NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on a Seismic survey by the Scripps Institution of Oceanography, and Issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA)

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 Agencies: National Science Foundation-Division of Ocean Sciences and NOAA's National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division

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TABLE OF CONTENTS

Page

LIST OF TABLES

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 concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

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

The action agency for this consultation are the National Science Foundation (NSF) and the NMFS' Permits and Conservation Division. Two federal actions are considered in this biological opinion. The first is the NSF's proposal to fund a seismic survey off the coast of Oregon in late September 2017, in support of an NSF-funded collaborative research project, led by the Scripps Institution of Oceanography. 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, biological opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§401-16), and agency policy and guidance was conducted by NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we").This biological opinion (opinion) and incidental take statement were prepared by NMFS Office of Protected Resources Endangered Species Act Interagency

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

This document represents the NMFS opinion on the effects of these actions on endangered and threatened whales, 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 a seismic survey off the coasts of Oregon and Washington from September 22 to 29, 2017. In conjunction with this action, the NMFS Permits and Conservation Division would issue an IHA under the MMPA for marine mammal takes that could occur during the NSF seismic survey. This document represents NMFS's 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.

1.2 Consultation History

On March 22, 2017, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation pursuant to section 7 of the ESA from the NSF to incidentally harass marine mammal and sea turtle species during the seismic survey. On the same date, the NMFS' Permits and Conservation Division received an application from the Scripps Institution of Oceanography to incidentally harass marine mammal species pursuant to the MMPA during the proposed seismic survey.

The Permits and Conservation Division and the ESA Interagency Cooperation Division had several questions on the modelling presented in the IHA request, and requested additional explanations. As a result, the NSF submitted three additional revised versions of the IHA request, on May 8, 2017, on July 5, 2017, and July 27, 2017.

A revised draft Environmental Analysis from NSF was received on July 27, 2017. Information was sufficient to initiate consultation with the NSF on this date.

On July 31, 2017, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation under section 7 of the ESA from the NMFS' Permits and Conservation Division.

On August 16, 2017, the NMFS' Permits and Conservation Division sent the application for the proposed seismic survey out to reviewers and published a notice in the Federal Register soliciting public comment on their intent to issue an IHA on August 17, 2017.

This opinion is based on information provided in the:

- MMPA IHA application.
- Draft public notice of proposed IHA.

- Draft environmental assessment prepared pursuant to the National Environmental Policy Act.
- Monitoring reports from similar activities.
- Published and unpublished scientific information on endangered and threatened species and their surrogates.
- Scientific and commercial information such as reports from government agencies and the peer-reviewed literature.
- Biological opinions on similar activities.
- Other sources of information.

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 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 use, 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 Designated Critical Habitat Not Considered Further in the Opinion (Section 7): we identify those resources will either not be affected or are not likely to be adversely affected.

Species and Critical Habitat Likely to be Adversely Affected (Section 8):we identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors identified in Section 6.

Status of Species and Designated Critical Habitat (Section 9): we identify the status of ESA-listed species and designated critical habitat 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, 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 sex of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations 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 given their probable exposure. We also consider how the action may affect designated critical habitat. This is our response analysis. We 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 adverse modification analysis considers the impacts of the proposed action on the essential biological features and conservation value of designated critical habitat.

Integration and Synthesis (Section 12): we integrate the analyses in the opinion to summarize the consequences 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 C.F.R. §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 subpopulations and on essential habitat features when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

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

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

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

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. 50 C.F.R. §402.14(j). Finally, we identify the circumstances in which reinitiation of consultation is required. 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 Permits and Conservation Division and the National Science Foundation.
- Government reports (including NMFS biological opinions and stock assessment reports).
- NOAA technical memos.
- 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 *Roger Revelle*, operated by the Scripps Institution of Oceanography, to conduct a seismic survey off the coast of Oregon in September 2017. 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 Environmental Analysis provided by NSF as part of the initiation package.

3.1 Proposed Activities: National Science Foundation

The NSF proposes to fund the use of the U.S. Navy's research vessel *Roger Revelle* (*Revelle*) to conduct a seismic survey off the coast of Oregon and Washington. An array of two operational airguns will be deployed as an energy source. In addition, a multibeam echosounder and sub-bottom profiler will continuously operate from the *Revelle* during the entire cruise, but not during transit to and from the survey areas.

The proposed survey would take place on an active continental margin to gather data to understand the sediment and crustal structure within the Cascadia continental margin. The study would also serve as a tool to train early career scientists in how to effectively plan a seismic survey.

3.1.1 Survey Overview and Project Objectives

The survey will occur from September 22 to 29, 2017. Seismic operations will take place for five days, allowing approximately two days for the vessel to transit to and from Newport, Oregon. The survey will have two potential survey sites: one off northern Oregon off the mouth of the Columbia River, over a feature called the Astoria Fan, and the other located off the southern Oregon margin (Figure 2). The specific project objectives would depend on the survey site. The Astoria Fan study area covers a major seismic gap, so that study would focus on gathering information on flexure, accretionary wedge mechanisms and gas hydrates. The southern Oregon survey area covers a megaslump[1] segment of the Cascadia subduction zone, which has no previous seismic data. A survey there would focus on paleo objectives related to geological history and performing a detailed survey of the megaslump segment.

The proposed seismic survey would take place in waters from 130 to 2,600 meters deep. The majority of the survey lines for both proposed survey areas will take place in waters over 1,000 meters deep (Table 1). No survey work will take place in shallow waters (i.e., less than 100 meters deep).

[1] In geological terms, a slump occurs when a coherent mass of loosely consolidated materials or rock layers moves a short distance down a slope.

Table 1. Proposed survey area descriptions.

Survey Area	Amount of survey line kilometers	Percent of line kilometers in intermediate depth (100 to 1,000 meters)	Percent of line kilometers in depth greater than 1,000 meters
Astoria Fan	1,057 kilometers	23%	77%
Southern Oregon	1,013 kilometers	5%	95%

3.1.2 Source Vessel Specifications

The *Revelle* will tow the airgun array along predetermined lines (Figure 2). The operating speed during seismic acquisition is typically nine kilometers per hour (5 knots). When not towing seismic survey gear, the *Revelle* typically cruises at 22 to 23 kilometers per hour (12 to 12.5 knots). The *Revelle* also serves as the platform that protected species visual observers (observers) watch for animals.

3.1.3 Airgun Description

The airgun configuration includes two active 45 cubic inch generator-injector airguns, with its source output directed downward (Table 2). The airguns will be towed 21 meters behind the vessel, two meters apart, at a depth of three meters and fire every eight to ten seconds, or every 20 to 25 meters travelled. An 800-meter streamer would be towed along with the airgun array to receive the reflected signals and transfer the data to the on-board processing system. During firing, a brief (approximately 0.1 second) pulse of sound will be emitted. This signal attenuates as it moves away from the source, decreasing in amplitude, but also increasing in signal duration. Airguns will operate continually during the survey period (i.e., while surveying the tracklines) except for unscheduled shutdowns.

Because the actual source originates from the pair of airguns, rather than a single point source, the highest sound levels measurable at any location in the water are less than the nominal sound source level emitted by the airguns. In addition, the effective source level for sound spreading in near-horizontal directions will be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of sound from the airgun array.

Table 2. Source array specifications for the proposed survey.

Source array specifications	
Energy source	Two inline 45 cubic inches airguns two meters apart
Source output (downward)-4 airgun array	Zero to peak = 230.8 dB re 1 μPa-m Peak to peak = 236.4 dB re 1 μPa-m
Air discharge volume	~ 90 in^3
Dominant frequency components	0 to 188 hertz
Tow depth	3 meters

3.1.4 Multibeam Echosounder and Sub-bottom Profiler

Along with airgun operations, additional acoustical data acquisition systems will operate during the surveys from the *Revelle*. The multibeam echosounder as well as sub-bottom profiler systems will map the ocean floor during the cruise. These sound sources will operate from the *Revelle* simultaneously with the airgun array, as well as when the airguns are shutdown. They will not be in use while the vessel is in transit.

The sub-bottom profiler (Knudsen 3260) is a hull-mounted sonar system that operates at 3.5 to 210 kilohertz with a single 27 degrees bottom-directed beam. The nominal power output is 10 kilowatts, but the actual maximum radiated power is three kilowatts or 222 dB re 1 μPa·m. The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pings at one-second intervals.

The multibeam echosounder (Kongsberg EM 122) is also a hull-mounted system operating at 12 kilohertz. The beam width is one or two degrees fore aft and 150 degrees perpendicular to the ship's line of travel. The maximum source level is 242 dB re 1 $\mu Pa \cdot m_{rms}$. Each "ping" consists of four or eight successive fan-shaped transmissions, each two to 15 milliseconds in duration and each ensonifying a sector that extends one degree fore aft. Four or eight successive transmissions span an overall cross-track angular extent of about 150 degrees.

3.1.5 Proposed Exclusion Zones

The NSF identifies in its EA that the Scripps Institution of Oceanography will implement exclusion zones around the *Revelle* to minimize any potential adverse effects of airgun 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 sound levels expected to produce potential fitness consequences. These exclusion zones are based upon modeled sound levels at various distances from the *Revelle*, described below.

3.1.5.1 Predicted Sound Levels versus Distance and Depth

The LGL used modeling by Lamont-Doherty Earth Observatory to predict received sound levels, in relation to distance and direction from two 45-in^3 GI airguns in deep water (Figure 1). 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 airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004) and in 2007 to 2009 aboard the *R/V Langseth* (Diebold 2010; Tolstoy et al. 2009). As a two-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 (six meters) from in the proposed survey (three meters). Because propagation varies with array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

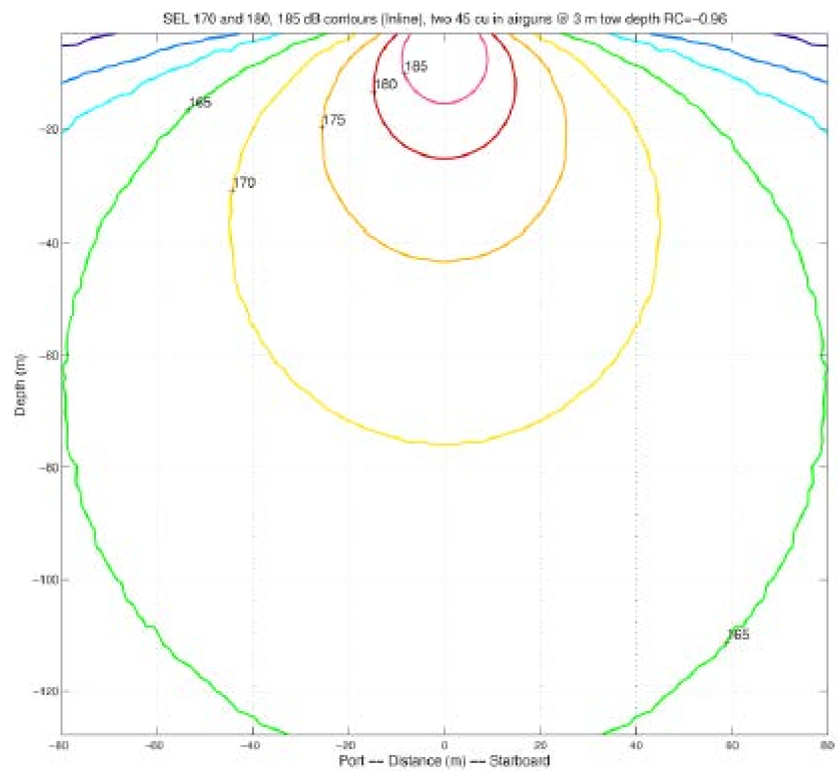

Figure 1. Modeled received sound levels (SELs) from two 45-in3 G airguns operating in deep water at a three-meter tow depth. Received rms levels (SPLs) are likely ~10 dB higher.

Table 3 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the airgun array. 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 most other recent Lamont-Doherty Earth Observatory seismic projects (Holst and Smultea 2008b; Holst et al. 2005a; Holst 2008; Holt 2008b; Smultea et al. 2004).

Table 3. Predicted distances to which sound levels ≥160 and 175 dB re: 1 μPa$_{rms}$ could be received from the two-airgun, 90-in3 array towed at 3 m.

Water depth (meters)	Predicted rms radii (meters)	
	160 dB	175 dB
>1,000 m	448	80
100-1,000 m	672	120

The 175 dB isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airguns. The 160 dB re 1 μPa$_{rms}$ distance is the distance at which MMPA take, by Level B harassment, is expected to occur.

3.2 Proposed Activities: NMFS Permits and Conservation Division's Incidental Harassment Authorization

The NMFS' Permits and Conservation Division is proposing to issue an IHA authorizing non-lethal "takes" by Level B harassment of marine mammals incidental to the planned seismic survey. The IHA will be valid for a period of one year from the date of issuance. The IHA will authorize the incidental harassment of the following species: blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), sei whales (*Balaenoptera borealis*), sperm whales (*Physeter macrocephalus*), and other marine mammals listed under the Marine Mammal Protection Act. The proposed IHA identifies the following requirements that Scripps Institution of Oceanography must comply with as part of its authorization:

1. This IHA is valid for a period of one year from the date of issuance.
2. This IHA is valid only for marine geophysical survey activity, as specified in the SIO's IHA application and using an airgun array aboard the R/V *Revelle* with characteristics specified in the application, in the northeast Pacific Ocean.
3. General Conditions
    a. A copy of this IHA must be in the possession of SIO, the vessel operator and other relevant personnel, the lead protected species observer (PSO), and any other relevant designees of SIO operating under the authority of this IHA.
    b. The species authorized for taking are listed in Table 8. The taking, by harassment only, is limited to the species and numbers listed in Table 8. Any taking exceeding the authorized amounts listed in Table 8 is prohibited and may result in the modification, suspension, or revocation of this IHA.

c. The taking by serious injury or death of any species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.
d. During use of the airgun(s), if marine mammal species other than those listed in Table 8 are detected by PSOs, the acoustic source must be shut down to avoid unauthorized take.
e. SIO shall ensure that the vessel operator and other relevant vessel personnel are briefed on all responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and IHA requirements prior to the start of survey activity, and when relevant new personnel join the survey operations.

4. Mitigation Requirements. The holder of this Authorization is required to implement the following mitigation measures:
   a. SIO must use at least three (3) dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval.
   b. At least one PSO must have a minimum of 90 days at-sea experience working as a PSO during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One “experienced” visual PSO shall be designated as the lead for the entire protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator.
   c. Visual Observation
      i. During survey operations (*e.g.*, any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, PSO(s) 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).
      ii. Visual monitoring must begin not less than 30 minutes prior to ramp-up, including for nighttime ramp-ups of the airgun array, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.
      iii. PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.
      iv. 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 observation per 24 hour period.
      v. During good conditions (*e.g.*, daylight hours; Beaufort sea state 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without

use of the acoustic source and between acquisition periods, to the maximum extent practicable.

d. Exclusion Zone and buffer zone – PSOs shall establish and monitor a 100 m exclusion zone (EZ) and 200 m buffer zone. The zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the EZ but within 200 m from any element of the airgun array shall be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the EZ, or on a course to enter the EZ, shall trigger further mitigation measures as described below.
    i. Ramp-up – A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45-in3 airgun, and the second 45-in3 airgun would be added after 5 minutes.
    ii. If the airgun array has been shut down due to a marine mammal detection, ramp-up shall not occur until all marine mammals have cleared the EZ. A marine mammal is considered to have cleared the EZ if:
        1. It has been visually observed to have left the EZ; or
        2. It has not been observed within the EZ, for 15 minutes (in the case of small odontocetes) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).
    iii. Thirty minutes of pre-clearance observation of the 100 m EZ and 200 m buffer zone are required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the 100 m EZ during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and 30 minutes for all other species).
    iv. During ramp-up, PSOs shall monitor the 100 m EZ and 200 m buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100 m EZ. If a marine mammal is observed within or approaching the 100 m EZ during ramp-up, a shutdown shall be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100 m EZ or until an additional time period has elapsed with no further sightings (*i.e.*, 15 minutes for small odontocetes and 30 minutes for mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).
    v. If the airgun array has been shut down for reasons other than mitigation (*e.g.*, mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant visual observation and no visual detections of any marine mammal have occurred within the buffer zone.

   vi. Ramp-up at night and at times of poor visibility shall only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100 m EZ and 200 m buffer zone have been continually monitored by visual PSOs for 30 minutes prior to ramp-up with no marine mammal detections.
   vii. The vessel operator must notify a designated PSO of the planned start of ramp-up. A designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.

