NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION

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

Activity Considered: **1)** Seismic survey by the Lamont-Doherty Earth Observatory in the Southeast Pacific Ocean, and

2) Issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service

Approved:

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Date: 8/1/16

Public Consultation Tracking System (PCTS) number: FPR-2016-9155

TABLE OF CONTENTS

Page

1 Introduction 1
1.1 Background 2
1.2 Consultation History 2

2 Description of the Proposed Action 2
2.1 National Science Foundation Proposed Activities 3
2.1.1 Schedule 3
2.1.2 Source Vessel Specifications 4
2.1.3 Airgun Description 4
2.1.4 Ocean Bottom Seisometers Deployment 5
2.1.5 Multibeam Echosounder and Sub-bottom Profiler 6
2.1.6 Wave Glider 7
2.1.7 Proposed Exclusion Zones 7
2.2 NMFS' Permits and Conservation Division's Incidental Harassment Authorization 10
2.2.1 Schedule 18
2.3 Action Area 18
2.3.1 Chilean Territorial Seas and the Action Area 20
2.4 Interrelated and Interdependent Actions 21

3 Overview of NMFS' Assessment Framework 22
3.1 Assessment Approach Applied to this Consultation 24

4 Status of ESA-listed Species 25
4.1 ESA-listed Species and Critical Habitat Not Likely to be Adversely Affected 26
4.2 ESA-listed Species and Critical Habitat Likely to be Adversely Affected 27
4.2.1 Sei Whale 28
4.2.2 Fin Whale 30
4.2.3 Southern Right Whale 34
4.2.4 Blue Whale 38
4.2.5 Humpback Whale 44
4.2.6 Sperm Whale 50
4.2.7 Green Sea Turtle—East Pacific Distinct Population Segment 57
4.2.8 Leatherback Sea Turtle 63
4.2.9 Loggerhead Sea Turtle-South Pacific Distinct Population Segment 69
4.2.10 Olive Ridley Sea Turtle 73

5 Environmental Baseline 78
5.1 Physical and Oceanographic Features 78

5.2 Fisheries Interactions ... 80
5.3 Climate Change ... 81
5.4 Harvest ... 86
5.5 Habitat Degradation ... 86
5.6 Noise ... 87
5.7 Ship Strike ... 88
5.8 Pollution ... 89
5.9 Oil Spills ... 91
5.10 Scientific and Research Activities ... 91
5.11 Impact of the Baseline on ESA-listed Species ... 91
5.11.1 Marine Mammals ... 92
5.11.2 Sea Turtles ... 94

6 Effects of the Action on ESA-Listed Species and Critical Habitat ... 94
6.1 Stressors Associated with the Proposed Action ... 95
6.1.1 Pollution by Oil or Fuel Leakage ... 95
6.1.2 Ship Strike ... 95
6.1.3 Disturbance from Engine Noise ... 96
6.1.4 Gear Entanglement ... 96
6.2 Mitigation to Minimize or Avoid Exposure ... 97
6.3 Exposure and Response Analysis ... 97
6.3.1 Exposure Analysis ... 97
6.3.2 NSF Exposure Estimates ... 99
6.3.3 NMFS Exposure Estimates ... 100
6.3.4 Exposure Estimates in the Action Area ... 103
6.3.5 Sea Turtles ... 105
6.3.6 Response Analysis ... 107
6.4 Cumulative Effects ... 124
6.5 Integration and Synthesis ... 125

7 Conclusion ... 127

8 Incidental Take Statement ... 127
8.1 Amount or Extent of Take ... 127
8.2 Effects of the Take ... 129
8.3 Reasonable and Prudent Measures ... 129
8.4 Terms and Conditions ... 130

9 Conservation Recommendations ... 137

10 Reinitiation of Consultation ... 137

11 References ... 139

LIST OF TABLES

Page

Table 1. Specifications of the source array to be used by the *Langseth* during the proposed seismic activities. 5

Table 2. Specifications for the OBSs to be used during the proposed seismic activities in the Southeast Pacific Ocean. 6

Table 3. Sub-bottom profiler specifications of *Langseth*..... 7

Table 4. Predicted distances to which sound levels of 180, 166, and 160 dB re 1 μPa_{rms} could be received from the 36-airgun array as well as the 40 in^3 airgun in water depths greater than 1,000 m. Adapted from LGL 2016. 10

Table 5. Ensonified areas for the seismic survey tracklines in the northern, central and southern survey areas. 21

Table 6. Threatened and endangered species that may be affected by NSF's proposed action of seismic activities in the southeast Pacific Ocean off the coast of Chile..... 25

Table 7. Summary of past and present sei whale abundance..... 30

Table 8. Summary of past and present fin whale abundance..... 33

Table 9. Summary of past and present blue whale abundance. 43

Table 10. Summary of past and present humpback whale abundance. 49

Table 11. Summary of past and present sperm whale abundance. 55

Table 12. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF), annual nests (AN), annual egg production (EP), and annual egg harvest (EH). 59

Table 13 Recent estimates of olive ridley arribada size. 74

Table 14. Locations of olive ridley arribada and solitary nesting beaches in the eastern Pacific and estimates of arribada sizes. 75

Table 15. Comparisons of the proposed take estimates calculated by the NMFS' Permits and Conservation Division and the NSF for ESA-listed marine mammals..... 101

Table 16. Exposure estimates of ESA-listed species in the entire action area and in non-territorial seas. 103

Table 17. Amount of incidental take of ESA-listed marine mammals authorized by the Incidental Take Statement..... 128

LIST OF FIGURES

Page

Figure 1. Modelled distances for the 36-airgun array at nine meter tow depth in deep water; top plot provides the radius to the 170-dB SEL isopleth, bottom plot provides the radius to the 150-dB SEL isopleth. From LGL 2016. 8

Figure 2. Modelled distances for the 36-airgun array at twelve meter tow depth in deep water; top plot provides the radius to the 170-dB SEL isopleth, bottom plot provides the radius to the 150-dB SEL isopleth. From LGL 2016. 9

Figure 3. Map of the proposed action area for NSF's Seismic survey in the southeast Pacific Ocean off Chile (LGL 2016) 19

Figure 4. Worldwide distribution of the 14 identified humpback whale distinct population segments 45

Figure 5. Southern Hemisphere humpback stocks (populations) (IWC 2005). 46

Figure 6. Map depicting DPS boundaries for green turtles. 58

Figure 7. Map depicting the loggerhead sea turtle DPS boundaries. 69

Figure 8. Overview of the Humboldt Current along South America. From UNEP (2005). 79

1 INTRODUCTION

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. When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the USFWS concurs with that conclusion (50 CFR §402.14(b)).

Section 7 (b)(3) of the ESA requires that at the conclusion of consultation, NMFS and/or USFWS provide an opinion stating how the Federal agencies' actions will affect ESA-listed species and their critical habitat under their jurisdiction. If an incidental take is expected, section 7 (b)(4) requires the consulting agency to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

For the actions described in this document, the action agencies 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 allow the use of its research vessel, *Marcus G. Langseth* (*Langseth*), which is operated by the Lamont-Doherty Earth Observatory (L-DEO), to conduct a seismic survey in the waters off Chile in the southeast Pacific Ocean for approximately 80 days in 2016 and into 2017. The research is funded by NSF and will be carried out by researchers from Oregon State University and the University of Texas at Austin, Institute for Geophysics. 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). The consulting agency is the NMFS' ESA Interagency Cooperation Division.

The biological opinion (opinion) and incidental take statement were prepared by NMFS' ESA Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402. This document represents NMFS' opinion on the effects of these actions on endangered and threatened species and critical habitat that has been designated 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 beginning in August 2016 in the southeast Pacific Ocean in the waters off Chile. 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' 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 January 15, 2016, 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 L-DEO to incidentally harass marine mammal species pursuant to the MMPA during the proposed seismic survey.

On March 18, 2016, 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. Information was sufficient to initiate consultation on this date.

On April 19, 2016, 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.

This opinion is based on information provided in the:

- MMPA IHA application,
- draft public notice of proposed IHA,
- a 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, and
- other sources of information.

2 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 allow the use of its research vessel, *Langseth*, operated by the L-DEO, to conduct a seismic survey in the southeast Pacific Ocean off the coast of Chile beginning in August 2016, in support of an NSF-funded collaborative research project led by Oregon State University and the University of Texas at Austin. 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.

2.1 National Science Foundation Proposed Activities

The NSF proposes to allow the use the *Langseth*, to conduct a seismic survey in the waters off of Chile beginning in August 2016, and continue over an 80-day period. There are three survey areas off the Chilean coast, and the survey will take place in the exclusive economic zone and the territorial waters of Chile. An array of thirty-six airguns will be deployed as an energy source.

The survey would entail a total of 9,630 km of transect lines. In the northern survey area, approximately 4,540 transect lines would be surveyed; approximately 790 km surveyed in the central survey area, and approximately 4,300 transect lines surveyed in the southern survey area. The receiving system for the survey would consist of fifty ocean bottom seismographers (OBSs) and a single 8-15 km hydrophone streamer. The OBSs would be deployed at sites along the transect lines. In addition, a multibeam echosounder and a sub-bottom profiler will continuously operate throughout the survey (LGL 2016). NSF is also proposing to use a SV2 Wave Glider during the survey to collect data from seafloor sensors.

The purpose of the proposed activities is to collect and analyze reflection and refraction seismic data at three locations along the Chilean coast (LGL 2016). The seismic activities conducted at each survey location will have a specific purpose, but the overarching purpose of the proposed activity is to gather seismic data to use in analyzing the effects of earthquakes in the region. In the northen survey area (70.2-73.2°W, 18.3-22.4°S), the primary purpose of the proposed action would be to collect seismic data on the continental margin of northern Chile related to the 2014 Pisagua/Iquique earthquake, including understanding how the geological structure in the region affected the rupture sequence. In the central suvery area (71.8-73.4°W, 33.9-44.1°S), the survey will be conducted to examine the extent and location of seafloor displacement and related subsurface fault movement of the 2015 Illapel earthquake (LGL 2016). To gather information on geological features of the south-Chile margin in the southern suvey area (72.2-76.1°W, 33.9-44.1°S), the research objectives will focus on examining the deep plate-boundary thrust fault in the area.

2.1.1 Schedule

The NSF proposes to allow the use of the *Langseth* by L-DEO during roughly 80 days of seismic operations and an additional 23 days of non-airgun operations (e.g., OBS deployment and retrieval, hydrophone streamer deployment and retrieval) (LGL 2016). The northern survey

activities are expected to take approximately 45 days. The 45-day window entails 28 days of seismic operation, 13 days of OBS deployment and retrival, and 4 days of transit time. Activities for the central survey area are expected to take about six days (five days of seismic operation and one day of equipment retrieval). The southern survey is expected to take 32 days (with 27 days of seismic operations and five days of transit time). Since the central and southern survey areas are close in proximity to one another, these surveys will be conducted in the same time frame.

Some minor deviation from the proposed dates is possible, depending on logistics, weather conditions, and the need to repeat some survey lines if data quality is substandard. During an approximate 80 day period starting in August 2016 through July 2017, corresponding to an effective IHA, the *Langseth* would survey the action area.

