11*(6), 1387-1396.

Whitehead, H., & Weilgart, L. (1991). Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. *Behaviour, 118*(3/4), 275–295.

Wiggins, S. M., Oleson, E. M., McDonald, M. A., & Hildebrand, J. A. (2005). Blue whale (Balaenoptera musculus) diel call patterns offshore of southern California. *Aquatic Mammals, 31*(2), 161-168.

Wilcock, W. S. D., Stafford, K. M., Andrew, R. K., & Odom, R. I. (2014). Sounds in the Ocean at 1-100 Hz. *Annual Review of Marine Science, 6*, 117-140.

Wilcove, D. S., Rothstein, D., Dubow, J., Phillips, A., & Losos, E. (1998). Quantifying threats to imperiled species in the United States. *BioScience, 48*(8), 607-615.

Wilcox, C., Heathcote, G., Goldberg, J., Gunn, R., Peel, D., & Hardesty, B. D. (2015). Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia. *Conservation Biology, 29*(1), 198-206. doi:10.1111/cobi.12355

Wiley, D. N., Asmutis, R. A., Pitchford, T. D., & Gannon, D. P. (1995). Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. *Fishery Bulletin, 93*(1), 196–205.

Williams, R. M., Trites, A. W., & Bain, D. E. (2002). Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. *Journal of Zoology, 256*(2), 255–270.

Willis-Norton, E., Hazen, E. L., Fossette, S., Shillinger, G., Rykaczewski, R. R., Foley, D. G., Dunne, J. P., & Bograd, S. J. (2015). Climate change impacts on leatherback turtle pelagic habitat in the Southeast Pacific. *Deep Sea Research Part II: Topical Studies in Oceanography, 113*, 260-267.

Winn, H. E., Perkins, P. J., & Poulter, T. C. (1970). *Sounds of the humpback whale*. Paper presented at the Proceedings of the 7th Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute Menlo Park CA. p.39-52.

Winsor, M. H., & Mate, B. R. (2006). *Seismic survey activity and the proximity of satellite tagged sperm whales*. Retrieved from

Winsor, M. H., & Mate, B. R. (2013). Seismic survey activity and the proximity of satellite-tagged sperm whales *Physeter macrocephalus* in the Gulf of Mexico. *Bioacoustics, 17*, 191-193.

Witherington, B., Hirama, S., & Hardy, R. (2012). Young sea turtles of the pelagic *Sargassum*-dominated drift community: habitat use, population density, and threats. *Marine Ecology Progress Series, 463*, 1–22. doi:10.3354/meps09970

Work, P. A., Sapp, A. L., Scott, D. W., & Dodd, M. G. (2010). Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology, 393*(1-2), 168–175.

Woude, S. v. d. (2013). Assessing effects of an acoustic marine geophysical survey on the behaviour of bottlenose dolphins *Tursiops truncatus*. *Bioacoustics, 17*, 188-190.

Wursig, B., Lynn, S. K., Jefferson, T. A., & Mullin, K. D. (1998). Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals, 24*(1), 41-50.

Würsig, B. G., Weller, D. W., Burdin, A. M., Reeve, S. H., Bradford, A. L., Blokhin, S. A., & R.L Brownell, J. (1999). *Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint U.S.-Russian scientific investigation. Final Report*. Retrieved from Yuzhno-Sakhalinsk, Russia:

Wysocki, L. E., Amoser, S., & Ladich, F. (2007). Diversity in ambient noise in European freshwater habitats: Noise levels, spectral profiles, and impact on fishes. *Journal of the Acoustical Society of America, 121*(5), 2559-2566. doi:10.1121/1.2713661

Yazvenko, S. B., McDonald, T. L., Blokhin, S. A., Johnson, S. R., Meier, S. K., Melton, H. R., Newcomer, M. W., Nielson, R. M., Vladimirov, V. L., & Wainwright, P. W. (2007a). Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environmental Monitoring and Assessment, Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9809-9. 29p.*

Yazvenko, S. B., McDonald, T. L., Blokhin, S. A., Johnson, S. R., Melton, H. R., Newcomer, M. W., Nielson, R., & Wainwright, P. W. (2007b). Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. *Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9810-3. 14p.*

Zaitseva, K. A., Morozov, V. P., & Akopian, A. I. (1980). Comparative characteristics of spatial hearing in the dolphin *Tursiops truncatus* and man. *Neuroscience and Behavioral Physiology, 10*(2), 180-182.