e. Shutdown requirements – An exclusion zone of 100 m shall be established and monitored by PSOs. If a marine mammal is observed within, entering, or approaching the 100 m exclusion zone all airguns shall be shut down.
   i. Any PSO on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant PSO(s) must call for such action immediately.
   ii. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.
   iii. When a shutdown is called for by a PSO, the shutdown must occur and any dispute resolved only following shutdown.
   iv. The shutdown requirement is waived for dolphins of the following genera: *Tursiops*, *Stenella*, *Delphinus*, *Lagenorhynchus* and *Lissodelphis*. The shutdown waiver only applies if animals are traveling, including approaching the vessel. If animals are stationary and the vessel approaches the animals, the shutdown requirement applies. If there is uncertainty regarding identification (*i.e.*, whether the observed animal(s) belongs to the group described above) or whether the animals are traveling, shutdown must be implemented.
   v. Upon implementation of a shutdown, the source may be reactivated under the conditions described at 4(e)(vi). Where there is no relevant zone (*e.g.*, shutdown due to observation of a calf), a 30-minute clearance period must be observed following the last observation of the animal(s).
   vi. Shutdown of the array is required upon observation of a whale (*i.e.*, sperm whale or any baleen whale) with calf, with "calf" defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult, at any distance.
   vii. Shutdown of the array is required upon observation of an aggregation (*i.e.*, six or more animals) of large whales of any species (*i.e.*, sperm whale or any baleen whale) that does not appear to be traveling (*e.g.*, feeding, socializing, etc.) at any distance.
   viii. Shutdown of the array is required upon observation of a killer whale at any distance.

f. Vessel Strike Avoidance – Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course, as appropriate, to avoid striking any marine mammal, unless such action represents a human safety concern. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.

   i. The vessel must maintain a minimum separation distance of 100 m from large whales, unless such action represents a human safety concern. The following avoidance measures must be taken if a large whale is within 100 m of the vessel:
      1. The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established unless such action represents a human safety concern.
      2. If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 m unless such action represents a human safety concern.
   ii. The vessel must maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for animals described in 4(e)(iv) that approach the vessel. If an animal is encountered during transit, the vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course unless such action represents a human safety concern.
   iii. Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel unless such action represents a human safety concern.

g. Miscellaneous Protocols
   i. The airgun array must be deactivated when not acquiring data (as in during transit) or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Operational capacity of 90 in^3 (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.
   ii. Testing of the acoustic source involving all elements requires normal mitigation protocols (*e.g.*, ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

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

   i. The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.
   ii. PSOs must also be equipped with reticle binoculars (*e.g.*, 7 x 50) of appropriate quality (*i.e.*, Fujinon or equivalent), GPS, digital single-lens reflex camera of appropriate quality (*i.e.*, Canon or equivalent), compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

i. PSO Qualifications
   i. PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program.
   ii. PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification. 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 marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

j. Data Collection – PSOs must use standardized data forms, whether hard copy or electronic. PSOs shall 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 to resume survey. If required mitigation was not implemented, PSOs should submit a description of the circumstances. The NMFS Permits and Conservation Division requires that, at a minimum, the following information be reported:
   i. PSO names and affiliations
   ii. Dates of departures and returns to port with port name
   iii. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort
   iv. Vessel location (latitude/longitude) when survey effort begins and ends; vessel location at beginning and end of visual PSO duty shifts
   v. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change

vi. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions change significantly), including wind speed and direction, Beaufort sea state, Beaufort wind force, swell height, weather conditions, cloud cover, sun glare, and overall visibility to the horizon

vii. Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (*e.g.*, vessel traffic, equipment malfunctions)

viii. 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-ramp-up survey, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.)

ix. If a marine mammal is sighted, the following information should be recorded:

1. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
2. PSO who sighted the animal;
3. Time of sighting;
4. Vessel location at time of sighting;
5. Water depth;
6. Direction of vessel's travel (compass direction);
7. Direction of animal's travel relative to the vessel;
8. Pace of the animal;
9. Estimated distance to the animal and its heading relative to vessel at initial sighting;
10. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified); also note the composition of the group if there is a mix of species;
11. Estimated number of animals (high/low/best);
12. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
13. 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);
14. Detailed behavior observations (*e.g.*, number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
15. Animal's closest point of approach (CPA) and/or closest distance from the center point of the acoustic source;
16. Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other); and
17. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up, speed or course alteration, etc.)

and time and location of the action.

k. Reporting
   i. SIO shall submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used must be provided as an ESRI shapefile with all necessary files and appropriate metadata. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the data collected as required under condition 5(d) of this IHA. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.
   ii. Reporting injured or dead marine mammals:
   iii. In the event that the specified activity clearly causes the take of a marine mammal in a manner not authorized by this IHA (if issued), such as serious injury or mortality, SIO shall immediately cease the specified activities and immediately report the incident to NMFS. The report must include the following information:
      1. Time, date, and location (latitude/longitude) of the incident;
      2. Vessel's speed during and leading up to the incident;
      3. Description of the incident;
      4. Status of all sound source use in the 24 hours preceding the incident;
      5. Water depth;
      6. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);
      7. Description of all marine mammal observations in the 24 hours preceding the incident;
      8. Species identification or description of the animal(s) involved;
      9. Fate of the animal(s); and
      10. Photographs or video footage of the animal(s).

   Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS.
   iv. In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is

unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), SIO shall immediately report the incident to NMFS. The report must include the same information identified in condition 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.

v. In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to NMFS within 24 hours of the discovery. SIO shall provide photographs or video footage or other documentation of the sighting to NMFS.

5. 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.

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 action would take place in the northeast Pacific Ocean, off the coasts of Oregon and Washington during September 2017. The survey would take place off the continental margin out to 127.5 degrees West, and between about 43 and 46.5 degrees North (Figure 2). The survey area covers water depths from 130 to 2,600 meters. The action area would also include the area covered by the Revelle while transiting from its port in Newport, Oregon to the survey area. We do not anticipate any effects outside the area shown on the map in Figure 2.

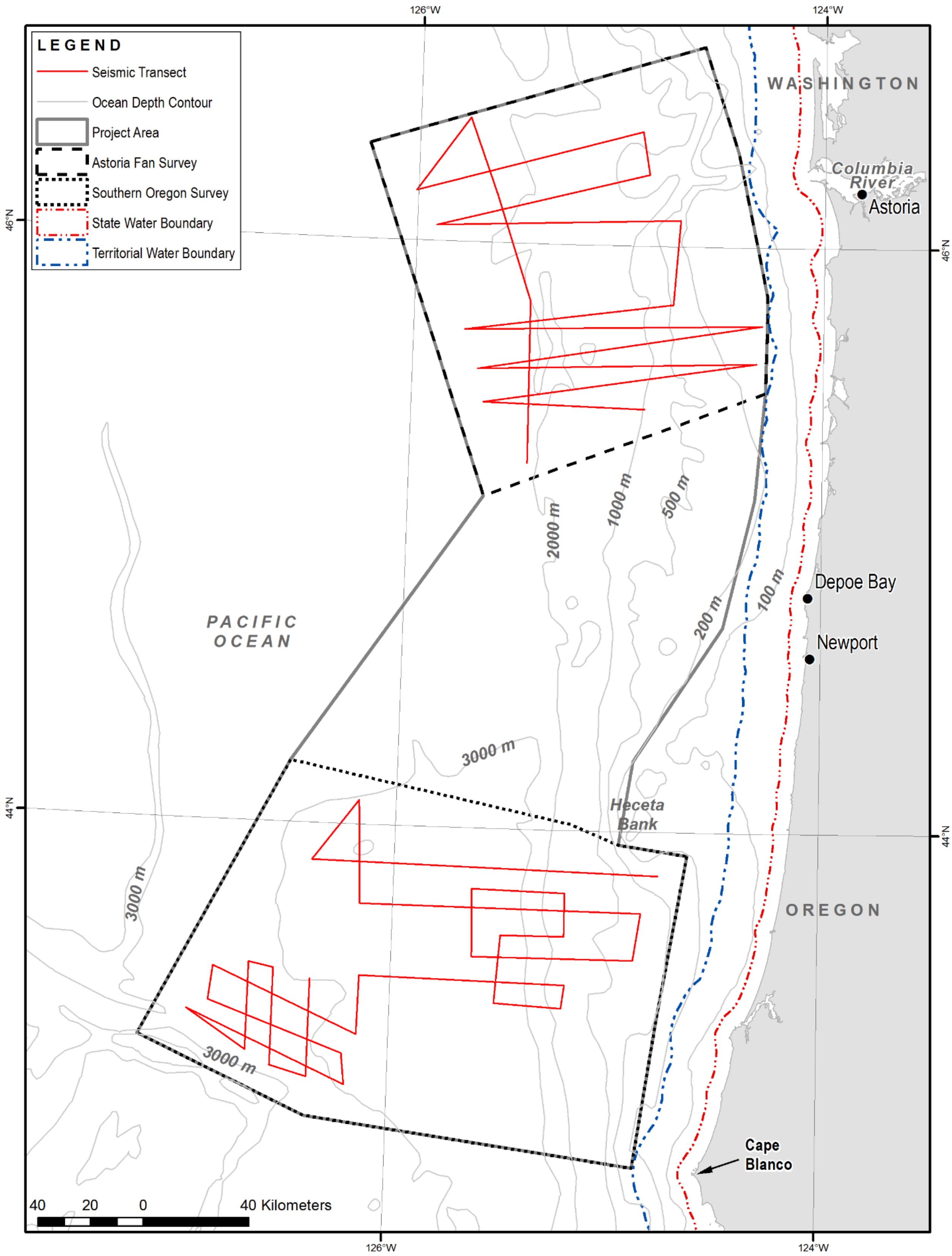

Figure 2. Map of the proposed action area.

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 in this opinion are interdependent. The Permits and Conservation Division's proposal to issue an MMPA authorization is interdependent on NSF's proposed seismic activities, as it would not have an independent use if not for the actual activity NSF proposed. Likewise, NSF's proposed action would not carry forward without the authorization to exempt marine mammal take from the Permits and Conservation Division.

6 Potential Stressors

There are several potential stressors that we expect to occur because of the proposed action. These include those associated with vessel activity (e.g., pollution by oil or fuel leakage, ship strikes, and acoustic interference from engine noise) and research activity (e.g., entanglement in the towed hydrophone streamer and the sound produced by the airguns, sub-bottom profiler, and multibeam echosounder). These stressors are evaluated in detail in Section 11.1.

7 Species and Critical Habitat Not Likely to be Adversely Affected

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 4 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 could result from the action and that would be an adverse effect if it did impact a listed species),but it is very unlikely to occur.

7.1 Southern Resident killer whales

Southern Resident DPS killer whales are not expected to occur in the area of the proposed survey as the easternmost track lines of the proposed survey (those that approach nearest to shore) are further west than the migratory range of the Southern Resident stock off Oregon and southern Washington (pers. comm., B. Hanson, NMFS Northwest Fishery Science Center to C. Cairns, NMFS OPR, April 12, 2017). At the time the action will occur, we expect Southern Resident killer whales to be outside of the action area. The summer range (i.e., May through September) of the Southern Resident killer whale is near Haro Strait, Boundary Pass, San Juan Island, and the Strait of Juan de Fuca, Washington and British Columbia. Southern Resident killer whales do occur off the Washington and Oregon coasts, (e.g., around the Columbia River), but in winter, during the months of February and March.[2] In 2012, NSF funded seismic surveys in the Pacific Ocean off the coast of Washington in June and July, and reported no killer whales during those surveys.

However, as the known migratory range of the Southern Resident DPS occurs near the proposed survey area, and due to the precarious conservation status of the Southern Resident killer whale DPS, the NMFS Permits and Conservation Division developed measures that it believes are reasonable, conservative, and also practicable in order to prevent the potential for a Southern Resident killer whale to be exposed to airgun sounds. Thus, the requirement to shut down the array upon observation of a killer whale at any distance is designed to avoid any potential for harassment of any Southern Resident killer whales.

Since the proposed action would take place in a location and time of year when we do not expect Southern Resident killer whales to be present, we do not expect them to be exposed to the proposed action, including the stressors related to vessel activity and the seismic research. In the very unlikely event that Southern Resident killer whales are near the action area, we believe that the requirement to shut down the airgun array upon sighting any killer whales will prevent exposure from the seismic activity. We therefore conclude that the effects of the proposed action to these species are discountable and will not be considered further in this opinion.

[2] https://www.nwfsc.noaa.gov/news/blogs/display_blogentry.cfm?blogid=5

7.2 ESA-listed fishes

Numerous species of ESA-listed or proposed fish species could occur in and around the action area.

7.2.1 ESA-listed Pacific salmonids

The proposed action would take place in the waters of the Pacific Ocean off Oregon and Washington. There are several distinct population segments or evolutionarily significant units of Pacific salmonids that could occur in the area during their oceanic life phase, including:

- Steelhead trout, (*Oncorhynchus mykiss*)
  - Lower Columbia River, Middle Columbia River, Upper Columbia River, Puget Sound, and Upper Willamette River;
- Chinook salmon, (*Oncorhynchus tshawytscha)*
  - Upper Willamette River, Lower Columbia River, Upper Columbia River Spring-Run, Puget Sound;
- Coho salmon, (*Oncorhynchus kisutch*)
  - Lower Columbia River, Southern Oregon/Northern California Coast, Oregon Coast;
- Chum salmon, (*Oncorhynchus keta*)
  - Columbia River, Hood Canal.

It is not well-understood where in the ocean these (or any) Pacific salmonids go (Meyers 1998); the distinct population segments or evolutionarily significant units noted above are those in the Oregon and Washington region, and thus closest to the action area, and more likely to be present. It is possible that other ESA-listed populations of Pacific salmonids that are farther away (e.g., from California) could be present in the action area, though we consider that less likely due to the distance.

The proposed action will not involve any capture methods or sampling techniques that would capture or impact ESA-listed Pacific salmonids. Since the proposed action would involve vessel operation and seismic activities that are not expected to interact with ESA-listed Pacific salmonids, we do not expect them to be adversely affected by the proposed action. We therefore conclude that the effects of the proposed action to these species are discountable and will not be considered further in this opinion.

7.2.2 ESA-listed and proposed sharks and rays

The giant manta ray (*Manta birostris*) and oceanic whitetip shark (*Carcharhinus longimanus*) are proposed to be listed as threatened under the ESA. Giant manta rays are found as far north as southern California (82 FR 3694), and oceanic whitetip sharks range as far north as 30 degrees north latitude (Young 2016). The proposed action area will be from 43 to 46.5 degrees North, off the coasts of Oregon and Washington, well out of range of both species. We conclude that there will be no effect from the proposed action on giant manta rays or oceanic whitetip sharks.

The scalloped hammerhead (*Sphyrna lewini*) Eastern Pacific DPS is listed as endangered. Each of these species range throughout the Pacific Ocean. Scalloped hammerheads are restricted by water temperature, and are rarely found in waters cooler than 22 degrees Celsius (Wilson 2013). They are typically found in tropical and warm temperate waters around the globe. Average water temperatures in the action area (e.g., Newport, Oregon, and Astoria, Oregon) for the time period the action will be occurring (i.e., late September) are 13 and 16 degrees Celsius, respectively.[3] Since the water temperatures will be far too cold for scalloped hammerheads, we believe that they will not be present in the action area, and there will be no effect from the proposed action.

7.2.3 Bocaccio

Puget Sound/Georgia Basin DPS bocaccio (*Sebastes paucispinis*) are found in Puget Sound, Washington, mostly south of the Tacoma Narrows. Since the action will take place off the coasts of Washington and Oregon, outside of the expected range of Puget Sound/Georgia Basin bocaccio, we conclude that there will be no effect of the proposed action on this species.

7.2.4 Green Sturgeon

Southern DPS green sturgeon (*Acipenser medirostris*) consists of populations originating from coastal watersheds south of the Eel River, California. Sub-adult and adult green sturgeon spend most of their lives in the marine environment, at water depths between 20 and 70 meters (NMFS 2015a). No part of the proposed survey lines will take place in waters less than 100 meters deep; therefore, we do not believe green sturgeon will be exposed to the seismic activities of the proposed action. Green sturgeon are benthic, thus minimizing the risk of ship strike while the *Revelle* transits from port to the action area. We conclude that there will be no effect to Southern DPS green sturgeon from the proposed action.

7.3 ESA-listed sea turtles

Olive ridley sea turtles (*Lepidochelys olivacea*) and hawksbill sea turtles (*Eretmochelys imbricata*) range broadly throughout the Pacific Ocean. However, both species have a circumtropical distribution restricted by ocean temperature, with southern California being the northern limit of their distribution (USFWS 2014). Because olive ridley and hawksbill sea turtles are not found in the action area, we have determined that there will be no effect to either species.

Green turtle (*Chelonia mydas*) East Pacific DPS and loggerhead (*Caretta caretta*) North Pacific DPS range along the West Coast of the United States, within the vicinity of the action area. However, green and loggerhead turtles are only rarely found in Washington or Oregon waters (WDFW 2012). Because of their scarcity in the waters in and around the action area, we believe it is extremely unlikely that green or loggerhead sea turtles will be exposed to the proposed action, and the effects are discountable. We conclude that the action is not likely to adversely affect these species.

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[3] See water temperature data at: https://www.nodc.noaa.gov/dsdt/cwtg/npac.html

7.4 Designated critical habitat

Critical habitat has been designated in or near the action area for the following species: Southern Resident killer whale, Eastern DPS Steller sea lion, and Southern DPS eulachon. The proposed action—including vessel transit and seismic activities—will occur outside each of these critical habitat designations. We conclude that there will be no effect from the proposed action to the critical habitat designations for Southern Resident killer whale, Eastern DPS Steller sea lion, and Southern DPS eulachon.