2.1.2 Source Vessel Specifications

The *Langseth* will tow a source array along predetermined lines (LGL 2016). The *Langseth's* design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic acquisition is typically about 8.3 km/h (4.5 knots). When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km/h (10 knots). No chase vessel will be used during operations.

The *Langseth* will also serve as the platform from which protected species visual observers (PSVOs) would watch for animals.

2.1.3 Airgun Description

The airgun array will consist of the full airgun array of four strings with 36 airguns, plus four spares (Table 1). The total discharge volume will be 6,600 in^3. The airgun configuration includes four of linear arrays or "strings". Each string will have ten airguns. Up to nine airguns in one string would fire at any one time. The four-airgun strings will be towed approximately 150 m behind the vessel. The tow depth of the array will be 9 or 12 m, depending on the survey location (LGL 2016). For the northern survey, the airgun array will be towed at a depth of 9-12 m. The central and southern surveys will use a tow depth of 9 m.

There will be different shot intervals for the different survey areas (northern, central and southern). For the northern survey, the streamer for multi-channel seismic (MCS) acquisition will use a shot interval of 25-50 m (approximately 10-22 s); the shot intervals for OBS lines would be approximately 300 m (approximately 2-3 min). After this portion is complete, the grid lines for the 3-D refraction imaging would be surveyed, with a shot interval of approximately 100-150 m (approximately 40-60 s). The central survey would have a shot interval of approximately 25 m (approximately 10 s) for the MCS lines (each shot once). The MCS lines for the southern survey would be shot once, at an interval of approximately 37.5 m (16 s). During firing, a brief (approximately 0.1 s) pulse of sound will be emitted, but will be silent during the intervening periods. 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 except for unscheduled shutdowns.

Table 1. Specifications of the source array to be used by the *Langseth* during the proposed seismic activities.

Source array specifications	
Energy source	20 Bolt 1500LL airguns @ 180-360 in3 16 Bolt 1900LLX airguns @ 40-120 in3 Four strings of nine operating airguns per string
Source output (downward)-4 airgun array	0-pk = 259 dB re 1 μPa-m pk-pk = 265 dB re 1 μPa-m or 0-pk = 258 dB re 1 μPa-m pk-pk = 264 dB re 1 μPa-m
Air discharge volume	~ 6,600 in^3
Dominant frequency components	0–188 Hz

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

2.1.4 Ocean Bottom Seisometers Deployment

The *Langseth* would deploy a total of 50 OBSs for use in the northern survey; OBSs would not be used in the central or southern surveys. OBSs would be placed approximately 15 m apart, at depths between 5,500 and 6,000 m. The OBSs would be recovered after the line is completed. OBSs from two sources would be used during the proposed activities—Woods Hole Oceanographic Institution and Scripps Institution of Oceanography (LGL 2016). The OBSs differ slightly in their configurations (Table 2).

It is possible that the proposed activities will use 14 additional OBSs funded and deployed by GEOMAR. The use of these additional OBSs is pending.

Table 2. Specifications for the OBSs to be used during the proposed seismic activities in the Southeast Pacific Ocean.

Dimensions	Woods Hole Oceanographic Institution OBS	Scripps Instituion of Oceanography OBS
Height	1 m	0.9 m
Diameter	50 cm	97 cm
Anchor Description	Hot-rolled steel; 23kg	Iron grates; 36kg
Anchor Dimensions	2.5 x 30.5 x 38.1 cm	7 x 91 x 91.5 cm

To retrieve an OBS, an acoustic release transponder activates the instrument at a frequency of 8-11 kHz, and the receiver detects the response at a frequency of 11.5-13 kHz, at which point the burn-wire releases the instrument from the anchor and the devices floats to the surface.

2.1.5 Multibeam Echosounder and Sub-bottom Profiler

Along with airgun operations, two additional acoustical data acquisition systems will operate during the survey from the *Langseth*. The multibeam echosounder and sub-bottom profiler systems will map the ocean floor during the survey. These sound sources will operate from the *Langseth* simultaneously with the airgun array.

The multibeam echosounder is a hull-mounted system operating at 10.5-13 kHz. The beamwidth is 1 or 2° fore–aft and 150° perpendicular to the ship's line of travel. The maximum source level is 242 dB re 1 $\mu Pa \cdot m_{rms}$. For deepwater operation, each "ping" consists of eight successive fan-shaped transmissions, each 2 to 15 ms in duration and each ensonifying a sector that extends 1° fore–aft. The eight successive transmissions span an overall cross-track angular extent of about 150°, with 2 ms gaps between the pulses for successive sectors (Maritime 2005).

The sub-bottom profiler provides information about the sedimentary features and the bottom topography that is being mapped simultaneously by the multibeam echosounder (Table 3). The output varies with water depth from 50 watts in shallow water to 1,000 (204 dB) watts in deep water. The pulse interval is 1 s, but a common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

Table 3. Sub-bottom profiler specifications of *Langseth*.

***Langseth* sub-bottom profiler specifications**	
Maximum/normal source output (downward)	204 dB re 1 μPa·m; 800 watts
Dominant frequency component	3.5 kHz
Bandwidth	1.0 kHz with pulse duration 4 ms
	0.5 kHz with pulse duration 2 ms
	0.25 kHz with pulse duration 1 ms
Nominal beam width	30°
Pulse duration	1, 2, or 4 ms

2.1.6 Wave Glider

To collect data from seafloor sensors, the researchers will deploy a Liquid Robotics SV2 Wave Glider during the proposed surveys (LGL 2016). The glider is unmanned and untethered, remotely piloted and is wave propelled. The glider has a global positioning system and an acoustic data logger that transmits data from the glider platform to a control center via satellite. The SV2 Wave Glider is 2.1 m long by 60 cm wide.

2.1.7 Proposed Exclusion Zones

The NSF identifies in its EA that the L-DEO will implement exclusion zones around the *Langseth* to minimize any potential adverse effects of airgun sound on MMPA and ESA-listed species. These exclusion 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 *Langseth*, described below.

2.1.7.1 Predicted sound levels vs. distance and depth

The L-DEO has predicted received sound levels in deep water (free-field model), in relation to distance and direction from a 36-airgun array as well as a 40 in^3 single 1900LLX airgun used during power-downs. In shallow water, empirical data concerning 180 and 160 dB re 1 μPa_{rms} distances were acquired during the acoustic calibration study of the *Langseth*'s 36-airgun 6,600 in^3 array in the Gulf of Mexico (Diebold et al. 2010). However, the tow depth was different in the Gulf of Mexico calibration study (6 m tow depth) than in the proposed survey (9 m tow depth). To adapt the shallow-water measurements obtained during the calibration survey to the

proposed tow depth(s), scaling factors were applied to the distances reported by Diebold et al. (2009) for shallow waters, and this scaling is done according to the sound exposure level (SEL) contours obtained from the free-field modeling. The deep-water exclusion zone radii (greater than 1,000 m) were obtained from L-DEO model results (to a water depth of 2,000 m). The exclusion zone radii for intermediate water depths (100-1,000 m) were derived from the deep-water ones by applying a 1.5 correction factor. Figure 1 and Figure 2 show predicted distances of the various configurations of the airguns.

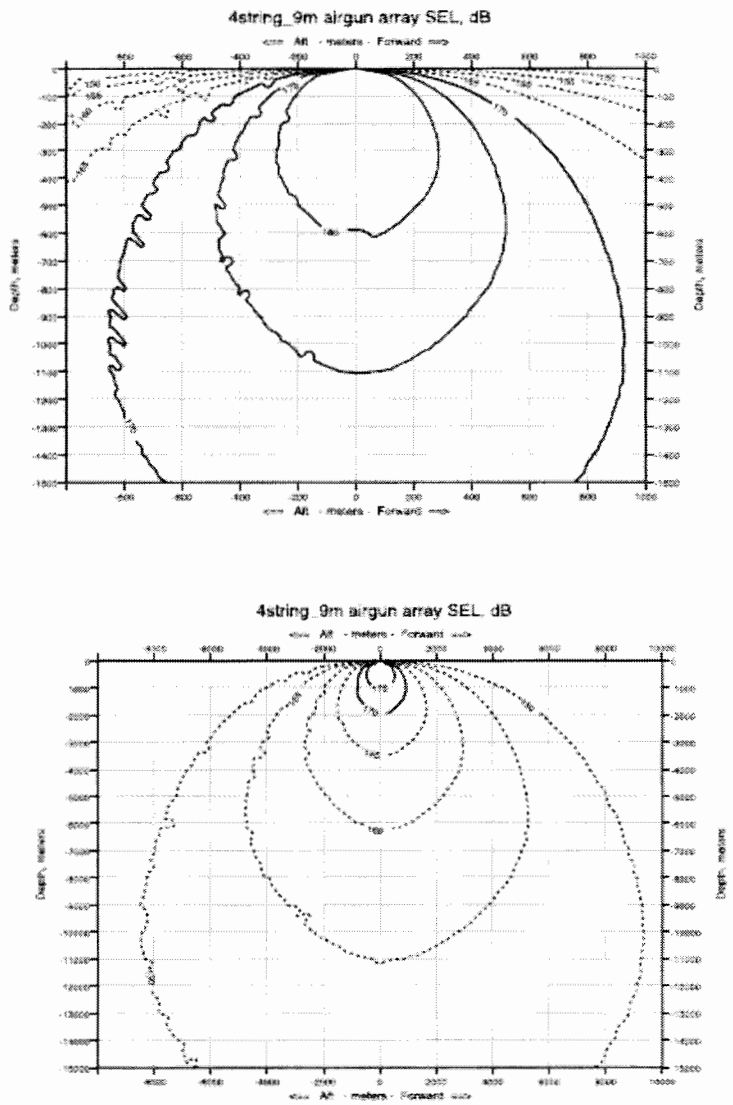

Figure 1. Modelled distances for the 36-airgun array at nine meter tow depth in deep water; top plot provides the radius to the 170-dB SEL isopleth, bottom plot provides the radius to the 150-dB SEL isopleth. From LGL 2016.