Zoidis, A. M., Smultea, M. A., Frankel, A. S., Hopkins, J. L., Day, A. J., McFarland, S. A., Whitt, A. D., & Fertl, D. (2008). Vocalizations produced by humpback whale

(*Megaptera novaeangliae*) calves recorded in Hawaii. *The Journal of the Acoustical Society of America, 123*(3), 1737-1746.

19 Appendices

19.1 Appendix A

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a marine geophysical survey in the Gulf of Alaska, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid from June 1, 2019 to May 31, 2020.

2. This IHA is valid only for marine geophysical activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Gulf of Alaska.

3. General Conditions

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

   (b) The species authorized for taking are listed in Table 1

   (c) The taking, by Level A and B harassment, is limited to the species listed in condition 3(b). Table 1 provides the authorized number of takes per species and stock.

   (d) The taking, by serious injury or death of any of species listed in condition 3(b) of this IHA is prohibited.

   (e) The taking, by Level A harassment, Level B harassment, serious injury, or death, of marine mammal species not identified in condition 3(b) is prohibited.

4. Mitigation Measures

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

   (a) L-DEO must use at least six dedicated, trained, NMFS-approved Protected Species Observers (PSOs). The PSOs must have no tasks other than to conduct

observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements.

(b) At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience

(c) Visual Observation

(i) During survey operations (e.g., any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up, including nighttime ramp-ups, of the airgun array.

(ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

(iii) Visual PSOs must immediately communicate all marine mammal observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iv) During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(v) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) Acoustic PSOs must immediately communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

Exclusion zone and buffer zone

(i) PSOs must establish and monitor a 500 m exclusion zone and 1,000 m buffer zone. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 meters from the edges of the airgun array (0–500 meters). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 meter exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000

meters). PSOs must monitor beyond 1,000 meters and enumerate any takes that occur beyond the buffer zone.

(f) Pre-clearance and Ramp-up

(i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds and 30 minutes for mysticetes and large odontocetes all other species).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon observation of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown or powerdown, but such observation must be communicated to the operator to prepare for the potential shutdown or powerdown.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown and powerdown (*e.g.*, mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-clearance watch of 30 min is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance of 30 min.

(g) Shutdown and Powerdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown or powerdown of the acoustic source if a marine mammal is detected within the 500 m exclusion zone (100 m when shutdown has been waived as described in 4(g)(v).

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown and powerdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up and powerdown) and (1) a marine mammal (excluding delphinids) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any questions regarding a PSO shutdown must be resolved after deactivation.

(iv) Shutdown must occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) (other than delphinids) in the 500 m exclusion zone. During daylight hours, if the acoustic PSO cannot confirm presence within exclusion zone, visual PSOs must be notified but shutdown is not required.

(v) The shutdown requirement shall be waived for small dolphins of the following genera: *Lagenorhynchus* and *Grampus.*

a. The acoustic source must be powered down to 40-in^3 airgun if an individual belonging to these genera is visually detected within the 500 m exclusion zone.

b. When the acoustic source is powered down to the 40-in^3 airgun due to the presence of dolphins specified in 4(g)(v), an exclusion zone of 100 m and Level B harassment zone of 430 m will be in effect for species other than specified dolphin genera that may approach the survey vessel.

c. Powerdown conditions must be maintained until delphinids, for which shutdown is waived, are no longer observed within the 500 m exclusion zone, following which full-power operations may be resumed without ramp-up. Visual PSOs may elect to waive the powerdown requirement if delphinids for which shutdown is waived appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and must use best professional judgment in making this decision.

d. If PSOs observe any behaviors in delphinids for which shutdown is waived that indicate an adverse reaction, then powerdown must be initiated.

e. Visual PSOs must use best professional judgment in making the decision to call for a shutdown if there is uncertainty regarding identification (i.e., whether the observed marine mammal(s) belongs to one of the delphinid genera for which shutdown is waived).