Designated critical habitat for several evolutionarily significant units and distinct population segments of steelhead and chinook, sockeye and chum salmon includes nearshore marine waters contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters (98 feet) relative to mean lower low water (70 FR 52630; September 2, 2005). The primary constituent elements for these critical habitat designations include nearshore marine areas free of obstruction and excessive predation with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; natural cover; and offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation. There would be no effect to these critical habitat areas because the proposed activities would not cause obstruction or significantly affect predation, would not cause any significant changes to water quality in designated critical habitat, would not affect forage or the ability for critical habitat areas to support growth and maturation of ESA-listed salmon and would not affect the natural cover in these areas. Therefore, the proposed activities are not expected to adversely affect the conservation value of designated critical habitat for these species.

Green sturgeon critical habitat was designated in several locations throughout Washington, Oregon, and California. The coastal marine habitat designation is the only unit that falls within the action area. Green sturgeon coastal marine critical habitat is defined as waters up to 110 meters deep, from Monterey Bay, California, to Cape Flattery, Washington. The proposed seismic activities will take place mostly in deep waters (greater than 1,000 meters deep); with some survey lines in waters between 100 and 1,000 meters deep (see Table 1). Vessel activity associated with the proposed action would involve transit through the critical habitat. The essential biological features of coastal marine habitat are migratory corridors for safe passage of green sturgeon, water quality (i.e., appropriate dissolved oxygen levels and low levels of contaminants), and adequate food resources. The proposed action will involve seismic activities and vessel transit, which will not degrade water quality, impede green sturgeon migration, or reduce available prey. We conclude that there will be no effect to green sturgeon critical habitat.

Critical habitat for leatherback sea turtles on the Pacific coast was designated in 2012 (77 FR 4170). It includes approximately 16,910 square miles (43,798 square kilometers) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square kilometers) from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The proposed activity would take place off the coasts of Washington and Oregon, and would occur within leatherback designated critical habitat.

Only one primary constituent element was identified for leatherback critical habitat: the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

The proposed action would involve activities in critical habitat areas for leatherback sea turtles, including vessel activities and seismic research, but the action is not expected to adversely affect any aspect of prey availability that forms the primary constituent element for the critical habitat. As such, the proposed action is expected to have no effect on designated critical habitat for leatherback sea turtle and will not be discussed further in this opinion.

8 Species and Critical Habitat Likely to be Adversely Affected

This section identifies the ESA-listed species that occur within the action area Figure 2 that may be affected by NSF's proposed seismic activities off the coasts of Washington and Oregon, and the Permits and Conservation Division's issuance of an IHA (Table 4). All of the species potentially occurring within the action area are ESA-listed in Table 4 along with their regulatory status.

Table 4. Threatened and endangered species that may be affected by NSF and the NMFS Permits and Conservation Division's proposed action of seismic activities off the coast of Washington and Oregon and the issuance of an Incidental Harassment Authorization.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538
Sei Whale (Balaenoptera borealis)	E – 35 FR 18319	-- --	76 FR 43985
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T -- 81 FR 62259	-- --	55 FR 29646
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E -- 81 FR 62259	-- --	55 FR 29646
Sea Turtles			
Leatherback turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	63 FR 28359

9 Status of Species and Critical Habitat Likely to be Adversely Affected

This section examines the status of each species that would be 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," 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].

This section also examines the condition of critical habitat throughout the designated area (such as various watersheds and coastal and marine environments that make up the designated area), and discusses the condition and current function of designated critical habitat, including the essential physical and biological features that contribute to that conservation value of the critical habitat.

One factor affecting the range wide status of ESA-listed whales and leatherback sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in the Environmental Baseline section.

9.1 Blue Whale

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

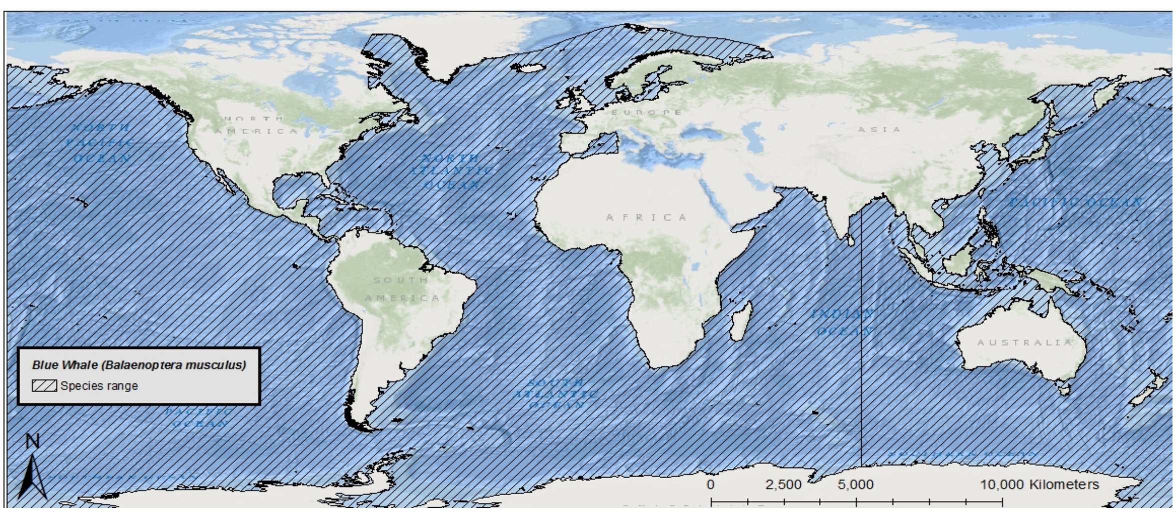

Figure 3. Map identifying the range of the blue whale.

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 are a mottled gray color that appears light blue when seen through the water (Figure 4). The blue whale was originally listed as endangered on December 2, 1970 (35 FR 18319) (Table 5).

Figure 4. Blue whale. Photo: NOAA.

Table 5. Blue whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Balaenoptera musculus	**Blue whale**	**None**	**Endangered** range wide	None	35 FR 18316	1998 Intent to update (77 FR 22760)	None Designated

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (COSEWIC 2002) were used to summarize the life history, population dynamics and status of the species as follows. There are three stocks of blue whales designated in U.S. waters: the eastern North Pacific stock occupies the U.S. West Coast, and individuals from this stock are likely to be affected by the proposed action.

Life History

The average life span of blue whales is eighty to ninety 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 fifteen 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 daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 meters.

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, North Pacific, and Southern Hemisphere. The eastern North Pacific stock and has a population estimate of N = 1,647 (N_{min} = 1,551) (Calambokidis and Barlow 2013).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis 2009). An overall population growth rate for the species or a growth rate for the eastern North Pacific stock are not available at this time.

Little genetic data exist on blue whales globally. 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 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations 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 3). In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off of the Aleutian Islands and the Bering Sea.

Vocalization and Hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5 to 400 hertz, with dominant frequencies from 16 to 25 hertz, and songs that span frequencies from 16 to 60 hertz that last up to 36 seconds repeated every one to two minutes (see Cummings and Thompson 1971; Cummings 1977; Edds-Walton 1997a; Edds 1982; McDonald et al. 1995a; Thompson 1982). Non-song vocalization are also low-frequency in nature (generally below 200 hertz, but one of six types up to 750 hertz) between 0.9 and 4.4 seconds long (Redalde-Salas 2014). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0 to 78.7 hertz. Reported source levels are 180 to 188 dB re 1μPa, but may reach 195 dB re 1μPa (Aburto et al. 1997; Clark and Ellison 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 meter in the 17 to 30 hertz range and pygmy blue whale calls at 175± 1 dB re: 1 μPa_{rms} at 1 meter in the 17 to 50 hertz range. Source levels around Iceland have been 158 to 169 dB re: 1 μPa_{rms} (Rasmussen 2013). Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish 1971; Cummings et al. 1972; Cummings and Thompson 1971; Cummings and Thompson 1994; Cummings 1977; Rivers 1997; Thompson 1996). Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

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 1997b; Payne and Webb 1971; Thompson et al. 1992a). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently during summer in high-latitude feeding areas. Short, rapid sequences of 30 to 90 hertz calls are associated with socialization and may be displays by males based on call seasonality and structure.

Status

The blue whale is endangered because of past commercial whaling. In the North Pacific, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are 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 blue whales in the North Pacific appear to be increasing in size, the population appears to be somewhat resilient to current threats; however, it 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 down listing/delisting criteria for each of the following recovery goals.

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere
2. Estimate the size and monitor trends in abundance of blue whale populations
3. Identify and protect habitat essential to the survival and recovery of blue whale populations
4. Reduce or eliminate human-caused injury and mortality of blue whales
5. Minimize detrimental effects of directed vessel interactions with blue whales

6. Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales
8. Establish criteria for deciding whether to delist or down list blue whales.

9.2 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* is found in the Northern Hemisphere (Figure 5). On the U.S. West Coast, fin whales are distributed off California, Oregon, and Washington.

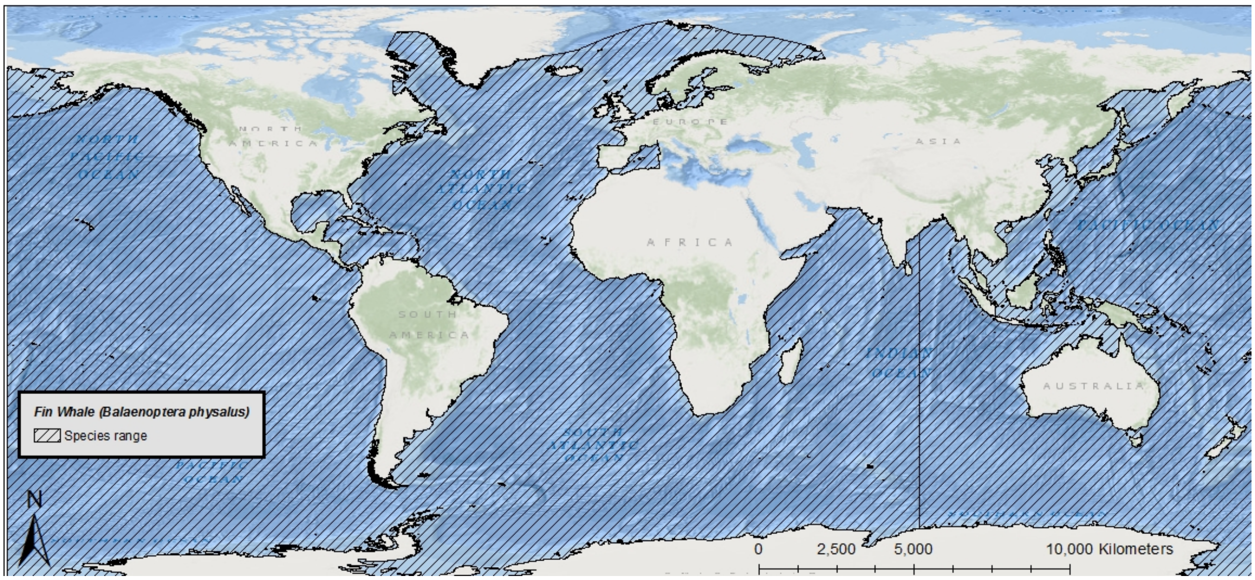

Figure 5. Map identifying the range of the fin whale.

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 (Figure 6). The fin whale was originally listed as endangered on December 2, 1970 (35 FR 18319) (Table 6).

Figure 6. Fin whale. Photo: NOAA

Table 6. Fin whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Balaenoptera physalus	**Fin whale**	**None**	**Endangered** range wide	2011	35 FR 18319	2010	None Designated

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Fin whales can live, on average, eighty to ninety 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. 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 was 42,000 to 45,000 (Ohsumi 1974). In the North Pacific, at least 74,000 whales were killed between 1910 and 1975. Currently, The best current estimate of abundance for fin whales off of California, Washington, and Oregon is approximately 9,029 (N_{min}=8,127) individuals (Nadeem et al. 2016).

Current estimates indicate a 7.5 percent increase in the California/Oregon/Washington fin whale population (Nadeem et al. 2016).

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mtDNA genome for 154 fin whales sampled in the North Atlantic, North Pacific, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within ocean basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some population's 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, North Pacific, and Southern Hemisphere (Figure 5) where they appear to be reproductively isolated. The availability of 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 hertz range (Edds 1988; Thompson et al. 1992a; Watkins 1981; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to 2 seconds) in the 18 to 35 hertz range, but only males are known to produce these (Croll et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995a) reported the most common sound as a one second vocalization of about 20 hertz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns during winter. Au (2000b) reported moans of 14 to 118 hertz, with a dominant frequency of 20 hertz, tonal vocalizations of 34 to 150 hertz, and songs of 17 to 25 hertz (Cummings and Thompson 1994; Edds 1988; Watkins 1981). Source levels for fin whale vocalizations are 140 to 200 dB re 1μPa·m (Clark and Ellison. 2004; Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 meters (Watkins et al. 1987). In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). Short sequences of rapid pulses in the 20 to 70 hertz band are associated with animals in social groups (McDonald et al. 1995b). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Although their function is still debated, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997b; Payne and Webb 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins 1987), while the individual counter-calling data of McDonald et al. (1995b) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson et al. 1992b).

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. 1995c).

Status

The fin whale is endangered because 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 Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. Fin whales in California, Oregon, and Washington have a relatively large population size and increasing trend may provide some resilience to current threats, but the population is still well below pre-harvest levels.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

See the 2010 Final Recovery Plan for the fin whale for complete down listing/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.

9.3 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 7). Sei whales in the Eastern North Pacific are found off the coasts of California, Oregon, and Washington.

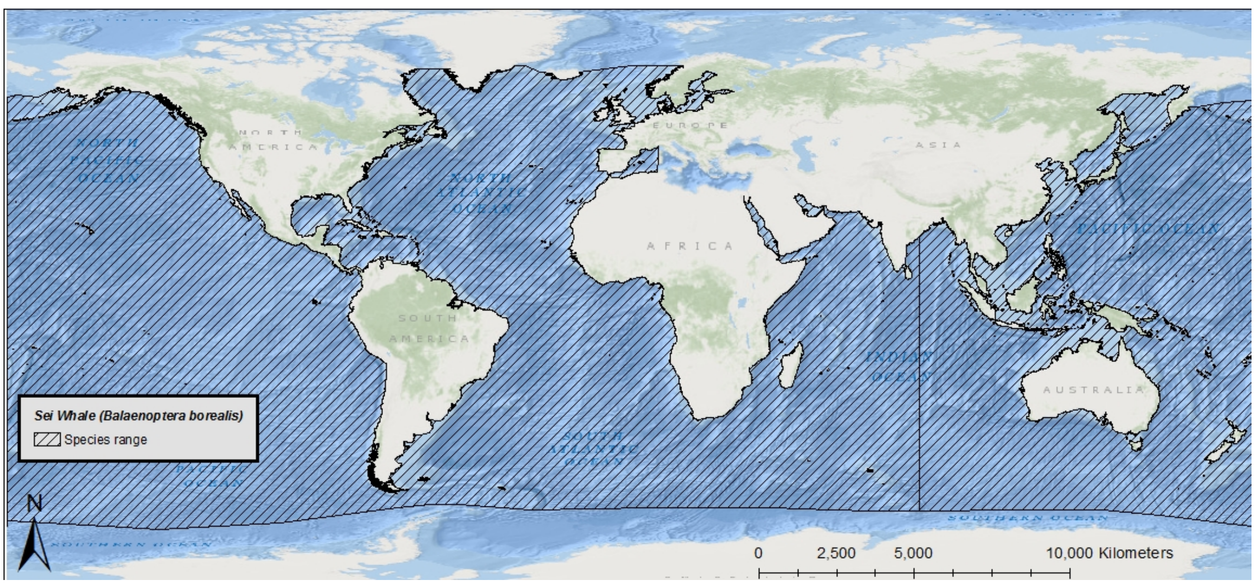

Figure 7. Map identifying the range of the sei whale.

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 (Figure 8). Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. The sei whale was originally listed as endangered on December 2, 1970 (35 FR 18319).

Figure 8. Sei whale. Photo: NOAA

Table 7. Sei whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Balaenoptera borealis	**Sei whale**	**None**	**Endangered** range wide	2012	35 FR 18316	2011	None Designated

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (NMFS 2012) 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 fifty and seventy years. They have a gestation period of ten to twelve months, and calves nurse for six to nine months. Sexual maturity is reached between six and twelve 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.

Models indicate that total sei whale abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific. Sei whale abundance in the Eastern North Pacific is estimated at 519 individuals (N_{min}=374) (Barlow 2016).

A population growth rate for sei whales in the Eastern North Pacific is not available at this time.

While some genetic data exist sei whales, current samples sizes are small limiting our confidence in their estimates of genetic diversity (NMFS 2011b). 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 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations 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.

There are approximately 80,000 sei whales worldwide, occurring in the North Atlantic, North Pacific, and Southern Hemisphere (Figure 7).