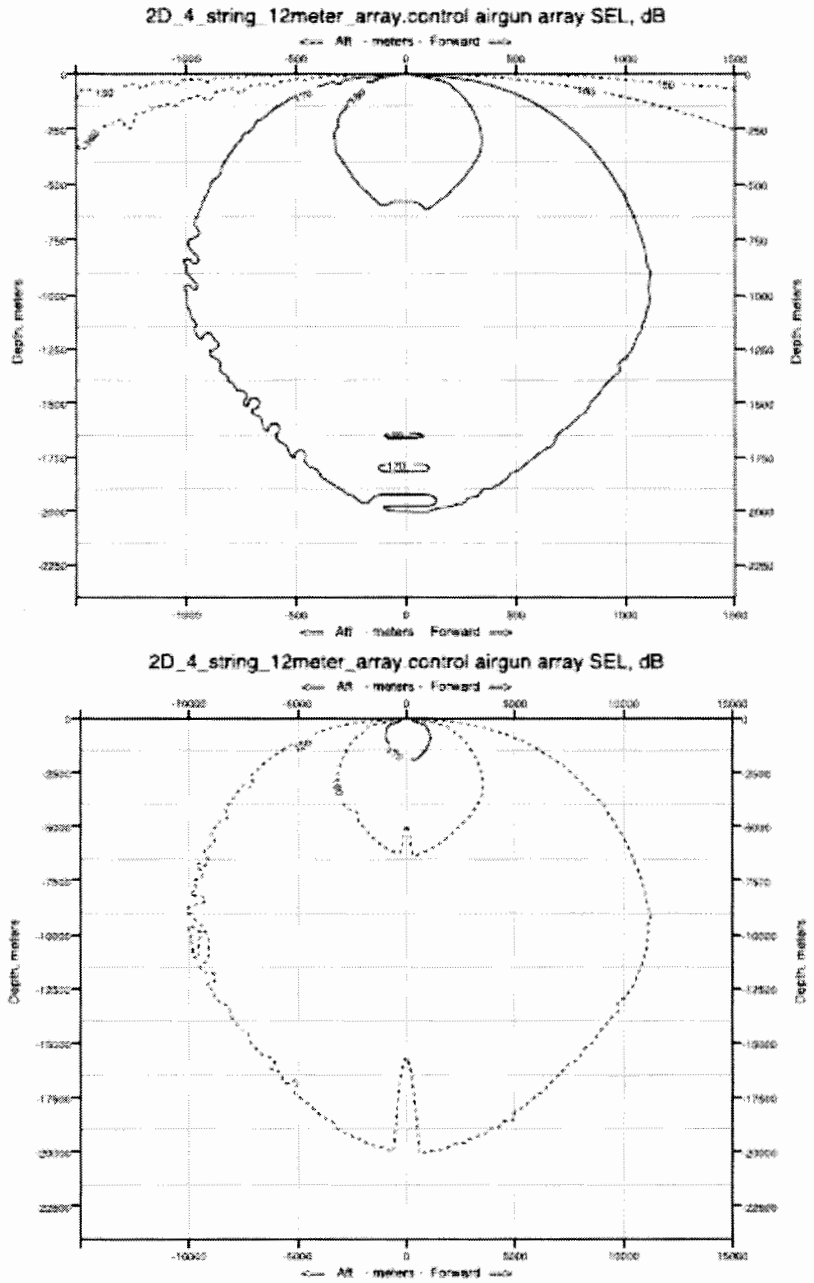

Figure 2. Modelled distances for the 36-airgun array at twelve meter tow depth in deep water; top plot provides the radius to the 170-dB SEL isopleth, bottom plot provides the radius to the 150-dB SEL isopleth. From LGL 2016.

Table 4 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the 36-airgun arrays and a single airgun at different depth strata. Because the proposed action would take place in an area with depths 1,000m or greater, NSF provided predicted distances to which sound levels could be received at greater than 1,000 m. The 180 dB

re 1 μPa_{rms} distance is the safety criteria as specified by NMFS (1995) as applicable to cetaceans under the MMPA. The 180 dB will be used as the exclusion zone for marine mammals, as required by NMFS during most other recent L-DEO seismic projects (Holst and Beland 2008; Holst and Smultea 2008b; Holst et al. 2005a; Holt 2008; Smultea et al. 2004). The 180 dB isopleth would also be the exclusion zone boundary for sea turtles. The 166 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.

Table 4. Predicted distances to which sound levels of 180, 166, and 160 dB re 1 μPa_{rms} could be received from the 36-airgun array as well as the 40 in^3 airgun in water depths greater than 1,000 m. Adapted from LGL 2016.

Source, volume, and tow depth	Water Depth (m)	Predicted RMS radii (m)		
		180 dB	166 dB	160 dB
36-airgun array 6600 in^3 @ 12 m	>1,000	1,116	4,411	6,908
	100-1,000	1,674	6,617	10,362
	< 100	2,480	12,630	27,130
36-airgun array 6600 in^3 @ 9 m	>1,000	927	3,740	5,780
	100-1,000	1,391	5,610	8,670
	< 100	2,060	10,862	22,580
single Bolt airgun, 40 in^3 @ 9 or 12 m	>1,000	100	185	431
	100-1,000	100	324	647
	< 100	96	501	1,041

2.2 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 from August 1, 2016, through July 31, 2017. The NMFS' Permits and Conservation Division proposes to issue the IHA by August 1, 2016, so that NSF will have the IHA in hand prior to the start of the proposed activities. The IHA will authorize the incidental harassment of the following endangered species: southern right whales (*Eubalaena australis*),

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 MMPA. The proposed IHA identifies the following requirements that L-DEO must comply with as part of its authorization.

Incidental Harassment Authorization

We hereby authorize the Lamont-Doherty Earth Observatory (Lamont-Doherty), Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, New York 10964-8000, under section 101(a)(5)(D) of the MMPA (16 U.S.C. 1371(a)(5)(D)) and 50 CFR 216.107, to incidentally harass small numbers of marine mammals incidental to a marine geophysical survey conducted by the *Langseth* marine geophysical survey in the Southeast Pacific Ocean between August 2016 and July 2017.

1. Effective Dates

This Authorization is valid between August 1, 2016 and July 31, 2017.

2. Specified Geographic Region

This Authorization is valid only for specified activities associated with the *Langseth's* seismic operations as specified in Lamont-Doherty's Incidental Harassment Authorization (Authorization) application and environmental analysis in the following specified geographic area:

a. in the Southeast Pacific Ocean, located approximately within the exclusive economic zone of Chile, between 18° and 44°S as specified in Lamont-Doherty's application and the National Science Foundation's environmental analysis.

3. Species Authorized and Level of Takes

a. This authorization limits the incidental taking of marine mammals, by harassment only, to the species in the area described in Tables 5 - 8 in this notice.

i. During the seismic activities, if the Holder of this Authorization encounters any marine mammal species that are not listed in Condition 3(a) for authorized taking and are likely to be exposed to sound pressure levels greater than or equal to 160 decibels (dB) re: 1 μPa, then the Holder must alter speed or course or shut-down the airguns to avoid take.

b. The taking by serious injury or death of any of the species listed in Condition 3(a) or the taking of any kind of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this Authorization.

c. This Authorization limits the methods authorized for taking by harassment to the following acoustic sources:

i. a sub-airgun array with a total capacity of 6,600 in^3 (or smaller);

4. Reporting Prohibited Take

The Holder of this Authorization must report the taking of any marine mammal in a manner prohibited under this Authorization immediately to the Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to the Chief, NMFS' Permits and Conservation Division.

5. Cooperation

We require the Holder of this Authorization to cooperate with the Office of Protected Resources, NMFS, and any other Federal, state, or local agency monitoring the impacts of the activity on marine mammals.

6. Mitigation and Monitoring Requirements

We require the Holder of this Authorization to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable adverse impact on affected marine mammal species or stocks:

Visual Observers

- a. Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (visual observers) to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night.
    - i. At least one visual observer will be on watch during meal times and restroom breaks.
    - ii. Observer shifts will last no longer than four hours at a time.
    - iii. Visual observers will also conduct monitoring while the *Langseth* crew deploy and recover the airgun array and streamers from the water.
    - iv. When feasible, visual observers will conduct observations during daytime periods when the seismic system is not operating for comparison of sighting rates and behavioral reactions during, between, and after airgun operations.
    - v. The *Langseth's* vessel crew will also assist in detecting marine mammals, when practicable.
    - vi. Visual observers will have access to reticle binoculars (7x50 Fujinon), and big-eye binoculars (25x150).

Exclusion Zones

- b. Establish a 180-decibel (dB) exclusion zone for cetaceans, before starting the airgun subarray (6,660 in^3); and a 180-dB or 190-dB exclusion zone for cetaceans and pinnipeds, respectively for the single airgun (40 in^3). Observers will use the predicted radius distance for the 180-dB or 190-dB exclusion zones for cetaceans and pinnipeds.

Visual Monitoring at the Start of Airgun Operations

- c. Monitor the entire extent of the exclusion zones for at least 30 minutes (day or night) prior to the ramp-up of airgun operations after a shutdown.
- d. Delay airgun operations if the visual observer sees a cetacean within the 180-dB exclusion zone for cetaceans or 190-dB exclusion zone for pinnipeds until the marine mammal(s) has left the area.
- i. If the visual observer sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the observer sees no marine mammals during that time, he/she should assume that the animal has moved beyond the 180-dB exclusion zone for cetaceans or 190-dB exclusion zone for pinnipeds.
- ii. If for any reason the visual observer cannot see the full 180-dB exclusion zone for cetaceans or the 190-dB exclusion zone for pinnipeds for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or within zone, the *Langseth* may not resume airgun operations.
- iii. If one airgun is already running at a source level of at least 180 dB re: 1 μPa or 190 dB re: 1 μPa, the *Langseth* may start the second gun–and subsequent airguns–without observing relevant exclusion zones for 30 minutes, provided that the observers have not seen any marine mammals near the relevant exclusion zones (in accordance with Condition 6(b) of the IHA, exclusion zones).

Passive Acoustic Monitoring

- e. Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One visual observer and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

- f. Do and record the following when an observer detects an animal by the PAM:
    - i. notify the visual observer immediately of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;
    - ii. enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale, monk seal), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

Ramp-Up Procedures

- g. Implement a "ramp-up" procedure when starting the airguns at the beginning of seismic operations or any time after the entire array has been shutdown, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the observers will monitor the exclusion zone, and if marine mammals are sighted, a course/speed alteration, power-down, or shutdown will be implemented as though the full array were operational.

Recording Visual Detections

- h. Visual observers must record the following information when they have sighted a marine mammal:
  - i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and
  - ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, and sun glare; and
  - iii. The data listed under 6(f)(ii) at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

Speed or Course Alteration

- i. Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant exclusion zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the exclusion zone, the Holder of this Authorization will implement further mitigation measures, such as a shutdown.

Power-Down Procedures

- j. Power down the airguns if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zones. A power-down means reducing the number of operating airguns to a single operating 40 in3 airgun. This would reduce the exclusion zone to the degree that the animal(s) is outside of it.

Resuming Airgun Operations after a Power-Down

- k. Following a power-down, if the marine mammal approaches the smaller designated exclusion zone, the airguns must then be completely shut-down. Airgun activity will not resume until the observer has visually observed the marine mammal(s) exiting the

exclusion zone and is not likely to return, or has not been seen within the exclusion zone for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).

- l. Following a power-down and subsequent animal departure, the *Langseth* may resume airgun operations at full power. Initiation requires that the observers can effectively monitor the full exclusion zones described in Condition 6(b) of the IHA, exclusion zones. If the observer sees a marine mammal within or about to enter the relevant zones then the *Langseth* will implement a course/speed alteration, power-down, or shutdown.

Shutdown Procedures

- m. Shutdown the airgun(s) if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zone. A shutdown means that the *Langseth* turns off all operating airguns.