(vi) L-DEO must implement a shutdown when a large whale with a calf or an aggregation of large whales (defined as 6 or more mysticetes or sperm whales) is observed regardless of the distance from the *Langseth*.

(vii) L-DEO must implement a shutdown when a North Pacific right whale or group of North Pacific right whales is observed at any distance.

(viii) L-DEO must implement a shutdown when a fin whale or group of fin whales is observed, within the species' Gulf of Alaska feeding Biologically Important Area (BIA), within 1,500 m of the acoustic source.

(ix) L-DEO must implement a shutdown upon observation of any marine mammal species not authorized for take that is entering or approaching the vessel's respective Level B harassment zone.

(x) L-DEO must implement a shutdown upon observations of any authorized marine mammal species that has reached its total allotted number of takes by Level B harassment that is entering or approaching the vessel's respective Level B harassment zone.

(xi) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds and 30 minutes for mysticetes and large odontocetes) with no further observation of the marine mammal(s).

(h) Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for strike is minimized.

(i) Vessel speeds must be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

(ii) Vessels must maintain a minimum separation distance of 100 m from large whales (i.e., sperm whales and all baleen whales.

(iii) Vessels must attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those animals that approach the vessel.

(iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

(i) Actions to Minimize Additional Harm to Live Stranded (or Milling) Marine Mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(i) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise the IHA-holder that the shutdown around the animals' location is no longer needed.

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

(ii) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with the IHA-holder will be required

to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(j) Sensitive Habitat Measures

(i) L-DEO must not approach within 3 n. mi. of all known Steller sea lion rookeries and major haul-outs.
(ii) L-DEO must conduct survey operations in the North Pacific right whale critical habitat during daylight hours only.
(iii) L-DEO must reduce vessel speed to at most 5 kn (knots) when transiting through North Pacific right whale critical habitat during darkness, or conditions of similarly limiting visibility.
(iv) While in the fin whale Gulf of Alaska feeding BIA, L-DEO must implement a shutdown if a fin whale or group of fin whales is observed within a 1,500 meter radius from the acoustic source.

(k) L-DEO must conduct outreach with subsistence communities near the planned seismic survey to identify and avoid areas of potential conflict.

5. Monitoring Measures

The holder of this IHA is required to abide by the following marine mammal and acoustic monitoring measures:

(a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (i.e., Fujinon or equivalent) solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

(b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

(i) PAM must include a system that has been verified and tested by the acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) At least one night-vision device suited for the marine environment for use during nighttime pre-clearance and ramp-up that features automatic brightness and gain control, bright light protection, infrared illumination, and/or optics suited for low-light situations (e.g., Exelis PVS-7 night vision goggles; Night Optics D-300 night vision monocular; FLIR M324XP thermal imaging camera or equivalents).

(iii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (i.e., Fujinon or equivalent) (at least one per PSO, plus backups).

(iv) Global Positioning Units (GPS) (at least one per PSO, plus backups).

(v) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (i.e., Canon or equivalent) (at least one per PSO, plus backups).

(vi) Compasses (at least one per PSO, plus backups).

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

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

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

(i) PSOs must be independent, dedicated, trained visual and acoustic PSOs and must be employed by a third-party observer provider.

(ii) PSOs must have no tasks other than to conduct observational effort (visual or acoustic), collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and

(iii) PSOs must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(iv) PSOs can act as acoustic or visual observers (but not at the same time) as long as they demonstrate that their training and experience are sufficient to perform the task at hand.

(v) NMFS must review and approve PSO resumes.