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 hertz range with 1.5 seconds duration and tonal and upsweep calls in the 200 to 600 hertz range of one to three second durations (McDonald et al. 2005). Source levels of 189 ±5.8 dB re: 1 μPa at 1 meter have been established for sei whales in the northeastern Pacific (Weirathmueller 2013). Differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007). The first variation consisted of sweeps from 100 to 44 hertz, over 1.0 second. During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency down swept calls. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 to 21 hertz over 1.3 seconds. These vocalizations are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters. Vocalizations from the North Atlantic consisted of paired sequences (0.5 to 0.8 second, separated by 0.4 to 1.0 second) of 10 to 20 short (four milliseconds) frequency module sweeps between 1.5 to 3.5 kilohertz (Thomson and Richardson 1995).

Status

The sei whale is endangered because of past commercial whaling. Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and noise. The species' 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 sei whale.

Recovery Goals

See the 2011 Final Recovery Plan for the sei whale for complete down listing/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.

9.4 Sperm Whale

The sperm whale is a widely distributed whale found in all major oceans (Figure 9). Off the U.S. West Coast, sperm whales are found in Washington and Oregon in spring, summer, and fall, and in California year-round.

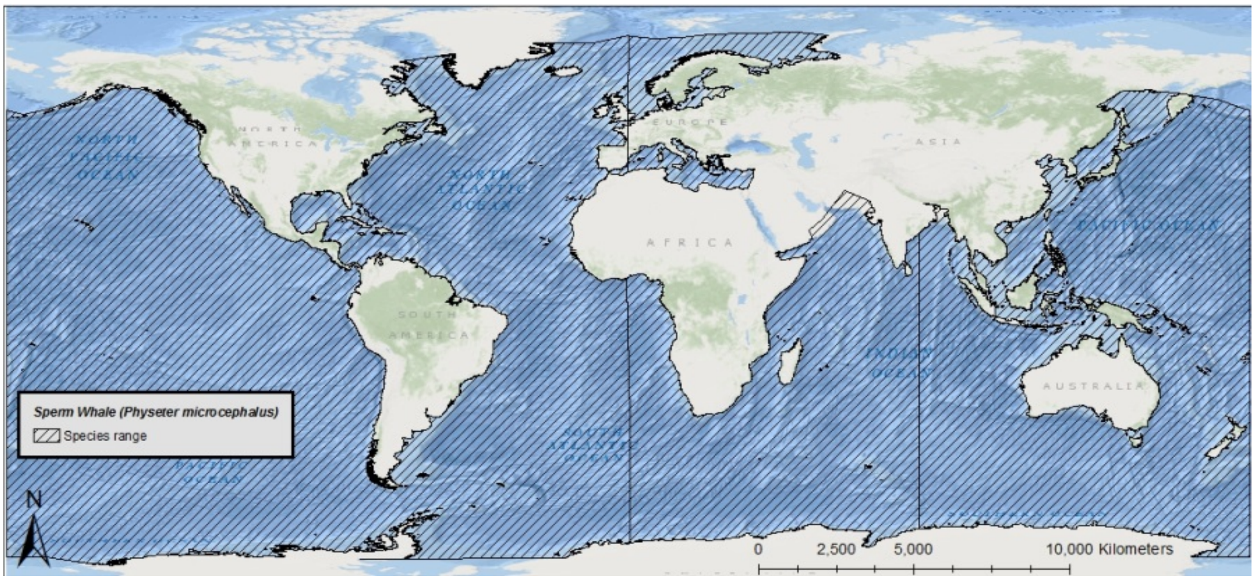

Figure 9. Map identifying the range of the sperm whale.

Sperm whales are the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up to twenty-five percent to thirty-five percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip (Figure 10). The sperm whale was originally listed as endangered on December 2, 1970 (35 FR 18319) (Table 8).

Figure 10. Sperm whale. Photo: NOAA.

Table 8. Sperm whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Physeter microcephalus	**Sperm whale**	**None**	**Endangered:** range wide	2015	35 FR 18319	2010	None Designated

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016a), and status review (NMFS 2015b) 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 thirteen years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 meters (1,968 feet) or more, and are uncommon in waters less than 300 meters (984 feet) 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, the reason for ESA listing. There are six recognized stocks of sperm whales that exist in U.S. waters: abundance for the California/Oregon/Washington stock of sperm whales is estimated at N=2,106 (N_{min}=1,332) (Moore and Barlow 2014).

The is insufficient data to evaluate trends in abundance and growth rates of sperm whales off of California, Oregon, and Washington at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and

Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). 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 (Figure 9). While both males and females can be found in latitudes less than 40º, only adult males venture into the higher latitudes near the poles. In shipboard and aerial surveys, they are commonly sighted near the 1,000-meter isobaths.

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 hertz to 20 kilohertz that can be extremely loud for a biological source (200 to 236 dB re: 1μPa), although lower source level energy has been suggested at around 171 dB re: 1 μPa (Goold and Jones 1995; Møhl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around two to four kilohertz and 10 to 16 kilohertz (Goold and Jones 1995; NMFS 2006d; Weilgart and Whitehead 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972; Norris and Harvey. 1972). Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intragroup interactions (Weilgart and Whitehead 1993). They may also aid in intra-specific communication. Another class of sound, "squeals", are produced with frequencies of 100 hertz to 20 kilohertz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kilohertz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999).

Status

The sperm whale is endangered because 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, pollution, 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

See the 2010 Final Recovery Plan for the sperm whale for complete down listing/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.

9.5 Humpback Whale Mexico and Central America Distinct Population Segments

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 11). Two distinct population segments may be found in the proposed action area: the Central America and Mexico DPSs (areas five and six on the map). Both are discussed in this section.

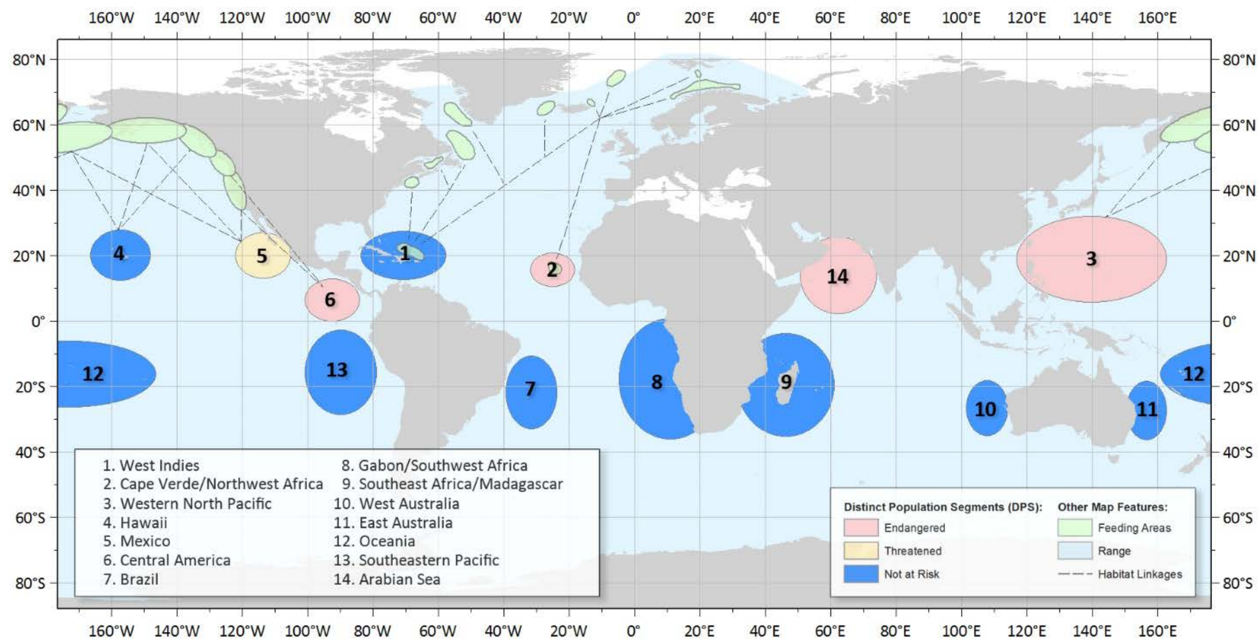

Figure 11: Map identifying 14 distinct population segments with one threatened and four endangered, based on primary breeding location of the humpback whale, their range, and feeding areas (Bettridge 2015).

Humpbacks are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white (Figure 12). The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated fourteen DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific,

Figure 12. Humpback whale. Photo: NOAA.

Central America, and Arabian Sea) and one as threatened (Mexico) (81 FR 62259) (Table 9).

Table 9. Humpback whale information bar.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Megaptera novaeangliae	**Humpback whale**	**Mexico**	**Threatened**	2015	81 FR 62259	1991	None Designated
Megaptera novaeangliae	**Humpback whale**	**Central America**	**Endangered**	2015	81 FR 62259	1991	None Designated

Information available from the recovery plan (NMFS 1991), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016b), the status review (Bettridge 2015), and the final listing (81 FR 62259) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpbacks can live, on average, fifty years. They have a gestation period of eleven to twelve months, and calves nurse for one year. Sexual maturity is reached between five to eleven years of age with an average calving interval of two to three years. Humpbacks mostly inhabit coastal and continental shelf waters. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpbacks 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 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 and Central American humpback whale DPSs.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman 2003). The abundance and population trends of ESA-listed humpback whale Mexico and Central America DPSs are summarized in Table 10.

Table 10: Abundance and population trend estimates for humpback whale distinct population segments as listed under the Endangered Species Act (81 FR 62259).

Distinct Population Segment	ESA Status	Abundance	Population Trend
Central America	Endangered	411	Unknown
Mexico	Threatened	3,264	Unknown

Population growth rates are currently unavailable for the Mexico and Central America humpback whale DPSs (Table 10).

For humpback whales, distinct population segments 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 five hundred individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Populations 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. The Central America has below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance (81 FR 62259, Bettridge 2015).

The Mexico DPS consists of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands and transit through the Baja California Peninsula coast. The 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 Gulf of Alaska and Bering Sea feeding grounds (Figure 11) (81 FR 62259). The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras and Nicaragua. This DPS feeds almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds (Figure 11) (81 FR 62259).

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 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 hertz to 4 kilohertz with estimated source levels from 144 to 174 decibels (Au 2000b; Au et al. 2006; Frazer and Mercado 2000; Payne 1970; Richardson et al. 1995c; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 hertz to 10 kilohertz and having most energy below three kilohertz (Silber 1986a; Tyack 1983). Such sounds can be heard up to nine kilometers away (Tyack and Whitehead 1983). Other social sounds from 50 hertz to ten kilohertz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995c; Tyack and Whitehead 1983). While in northern feeding areas, both sexes vocalize in grunts (25 hertz to 1.9 kilohertz), pulses (25 to 89 hertz), and songs (ranging from 30 hertz to eight kilohertz but dominant frequencies of 120 hertz to four kilohertz) which can be very loud (175 to 192 dB re 1 μPa at 1 m; (Au 2000b; Erbe 2002a; Payne and Payne 1985; Richardson et al. 1995c; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the Central America and Mexico DPSs that remain listed 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 indicates that it may be 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. The Central America DPS still faces a risk of extinction due to its small population size.

Critical Habitat

No critical habitat has been designated for any distinct population segment of humpback whales.

Recovery Goals

See the 1991 Final Recovery Plan for the Humpback whale for 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.

9.6 Leatherback Turtle

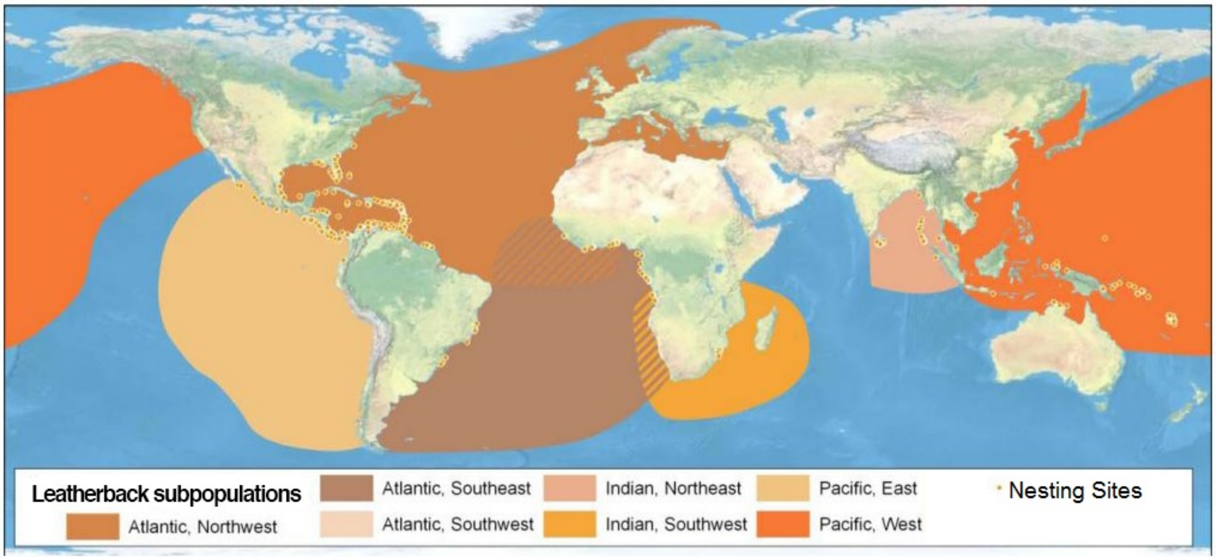

Figure 13. Map identifying the range of the leatherback sea turtle. Adapted from (Wallace et al. 2010).

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 13).

Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly (Figure 14).

Figure 14. Leatherback turtle. Photo: R.Tapilatu.

The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973 (Table 11).

Table 11. Leatherback turtle summary information.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Dermochelys coriacea	**Leatherback sea turtle**	**None**	**Endangered** range wide	2013	E – 35 FR 8491	U.S. Caribbean, Atlantic and Gulf of Mexico	44 FR 17710 and 77 FR 4170

We used information available in the five year review (NMFS 2013) and available literature to summarize the life history, population dynamics and status of the species, as follows.

Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to twenty-nine years (Avens 2009; Spotila 1996). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (Reina et al. 2002; Wallace 2007). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately fifty percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh about thirty-three percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James 2005; Wallace 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

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 leatherback sea turtle.

Leatherbacks are globally distributed, with nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Leatherback populations in the Pacific are much lower than in the Atlantic, where the population has been increasing. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and sub adults (Spotila et al. 2000).

Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu 2013).

Analyses of mitochondrial DNA from leatherback sea turtles worldwide and in the Pacific indicate a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton 1999).

Leatherback sea turtles are distributed in oceans throughout the world. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

Vocalization and Hearing

Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 hertz, with a range of maximum sensitivity between 100 and 800 hertz (Bartol 1999; Lenhardt 1994a; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found leatherback hatchlings capable of hearing underwater sounds at frequencies of 50 to 1,200 hertz (maximum sensitivity at 100 to 400 hertz). Hearing below 80 hertz is less sensitive but still possible (Lenhardt 1994a).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 hertz, with slow declines below 100 hertz and rapid declines above 700 hertz and almost no sensitivity above 3 kilohertz (Wever 1956). Wood turtles are sensitive up to about 500 hertz, followed by a rapid decline above one kilohertz and almost no responses beyond three or four kilohertz (Patterson 1966).

Status

The leatherback sea turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise. The species' resilience to additional perturbation is low. Leatherback populations in the Pacific are in particular danger due to the severe declines, and the threats have not abated (NMFS 2016).

Recovery Goals

See the 1998 Recovery Plan for the U.S. Pacific leatherback sea turtles for complete down-listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan:

1. Reduce fisheries interactions.
2. Improve nesting beach protection and increase reproductive output.
3. International cooperation.
4. Monitoring and research.
5. Public engagement.

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).

10.1 Climate Change

We primarily discuss climate change as a threat common to all species addressed in this opinion, rather than in each of the species-specific narratives.

The 2014 Assessment Synthesis Report from the Working Groups on the Intergovernmental Panel on Climate Change concluded climate change is unequivocal (IPCC 2014). The report concludes oceans have warmed, with ocean warming the greatest near the surface (e.g., the upper 75 meters (246 feet) have warmed by 0.11 degrees Celsius per decade over the period 1971 to 2010) (IPCC 2014). Global mean sea level rose by 0.19 meters (0.62 feet) between 1901 and 2010, and the rate of sea-level rise since the mid-19th century has been greater than the mean rate during the previous two millennia (IPCC 2014). Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney 2012). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, heat waves, and droughts (IPCC 2014). Climate change has the potential to impact species abundance, geographic distribution, migration patterns, timing of seasonal activities (IPCC 2014), and species viability into the future. Though predicting the precise consequences of climate change on highly mobile marine species, such as many of those considered in this opinion, is difficult (Simmonds 2007), recent research has indicated a range of consequences already occurring.

Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney 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. He 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 sea turtles were predicted to gain core habitat area, whereas loggerhead sea turtles are predicted to experience losses in available core habitat. McMahon and Hays (2006) predicted increased ocean temperatures would expand the distribution of leatherback sea 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 would be affected by climate change, with 47 percent likely to be negatively affected. Willis-Norton et al. (2015) acknowledge there would be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback sea turtles in the eastern south Pacific Ocean.

Similarly, climate-mediated changes in important prey species populations are likely to affect predator populations. For ESA-listed sea turtles that undergo long migrations (e.g., leatherbacks), if either prey availability or habitat suitability is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009).