Resuming Airgun Operations after a Shutdown

- n. Following a shutdown, if the observer has visually confirmed that the animal has departed the 180-dB zone for cetaceans or the 190-dB zone for pinnipeds within a period of less than or equal to 8 minutes after the shutdown, then the *Langseth* may resume airgun operations at full power.
- o. If the observer has not seen the animal depart the 180-dB zone for cetaceans or the 190-dB zone for pinnipeds, the *Langseth* shall not resume airgun activity until 15 minutes has passed for species with shorter dive times (i.e., small odontocetes and pinnipeds) or 30 minutes has passed for species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales). The *Langseth* will follow the ramp-up procedures described in Conditions 6(g) of the IHA, Ramp-up Procedures.

Survey Operations at Night

- p. The *Langseth* may continue marine geophysical surveys into night and low-light hours if the Holder of the Authorization initiates these segment(s) of the survey when the observers can view and effectively monitor the full relevant exclusion zones.
- q. This Authorization does not permit the Holder of this Authorization to initiate airgun array operations from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the visual observers cannot view and effectively monitor the full relevant exclusion zones.

Mitigation Airgun

- s. The *Langseth* may operate a small-volume airgun (i.e., mitigation airgun) during turns and maintenance at approximately one shot per minute. The *Langseth* would not operate

the small-volume airgun for longer than three hours in duration during turns. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

Special Procedures for Concentrations of Large Whales

- t. The *Langseth* will power-down the array and avoid concentrations of large whales if possible (i.e., avoid exposing concentrations of these animals to sounds greater than 160 dB re: 1 μPa). For purposes of the survey, a concentration or group of whales will consist of six or more individuals visually sighted that do not appear to be traveling (e.g., feeding, socializing, etc.). The *Langseth* will follow the procedures described in Conditions 6(k) for resuming operations after a power down.

7. *Reporting Requirements*

- This Authorization requires the Holder of this Authorization to:
  - a. Submit a draft report on all activities and monitoring results to the Office of Protected Resources, National Marine Fisheries Service, within 90 days of the completion of the *Langseth*'s cruise. This report must contain and summarize the following information:
  - i. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings.
  - ii. Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of shutdowns), observed throughout all monitoring activities.
  - iii. An estimate of the number (by species) of marine mammals with known exposures to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re: 1 μPa and/or 180 dB re 1 μPa for cetaceans and 190-dB re 1 μPa for pinnipeds and a discussion of any specific behaviors those individuals exhibited.
  - iv. An estimate of the number (by species) of marine mammals with estimated exposures (based on modeling results and accounting for animals at the surface but not detected [i.e., g(0) values] and for animals present but underwater and not available for sighting [i.e., f(0) values]) to the seismic activity at received levels greater than or equal to 160 dB re: 1 μPa and/or 180 dB re 1 μPa for cetaceans and 190-dB re 1 μPa for pinnipeds with a discussion of the nature of the probable consequences of that exposure on the individuals.
  - v. A description of the implementation and effectiveness of the:
    - (A) terms and conditions of the biological opinion's Incidental Take Statement (attached); and
    - (B) mitigation measures of the Incidental Harassment Authorization. For the biological opinion, the report will confirm the implementation of each Term and Condition, as well as any conservation recommendations, and

describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act listed marine mammals.

- b. Submit a final report to the Chief, NMFS' Permits and Conservation Division, Office of Protected Resources, within 30 days after receiving comments from us on the draft report. If we decide that the draft report needs no comments, we will consider the draft report to be the final report.

8. Reporting Prohibited Take

- In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner not permitted by the authorization (if issued), such as an injury, serious injury, or mortality (e.g., ship-strike, gear interaction, and/or entanglement), Lamont-Doherty shall immediately cease the specified activities and immediately report the take to the Chief, NMFS' Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email. The report must include the following information:
  - Time, date, and location (latitude/longitude) of the incident;
  - Name and type of vessel involved;
  - Vessel's speed during and leading up to the incident;
  - 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) (if equipment is available).
- Lamont-Doherty shall not resume its activities until we are able to review the circumstances of the prohibited take. We shall work with Lamont-Doherty to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. Lamont-Doherty may not resume their activities until notified by us via letter, email, or telephone.

9. Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death

- In the event that Lamont-Doherty discovers an injured or dead marine mammal, and the lead visual observer determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as we describe in the next paragraph), Lamont-Doherty will immediately report the incident to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email. The report must include the same information identified in the paragraph above this section. Activities may continue while NMFS reviews the circumstances of the incident. NMFS would work with Lamont-Doherty to determine whether modifications in the activities are appropriate.

10. Reporting an Injured or Dead Marine Mammal Unrelated to the Activities

- In the event that Lamont-Doherty discovers an injured or dead marine mammal, and the lead visual observer determines that the injury or death is not associated with or related to the authorized activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Lamont-Doherty would report the incident to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email, within 24 hours of the discovery. Lamont-Doherty would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.

11. Endangered Species Act Biological Opinion and Incidental Take Statement

- Lamont-Doherty is required to comply with the Terms and Conditions of the Incidental Take Statement corresponding to the Endangered Species Act Biological opinion issued to the National Science Foundation and NMFS' Permits and Conservation Division. A copy of this Authorization and the Incidental Take Statement must be in the possession of all contractors and protected species observers operating under the authority of this Incidental Harassment Authorization.

2.2.1 Schedule

To correspond with NSF's proposed seismic survey (section 2.1), the NMFS's Permits and Conservation Division proposes to issue an authorization that is effective from August 1, 2016 to July 31, 2017.

2.3 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 CFR 402.02). The proposed action will occur in three locations in the southeast Pacific ocean, off the coast of Chile (Figure 3).

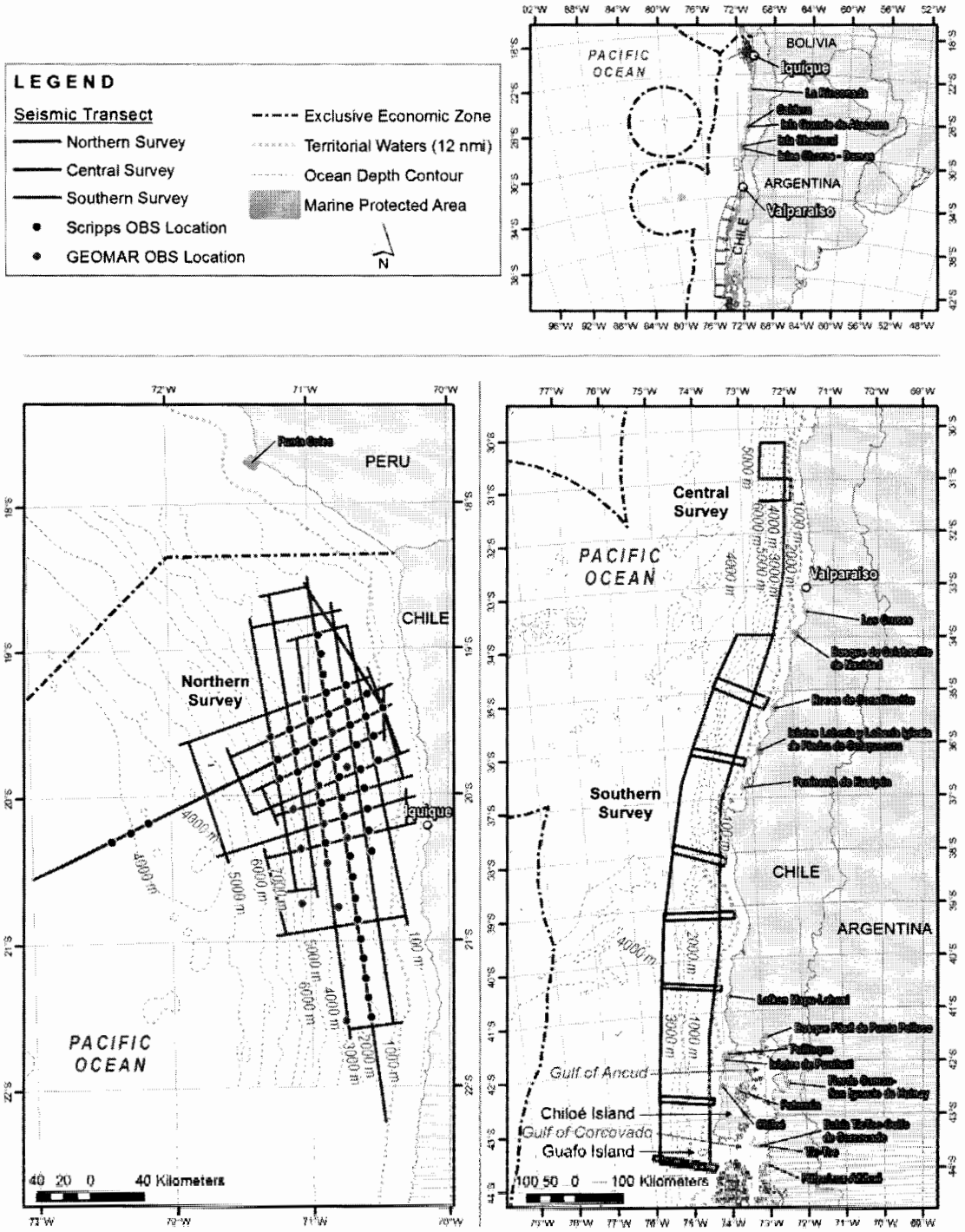

Figure 3. Map of the proposed action area for NSF's Seismic survey in the southeast Pacific Ocean off Chile (LGL 2016)

2.3.1 Chilean Territorial Seas and the Action Area

Chile considers its territorial seas to extend out 12 nautical miles (n mi). A nation's territorial seas is the sovereign territory of that country. According to the draft Environmental Analysis that NSF prepared for this action, most of the survey lines will take place outside the 12 n mi line (LGL 2016). NSF estimated that approximately 9 percent of the survey lines would be surveyed within Chilean territorial seas, and most of these are in the southern survey area (Figure 3).

In its draft Environmental Analysis, NSF presented the action area in terms of the Chilean territorial seas—that is, 12 n mi—and did not provide take estimates for areas inside the 12 n mi boundary. NMFS' jurisdiction under the ESA and MMPA only applies to the portions of the seismic survey which occur outside the 12 n mi boundary.

The fact that portions of the proposed action fall both inside and outside of the 12 n mi boundary (the high seas under the ESA) presents us with a complicated situation. For ESA section 7 consultations, we are required to examine the effects of the action throughout the entire action area in making our jeopardy determination. However, we do not have authority under the ESA to authorize incidental take within the sovereign territory of Chile (i.e., within 12 n mi).

The ESA defines action area as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." Although portions of the tracklines do not occur in the high seas (where the ESA has explicit jurisdiction), we are obligated to consider the effects of the action throughout the entire action area. Therefore, we must consider the 12 n mi boundary in relation to:

- The location of the tracklines, and
- The extent of the ensonified area.

The ensonified area refers to the predicted distances to which sound levels are expected to be received. In the draft environmental assessment, NSF presents the predicted distances to which sound levels are expected to occur for different decibel levels and at different water depths. Generally, sound travels farther in shallow water than it does in deep water.