(vi) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(vii) One visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. To the maximum extent

practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(viii) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(ix) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

(x) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

a. Vessel names (source vessel and other vessels associated with survey) and call signs;

b. PSO names and affiliations;

c. Date and participants of PSO briefings (as discussed in General Requirement);

d. Dates of departures and returns to port with port name;

e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any protected species, the following information must be recorded:

a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

b. PSO who sighted the animal;

c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

f. Direction of vessel's travel (compass direction);

g. Direction of animal's travel relative to the vessel;

h. Pace of the animal;

i. Estimated distance to the animal and its heading relative to vessel at initial sighting;

j. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

k. Estimated number of animals (high/low/best);

l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

p. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and

q. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information should be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The draft report must include the following:

(i) Summary of all activities conducted and sightings of protected species near the activities;

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

(iii) Summary of dates and locations of survey operations and all protected species sightings (dates, times, locations, activities, associated survey activities);

(iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(v) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system;

(vi) Raw observational data;

(vii) Summary of the information submitted in interim monthly reports as well as additional data collected as described above in Data Collection and the IHA;

(viii) Estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability;

(ix) Certification from the lead PSO as to the accuracy of the report

a. The lead PSO may submit statement directly to NMFS concerning implementation and effectiveness of the required mitigation and monitoring.

(x) A final report must be submitted within 30 days following resolution of any comments on the draft report.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS Region Stranding Coordinator (907-586-7209) as soon as feasible. The report must include the following information: Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to regional stranding coordinators as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the incident;

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

g. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

h. Estimated size and length of animal that was struck;

i. Description of the behavior of the marine mammal immediately preceding and following the strike;

j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

k. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

l. To the extent practicable, photographs or video footage of the animal(s).

(iii) Additional Information Requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted (example circumstances noted below), and an investigation into the stranding is being pursued, NMFS will submit a written request to the IHA-holder indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

a. Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

b. If available, description of the behavior of any marine mammal(s) observed preceding (i.e., within 48 hours and 50 km) and immediately after the discovery of the stranding.

c. In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

8. Renewals - On a case-by-case basis, NMFS may issue a one-year IHA renewal with an expedited public comment period (15 days) when 1) another year of identical or nearly identical activities is planned or 2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that allowed for under this IHA, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to expiration of the current IHA.

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

(i) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, take estimates, or mitigation and monitoring requirements.

(ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no

more than minor changes in the activities, the mitigation and monitoring measures remain the same and appropriate, and the original findings remain valid.

___________________________________ ________________________

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

Table 1: Numbers of Instances of Incidental Take of Marine Mammals Authorized During Gulf of Alaska Survey.

	Stock	**Level B**	**Level A**
North Pacific Right Whale	Eastern North Pacific	11	0
Humpback Whale	Central North Pacific (Hawaii DPS)	5,079	21
	Central North Pacific (Mexico DPS)	599	3
	Western North Pacific	28	1
Blue whale	Eastern North Pacific	47	2
	Central North Pacific		
Fin Whale	Northeast Pacific	3,897	16
Sei Whale	Eastern North Pacific	7	2
Minke Whale	Alaska	52	2
Gray Whale	Eastern North Pacific	2,146[1]	9
	Western North Pacific	28[1]	0
Sperm Whale	North Pacific	86	0
Killer Whale	Alaska Resident	279[2]	0
	Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	218[2]	0
	Offshore	90[2]	0
Pacific White-Sided Dolphin	North Pacific	1,838	0
Cuvier's Beaked Whale	Alaska	195	0
Baird's Beaked Whale	Alaska	45	0
Stejneger's Beaked Whale	Alaska	64	0
Risso's Dolphin	CA/OR/WA	16	0
Harbor Porpoise	Gulf of Alaska	1,830	51
	Southeast Alaska	203	6
Dall's Porpoise	Alaska	13,196	481
Steller Sea Lion	Eastern U.S.	2,165	3
	Western U.S.		
California Sea Lion	U.S.	1	1
Northern Fur Seal	Eastern Pacific	1,182	2
Northern Elephant Seal	California Breeding	193	2
Harbor Seal	South Kodiak	441	2

	Cook Inlet/Shelikof Strait		
	Prince William Sound		

[1] The authorized numbers of take attributed to the Eastern North Pacific and Western North Pacific stocks of Gray whale are approximations based on the relative sizes of these two stocks. The method is discussed more fully in the Federal Register Notices associated with this action.

[2] The authorized numbers of take attributed to the Alaska Resident, Gulf of Alaska, Aleutian Islands, and Bering Sea Transient, and Offshore stocks of killer whale are approximations based on the relative sizes of these two stocks. The method is discussed more fully in the Federal Register Notices associated with this action.