Changes in global climatic patterns are expected to have profound effects on coastlines worldwide, potentially having significant consequences for the ESA-listed species considered in this opinion that are partially dependent on terrestrial habitat areas (i.e., sea turtles). For example, rising sea levels are projected to inundate some sea turtle nesting beaches (Caut et al. 2009; Wilkinson 2008), change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and increase the number of sea turtle nests destroyed by tropical storms and hurricanes (Wilkinson 2008). The loss of nesting beaches may have catastrophic effects on global sea turtle populations if they are unable to colonize new beaches, or if new beaches do not provide the habitat attributes (e.g., sand depth, temperature regimes, refuge) necessary for egg survival. Additionally, increasing temperatures in sea turtle nests, as is expected with climate change, alters sex ratios, reduces incubation times (producing smaller hatchlings), and reduces nesting success due to exceeded thermal tolerances (Fuentes 2009; Fuentes et al. 2009; Fuentes et al. 2010; Glen 2003). All of these temperature related impacts have the potential to significantly impact sea turtle reproductive success and ultimately, long-term species viability. Poloczanska (2009) noted that extant sea turtle species have survived past climatic shifts, including glacial periods and warm events, and therefore may have the ability to adapt to ongoing climate change (e.g., by finding new nesting beaches). However, the authors also suggested since the current rate of warming is very rapid, expected change might outpace sea turtles' ability to adapt.

Previous warming events (e.g., El Niño, the 1977 through 1998 warm phase of the Pacific Decadal Oscillation) may illustrate the potential consequences of climate change. Off the U.S.

west coast, past warming events have reduced nutrient input and primary productivity in the California Current, which also reduced productivity of zooplankton through upper-trophic level consumers (Doney 2012; Sydeman et al. 2009; Veit et al. 1996).

This is not an exhaustive review of all available literature regarding the potential impacts of climate change to the species considered in this opinion. However, this review provides some examples of impacts that may occur. While it is difficult to accurately predict the consequences of climate change to the species considered in this opinion, a range of consequences are expected, ranging from beneficial to catastrophic.

10.2 Harvest

Prior to 1900, aboriginal hunting and early commercial whaling on the high seas, using hand harpoons, took an unknown number of whales (Johnson and Wolman 1984). Modern commercial whaling removed about 50,000 whales annually. In 1965, the International Whaling Commission banned the commercial hunting of whales. Although commercial harvesting no longer targets whales in the proposed action area, prior exploitation may have altered the population structure and social cohesion of the species such that effects on abundance and recruitment can continue for years after harvesting has ceased.

Directed harvest of sea turtles and their eggs for food and other products has existed for years and was a significant factor causing the decline of several sea turtle species, including leatherback sea turtles. At present, despite conservation efforts such as bans and moratoriums by the responsible governments, the harvest of leatherbacks and their eggs on nesting beaches still occurs throughout the action area. Countries including Papua Barat Indonesia, Mexico, Peru and the Philippines have attempted to reduce the threats to sea turtles, but illegal harvesting still occurs (NMFS 2016). In Vietnam and Fiji, harvest of turtle meat and eggs remains unregulated.

10.3 Noise

Noise generated by human activity has the potential to affect whales and sea turtles, although effects to sea turtles are not well understood. This includes sound generated by commercial and recreational vessels, aircraft, commercial sonar, military activities, seismic exploration, in-water construction activities and other human activities. These activities all occur within the action area to varying degrees throughout the year. Whales generate and rely on sound to navigate, hunt and communicate with other individuals. As a result, anthropogenic noise can interfere with these important activities. The effects of noise on marine mammals can range from behavioral effects to physical damage (Richardson et al. 1995b).

Commercial shipping traffic is a major source of low-frequency anthropogenic noise in the oceans (NRC 2003a). Although large vessels emit predominantly low-frequency sound, studies report broadband noise from large cargo ships that includes significant levels above 2 kHz, which may interfere with important biological functions of cetaceans (Holt 2008a). Commercial sonar systems are used on recreational and commercial vessels and may affect marine mammals (NRC 2003a). Although, little information is available on potential effects of multiple commercial sonars to marine mammals, 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 (Richardson et al. 1995b).

Seismic surveys using towed airguns occur within the action area and are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. Airguns generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10 to 20 seconds for extended periods (NRC 2003a). Most of the energy from the guns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 decibels at dominant frequencies of 5 to 300 hertz (NRC 2003a). Most of the sound energy is at frequencies below 500 hertz.

10.4 Fisheries Interactions

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 marine mammals (see Dietrich et al. 2007). These entanglements also make animals more vulnerable to additional dangers (e.g., predation and ship strikes) by restricting agility and swimming speed. Marine mammals that die from entanglement in commercial fishing gear often sink rather than strand ashore thus making it difficult to accurately determine the extent of such mortalities.

Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Therefore, competition with humans for prey is a potential concern for whales. Reductions in fish populations, whether natural or human-caused, may affect listed whale populations and their recoveries. Whales are known to feed on several species of fish that are harvested by humans (Waring et al. 2008); however, the magnitude of competition is unknown.

Leatherbacks in the Pacific migrate about 7,000 miles from nesting beaches in the tropical Pacific (e.g., Indonesia, Papua New Guinea, Costa Rica, Mexico) to foraging grounds (e.g., off the U.S. West Coast. This migration puts leatherbacks in proximity of numerous fisheries, especially longlines, increasing bycatch risk. Roe et al. (Roe 2014) found areas of high bycatch risk in the north and central Pacific. By far, however, the greatest areas of bycatch risk were in the jurisdictional waters of several Indo-Pacific nations, largely affecting nesting individuals. The authors pointed to the difficulty in coordinating management efforts between several countries as a barrier to reducing risk of bycatch and supporting leatherback recovery.

10.5 Vessel Strike

Ships have the potential to affect whales through strikes, noise and disturbance by 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 2001; Samuels et al. 2000). Whale watching, a profitable and rapidly growing business with more than 9 million participants in 80 countries and territories, may increase these types of disturbance and negatively affect the species (Hoyt 2001).

Ship strikes are considered a serious and widespread threat to marine mammals. 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 1993; Wiley et al. 1995). In the region, blue whales are especially susceptible where shipping lanes overlap with common feeding areas, as they do in the Santa Barbara Channel (Redfern 2013). There is a concern that many ship strikes go undetected and unreported because the whale's carcass sinks (Cassoff 2011). As ships continue to become faster and more widespread, an increase in ship interactions with marine mammals is to be expected. For whales, studies show that the probability of fatal injuries from ship strikes increases as vessels operate at speeds above 14 knots (Laist et al. 2001).

Boat collisions can result in serious injury and death and may pose a threat to sea turtles in the action area although the extent of this threat is unknown.

10.6 Pollution

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

10.6.1 Marine Debris

Marine debris is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources. Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment. Whales often become entangled in marine debris. They may also ingest it while feeding, potentially leading to digestive problems, injury, or death. Types of marine debris include plastics, glass, metal, polystyrene foam, rubber and derelict fishing gear from human marine activities or transported into the marine environment from land. The sources of this debris include littering, dumping and industrial loss and discharge from land. Whales become entangled in marine debris, or ingest it, which may lead to injury or death. Given the limited knowledge about the impacts of marine debris on whales, it is difficult to determine the extent of the threats that marine debris poses to whales.

Ingestion of marine debris can be a serious threat to leatherback sea turtles. When feeding, leatherback sea turtles can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, a primary prey. Some types of marine debris may be directly or indirectly toxic, such as oil. Other types of marine debris, such as discarded or derelict fishing gear, may entangle and drown sea turtles. Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky 2009).

10.6.2 Pesticides and Contaminants

Exposure to pollution and contaminants has 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 and Ross 2002). Marine pollutants come from multiple municipal, industrial and household as well as from atmospheric transport (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata 1993).

The accumulation of persistent pollutants through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2008), including immune system abnormalities, endocrine disruption and reproductive effects (Krahn et al. 2007). 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 and Ross 2002; Mearns 2001).

In sea turtles, heavy metals, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc, have been found in a variety of tissues in levels that increase with turtle size (Anan et al. 2001; Barbieri 2009; Fujihara et al. 2003; Garcia-Fernandez et al. 2009; Gardner et al. 2006; Godley et al. 1999; Saeki et al. 2000; Storelli et al. 2008). Cadmium has been found in leatherbacks at the highest concentration compared to any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996).

Sea turtle tissues have been found to contain organochlorines, including chlorobiphenyl, chlordane, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT and PCB (Alava et al. 2006; Corsolini et al. 2000; Gardner et al. 2003; Keller et al. 2005; Keller et al. 2004a; Keller et al. 2004b; McKenzie et al. 1999; Miao et al. 2001; Monagas 2008; Oros 2009; Perugini et al. 2006; Rybitski et al. 1995; Storelli et al. 2007). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight; Davenport 1990; Oros 2009). PCBs have been found in leatherback sea turtles at concentrations lower than expected to cause acute toxic effects, but might cause sub-lethal effects on hatchlings (Stewart 2011).

Organochlorines could cause deficiencies in endocrine, developmental and reproductive health (Storelli et al. 2007) and are known to depress immune function in loggerhead sea turtles (Keller et al. 2006). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation.

10.6.3 Hydrocarbons

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 and Ross 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990). 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 and Saulitis 1997). Hydrocarbons also have the potential to impact prey populations and therefore may affect listed species indirectly by reducing food availability. Oil can also be hazardous to sea turtles, with fresh oil causing significant mortality and morphological changes in hatchlings, but aged oil having no detectable effects (Fritts and McGehee 1981).

10.7 Science and Research Activities

Scientific research permits issued by the NMFS currently authorize studies of listed species in the North Pacific Ocean, some of which extend into portions of the action area for the proposed project. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, and exposure to acoustic activities, and breath sampling. These research activities were not expected to jeopardize the survival or recovery of ESA-listed species and were largely anticipated to have short-term behavioral or stress effects to impacted individuals.

Authorized research on leatherback sea turtles includes capture, handling, and restraint, satellite, sonic, and passive integrated transponder tagging, blood and tissue collection, lavage, ultrasound, captive experiments, laparoscopy, and imaging. Research activities involve "takes" by harassment, with some resulting mortality. There have been numerous permits[4] issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles 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 activities would have no more than short-term effects and would not result in jeopardy to the species or adverse modification of designated critical habitat.

Additional "take" is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below represent the maximum number of "takes" authorized in a given year, monitoring and reporting indicate that the actual number of "takes" rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these "takes" will occur since they have been authorized. It is also noteworthy that these "takes" are distributed across the Pacific Ocean. Although whales and sea turtles are generally wide-ranging,

[4]. See https://apps.nmfs.noaa.gov/index.cfm for additional details.

we do not expect many of the authorized "takes" to involve individuals that would also be "taken" under the proposed research.

10.8 The Impact of the Baseline on ESA-listed Species

Listed resources are exposed to a wide variety of past and present state, Federal or private actions and other human activities that have already occurred or continue to occur in the action area. Any foreign projects in the action area that have already undergone formal or early section 7 consultation, and state or private actions that are contemporaneous with this consultation also impact listed resources. However, the impact of those activities on the status, trend, or the demographic processes of threatened and endangered species remains largely unknown. To the best of our ability, we summarize the effects we can determine based upon the information available to us in this section.

10.8.1 Marine Mammals

Climate change has wide-ranging impacts, some of which can be experienced by ESA-listed whales in the action area. Climate change has been demonstrated to alter major current regimes and may alter those in the action area as they are studied further (Johnson 2011; Poloczanska et al. 2009). Considering the sensitivity that North Atlantic right whales have to warm water temperatures during their southbound migration, warming water temperatures may delay their migratory movements. The availability and quality of prey outside the action area in northern feeding areas can also influence the body condition of individuals in the action area and potentially reduce the number of individuals that undertake migration through the action area.

Effects from anthropogenic acoustic sources, whether they are vessel noise, seismic sound, military activities, oil and gas activities, construction, or wind energy, could also have biologically significant impacts to ESA-listed whales in the action area. These activities increase the level of background noise in the marine environment, making communication more difficult over a variety of ranges. We expect that this increased collective noise also reduces the sensory information that individuals can gather from their environment; an important consideration for species that gather information about their environment primarily through sound. At closer ranges to some of anthropogenic sound sources, behavioral responses also occur, including deflecting off migratory paths and changing vocalization, diving, and swimming patterns. At even higher received sound levels, physiological changes are likely to occur, including temporary or permanent loss of hearing and potential trauma of other tissues. Although this exposure is a small fraction of the total exposure individuals receive, it is expected to occur in rare instances.

High levels of morbidity and mortality occur as a result of ship strike (particularly for humpback whales) and entanglement in fishing gear. Ship-strike and entanglement occur broadly along the U.S. West Coast, including in the action area. These two factors represent known mortality sources for all other ESA-listed whales in the action area. On the West Coast, NMFS has collaborated with the U.S. Coast Guard and NOAA Sanctuaries to make changes to shipping lanes to reduce the risk of vessel strikes for large whales. These changes should help to reduce these impacts, but data are not yet available to demonstrate their long-term effectiveness. However, these measures are likely reducing the severity and frequency of these interactions.

Authorized research on ESA-listed whales can have significant consequences for these species, particularly when viewed in the collective body of work that has been authorized. Researchers have noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Responses were different depending on the age, life stage, social status of the whales being observed (i.e., males, cows with calves) and context (feeding, migrating, etc.). Beale and Monaghan (2004) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity.

Several investigators reported behavioral responses to close approaches that suggest that individual whales might experience stress responses. Baker et al. (1983) described two responses of whales to vessels, including: (1) “horizontal avoidance” of vessels 2,000 to 4,000 meters away characterized by faster swimming and fewer long dives; and (2) “vertical avoidance” of vessels from 0 to 2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins et al. (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions.

Although these responses are generally ephemeral and behavioral in nature, populations within the action area can be exposed to several thousand instances of these activities per year, with some species having so many authorized activities that if they were all conducted, every individual in the population would experience multiple events. This can collectively alter the habitat use of individuals, or make what would normally be rare, unexpected effects (such as severe behavioral responses or infection from satellite tagging or biopsy work) occur on a regular basis.

10.8.2 Leatherback Sea Turtles

Several of the activities described in this environmental baseline have significant and adverse consequences for leatherback sea turtle that occur in the action area.

Climate change has and will continue to impact leatherback sea turtles throughout the action area as well as throughout the range of the species. Sex ratios are showing a bias, sometimes very strongly, towards females due to higher incubation temperatures in nests. We expect this trend will continue and possibly may be exacerbated to the point that nests may become entirely feminized, resulting in severe demographic issues for affected populations in the future. Hurricanes may become more intense and/or frequent, impacting the nesting beaches of sea turtles and resulting in increased loss of nests and nesting habitat over wide areas. Similarly, sea-level rise may result in loss of nesting habitat over wide areas. Disease and prey distributions may well shift in response to changing ocean temperatures or current patterns, altering the morbidity and mortality regime faced by sea turtles and the availability of prey.

Fisheries interactions are the largest in-water threat to leatherback sea turtle recovery. Leatherbacks are also caught incidentally in high seas longline fishery, which involves more than 2000 vessels, the majority of which are from Japan, Korea, and Taiwan. Current fishing effort is 400 million hooks per year in the western and central Pacific and 200 million hooks per year in the eastern Pacific (Dutton and Squires 2008). Other fisheries that incidentally catch sea turtles include: high seas drift gillnet, coastal driftnet, purse seining, groundfish trawling, and pound nets (Dutton and Squires 2008). Additional mortalities each year along with other impacts remain a threat to the survival and recovery of this species and could slow recovery for sea turtles.

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. Ship-strikes.
3. Acoustic interference from engine noise.
4. Entanglement in towed hydrophone streamer.

5. Sound fields produced by airguns, sub-bottom profiler, and multibeam echosounder.

Based on a review of available information, this opinion determined which of these possible stressors would be likely to occur and which would be discountable or insignificant.

11.1.1 Pollution by Oil or Fuel Leakage

The potential for fuel or oil leakages is extremely unlikely. An oil or fuel leak would 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 *Revelle* is unlikely to cause widespread, high dose contamination (excluding the remote possibility of severe damage to the vessel) that would impact listed species directly or pose hazards to their food sources. Because the potential for fuel or oil 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 whales or leatherback sea turtles.

11.1.2 Ship Strike

We are not aware of a ship-strike by a seismic survey vessel. The *Revelle* will be traveling at generally slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a ship-strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Our expectation of ship strike is discountably small due to the hundreds of thousands of kilometers the *Revelle* has traveled without a ship strike, general expected movement of marine mammals away or parallel to the *Revelle*, as well as the generally slow movement of the *Revelle* during most of its travels (Hauser and Holst 2009; Holst 2009; Holst 2010; Holst and Smultea 2008a). All factors considered, we have concluded the potential for ship strike from the research vessel is highly improbable. Because the potential for ship strike is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that ship strike is not likely to adversely affect ESA-listed whales or leatherback sea turtles.