It is possible that tracklines that are technically located within the 12 n mi boundary could, during the seismic survey, emit an ensonified area that goes beyond 12 n mi. Water depth will play a role as well, because the predicted distances to which sound can travel changes with depth. The water depths in the survey area range from 50-7,600 m, and approximately 3 percent of the total line kilometers would be surveyed in waters less than 100 m deep (LGL 2016).

This opinion is going to consider two exposure scenarios to fulfill our requirements under the ESA:

1. Estimate exposure to determine the effects of the proposed action throughout the <u>entire action area</u> (inside and outside the 12 n mi boundary) to reach the jeopardy determination, and

2. Estimate exposure in the portions of the action area where NMFS has jurisdiction under the ESA (to estimate numbers of allowed take for an incidental take statement).

By using GIS software and the GIS files provided to us by NSF as part of their initiation package, we were able to to calculate the total ensonified areas for each of the survey areas. Because sound from the seismic activities travels to different distances based on the water depth, we determined the amount of tracklines in each water depth strata (i.e., less than 100 m, 100-1,000 m and greater than 1,000 m). We then applied the appropriate exclusion zone representing the predicted RMS distance for 160dB at 12m tow depth (see Table 4) to each portion of the trackline in a particular depth strata. For example, if a trackline was in the greater than 1,000m depth strata, we applied the 6.9 km exclusion zone.

Once we had the total ensonified areas for the tracklines in the northern, central and southern survey areas, we applied the 12 n mi boundary to the total ensonified areas to determine the amount of the action inside and outside of the territorial seas of Chile (Table 5).

Table 5. Ensonified areas for the seismic survey tracklines in the northern, central and southern survey areas.

Chile Seismic Survey Trackline Location	Total Survey Area (km^2)	Survey Area inside Territorial Seas (<12 nmi)	Survey Area Outside Territorial Seas (>12 nmi)
Northern	61,295	11,650 km^2	49,645 km^2
		19%	81%
Central	10,593	278 km^2	10,315 km^2
		2.6%	97.4%
Southern	76,449	18,332 km^2	58,117 km^2
		24%	76%

To make our jeopardy determination, we will consider the effects of the action in the total survey area (Table 5), and we will use the area calculated outside the territorial seas to estimate numbers of allowed take for an incidental take statement.

2.4 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.

The two proposed actions considered in this opinion are interdependent. The NMFS' Permits and Conservation Division's proposal to issue an MMPA incidental take 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 NMFS' Permits and Conservation Division.

3 Overview of NMFS' Assessment Framework

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

"To jeopardize the continued existence of an ESA-listed species" 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 CFR §402.02). The jeopardy analysis considers both survival and recovery of the species.

Section 7 assessment involves the following steps:

1) We identify the proposed action and those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on the physical, chemical, and biotic environment within the action area, including the spatial and temporal extent of those stressors.

2) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time.

3) 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.

4) We identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. This is our exposure analysis.

5) We evaluate the available evidence to determine how those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.

6) We assess the consequences of these responses to the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. This is our risk analysis.

7) The adverse modification analysis considers the impacts of the proposed action on the critical habitat features and conservation value of designated critical habitat. This opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

8) We describe any cumulative effects of the proposed action in the action area.

   Cumulative effects, as defined in our implementing regulations (50 CFR §402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

9) We integrate and synthesize the above factors by considering the effects of the action to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

   a) Reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or

   b) Reduce the conservation value of designated or proposed critical habitat. These assessments are made in full consideration of the status of the species and critical habitat.

10) We state our conclusions regarding jeopardy and the destruction or adverse modification of 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, we must identify a reasonable and prudent alternative (RPA) to the action. The RPA must not be likely to jeopardize the continued existence of ESA-listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

To comply with our obligation to use the best scientific and commercial data available, the environmental assessment submitted by the NSF, monitoring reports submitted by past and present seismic survey operators, reports prepared by natural resource agencies in states and other countries, reports from non-governmental organizations involved in marine conservation issues, the information provided by NMFS' Permits and Conservation Division when it initiates formal consultation, the general scientific literature, and our expert opinion.

To identify information relevant to the potential stressors and responses of marine mammals, sea turtles, and fish species that may be affected by the proposed action to draw conclusions about the likely risks to the continued existence of these species and the conservation value of their

critical habitat during the consultation, we conducted electronic searches of the general scientific literature using search engines, including Aquatic Sciences and Fisheries Abstracts, JSTOR, Google Scholar, and Science Direct. We also referred to an internal electronic library that represents a major repository on the biology of ESA-listed species under the NMFS' jurisdiction.

We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion (for example, a study that suggests whales will exhibit a particular response to acoustic exposure or close vessel approach) as well as data that do not support that conclusion. When data are equivocal or when faced with substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

3.1 Assessment Approach Applied to this Consultation

In this particular assessment, we identified the potential stressors associated with the action and determined which were probable based upon previous seismic surveys. Of the probable stressors, we identified the species that are expected to co-occur with the effects of the action, particularly the acoustic isopleths of the airgun and other sound sources. Utilizing survey data from previous years and predictive environmental factors, density estimates per unit area of ESA-listed whales were multiplied by the area to be ensonified where effects were expected. Our primary concerns in this consultation revolve around exposure of listed individuals to anthropogenic sound sources, where those individuals may respond with behaviors that may result in fitness consequences (Francis and Barber 2013; Nowacek and Tyack 2013) However, it should not be assumed that anthropogenic stressors lead to fitness consequences at the individual or population levels (New et al. 2013).

In order to reach conclusions regarding whether proposed actions are likely to jeopardize ESA-listed species, we had to make several assumptions. These included:

- Baleen whales can generally hear low-frequency sound (Southall et al. 2007b) better than high frequencies (Southall et al. 2007b), as the former is primarily the range in which they vocalize. Humpback whales frequently vocalize with mid-frequency sound (Southall et al. 2007b) and are likely to hear at these frequencies as well. Because of this, we can partition baleen whales into two groups: those that are specialists at hearing low frequencies (e.g., fin, North Atlantic right, and sei whales) and those that hear at low- to mid-frequencies (blue and humpback whales). Sperm whales are better adapted to hear mid- and high-frequency sound for the same reason (although this species also responds to low-frequency sound and is considered to hear at low-, mid-, and high frequencies; i.e., vocalization, as is assumed for baleen whales). Sperm whales are also assumed to have similar hearing qualities as other, better studied, toothed whales. Hearing in sea turtles is

generally similar within the taxa, with data from loggerhead and green sea turtles being representative of the taxa as a whole.

- Species for which little or no information on response to sound at different received sound levels will respond similarly to their close taxonomic or ecological relatives (i.e., baleen whales respond similarly to each other; same for sea turtles).

4 STATUS OF ESA-LISTED SPECIES

This section identifies the ESA-listed species that potentially occur within the action area (Figure 3) that may be affected by the proposed seismic activities (Table 6). It then summarizes the biology and ecology of those species and what is known about their life histories in the action area. The species potentially occurring within the action area are listed in Table 6, along with their regulatory status.

Table 6. Threatened and endangered species that may be affected by NSF's proposed action of seismic activities in the southeast Pacific Ocean off the coast of Chile.

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
Humpback Whale (*Megaptera novaeangliae*)	E – 35 FR 18319 and 80 FR 22304 (Proposed)	-- --	55 FR 29646
Southern Right Whale (*Eubalaena australis*)	E – 35 FR 8491	-- --	-- --
Sei Whale (Balaenoptera borealis)	E – 35 FR 18319	-- --	76 FR 43985
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584
Sea Turtles			
Green Turtle, (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	-- --
Leatherback Turtle (*Dermochelys coriacea*)	E – 61 FR 17	44 FR 17710	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*)	T – 43 FR 32800	-- --	-- --
Loggerhead Turtle (*Caretta caretta*) – South Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693	57 FR 38818

Species	ESA Status	Critical Habitat	Recovery Plan
	Fishes		
Scalloped Hammerhead Shark (*Sphyrna lewini*) Eastern Pacific DPS	E – 79 FR 38213	-- --	-- --

4.1 ESA-listed 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 6 and we summarize our results below.

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

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

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

4.1.1.1 Hawksbill sea turtles

Hawksbill sea turtles (*Eretmochelys imbricata*) are circumtropical, and found in the Atlantic, Indian, and Pacific oceans.

There is a small (approximately 15 females) nesting population of hawksbill sea turtles in Ecuador (Gaos et al. 2010; NMFS 2013). After nesting, hawksbill turtles migrate to foraging

grounds, typically coral reefs, where they eat sponges and other invertebrates (USFWS 1993). There are no coral reefs in the action area where we might expect hawksbill turtles to forage. The nesting site in Ecuador is over 2,000 km north of the northern survey area for the proposed action.

Since the proposed action would take place in an area where we do not expect hawksbill sea turtles to be, we do not expect them to be adversely affected by the proposed action. We therefore conclude that the effects of the proposed action to hawksbill turtles are discountable, and will not be considered further in this opinion.

4.1.1.2 Scalloped hammerhead sharks

Scalloped hammerhead shark (*Sphyrna lewini*) are distributed worldwide in coastal warm and tropical waters. The Eastern Pacific DPS was listed as endangered; its range in the eastern Pacific extends from southern California to Ecuador (and possibly Peru) (Miller et al. 2013). Because the range of the species is outside the proposed action area, scalloped hammerheads are not likely to be exposed to the effects of the proposed action. We therefore conclude that the effects of the proposed action to scalloped hammerhead shark are discountable, and will not be considered further in this opinion.

4.2 ESA-listed Species and Critical Habitat Likely to be Adversely Affected

This opinion examines the status of each species that would be affected by the proposed action. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 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].

The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

One factor affecting the rangewide status of sei, fin, blue, southern right, humpback, and sperm whales, olive ridley, East Pacific DPS green, South Pacific Ocean DPS loggerhead, and leatherback sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in the environmental baseline section following the status of the species.

4.2.1 Sei Whale

4.2.1.1 Species description and distrubtion

The sei whale is a widely distributed baleen whale, between 40-60 feet in length, and up to 100,000 pounds. They are long and sleek, with the top of the body dark bluish gray to black in color with white on the ventral surface.

4.2.1.2 Population structure

The population structure of sei whales is unknown. Populations herein assume (based upon migratory patterns) population structuring is discrete by ocean basin (North Pacific and North Atlantic), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones (NMFS 2012). The discussion in this opinion will focus on sei whales in the Southern Ocean, since that is the population most likely to be exposed to the proposed action.

Sei whales occur throughout the Southern Ocean during the austral summer, generally between 40-50° S (Gambell 1985c). During the austral winter, sei whales occur off Brazil and the western and eastern coasts of southern Africa and Australia, although all of the 20 sightings off Argentina occurred in August or September (Iniguez et al. 2010). However, sei whales generally do not occur north of 30° S in the Southern Hemisphere (Reeves et al. 1999). However, confirmed sighting records exist for Papua New Guinea and New Caledonia, with unconfirmed sightings in the Cook Islands (Programme) 2007).