11.1.3 Disturbance from Engine Noise

We expect that the *Revelle* will add to the local noise environment in its operating area due to the propulsion and other noise characteristics of the vessel's machinery. This contribution is likely small in the overall regional sound field. The *Revelle's* passage past a whale or sea turtle would 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 whales 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 *Revelle* will be traveling at slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a ship strike for whales and sea turtles (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Because the potential acoustic interference from engine noise would be undetectable or so minor that it could not 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 whales or leatherback sea turtles.

11.1.4 Gear Entrapment

The towed hydrophone streamer could come in direct contact with a listed species and sea turtle entanglements have occurred in towed seismic gear. For example, a seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley sea turtle in the foil of towed seismic gear; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the streamer design as well as observations of sea turtles investigating the streamer and not becoming entangled or operating in regions of high turtle density and entanglements not occurring (Hauser 2008; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). To the best of our knowledge, leatherback sea turtles do not occur in high densities in the action area. Instances of such entanglement events with ESA-listed whales are unknown to us. Although the towed hydrophone streamer or passive acoustic array could come in direct contact with a listed species, entanglements are highly unlikely and considered discountable.

Accordingly, this consultation focused on the following stressor likely to occur from the proposed seismic activities and may adversely affect ESA-listed species: acoustic energy introduced into the marine environment by the airgun array and the multibeam echosounder and sub-bottom profiler.

11.2 Mitigation to Minimize or Avoid Exposure

NSF's proposed action includes the use of exclusion zones, protected species observers and operational shutdown in the presence of ESA-listed species. The NMFS' Permits and Conservation Division's proposed IHA would contain additional mitigation measures to minimize or avoid exposure. Both are described in the description of the action, exposure and response analysis were considered throughout our analysis.

11.3 Exposure and Response Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the actions' 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 actions' effects and the population(s) or subpopulation(s) those individuals represent. The *Response Analysis* also considers information on the potential for stranding and the potential effects on the prey of ESA-listed whales and leatherback sea turtles in the action area.

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 airguns.

As part of the application for the IHA pursuant to the MMPA, the NSF provided an estimate of the number of marine mammals that would be exposed to levels of sound in which they would be considered "taken" during the proposed survey. NSF did not provide any take estimates from sound sources other than the airguns, although other equipment producing sound will be used during airgun operations (e.g., the multibeam echosounder and the sub-bottom profiler). In their Federal Register Notice of the proposed IHA, the NMFS' Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed that of the airgun array. Therefore, the NMFS' Permits and Conservation Division did not expect additional exposure from sound sources other than the airguns. Since the sub-bottom profiler and the multibeam echosounder have a lower or roughly equivalent source output as the airgun array (Table 2 and section 3.1.4), we agree with this assessment and similarly focus our analysis on exposure from the airgun array.

During the development of the IHA, the NMFS' Permits and Conservation Division conducted an independent exposure analysis. In this section, we describe both the NSF and the NMFS analytical methods to estimate the number of ESA-listed species that might be exposed to the sound field and considered "taken" as required under the ESA.

The methodology for estimating the number of ESA-listed species that might be exposed to the sound field used by NSF and the NMFS' Permits and Conservation Division were largely the same. Both estimated the number of marine mammals predicted to be exposed to sound levels that would result in harassment by using radial distances to predicted isopleths. Both used those distances to calculate the ensonified area around the airgun array (204.2 square kilometers). To account for possible delays during the survey (e.g., weather, equipment malfunction), a 25 percent contingency was added in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed.

Both NSF and the NMFS Permits and Conservation Division used density estimates from Barlow (2016). The estimated density of each marine mammal species within an area (animals/km^2) is multiplied by the total ensonified areas (km^2) that correspond to the Level B harassment thresholds for the species. The product (rounded) is the estimated number of instances of take for each species. The number of instances of take for each species is then multiplied by 1.25 to account for the 25 percent contingency, as described above. The result is an estimate of the number of instances that marine mammals are predicted to be exposed to airgun sounds above the Level B harassment threshold over the duration of the proposed survey. The total area estimated to be ensonified to the Level B harassment threshold for the proposed survey is 204.2 km^2.

After performing the calculations, NSF increased their take authorization request to one percent of the population size (based on Barlow 2016 estimates). Their purpose in doing so is to ensure that the proposed action has an adequate amount of take authorization. This resulted in a substantial increase between the calculated take and the requested take. For example, for humpback whales, the number of calculated exposures was three; increased to one percent, the requested take authorization was 218. Based on what we know about the marine mammal densities in the action area, we believe that for a cruise of relatively short duration, it is extremely unlikely that this level of take would be reached.

Upon discussions with the NMFS' Permits and Conservation Division, we agreed to adopt the take numbers developed through the calculation method described above. In cases where the calculated take numbers were lower than the mean group size (i.e., sei and sperm whales), we increased the take request to the mean group size. Our rationale was that in the event that a group was encountered during the survey, it was reasonable to expect that the number of individuals in that group would more likely be the mean group size, and less likely that it would be less than that amount.

For our ESA consultation, we evaluated both methods for estimating the number of ESA-listed individuals that would be "taken" relative to the definition of harassment discussed above. We concur with the NMFS' Permits and Conservation Division's analysis.

NMFS applies certain acoustic thresholds to help determine at what point during exposure to seismic airguns (and other acoustic sources) marine mammals are considered "harassed," under the MMPA. These thresholds are used to develop exclusion radii around a source and the necessary power-down or shut down criteria to limit marine mammals and sea turtles' exposure to harmful levels of sound (NMFS 1995). The 175 dB isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airguns, and would serve as the exclusion radii for sea turtles. The 160 dB re 1 μPa_{rms} distance is the distance at which MMPA take, by Level B harassment, is expected to occur, and the threshold at which the NMFS' Permits and Conservation Division is proposing to issue take authorizations for marine mammals. The ESA does not define harassment nor has the NMFS defined the term pursuant to the ESA through regulation. The MMPA of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, "...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is similar to language in the USFWS's regulatory definition of "harass"[5] pursuant to the ESA. For this opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

[5] An intentional or negligent act or omission which creates 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 (50 CFR 17.3)

Airguns contribute a massive amount of anthropogenic energy to the world's oceans ($3.9x10^{13}$ joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kilohertz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

The exposure analysis for this opinion is concerned with the number of fin, sei, blue, humpback, and sperm whales, as well as leatherback sea turtles likely to be exposed to received levels greater than 160 dB re 1 μPa_{rms} (175 dB for sea turtles), which constitute the best estimate of adverse response by listed whales and leatherback sea turtles. The NSF and NMFS' Permits and Conservation Division estimated the expected number of ESA-listed whales exposed to receive levels ≥160 dB re 1 μPa_{rms}. The NMFS' Permits and Conservation Division's data and methodology used were adopted in this opinion because the NMFS' ESA Interagency Cooperation Division believed they represent the best available information and methods to evaluate exposure to listed species.

11.3.2 Whales

Throughout consultation, we worked with the Permits and Conservation Division to develop exposure estimates. We agreed with and adopted the Permits and Conservation Division's methodology for estimating exposure of ESA-listed marine mammals to the proposed action.

Blue, fin, sei, sperm and humpback whales of all age classes are likely to be exposed. Given that the survey will take place in late September, we expect that most whales will be on their feeding grounds or beginning to migrate to their breeding grounds. Whales are expected to be feeding, traveling, or migrating in the area and some females would have young-of-the-year accompanying them. We would normally assume that sex distribution is even for fin, sei, humpback, and blue whales, and sexes are exposed at a relatively equal level. However, sperm whales in the area likely consist of groups of adult females and their offspring and generally consist of more females than males in the group. Therefore, we expect a female bias to sperm whale exposure. For sperm whales, exposure for adult male sperm whales is expected to be lower than other age and sex class combinations.

Table 12. Exposure estimates of ESA-listed species in the action area.

Species	NMFS Exposure Estimate
Humpback Whale*	3
Fin Whale	6
Sei Whale	2
Sperm Whale	6
Blue Whale	1

*See discussion below for details on humpback whale exposure by distinct population segment.

11.3.2.1 Humpback Whale Exposure

In 2016, NMFS revised the listing of humpback whales to identify fourteen distinct population segments (DPS) and listed four as endangered and one as threatened (81 FR 62260). There are three humpback whale distinct population segments that are found off the coasts of California, Washington, and Oregon, while foraging within the region during summer: the Mexico DPS, listed as threatened, and the Central America DPS, listed as endangered. The Hawaii DPS is found off Washington and southern British Columbia, but it is not listed under the ESA. The ESA-listed Mexico and Central America DPSs could both be present within the action area, and it would not be possible for the protected species observers to identify an individual humpback to either DPS during the proposed activities.

To address the difficulty in assigning take given the humpback whale DPS revision of listing, the NMFS West Coast Region Protected Species Division developed guidance to assist in assigning take of humpback whales to a particular DPS based on information of the distribution and abundance of the DPSs off the West Coast. Three DPSs may be present off the U.S. West Coast: Mexico, Central America, and Hawaii DPSs. The Mexico DPS breeding population is estimated at about 3,200, while the Central America DPS breeding population has about 400 individuals. The Hawaii DPS, which is not listed under the ESA, has about 11,400 individuals (Wade et al. 2016).

Humpbacks feed in aggregations off northern Washington and southern British Columbia, in and around Vancouver Island, Queen Charlotte Island, and Cape Flattery. The feeding areas off California and Oregon are well documented, but there is a gap in sightings of humpback whales between central Oregon and central Washington (Calambokidis et al. 2008; Wade et al. 2016). The action area falls between the summer feeding areas off California and Oregon, and those in northern Washington and southern British Columbia.

The action will take place in late September. At that time, we expect that humpbacks will still be either on the summer feeding grounds, or starting to migrate south towards their breeding areas. Since the summer feeding grounds off California and Oregon are south of the action area, we do not believe that individuals from this feeding area will be exposed to the proposed action.

Individuals from the northern Washington and southern British Columbia feeding area may be exposed to the proposed action as they transit through on their migration south.

The West Coast Region put forth a calculation method to determine the DPS origin of humpback whales in summer feeding areas along the U.S. West Coast based on estimates of abundance developed by Wade et al. (2016), and the probability of encountering individual humpbacks from a particular DPS. The probability of humpbacks of DPS origin present on the northern Washington and southern British Columbia is presented in (Table 13).

Table 13. Probability of distinct population segment origin for humpbacks on the northern Washington and southern British Columbia.

	DPS Origin (CV)	DPS Origin (CV)	DPS Origin (CV)
	Mexico (Threatened)	Central America (Endangered)	Hawaii (Not ESA-listed)
	41.9% (0.14)	5.2% (0.91)	52.9% (0.15)
95% confidence interval	30.2 – 53.6%	0 – 14.7%	37 – 69%

Humpback whales on (or migrating from) the northern Washington and southern British Columbia feeding grounds would primarily be from either the non ESA-listed Hawaii DPS (53 percent), or the Mexico DPS (42 percent). A smaller proportion of those humpbacks would be from the Central America DPS. In order to take a cautious approach to assessing impacts to the endangered Central America DPS, the West Coast Region applies a 15 percent probability of encountering a Central America DPS individual, the upper 95 percent confidence interval.

We expect that a total of three humpbacks may be exposed to the proposed action. There is about a 57 percent chance that the action could expose an ESA-listed humpback (42 percent Mexico and 15 percent Central America). By applying the guidance, we would expect that either up to two exposed humpbacks would be from the Mexico DPS (1.26 rounded to two individuals), and that one humpback would be from the Central America DPS (0.45 rounded to one individual). The incidental take statement still would only allow a maximum of three humpbacks taken as a result of the action.

11.3.3 Sea Turtles

NSF did not provide estimates for the expected number of ESA-listed sea turtles exposed to received levels greater than or equal to 175 dB re: 1 μPa_{rms}. Our exposure estimates stem from the best available information on sea turtle densities and a predicted RMS radius of approximately 120 meters along survey track lines. Based on information presented in the

Response Analysis, we expect all exposures at the 175 dB re 1 μPa_{rms} level and above to constitute "take".

11.3.3.1 Exposure of ESA-listed turtles to airguns

NSF presented estimated distances for the 175 dB re: 1 μPa_{rms} sound levels presented by the two 45 cubic inch GI guns. When the array is towed at three meters, in waters 100 to 1,000 meters deep, the predicted established distance at received levels in 120 meters. Sea turtles could experience fitness consequences as a result of the sound created by the airguns at these distances.

As discussed in the *Status of listed resources* section, there is one ESA-listed sea turtle species that is likely to be affected by the proposed action: leatherback sea turtles.

Estimating exposure for leatherback sea turtles in the action area was challenging, as there is scant information on sea turtle density or population estimates specific to the waters off the Pacific Ocean, off the coasts of Washington and Oregon. To estimated exposure for leatherback sea turtles, we relied on recent reports and scientific literature focusing on leatherbacks in the area.

Significant leatherback nesting sites occur in the western Pacific Ocean on beaches in Papua Barat Indonesia, Papua New Guinea, and the Solomon Islands, and in the eastern Pacific on beaches in Mexico, Costa Rica, and elsewhere throughout Central America (NMFS 2016). Leatherbacks in the Pacific nest from late fall through spring, with dates varying by region. Nesting typically occurs during November through March in Papua New Guinea (Benson 2007), and from October through January for leatherbacks nesting in Mexico (Fritts 1982). Since there are no nesting sites in or near the action area, we do not expect nesting females or leatherback hatchlings to be exposed to the proposed action.

After nesting, adults undergo long-distance migrations to foraging grounds. Leatherbacks tagged in Indonesia took ten to twelve months to travel across the Pacific to foraging areas about 50 to 100 kilometers off the coasts of Oregon and Washington (Benson 2007; Benson 2011). During aerial surveys, leatherbacks were sighted in the same area between June and September, mostly over slope waters (200 to 2,000 meters deep) and continental shelf waters (less than 200 meters deep) (Bowlby 1994). The fact that leatherback prey, cnidarians (i.e., jellyfish), occurs in high densities in the region and supports leatherback foraging was a primary reason for designating the area as critical habitat in 2012 (77 FR 41705). Based on this information, and the timing and location of the activities, we expect that foraging leatherbacks would be exposed to the proposed action.

We are unable to quantify the level of leatherback sea turtle exposure. We expect leatherback sea turtle exposure to occur because the available information indicates that the species is present in the action area during the proposed seismic activities. As discussed earlier, there are no reliable leatherback sea turtle population estimates for the South Atlantic. Thus, it is not possible to quantify the proportion of the overall population that may be exposed to the proposed activity.

11.3.3.2 Exposure of leatherback sea turtles to multibeam echosounder and sub-bottom profiler

Sea turtles hear in the low frequency range. The multibeam echosounder operates at 10.5 to 13 kilohertz and the sub-bottom profiler operates at 3.5 kilohertz, which emit sounds outside the hearing frequency of sea turtles. Thus, sea turtles are not expected to respond to sounds emitted by multibeam echosounder or sub-bottom profiler.

11.3.4 Response Analysis

A pulse of seismic airgun sound 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 whales and leatherback 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 the prey of ESA-listed whales and sea turtles in the action area.

As discussed in the *Approach to the assessment* section of this opinion, response analyses determine how listed resources are likely to respond after exposure to an action's effects on the environment or directly on 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 reducing the fitness of listed individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

11.3.4.1 Potential responses of ESA-listed whales to acoustic sources

Marine mammals and threshold shifts. Exposure of marine mammals to very strong sound pulses can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Threshold shift depends upon the duration, frequency, sound pressure, and rise time of the sound. A temporary threshold shift (TTS) results in a temporary hearing change (Finneran 2013), and can last minutes to days. Full recovery is expected. However, a recent mouse study 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 and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur, meaning lost auditory sensitivity is unrecoverable. These conditions can result either from 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. 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 2000).

Few data are available to precisely define each listed species' hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Low-frequency baleen whales (e.g., sei, fin, and humpback) have an estimated functional hearing frequency range of 7 hertz to 35 kilohertz (Table 14).

Table 14. Marine functional mammal hearing groups and their generalized hearing ranges.

Hearing Group	Generalized Hearing Range*
Low Frequency Cetaceans (Baleen Whales)	7 Hz to 35 kHz
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales)	150 Hz to 160 kHz
High Frequency Cetaceans (True Porpoises, Kogia spp., River Dolphins, Cephalorhynchid, Lagenorhynchus cruciger, and Lagenorhynchus australis)	275 Hz to 160 kHz

*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 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 would 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). 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 *Revelle's* airgun array, an individual would 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 and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 190 dB re 1 μPa_{rms}, PTS could occur. A marine mammal would have to be within 100 meters of the *Revelle's* airgun array to be within the 190 dB re 1 μPa_{rms} isopleth and risk a TTS. Estimates that are conservative for species impact evaluation are 230 dB re 1 μPa (peak) for a single pulse, or multiple exposures to approximately 198 dB re 1 μPa^2s.

Overall, we do not expect TTS or PTS to occur to any ESA-listed whale because of airgun exposure for several reasons. We expect that individuals will move away from the airgun array as it approaches. As the survey proceeds along each transect line 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 would induce TTS or PTS. Ramp-ups would also reduce the probability of TTS-inducing exposure at the start of seismic surveys for the same reasons, as acoustic intensity increases, animals will move away. Furthermore, mitigation measures would be in place to initiate a power-down if individuals enter or are about to enter the 180 dB or 190 dB isopleth during full airgun operations, which is below the levels believed to be necessary for potential TTS. As stated in the *Exposure analysis*, each individual is expected to be potentially exposed dozens of times to 160 dB re 1 μPa_{rms} levels. We do not expect this to produce a cumulative TTS, PTS, or other injury for several reasons. We expect that individuals will recover 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.