4.2.1.3 Movement

The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999). When on feeding grounds, larger groupings have been observed (Gambell 1985c).

4.2.1.4 Reproduction

Very little is known regarding sei whale reproduction. Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months, calves are weaned at 6-9 months, and the calving interval is about 2-3 years (Gambell 1985c; Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). Of 32 adult female sei whales harvested by Japanese whalers, 28 were found to be pregnant while one was pregnant and lactating during May-July 2009 cruises in the western North Pacific (Tamura et al. 2009).

4.2.1.5 Feeding

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2006). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Konishi et al. 2009; Mizroch et al. 1984; Rice 1977). In the Southern Hemisphere, the sei whales' diet is composed largely of krill (Laws 1977).

4.2.1.6 Vocalization and hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 sec duration and tonal and upsweep calls in the 200-600 Hz range of 1-3 sec durations (McDonald et al. 2005). Source levels of 189 ±5.8 dB re 1 μPa at 1m have been established for sei whales in the northeastern Pacific (Weirathmueller et al. 2013). Differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007a). The first variation consisted of sweeps from 100 to 44 Hz, over 1.0 sec. During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007b) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency downswept calls. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 to 21 Hz over 1.3 sec. 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 (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 ms) FM sweeps between 1.5-3.5 kHz (Thomson and Richardson 1995).

4.2.1.7 Status and trends

Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas.

The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. Consideration of the status of populations outside of the action area is important under the present analysis to determine the risk to the affected population(s) bears on the status of the species as a whole. **Table 7** provides estimates of historic and current abundance for ocean regions. The population in the Ross Sea is estimated to be around 100 animals (Pinkerton et al. 2010). In 2015, 337 whales were found dead along the coast of Patagonia, Chile; most are believed to be sei whales[1]. The cause of the stranding is still being investigated, although red tide is a possibility.

[1] http://news.nationalgeographic.com/2015/11/151120-worlds-largest-whale-stranding-sei-chile-animals/

Table 7. Summary of past and present sei whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	--	>105,000	--	25,000	--	(Braham 1991)
North Atlantic	Basinwide	--	--	>4000	--	(Braham 1991)
	~~			>13,500		(Sigurjonsson 1995)
	NMFS-Nova Scotia stock	--	--	386	--	(NMFS 2008; Waring et al. 2012)
	Northeast Atlantic	--	--	10,300	0.268	(Cattanach et al. 1993)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

4.2.1.8 Critical habitat

No critical habitat has been designated for sei whales.

4.2.2 Fin Whale

4.2.2.1 Species description and distribution

The fin whale is the second largest baleen whale and is widely distributed in the world's oceans. Fin whales can be up to 75-85 feet in length. Most fin whales in the Southern Hemisphere migrate seasonally from Antarctic feeding areas in the summer to low-latitude breeding and calving grounds in winter. Fin whales tend to avoid tropical and pack-ice waters, with the high-latitude limit of their range set by ice and the lower-latitude limit by warm water of approximately 15° C (Sergeant 1977). Fin whale concentrations generally form along frontal boundary, or mixing zones between coastal and oceanic waters, which corresponds roughly to the 200 m isobath (the continental shelf edge (Cotte et al. 2009b; Nasu 1974). Between July and October 2006-2014, researchers observed 95 fin whales in Mejillones Bay in northern Chile (23°S), mostly in nearshore waters (30-1,000 m deep) (Pacheco et al. 2015).

4.2.2.2 Population structure

Population structure has undergone only a rudimentary framing. Genetic studies by Bérubé et al. (1998) indicate that there are significant genetic differences among fin whales in differing geographic areas (Mediterranean, Sea of Cortez, Gulf of St. Lawrence, and Gulf of Maine). Further, individuals in the Sea of Cortez may represent an isolated population from other eastern North Pacific fin whales (Berube et al. 2002). Even so, mark-recapture studies also demonstrate

that individual fin whales migrate between management units designated by the IWC (Mitchell 1974; Sigujónsson and Gunnlaugsson 1989).

There are two recognized subspecies of fin whales, *Balaenoptera physalus physalus*, which occurs in the North Atlantic Ocean, and *B. p. quoyi*, which occurs in the Southern Ocean. These subspecies and North Pacific fin whales appear to be organized into separate populations, although there is a lack of consensus in the published literature as to population structure.

4.2.2.3 Movement

Fin whales along Southern California were found to be traveling 87 percent of the time and milling 5 percent in groups that averaged 1.7 individuals (Bacon et al. 2011). Fin whales tend to avoid tropical and pack-ice waters, with the high-latitude limit of their range set by ice and the lower-latitude limit by warm water of approximately 15° C (Sergeant 1977). Fin whale concentrations generally form along frontal boundaries or mixing zones between coastal and oceanic waters, which corresponds roughly to the 200 m isobath (the continental shelf edge (Cotte et al. 2009a; Nasu 1974).

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4.2.2.4 Reproduction

Fin whales reach sexual maturity between 5-15 years of age (COSEWIC 2005; Gambell 1985a; Lockyer 1972). Mating and calving occurs primarily from October-January, gestation lasts approximately 11 months, and nursing occurs for 6-11 months (Boyd et al. 1999; Hain et al. 1992). The average calving interval in the North Atlantic is estimated at about 2-3 years (Agler et al. 1993; Christensen et al. 1992a). The location of winter breeding grounds is uncertain but mating is assumed to occur in pelagic mid-latitude waters (Perry et al. 1999). This was recently contradicted by acoustic surveys in the Davis Strait and off Greenland, where singing by fin whales peaked in November through December; the authors suggested that mating may occur prior to southbound migration (Simon et al. 2010). Although seasonal migration occurs between presumed foraging and breeding locations, fin whales have been acoustically detected throughout the North Atlantic Ocean and Mediterranean Sea year-round, implying that not all individuals follow a set migratory pattern (Notarbartolo-Di-Sciara et al. 1999; Simon et al. 2010). Reductions in pregnancy rates appear correlated with reduced blubber thickness and prey availability (Williams et al. 2013).

Not much is known regarding the age distribution of fin whales in the Southern Hemisphere. Aguilar and Lockyer (1987) suggested annual natural mortality rates in northeast Atlantic fin whales may range from 0.04 to 0.06. Fin whales live 70-80 years (Kjeld et al. 2006).

4.2.2.5 Feeding

Fin whales in the North Atlantic eat pelagic crustaceans (mainly krill and schooling fish such as capelin, herring, and sand lance (Borobia and Béland 1995; Christensen et al. 1992a; Hjort and Ruud 1929; Ingebrigtsen 1929; Jonsgård 1966; Mitchell 1974; Overholtz and Nicolas 1979; Sergeant 1977; Shirihai 2002; Watkins et al. 1984)). In the Southern Ocean, fin whales mostly eat krill (Laws 1977). Fin whales frequently forage along cold eastern current boundaries (Perry et al. 1999). Feeding may occur in waters as shallow as 10 m when prey are at the surface, but most foraging is observed in high-productivity, upwelling, or thermal front marine waters (Gaskin 1972; Nature Conservancy Council 1979 as cited in ONR 2001; Panigada et al. 2008; Sergeant 1977). Fin whales have been observed feeding off the coast of north-central Chile (29°S to 32°S) (Perez et al. 2006).

4.2.2.6 Vocalization and hearing

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992a; Watkins 1981; Watkins et al. 1987b). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Croll et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995b) reported the most common sound as a 1 sec vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns during winter. Au (2000b) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981). Source levels for fin whale vocalizations are 140-200 dB re 1μPa·m (Clark and Ellison. 2004; Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987b). 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 1998b). Short sequences of rapid pulses in the 20-70 Hz 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 1997; Payne and Webb 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of 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 et al. 1987a), 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).

4.2.2.7 Status and trends

Fin whales have undergone significant exploitation, but are currently protected under the IWC. In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit NMFS (2006b). Japanese whalers plan to kill 50 whales per year starting in the 2007-2008 season and continuing for the next 12 years (IWC 2006; Nishiwaki et al. 2006).

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Although fin whale population structure remains unclear, various abundance estimates are available (Table 8). Consideration of the status of populations outside of the action area is important under the present analysis to determine the how the risk to the affected population(s) bears on the status of the species as a whole. Historically, worldwide populations were severely depleted by commercial whaling, with more than 700,000 whales harvested in the twentieth century (Cherfas 1989b; Cherfas 1989a).

Reliable estimates for fin whale population in the Southern Hemisphere are not available, although there have been several sighting surveys conducted in the Antarctic (i.e., south of 60°S). Estimates of fin whales in the Southern Ocean obtained from these surveys vary from 2,100 to 5,500 (Best 2005). Other more recent estimates put the population of Southern Ocean fin whales as high as 14,500, leading some to believe the population in that area is increasing (Matsuoka et al. 2004).

Table 8. Summary of past and present fin whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	>464,000	~~	119,000	~~	(Braham 1991)
North Atlantic	Basinwide	30,000-50,000	~~	~~	~~	(Sergeant 1977)
	~~	360,000	249,000-481,000	~~	~~	(Roman and Palumbi 2003)
	~~			>50,000		(Sigurjonsson 1995)
	Eastern North Atlantic			25,000		(2009) circa 2001

Central and northeastern Atlantic	~~	~~	30,000	23,000-39,000	(IWC 2007)
Western North Atlantic	~~	~~	3,590-6,300	~~	(Braham 1991)
NMFS-western North Atlantic stock	~~	~~	3,985	CV=0.24	(NMFS 2008; Waring et al. 2012)
Northeastern U.S. Atlantic cont'l shelf	~~	~~	2,200-5,000	~~	(Hain et al. 1992; Waring et al. 2000)
IWC-Newfoundland-Labrador stock	~~	~~	13,253	0-50,139*	(IWC 1992)
Bay of Biscay			7,000-8,000		(Goujon et al. 1994)
IWC-British Isles, Spain, and Portugal stock	10,500	9,600-11,400	4,485	3,369-5,600	(Braham 1991)
~~	~~	~~	17,355	10,400-28,900	(Buckland et al. 1992)
IWC-east Greenland to Faroe Islands	~~	~~	22,000	16,000-30,000	(IWC 2014)
IWC-west Greenland stock	~~	~~	4,500	1,900-10,000	(IWC 2014)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

4.2.2.8 Critical habitat

No critical habitat has been designated for fin whales.

4.2.3 Southern Right Whale

4.2.3.1 Species description and distribution

Southern right whales are between 45-55 feet in length, weighing up to 120,000 pounds. They are usually black in color, with distinctive large, white callosities on their heads. Southern right

whales occur exclusively in the southern hemisphere, currently up to 18° S latitude in the Atlantic and 12° S in the eastern Pacific (Iniguez et al. 2003; Richards 2009; Van Waerebeek et al. 1992; Van Waerebeek et al. 2009). The northern most recent sighting of a southern right whale in the western Pacific was at approximately 25° S of a mother-calf pair in Hervey Bay, Australia in 2000 and 2009 (Richards 2009). Townsend (1935) and Maury (1851; 1854) support historical distribution generally up to roughly 25-30° S latitude in the Pacific and Atlantic (Richards 2009). Sex ratios on summer feeding grounds in South Georgia and western Australia were 1:1 (Patenaude et al. 2007a).