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 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 (Marshall 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

There is frequency overlap between airgun sounds and vocalizations of ESA-listed whales, particularly baleen whales but also sperm whales. The proposed seismic surveys could mask whale calls at some of the lower frequencies. 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 whales clicks is concentrated at two to four kilohertz and ten to 16 kilohertz, and though the findings by Madsen et al. (2006) suggest frequencies of seismic pulses can overlap this range, the strongest spectrum levels of airguns are below 200 hertz (zero to 188 hertz for the *Revelle* airguns). Any masking that might occur would likely be temporary because seismic sources are not continuous and the seismic vessel would continue to transit through the area.

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 would be expected to pose a somewhat greater risk of masking. The *Langseth*'s airguns will emit a 0.1-second pulse when fired every five seconds. Therefore, pulses will not "cover up" the vocalizations of listed whales to a significant extent (Madsen et al. 2002).

We address the response of listed whales stopping vocalizations because of airgun sound in the *Marine mammals and behavioral responses* section below.

Although seismic sound pulses 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 shallow water environments, seismic 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 would not be as severe as the usual types of masking studies might suggest (Marshall 1995). The dominant background noise may be 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, beluga whale, and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain 1993; Bain 1994; Dubrovskiy 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 1974; Lesage 1999; Moore 1990; Romanenko 1992; Thomas 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 2004; Holt 2009; Lesage 1999; Lesage 1993; Parks 2009; Parks 2007; 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, Akopian (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 was 18 kilohertz, in contrast to the pronounced effect at higher frequencies. Studies have noted directional hearing at frequencies as low as 0.5 to two kilohertz in several marine mammals, including killer whales (Marshall 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 of such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such masking.

Marine mammals and behavioral responses. We expect the greatest response to airgun sounds in terms of number of responses and overall impact to be in the form of changes in behavior. Listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case the effects can equate to take but are unlikely to be significant at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic 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 2013). Although some studies are available which address responses of listed whales 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-listed or species outside the action area are also considered here. Individual differences in responding to stressful stimuli also appear to exist and appear to have at least a partial genetic basis in trout (Laursen 2011). Animals generally respond to anthropogenic perturbations as they would 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 2013).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to airgun sound. 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. 1995a; 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 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995a). 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 (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* (*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. Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and 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_{p-p} (Madsen et al. 2002; McCall Howard 1999). Some exposed individuals may cease calling in response to the *Revelle's* airguns. If individuals ceased calling in response to the *Revelle's* airguns during the course of the proposed survey, the effect would likely be temporary.

There are numerous studies of the responses of some baleen whale 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} as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c). Activity of individuals seems to influence response (Robertson 2013), as feeding individuals respond less than mother/calf pairs and migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999). Surface duration decreased markedly during seismic sound exposure, especially while individuals were engaged in traveling or non-calf social interactions (Robertson 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 kilometers, 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. 1995c; 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 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 2013). Despite the above information and exposure to repeated seismic surveys, bowheads continue to return to summer feeding areas and when displaced, appear to reoccupy areas 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 individuals that tolerate repeat exposures 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 and Williams 2006; Gailey et al. 2007; Johnson et al. 2007b; Malme and 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 and slight behavioral changes at 140 to 160 dB re 1 μPa_{rms} (Malme and Miles 1985; Malme et al. 1984). As with bowheads, 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. (2007a) reported that gray whales exposed to seismic airguns off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002–2005.

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 seven to 12 kilometers from the seismic 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 three to four kilometers, although some individuals (mainly males) approached to within 100 meters on occasion where sound levels were 179 dB re 1 μPa_{rms}. Changes in course and speed generally occurred at estimated received level of 157 to 164 dB re 1 μPa_{rms}.

Natural sources of sound also influence humpback behavior. Migrating humpbacks showed evidence of a Lombard effect in Australia, increasing vocalization in response to wind-dependent background noise (Dunlop 2014a). Since natural sources 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 humpbacks. In a preliminary study examining the responses by migrating humpbacks of exposure to a 20 cubic inch air gun, researchers found that the 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., a towed air gun, not in operation) (Dunlop 2014b). Whales in groups may pick up on 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 air gun array on humpback behavior (Dunlop 2014b).

Feeding humpbacks appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150 to 169 dB re: 1 µPa and no clear evidence of avoidance was apparent at received levels up to 172 re: 1 μPa_{rms} (Malme et al. 1984; Malme et al. 1985). Potter et al. (2007) found that humpbacks on feeding grounds in the Atlantic 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 and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities) as well as whales being more distant during seismic operations (Moulton et al. 2006a; Moulton et al. 2006b; Moulton and Miller 2005). When spotted at the average sighting distance, individuals would have likely been exposed to approximately 169 dB re: 1 μPa_{rms} (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found Atlantic sperm whales to show little or no response (Davis et al. 2000; Madsen et al. 2006;

Miller et al. 2009; Moulton et al. 2006a; Moulton and Miller 2005; Stone 2003; Stone and Tasker 2006; Weir 2008). Detailed study of Gulf of Mexico sperm whales suggests some alteration in foraging from less than 130 to 162 dB re: 1 μPa_{p-p}, although other behavioral reactions were not noted by several authors (Gordon et al. 2006; Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2004; Jochens 2003; 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 and 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 nonrandom distribution of satellite-tagged sperm whales at and beyond five kilometers from seismic airgun arrays, suggesting individuals were not displaced or move away from the array at and beyond these distances in the Gulf of Mexico (Mate 2013). However, no tagged whales within five kilometers were available to assess potential displacement within five kilometers (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 hertz) pulses produced by seismic airguns (Richardson et al. 1995c). Sperm whales are exposed to considerable energy above 500 hertz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 μPa lower at one kilohertz and 60 dB re: 1 μPa lower at 80 kilohertz 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 seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area at least temporarily. We also expect secondary foraging areas to be available that would allow whales to continue feeding. Although breeding may be occurring, we are unaware of any habitat features that whales would be displaced from that is essential for breeding if whales depart an area as a consequence of the *Revelle*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities. Individuals engaged in travel or migration would continue with these activities, although potentially with a deflection of a few kilometers from the route they would otherwise pursue.

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, these effects are not readily observable.

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 2001; Gulland 1999; St. Aubin 1988; St. Aubin 1996; Thomson 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 2003; Dickens 2010; Dierauf 2001; Elftman 2007; Fonfara 2007; Kaufman 1994; Mancia 2008; Noda 2007; Thomson 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner 1997; Hunt 2006; Keay 2006; Romero et al. 2008; St. Aubin 1996). Stress is lower in immature right whales than adults are and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt 2006; Keay 2006).

Loud noises generally increase stress indicators in mammals (Kight 2011). Romano (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re: 1 $\mu Pa \cdot m_{p-p}$) 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 United States; 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 would 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 expected to be accompanied by physiological stress responses (NMFS 2006g; NRC 2003b). As we do not expect individuals to experience

TTS or PTS, (see *Marine mammals and threshold shifts*), we also do not expect any listed individual to experience a stress response at high levels. We assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, the stressor (sounds associated with the airgun, multibeam echosounder, or sub-bottom profiler) will dissipate in a short period as the vessel (and stressors) transects away without significant or long-term harm to the individual via the stress response.

Exposure to loud noise 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 noteworthy that although various exposures to loud noise appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa; the impacts of even loud sound are complex and not universally negative (Kight 2011).

It is possible that an animal's prior exposure to seismic sounds influences its future response. We have little information available to us as to what response individuals would have to future exposures to seismic sources compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response would 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) (Andre 1997; André 1997; Gordon et al. 2006). We do not believe sensitization would occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to seismic sounds that would 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 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, 8,490 cubic inch airgun array 22 kilometers offshore the general area at the time that strandings occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002) as some vacationing marine mammal researchers who happened upon the stranding were ill-equipped to perform an adequate necropsy. 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 seismic sound sources and beaked whale strandings (Cox 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 2000; Kerby 2004; Moberg 2000; Relyea 2005; Romero 2004). At present, the factors of seismic airguns 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 to for use will cause marine mammal strandings. We do not expect listed whales to strand because 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 listed whales. Unfortunately, species-specific information on the prey of listed whales and pinnipeds is not generally available. Until information that is more specific is available, we expect that teleost, cephalopod, and krill prey of listed whales to react in manners similar to those fish and invertebrates described herein.

Some support has been found for fish or invertebrate mortality resulting from airgun exposure, and this is limited to close-range exposure to high-amplitudes (Bjarti 2002; D'Amelio 1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). We expect fish to be capable of moving away from the airgun array if it causes them discomfort.

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

By far the most common response by fishes is a startle or distributional response, where fish react shortly 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 generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (Fewtrell 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1 $\mu Pa_{0\text{-}p}$ and alarm responses at greater than 177 dB re: 1 $\mu Pa_{0\text{-}p}$ (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after seismic firing ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 re 1 $\mu Pa_{0\text{-}p}$. Caged European sea bass showed elevated stress levels when exposed to airguns, but levels returned to normal after 3 days (Skalski 1992). These fish also showed a startle response when the survey vessel was as much as 2.5 kilometers 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 exhibited a downward distributional shift upon exposure to 178 dB re: 1 $\mu Pa_{0\text{-}p}$ airgun sound, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to192 dB re: 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from airgun sound (Dalen and Knutsen 1986). Hake may redistribute downward (La Bella et al. 1996). Lesser sand eels exhibited initial startle responses and upward vertical movements before fleeing from the survey area upon approach of an active seismic vessel (Hassel et al. 2003; Hassel et al. 2004). McCauley et al. (2000; 2000a) found smaller 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 did not respond to airgun sounds received at 195 to 218 dB re: 1 $\mu Pa_{0\text{-}p}$, but did exhibit continual startle responses and fled from the seismic source when visible (Wardle et al. 2001). Blue whiting and mesopelagic fishes were found to redistribute 20 to 50 meters deeper in response to airgun ensonification and a shift away from the survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 $\mu Pa_{p\text{-}p}$ sound levels from an airgun (Thomsen 2002). Cod and haddock 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 $\mu Pa_{0\text{-}p}$ (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994). Increased swimming activity in response to airgun exposure, 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 $\mu Pa_{0\text{-}p}$ (Turnpenny and Nedwell

1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no differences in trawl catch data before and after seismic operations and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching airguns.

Squid responses to airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 μPa_{rms} by first ejecting ink and then moving rapidly away from the area (Fewtrell 2013b; McCauley et al. 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}. Tenera Environmental (2011) reported that Norris and Mohl (1983, summarized in Mariyasu et al. 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after three to 11 minutes. André (2011) exposed four cephalopod species (*Loligo vulgaris, Sepia officinalis, Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 hertz at 157 plus or minus five dB re 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 plus or minus five 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 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 (Christian 2013). However, feeding did increase in exposed individuals (Christian 2013).

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We do not expect krill (the primary prey of most listed baleen whales) to experience effects from airgun sound. 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. Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed survey. Based upon the best available information, fishes and squids ensonified by the approximately 160 dB isopleths could vacate the area and/or dive to greater depths, and be more alert for predators. We do not expect indirect effects from airgun activities through reduced feeding opportunities for listed whales and pinnipeds to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both sperm whales and their prey would re-distribute back into the area once survey activities have passed.

Marine mammal response to multibeam echosounder and sub-bottom profiler. We expect listed whales to experience ensonification from not only airguns, but also seafloor and ocean current mapping systems. The multibeam echosounder and sub-bottom profiler used in this survey operate at frequencies of 10.5 to 13 kilohertz, and 3.5 kilohertz, respectively. These frequencies are within the functional hearing range of baleen whales, such as the ESA-listed humpback, blue, fin and sei whales.[6] 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 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kilohertz within the 80 to 90 dB re: 1 μPa range, it is difficult to determine the significance of this because the 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 4.0 kilohertz 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 2013). Hearing is poorly understood for 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 multibeam echosounder and sub-bottom profiler systems (Ketten 1997; Oleson 2007; Richardson et al. 1995c).

Assumptions for humpback and sperm whale hearing are much different than for other listed whales. Humpback and sperm whales vocalize between 3.5 to 12.6 kilohertz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000a; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986b; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Weir et al. 2007; Winn et al. 1970). The response of a blue whale to 3.5 kilohertz sonar supports this species ability to hear this signal as well (Goldbogen 2013). Maybaum (1990; 1993) observed that Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kilohertz 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 would have to pass at close range and be swimming at speeds similar to the vessel. The animal would 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 casue TTS. Sperm whales have stopped vocalizing in response to six to 13 kilohertz pingers, but did not respond to 12 kilohertz echo-sounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975). Sperm whales exhibited a startle response to ten-kilohertz pulses upon exposure while resting and feeding, but not while traveling (Andre 1997; André 1997).

[6] http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kilohertz multibeam echosounder, similar in operating characteristics as that proposed for use aboard the *Revelle*, suggest that this sonar played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data to suggest a direct physical affect are lacking and the authors acknowledge that although the use of this type of sonar is widespread and common place 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 multibeam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Revelle*'s multibeam echosounder. Although effects such as this have not been documented for ESA-listed species, the combination of exposure to 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 would otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis 2013).

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 Scripps Institution of Oceanography differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multibeam echosounder and sub-bottom profiler. The sound energy received by any individuals exposed to the multibeam echosounder and sub-bottom profiler sources during the proposed activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multibeam echosounder and sub-bottom profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Although thousands of vessels around the world operate navigational sonars routinely, strandings have not been correlated to use of these sonars. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, fin, sei, sperm, or humpback whale communications to appreciably occur due to multibeam echosounder or sub-bottom profiler signal directionality, low duty cycle, and the brief period when an individual could be within its beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multibeam echosounder was less than three percent that of ship strike. Behavioral responses to the mulitbeam echosounder and sub-bottom profiler are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. However, the pulsed signals from the sub-bottom profiler are considerably weaker than those from the multibeam echosounder. In addition, we do not expect hearing impairment and other physical effects if the animal is in the area, and it would have to pass the transducers at close range and in order to be subjected to sound levels that could cause temporary threshold shift.

11.3.4.2 Potential responses of leatherback sea turtles to acoustic sources

As with marine mammals, leatherback sea turtles may experience:

- hearing threshold shifts,
- behavioral responses and
- non-auditory physical or physiological effects.

Sea turtles and threshold shifts. Although leatherback sea turtles detect low frequency sound, the potential effects on sea turtle biology remain largely unknown (Samuel et al. 2005). Few data are available to assess sea turtle hearing, let alone the effects seismic equipment may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead experienced TTS upon multiple airgun exposures in a shallow water enclosure, but recovered within one day.

As with marine mammals, we assume that sea turtles will not move towards a source of stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sources (McCauley et al. 2000a; McCauley et al. 2000b; Moein et al. 1994), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of seismic airgun pulses (Smultea and Holst 2003). For this reason, mitigation measures are also in place to limit sea turtle exposure. Although data on the precise levels that can result in TTS or PTS are lacking, because of the mitigation measures and our expectation that turtles would move away from sounds from the airgun array, we do not expect turtles to be exposed to sound levels that would result in TTS or PTS.

Sea turtles and behavioral responses. As with ESA-listed marine mammals, it is likely that sea turtles will experience behavioral responses in the form of avoidance. We do not have much information on how leatherback sea turtles specifically will respond, but we present the available information on other sea turtle species. O’Hara and Wilcox (1990) found loggerhead sea turtles exhibited an avoidance reaction at an estimated sound level of 175 to 176 dB re: 1 μPa $_{rms}$ (or slightly less) in a shallow canal. Green and loggerhead sea turtles avoided airgun sounds at received sound levels of 166 dB re 1 µPa and 175 dB re 1 µPa, respectively (McCauley et al. 2000a; McCauley et al. 2000b). Sea turtle swimming speed increased and becomes more erratic at 175 dB re 1 µPa, with individuals becoming agitated. Loggerheads also appeared to move towards the surface upon airgun exposure (Lenhardt 1994b; Lenhardt et al. 1983). However, loggerheads resting at the ocean surface were observed to startle and dive as active seismic source approached them (DeRuiter 2012). Responses decreased with increasing distance of closest approach by the seismic array (DeRuiter 2012). The authors developed a response curve based upon observed responses and predicted received exposure level. Recent monitoring studies show that some sea turtles move away from approaching airguns, although sea turtles may approach active seismic arrays within ten meters (Holst 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006e; NMFS 2006h).

A sea turtle's behavioral responses to sound are assumed variable and context specific. For instance, a single impulse may cause a brief startle reaction. A sea turtle may swim farther away from the sound source, increase swimming speed, change surfacing time, and decrease foraging if the stressor continues to occur. For each potential behavioral change, the magnitude of the change ultimately would determine the severity of the response; most responses would be short-term avoidance reactions.

Some studies have investigated behavioral responses of sea turtles to impulsive sounds emitted by airguns (McCauley 2000; Moein Bartol 1995; O'Hara 1990). There are no studies of sea turtle behavioral responses to sonar. Cumulatively, available airgun studies indicate that perception and a behavioral reaction to a repeated sound may occur with sound pressure levels greater than 166 dB re 1 μPa root mean square, and that more erratic behavior and avoidance may occur at higher thresholds around 175 to 179 dB re 1 μPa root mean square (McCauley 2000; Moein Bartol 1995; O'Hara 1990). When exposed to impulsive acoustic energy from an airgun above 175 dB re 1 μPa root mean square, sea turtle behavior becomes more erratic, possibly indicating the turtles were in an agitated state (McCauley et al. 2000). A received level of 175 dB re 1 μPa root mean square is more likely to be the point at which avoidance may occur in unrestrained turtles, with a comparable sound exposure level of 160 dB re 1 μPa2 -s (McCauley 2000). Airgun studies used sources that fired repeatedly over some duration. For single impulses at received levels below threshold shift (hearing loss) levels, the most likely behavioral response is assumed to be a startle response. Since no further sounds follow the initial brief impulse, the biological significance is considered minimal.

Behavioral responses of sea turtles to airgun exposures in caged enclosures are likely to be different from those from turtles exposed to impulsive acoustic sources from seismic activities in the open environment. Although information regarding the behavioral response of sea turtles to acoustic stressors is generally lacking, McCauley (2000) provides an indication that 175 dB re 1 μPa root mean square is a reasonable threshold criterion in the absence of more rigorous experimental or observational data. The 175 dB re 1 μPa root mean square threshold criterion for behavioral take in sea turtles may change with better available information in the future, but currently is the best available science. To assess the number of sea turtles expected to behaviorally respond to acoustic stress all turtles exposed to sound equal to, or greater than, 175 dB and less than the criterion for TTS were summed. No attempt to process these exposures or evaluate the effectiveness of mitigation measures was made, suggesting any behavioral take estimates of sea turtles from acoustic stressors are likely overestimates. We are unaware of any sea turtle response studies to non-impulsive acoustic energy; therefore, we used the same criteria as those for impulsive acoustic stressors.

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re: 1 μPa. At 175 dB re: 1 μPa, we anticipate some change in swimming patterns and a stress response of exposed individuals. Some turtles may approach the active seismic array to closer proximity, but we expect them to eventually turn away. We expect temporary displacement of exposed individuals from some portions of the action area while the *Revelle* transects through.

Sea turtles and stress. Direct evidence of seismic sound causing stress is lacking in sea turtles. However, we expect sea turtles to generally avoid high-intensity exposure to airguns in a fashion similar to predator avoidance. As predators generally induce a stress response in their prey (Dwyer 2004; Lopez 2001; Mateo 2007), we assume that sea turtles experience a stress response to airguns when they exhibit behavioral avoidance or when they are exposed to sound levels apparently sufficient to initiate an avoidance response (approximately 175 dB re: 1 µPa). We expect breeding adult females may experience a lower stress response, as female loggerhead, hawksbill, and green sea turtles appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). Individuals may experience a stress response at levels lower than approximately 175 dB re: 1 µPa, but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

Sea turtle response to multibeam echosounder and sub bottom profiler. Sea turtles do not possess a hearing range that includes frequencies emitted by these systems. Therefore, listed sea turtles will not hear these sounds even if they are exposed and are not expected to respond to them.

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 using changes in the individual’s fitness, which may be indicated by changes to the individual’s growth, survival, annual reproductive fitness, and lifetime reproductive success. When we do not expect ESA-listed animals exposed to an action’s effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise.

We expect that up to one blue, two fin, six sei, three humpback, and six sperm whales, or any leatherback sea turtles within the 120-meter area during airgun operations, to be exposed to the airguns during the seismic survey. Because of the mitigation measures in the IHA, and the relatively low-energy nature of the seismic survey, we do not expect any mortality to occur from the harassment or incidental capture that may occur because of the proposed action. The proposed action will result in temporary stress to the exposed whales or leatherback sea turtles that is not expected to have more than short-term effects on individual blue, fin, sei, sperm, or humpback whales, or leatherback sea turtles.

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 because 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 and Critical Habitat* (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.

For whales exposed to seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area at least temporarily. We also expect secondary foraging areas to be available that would allow whales to continue feeding. Although breeding may be occurring, we are unaware of any habitat features that whales would be displaced from that is essential for breeding if whales depart an area as a consequence of the *Revelle*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities. Individuals engaged in travel or migration would continue with these activities, although potentially with a deflection of a few kilometers from the route they would otherwise pursue.

We expect exposed leatherback sea turtles to experience some degree of stress response upon exposure the airguns. We also expect many of these individuals to respond behaviorally by exhibiting a startle response or by swimming away. We do not expect more than temporary displacement or removal of individuals for a period of hours from small areas because of the proposed actions. Individuals responding in such ways may temporarily cease feeding, breeding, resting, or otherwise disrupt vital activities. However, we do not expect that these disruptions will cause a measureable impact to any individual's growth or reproduction. Overall, we do not expect any population to experience a fitness consequence because of the proposed actions and, by extension, do not expect species-level effects.

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.

During this consultation, we searched for information on future state, tribal, local or private (non-Federal) actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline (Section 10), which we expect will continue in the future. Anthropogenic effects include climate change, ship strikes, sound, military activities, fisheries, pollution, and scientific research, although some of these activities would involve a federal nexus and thus, but subject to future ESA section 7 consultation. An increase in these activities could result in an increased effect on ESA-listed species; however, the magnitude and significance of any anticipated effects remain unknown at this time. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-listed whale or leatherback sea turtle populations.

14 Conclusion

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, 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, fin, sei, sperm, and Mexico DPS or Central America DPS humpback whales, or leatherback sea turtles. No critical habitat will be affected.

15 Incidental Take Statement

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 take of endangered or threatened species. 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. 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, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

NMFS also must provide reasonable and prudent measures that are necessary or appropriate to minimize the impacts to the species, and terms and conditions to implement the measures.

Section 7(o)(2) provides that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited under section 9(a) the ESA and regulations issued pursuant to section 4(d) if that action is performed in compliance with the terms and conditions of this incidental take statement.

15.1 Amount or Extent of Take

If the amount or location of track line surveyed changes, or the number of survey days is increased, then incidental take for marine mammals and sea turtles may be exceeded. As such, if more track lines are surveyed, an increase in the number of survey days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun source levels occur, re-initiation of consultation will be necessary.

15.1.1 Whales

The NMFS anticipates the proposed seismic survey in the East Pacific Ocean off the coast of Oregon and Washington is likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 15). We expect up to 1 blue, 2 fin, 6 sei, 3 humpback (two Mexico and one Central America DPS), and 6 individual sperm whales could be exposed to airgun sounds during the course of the proposed seismic survey, which will elicit a behavioral response that would constitute harassment. Harassment is expected to occur at received levels above 160 dB re: 1 μPa for ESA-listed whales.

For all species of marine mammals, this incidental take would result from exposure to acoustic energy during seismic operations and would be in the form of harassment, and is not expected to result in the death or injury of any individuals that are exposed.

Table 15. Amount of incidental take of ESA-listed marine mammals authorized by the Incidental Take Statement.

Species	Number of Individuals Authorized for Incidental Take
Blue whale	1
Fin whale	2
Sei whale	6
Humpback whale	3
Sperm whale	6

15.1.2 Sea turtles

We also expect individual leatherback sea turtles could be exposed to airgun sounds during the course of the proposed seismic survey that will elicit a behavioral response that would constitute harassment. No death or injury is expected for individual sea turtles who are exposed to the seismic activities.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take.

Because there are no reliable estimates of sea turtle population density in the action area, it is not practical to develop numerical estimates of sea turtle exposure. We are relying on the extent of the 175 dB exclusion zone as a surrogate for sea turtle take. Harassment for sea turtles is expected to occur at received levels above 175 dB re: 1 μPa, which includes a 14.4 km^2 area in the northeastern Pacific based upon the propagation and track line estimates provided by the NSF. A sea turtle within the 14.4 km^2 area during airgun operations would be affected by the stressor, and thus taken by harassment.

The extent of the ensonified area is calculated based on the number of airguns used during seismic operations, the tow depth of the airgun array, and the depth of the water in the action area. The tow depth and the water depth can change the predicted distances to which sound levels 175 dB re: 1 μPa are received, so we are assuming the largest predicted established distance of 14.4 km^2 for the 175 dB exclusion zone so as not to underestimate the effect of the stressor. As we cannot determine the number of individuals to which harassment will occur, we expect the extent of exposure will occur within the 175 dB isopleth of the *Revelle's* airgun array.

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. Reasonable and Prudent Measures

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 and the NSF must ensure that the SIO implements and monitors the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of blue, fin, sei, humpback, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA and as specified below for leatherback sea turtles. 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.

15.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the NSF, SIO, and NMFS' Permits and Conservation Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. The terms and conditions described below are nondiscretionary, and must be undertaken by NSF, Scripps Institution of Oceanography, and the Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply.

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, SIO, 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 SIO, and the NMFS' Permits and Conservation Division shall ensure the conditions listed in this section.

Mitigation Requirements

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

- SIO must use at least three dedicated, trained, NMFS-approved protected species observers. The protected species observers 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. The protected species observers' resumes shall be provided to NMFS for approval.
- At least one protected species observer must have a minimum of 90 days at-sea experience working as a protected species observer during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One "experienced" visual protected species observer shall be designated as the lead for the entire protected species observation team. The lead protected species observer shall serve as primary point of contact for the vessel operator.

Visual Observation

- During survey operations (e.g., any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, protected species observer(s) must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset).
- Visual monitoring must begin not less than 30 minutes prior to ramp-up, including for nighttime ramp-ups of the airgun array, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.
- Protected species observers shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

- Protected species observers 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 observation per 24-hour period.
- During good conditions (e.g., daylight hours; Beaufort sea state 3 or less), visual protected species observers shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

Exclusion Zone and Buffer Zone

- Protected species observers shall establish and monitor a 100-meter exclusion zone and 200-meter buffer zone. The zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the exclusion zone but within 200 meter from any element of the airgun array shall be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the exclusion zone, or on a course to enter the exclusion zone, shall trigger further mitigation measures as described below.

Ramp-up

- A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45 cubic inch airgun, and the second 45 cubic inch airgun would be added after five minutes.
- If the airgun array has been shut down due to a marine mammal detection, ramp-up shall not occur until all marine mammals have cleared the exclusion zone. A marine mammal is considered to have cleared the exclusion zone if:
    - It has been visually observed to have left the exclusion zone; or
    - It has not been observed within the exclusion zone, for 15 minutes (in the case of small odontocetes) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).
- Thirty minutes of pre-clearance observation of the 100-meter exclusion zone and 200-meter buffer zone are required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the 100 meter exclusion zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the exclusion zone or until an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).
- During ramp-up, protected species observers shall monitor the 100-meter exclusion zone and 200-meter buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100 meter exclusion zone. If

a marine, mammal is observed within or approaching the 100-meter exclusion zone during ramp-up, a shutdown shall be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100-meter exclusion zone or until an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes and 30 minutes for mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).

- If the airgun array has been shut down for reasons other than mitigation (e.g., mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if protected species observers have maintained constant visual observation and no visual detections of any marine mammal have occurred within the buffer zone.
- Ramp-up at night and at times of poor visibility shall only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100-meter exclusion zone and 200-meter buffer zone have been continually monitored by visual protected species observers for 30 minutes prior to ramp-up with no marine mammal detections.
- The vessel operator must notify a designated protected species observer of the planned start of ramp-up. A designated protected species observer must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the protected species observer to proceed.

Shutdown Requirements

- An exclusion zone of 100 meters shall be established and monitored by protected species observers. If a marine mammal is observed within, entering, or approaching the 100-meter exclusion zone all airguns shall be shut down.
- Any protected species observer on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant protected species observer must call for such action immediately.
- The operator must establish and maintain clear lines of communication directly between protected species observers on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing protected species observers to maintain watch.
- When a shutdown is called for by a protected species observer, the shutdown must occur and any dispute resolved only following shutdown.
- Upon implementation of a shutdown, the source may be reactivated under the conditions described previously (i.e., instructions for ramping up at night). Where there is no relevant zone (e.g., shutdown due to observation of a calf), a 30-minute clearance period must be observed following the last observation of the animal(s).

- Shutdown of the array is required upon observation of a whale (i.e., sperm whale or any baleen whale) with calf, with "calf" defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult, at any distance.
- Shutdown of the array is required upon observation of an aggregation (i.e., six or more animals) of large whales of any species (i.e., sperm whale or any baleen whale) that does not appear to be traveling (e.g., feeding, socializing, etc.) at any distance.
- Shutdown of the array is required upon observation of a killer whale at any distance.

Vessel Strike Avoidance

- Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course, as appropriate, to avoid striking any marine mammal, unless such action represents a human safety concern. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.
- The vessel must maintain a minimum separation distance of 100 meters from large whales, unless such action represents a human safety concern. The following avoidance measures must be taken if a large whale is within 100 meters of the vessel:
    - The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established unless such action represents a human safety concern.
    - If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 meters unless such action represents a human safety concern.
- The vessel must maintain a minimum separation distance of 50 meters from all other marine mammals, with an exception made for animals described previously above (i.e., protected species observer monitoring of the ramp-up) that approach the vessel. If an animal is encountered during transit, the vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course unless such action represents a human safety concern.
- Vessel speeds must be reduced to ten knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel unless such action represents a human safety concern.

Miscellaneous Protocols

- The airgun array must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Operational capacity of 90 cubic inches (not including redundant backup

airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the protected species observer(s) on duty and fully documented. The lead protected species observer must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.
- Testing of the acoustic source involving all elements requires normal mitigation protocols (e.g., ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

Monitoring Requirements

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

- The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the protected species observers. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.
- Protected species observers must also be equipped with reticle binoculars (e.g., 7 by 50) of appropriate quality (i.e., Fujinon or equivalent), global positioning system, digital single-lens reflex camera of appropriate quality (i.e., Canon or equivalent), compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

Protected Species Observer Qualifications

- Protected species observers must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program.
- Protected species observers must have successfully attained a bachelor’s degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the protected species observer has acquired the relevant skills through alternate experience. Requests for such a waiver must include written justification. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to protected species observer duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a protected species observer; the protected species observer should demonstrate good standing and consistently good performance of protected species observer duties.

Data Collection

- Protected species observers must use standardized data forms, whether hard copy or electronic. Protected species observers shall 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 to resume survey. If required mitigation was not implemented, protected species observers should submit a description of the circumstances. We require that, at a minimum, the following information be reported:
    - Protected species observer who sighted the animal;
    - Time of sighting;
    - Vessel location at time of sighting;
    - Water depth;
    - Direction of vessel's travel (compass direction);
    - Direction of animal's travel relative to the vessel;
    - Pace of the animal;
    - Estimated distance to the animal and its heading relative to vessel at initial sighting;
    - Identification of the animal (e.g., species/genus, lowest possible taxonomic level, or unidentified); also note the composition of the group if there is a mix of species;
    - Estimated number of animals (high/low/best);
    - Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
    - 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).
    - Detailed behavior observations (e.g., number of blows, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior).
    - Animal's closest point of approach and/or closest distance from the center point of the acoustic source.
    - Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
    - Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up, speed or course alteration, etc.) and time and location of the action.

Reporting

- SIO shall submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used must be provided as an ESRI shapefile with all necessary files and appropriate metadata. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the data collected as required under the condition described above concerning data collection. The draft report must be accompanied by a certification from the lead protected species observer as to the accuracy of the report, and the lead protected species observer may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.

- In the event that a humpback whale is taken during the survey, protected species observers must make all reasonable attempts to obtain a photograph of the animal, and submit it with the report (as described above). This is so that NMFS could compare this record to its own humpback whale photo-id catalogue and possibly identify it to a distinct population segment.

Reporting Injured or Dead Marine Mammals

- In the event that the specified activity clearly causes the take of a marine mammal in a manner not prohibited by this IHA (if issued), such as serious injury or mortality, SIO shall immediately cease the specified activities and immediately report the incident to NMFS. The report must include the following information:
    - Time, date, and location (latitude and longitude) of the incident;
    - Vessel speed’s during and leading up to the event;
    - Description of the incident;
    - Status of all sound source use in the 24 hours preceding the incident;
    - Water depth;
    - Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
    - Description of all marine mammal observations in the 24 hours preceding the incident;
    - Species identification or description of the animal(s) involved;
    - Fate of the animal(s); and
    - Photographs or video footage of the animal(s).
- Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS.

- In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), SIO shall immediately report the incident to NMFS. The report must include the same information identified previously in the IHA (i.e., condition regarding the reporting of injured or dead marine mammals). Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.
- In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to NMFS within 24 hours of the discovery. SIO shall provide photographs, video footage, or other documentation of the sighting to NMFS.

Authorization

- The IHA may be 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.

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 would provide information for future consultations involving seismic surveys and the issuance of Incidental Harassment Authorizations that may affect endangered large whales and endangered or threatened sea turtles.

1. The NSF should promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle species.
2. The NSF should develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun sources.

In order for NMFS' Office of Protected Resources 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 Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

17 Reinitiation Notice

This concludes formal consultation for the NSF and the NMFS Permits and Conservation Division. 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.

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