4.2.3.2 Population structure

Population structure remains uncertain, but some separation to the population level likely exists. Southern right whales breeding along Brazil and other western South Atlantic breeding areas likely belong to a single population due to the high rate of exchange within these groups (Cummings 1985; Ott et al. 2001). Genetically distinct populations also exist in waters surrounding New Zealand, southwestern Australia, and southern Africa (Baker et al. 1999; Carroll et al. 2010; Patenaude et al. 2007b; Richards 2009; Valenzuela et al. 2010). Strong maternal site fidelity to breeding locations likely maintains genetic discreetness between populations (Valenzuela et al. 2010; Valenzuela et al. 2009). Some subpopulation structure appears to exist within the southwestern Atlantic population (Ott et al. 2001).

Low-level genetic exchange or movement between breeding areas appears to be occurring. Genetic exchange, at least at a low level, occurs between New Zealand/southwestern Australia whales and the southwestern Atlantic population (Moore et al. 1999; Patenaude et al. 1999; Valenzuela et al. 2010). Movement of individuals has also been documented between southwestern Atlantic breeding grounds and South African locations, although genetic exchange between these locations needs further evaluation (Best et al. 1993). The subpopulation located off the coast of Peru and Chile is listed as "critically endangered" under the IUCN, and is thought to contain less than 50 mature individuals (Galletti Vernazzani et al. 2014) (Reilly 2013).

4.2.3.3 Movement

Southern right whales migrate between winter breeding areas in coastal waters of the South Atlantic, Pacific, and Indian Oceans from May to December and offshore summer (January to April) foraging locations in the Subtropical and Antarctic Convergence zones (Azevedo et al. 1999; Bannister et al. 1999; De Oliveira et al. 2009; Tormosov et al. 1998). Movements are not necessarily north-south, but may also be east-west, such as between South African breeding grounds and Gough Island (south-central South Atlantic Ocean) (Best et al. 1993; De Oliveira et al. 2009; Mate et al. 2011). Females with calves stay significantly longer (approximately 71 days) in calving grounds off southern Australia than do females without calves (approximately 20 days) (Burnell and Bryden 1997). Southern right whales have been seen in these waters from mid-May to late October, with 100 percent of calves being born by September/October (Burnell and Bryden 1997). Southern right whales appear in waters off New Zealand's South Island in May, likely for calving (Richards 2002). Clement (2010) suggested that East Cape may be a

point at which southern right whales concentrate along their migration route. Females with calves born late in the season stayed twice as long as those whose calves were born early in the season (80 versus 40 days) (Burnell and Bryden 1997).

Along Peninsula Valdes, South Africa, and Brazil (all breeding or calving areas) most southern right whales remain in very shallow water of less than 20 m (Azevedo et al. 1999; Crespo et al. 2000; Elwen and Best 2004a; Elwen and Best 2004b; Payne 1986). Furthermore, right whales along South Africa prefer near shore waters that are protected from swells and wind, have gently sloping sedimentary bottoms, and lack rocky shorelines (Elwen and Best 2004a; Elwen and Best 2004b). Individuals other than cow-calf pairs tended to occupy somewhat deeper water (Elwen and Best 2004a; Elwen and Best 2004b). This near shore tendency has also been observed in the extreme north of southern right whale range along Peru (Van Waerebeek et al. 2009). Local segregation of habitat by groups may exist in which mothers and calves occupy different areas than adult male and female groups and subadult mating groups (Payne 1986). Small-scale shifts in habitat have been documented, possibly as a result of anthropogenic impacts (Rowntree et al. 2001).

4.2.3.4 Reproduction

Southern right whales migrate between winter breeding areas in coastal waters of the South Atlantic, Pacific, and Indian Oceans from May to December and offshore summer (January to April) foraging locations in the Subtropical and Antarctic Convergence zones (Azevedo et al. 1999; Bannister et al. 1999; De Oliveira et al. 2009; Tormosov et al. 1998). Movements are not necessarily north-south, but may also be east-west, such as between South African breeding grounds and Gough Island (south-central South Atlantic Ocean) (Best et al. 1993; De Oliveira et al. 2009; Mate et al. 2011). Females with calves stay significantly longer (approximately 71 days) in calving grounds off southern Australia than do females without calves (approximately 20 days) (Burnell and Bryden 1997). Southern right whales have been seen in these waters from mid-May to late October, with 100 percent of calves being born by September/October (Burnell and Bryden 1997). Southern right whales appear in waters off New Zealand's South Island in May, likely for calving (Richards 2002). Clement (2010) suggested that East Cape may be a point at which southern right whales concentrate along their migration route. Females with calves born late in the season stayed twice as long as those whose calves were born early in the season (80 versus 40 days) (Burnell and Bryden 1997). A female and calf were observed off the coast of Isla de Chiloé (42°S) in October 2010 (Galletti Vernazzani et al. 2014).

4.2.3.5 Feeding

Southern right whales forage on krill and copepods in the Southern Ocean during the austral summer. The Scotia Sea is a particularly important feeding ground due to the high densities of krill there (NMFS 2015b).

4.2.3.6 Vocalization and hearing

Southern right whales are known to produce a variety of low-frequency vocalizations on breeding groups (Clark 1982a; Clark 1983). The most common is an "up" call (50-200 Hz with a frequency modulated upsweep) (Tellechea and Norbis 2012) that appears to establish contact and aggregate individuals (Clark 1982a; Clark 1983; Dunshea and Gedamke. 2010). Blows (100-400 Hz), apart from their respiratory function, may signal calves to remain close or inform approaching animals to stay away (particularly loud, pulsative, or tonal blows) (Clark 1981; Clark 1982b; Clark 1983). Slaps (50-1,000 Hz), "pulsatile" and "hybrid" (both complex 50-200 Hz) calls may have a threat, antagonism, or aggressive function in sexually active groups, but little or no communicative function in other groups (Clark 1981; Clark 1982b; Clark 1983; Tellechea and Norbis 2012). "Down" calls (100-200 Hz with frequency modulated downsweep) seem to have a similar function as "up" calls, but are produced by more excited individuals (Clark 1981; Clark 1982b; Clark 1983). "High" calls (200-500 Hz) may indicate an excited individual, excite other individuals, or attract whales to a group (Clark 1981; Clark 1982b; Clark 1983; Tellechea and Norbis 2012).

Resting and swimming groups are silent most of the time; resting groups do make "blow" sound, though, and resting individuals may make "up" calls. Swimming groups make "up" calls more than any other sound. As physical activity increases, so does the level of vocal activity (Clark 1981; Clark 1983). Mildly active groups were silent only one-quarter of the time and made large numbers of "slap" sounds by striking flukes or flippers on the water surface. Highly-active groups are rarely silent and make numerous slaps, blows, as well as, "up", "hybrid", "high", and "pulsative" calls. Sexually active groups have not been documented to make "up" calls or be silent, but make extensive "hybrid", "high", and "pulsative" calls (Clark 1981; Clark 1983). "Up" calls have also been recorded during winter on feeding grounds (Sirovic et al. 2006).

4.2.3.7 Status and trends

Southern right whales are currently subject to many of the same anthropogenic threats as other large whales face, such as ship strike, pollution, and recovering from the effects of whaling. Southern right whales underwent severe decline due to whaling during the 18th and 19th centuries (Costa et al. 2005; NHT 2005). At least 6,262 individuals were killed when Townsend (1935) published a summary of whaling records (Richards 2009). However, these numbers may be much higher, as Richards (2009) suggests roughly 20,000 individuals had been killed around New Zealand by 1927 alone. Illegal Soviet whaling removed at least an additional 3,368 individuals between 1951 and 1971 (Richards 2009; Tormosov et al. 1998). Some 53,000 to 58,000 were likely taken from waters along New Zealand and eastern Australia (Carroll et al. 2014).

Despite these pressures, southern right whale populations in general appear to be increasing at a robust rate. De Oliveira (2009) estimated that roughly 7,000 individuals exist today; 5-10 percent of the species' former abundance. The Australian recovery plan for southern right whales estimates that 60,000 southern right whales existed prior to commercial whaling; 1,500

individuals are estimated to visit waters around Australia (NHT 2005). Population growth off Australia is believed to be 7-13 percent annually (Bannister 2001). Southern right whale populations in Argentina and South Africa are increasing at about 6.9 percent per year (Belgrano et al. 2011). New Zealand has estimated that 16,000 individuals visited its waters prior to commercial exploitation; this number was believed to have been reduced to between 14-52 individuals and current abundance is less than 5 percent of historic levels (Patenaude 2003). Genetic analyses suggest a reproductive male population of 1,001 individuals for New Zealand southern right whales (Carroll et al. 2012). IWC (2014) estimated 12,000 southern right whales; other estimates place the Southern Hemisphere population at 15,000 (NMFS 2015a). However, the current population trend of southern right whales of the Chile/Peru subpopulation is unknown (Reilly 2013).

Genetic diversity of populations may also have been reduced as a result of extensive whaling, although this is not the case for all populations (Baker et al. 1999; Valenzuela et al. 2010).

4.2.3.8 Critical habitat

No critical habitat has been designated for southern right whales.

4.2.4 Blue Whale

4.2.4.1 Species description and distribution

Blue whales occur primarily in the open ocean from tropical to polar waters worldwide. Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998a). Blue whales typically occur alone or in groups of up to five animals, although larger foraging aggregations of up to 50 have been reported including aggregations mixed with other rorquals such as fin whales (Corkeron et al. 1999; Shirihai 2002).

Several blue whale subspecies have been characterized from morphological and geographical variability, but the validity of blue whale subspecies designations remains uncertain (McDonald et al. 2006). The largest, the Antarctic or true blue whale (*Balaenoptera musculus intermedia*), occurs in the highest Southern Hemisphere latitudes (Gilpatrick and Perryman. 2009). During austral summers, "true" blue whales occur close to Antarctic ice. A slightly smaller blue whale, *B. musculus musculus*, inhabits the Northern Hemisphere (Gilpatrick and Perryman. 2009). The pygmy blue whale (B. *musculus brevicauda*), may be geographically distinct from *B. m. musculus* (Kato et al. 1995). Pygmy blue whales occur north of the Antarctic Convergence (60°-80° E and 66°-70° S), while true blue whales are south of the Convergence (58° S) in the austral summer (Kasamatsu et al. 1996; Kato et al. 1995). A fourth subspecies, *B. musculus indica*, may exist in the northern Indian Ocean (McDonald et al. 2006).

4.2.4.2 Population structure

Little is known about population and stock structure[2] of blue whales. Studies suggest a wide range of alternative population and stock scenarios based on movement, feeding, and acoustic data. Some suggest there are as many as 10 global populations, while others suggest that the species is composed of a single panmictic population (Gambell 1979; Gilpatrick and Perryman. 2009; Reeves et al. 1998). For management purposes, the International Whaling Commission (IWC) considers all Pacific blue whales to be a single stock, whereas under the MMPA, the NMFS recognizes four stocks of blue whales: western North Pacific Ocean, eastern North Pacific Ocean, northern Indian Ocean, and Southern Hemisphere.

Until recently, blue whale population structure had not been tested using molecular or nuclear genetic analyses (Reeves et al. 1998). A recent study by Conway (2005) suggested that the global population could be divided into four major subdivisions, which roughly correspond to major ocean basins: eastern North and tropical Pacific Ocean, Southern Indian Ocean, Southern Ocean, and western North Atlantic Ocean. The eastern North/tropical Pacific Ocean subpopulation includes California, western Mexico, western Costa Rica, and Ecuador, and the western North Atlantic Ocean subpopulation (Conway 2005). Genetic studies of blue whales occupying a foraging area south of Australia (most likely pygmy blue whales) have been found to belong to a single population (Attard et al. 2010). For this opinion, blue whales are treated as four distinct populations as outlined by Conway (2005).

In the Southern hemisphere, blue whales range from the edge of the Antarctic pack ice (40°-78° S) during the austral summer north to Ecuador, Brazil, South Africa, Australia, and New Zealand during the austral winter (Shirihai 2002). Occurrence in Antarctic waters appears to be highest February-May as well as in November (Gedamke and Robinson. 2010; Sirovic et al. 2009). Gedamke and Robinson (2010) found blue whales to be particularly numerous and/or vocal north of Prydz Bay, Antarctica based upon sonobuoy deployments. Pygmy blue whales were also frequently heard in Antarctic waters, further south than they had previously been documented (Gedamke and Robinson 2010). Other than a single vocal record in Atlantic waters off Angola, pygmy blue whales have been exclusively documented in the Indian Ocean or western Pacific (Cerchio et al. 2010; Mccauley and Jenner 2010).

Blue whales are occasionally sighted in pelagic waters off the western coast of Costa Rica and Nicaragua, near the Galápagos Islands, and along the coasts of Ecuador and northern Peru (Aguayo 1974a; Clarke 1980b; Donovan 1984; LGL Ltd. 2007; Mate et al. 1999; Palacios 1999;

"Populations" herein are a group of individual organisms that live in a given area and share a common genetic heritage. While genetic exchange may occur with neighbouring populations, the rate of exchange is greater between individuals of the same population than among populations---a population is driven more by internal dynamics, birth and death processes, than by immigration or emigration of individuals. To differentiate populations, NMFS considers geographic distribution and spatial separation, life history, behavioral and morphological traits, as well as genetic differentiation, where it has been examined. In many cases, the behavioral and morphological differences may evolve and be detected before genetic variation occurs. In some cases, the term "stock" is synonymous with this definition of "population" while other usages of "stock" are not.

Reilly and Thayer 1990). Individuals here may represent two populations; the true and pygmy blue whales of the Southern Hemisphere (Gilpatrick and Perryman. 2009), although, recent analyses of vocalizations and photos have linked blue whales found in the Costa Rica Dome to the North Pacific population (Chandler and Calambokidis 2004).

Blue whales along the Chilean coast belong to the pygmy blue whale subspecies, or an at-present undescribed subspecies (based upon differences in call type, morphological features, abundance, and distribution) (Branch et al. 2007a; Buchan et al. 2008; Buchan et al. 2010). Average group size along Chile has consistently been reported as between one and two individuals (Branch et al. 2007a; Galletti Vernazzani et al. 2007). Blue whales sighted during a 1964 cruise offshore of Chile in the Humboldt Current and through the action area found blue whales traveling south (Clarke et al. 1978). Nine blue whales were sighted within the survey area in a boat-based survey between December 1997 and January 1998 (Williams et al. 2009). A recently-discovered feeding location in the Chilean Archipelago around Chiloe Island (approximately 41-42° S) is a major concentrating area for blue whales along Chile, at least during the periods during which surveys have been conducted there (January-March) (Galletti et al. 2005; Galletti Vernazzani et al. 2006; Galletti Vernazzani et al. 2005; Hucke-Gaete et al. 2006a; Maritime Affairs Department Environmental- Antarctic Maritime Affairs Division Ministry of Foreign Affairs 2010; Vernazzani et al. 2009; Vernazzani et al. 2011). High levels of primary productivity in the area likely support blue whale occurrence here (Hucke-Gaete et al. 2003; Viddi et al. 2010). "Skinny" blue whales are frequently seen here, although it is unclear whether this is due to normal annual fasting or another cause (Galletti et al. 2005; Galletti Vernazzani et al. 2007; Galletti Vernazzani et al. 2006; Galletti Vernazzani et al. 2005; Vernazzani et al. 2008a). A greater proportion of skinny blue whales was correlated with higher sea surface temperatures (and likely reduced primary productivity) (Vernazzani et al. 2008a). Satellite tagging indicates that blue whales are resident here for extended periods, but also move offshore and north, with some moving into a potential breeding area and/or feeding area over the Nazca Ridge (an area of upwelling roughly 800 km offshore near 25° S) (Hucke-Gaete and Mate 2005). An area just south of Chiloe Island, the Gulf of Cordova (approximately 44° S) appears to be an area for both feeding and nursing from January through April (Hucke-Gaete et al. 2004a). Aerial surveys conducted from 35° to 44° S along the Chilean coast in February and April found 14 blue whale groups composed of 18 individuals (Maritime Affairs Department Environmental- Antarctic Maritime Affairs Division Ministry of Foreign Affairs 2007).

4.2.4.3 Movement

Satellite tagging indicates that, for blue whales tagged off southern California, movement is more linear and faster (3.7 km/h) while traveling versus while foraging (1.7 km/h) (Bailey et al. 2009). Residency times in what are likely prey patches averages 21 days and constituted 29 percent of an individual's time overall, although foraging could apparently occur at any time of year for tagged individuals (Bailey et al. 2009). Broad scale movements also varied greatly, likely in response to oceanographic conditions influencing prey abundance and distribution

(Bailey et al. 2009). Blue whales avoid oligotrophic gyres in all major ocean basins, but concentrate at locations of high phytoplankton occurrence, such as along frontal and upwelling features (prominent within the Humboldt Current) (Branch et al. 2007a). Resighting data from a feeding area south of the action area indicate blue whales are not long residents (although they return regularly) and that individuals likely disperse within a wider area (Cabrera et al. 2006; Hucke-Gaete and Mate 2005).

Blue whales spend greater than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 sec intervals before a deep dive of 3-30 min (Croll et al. 1999; Leatherwood et al. 1976; Mackintosh 1965; Maser et al. 1981; Strong 1990; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

Blue whales occur singly or in groups of two or three (Aguayo 1974a; Mackintosh 1965; Nemoto 1964; Pike and MacAskie 1969; Ruud 1956; Slijper 1962). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Fiedler et al. 1998; Schoenherr 1991).

4.2.4.4 Reproduction

Gestation takes 10-12 months, followed by a 6-7 month nursing period. Sexual maturity occurs at 5-15 years of age and calves are born at 2-3 year intervals (COSEWIC 2002; NMFS 1998b; Yochem and Leatherwood 1985). Recent data from illegal Russian whaling for Antarctic and pygmy blue whales support sexual maturity at 23 m and 19-20 m, respectively (Branch and Mikhalev 2008). Blue whales may reach 70–80 years of age (COSEWIC 2002; Yochem and Leatherwood 1985).

4.2.4.5 Feeding

Data indicate that some summer feeding takes place at low latitudes in upwelling-modified waters, and that some whales remain year-round at either low or high latitudes (Clarke and Charif 1998a; Hucke-Gaete et al. 2004b; Reilly and Thayer 1990; Yochem and Leatherwood 1985). One population feeds in California waters from June to November and migrates south in winter/spring (Calambokidis et al. 1990; Mate et al. 1999). Prey availability likely dictates blue whale distribution for most of the year (Burtenshaw et al. 2004; Clapham et al. 1999; Sears 2002 as cited in NMFS 2006a). The large size of blue whales requires higher energy requirements than smaller whales and potentially prohibits fasting Mate et al. (1999). Krill are the primary prey of blue whales in the North Pacific (Kawamura 1980; Yochem and Leatherwood 1985).

While feeding, blue whales show slowed and less obvious avoidance behavior then when not feeding (Sears et al. 1983 as cited in NMFS 2005b).

4.2.4.6 Vocalization and hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 s repeated every 1 to 2 min (see McDonald et al. 1995a). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. However, blue whales along Chile have a distinct and regular higher-frequency component over 400 Hz (Buchan et al. 2008; Buchan et al. 2010). Reported source levels are 180-188 dB re 1μPa, but may reach 195 dB re 1μPa (Aburto et al. 1997; Clark and Ellison 2004; Ketten 1998; McDonald et al. 2001).

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources; (Edds-Walton 1997; Payne 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 while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure.

Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

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).

4.2.4.7 Status and trends

Blue whales have faced threats from several historical and current sources. Blue whale populations are severely depleted originally due to historical whaling activity. Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973.

Table 9 contains historic and current estimates of blue whales by region. Globally, blue whale abundance has been estimated at between 5,000-13,000 animals (COSEWIC 2002; Yochem and Leatherwood 1985); a fraction of the 200,000 or more that are estimated to have populated the oceans prior to whaling (Maser et al. 1981; U.S. Department of Commerce 1983).

Table 9. Summary of past and present blue whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	200,000	--	11,200-13,000	--	(DOC 1983; Maser et al. 1981)
				5,000-12,000		(COSEWIC 2002)
North Atlantic	Basinwide	1,100-1,500	--	100-555	--	(Braham 1991; Gambell 1976)
	NMFS - Western North Atlantic stock	--	--	308	--	(Sears et al. 1987)
North Pacific	Basinwide	4,900	--	1,400-1,900	--	(Gambell 1976)
				3,300	--	(Wade and Gerrodette 1993) and (Barlow 1997) as combined in (Perry et al. 1999)
	Eastern Tropical Pacific	--	--	1,415	1,078-2,501	(Wade and Gerrodette 1993)
	Costa Rica	--	--	48	22-102*	(Gerrodette and Palacios 1996)
	Areas north of Central America and Costa Rica	--	--	94	34-257*	(Gerrodette and Palacios 1996)
	Eastern North Pacific	--	--	2,997	2,175-3,819*	(Calambokidis and Barlow 2004)
	NMFS - western North Pacific stock	--	--	n/a	--	(Carretta et al. 2006)
	NMFS - eastern North Pacific stock	--	--	2,842	CV=0.41	(Carretta et al. 2009)
Southern Hemisphere	Basinwide	150,000-210,000	--	5,000-6,000	--	(Gambell 1976; Yochem and Leatherwood 1985)
		300,000	--	--	--	(COSEWIC 2002)
		--	--	400-1,400	400-1,400	IWC, for years 1980-2000
		--	--	1,700	860-2,900	(IWC 2005c), point estimate for 1996
	Within IWC survey areas	--	--	1,255	--	(IWC 1996)
	Pygmy blue whale population	10,000	--	5,000	--	(Gambell 1976)
		13,000	--	6,500	--	(Zemsky and Sazhinov 1982)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

Estimates of 4-5 percent for an average rate of population growth have been proposed for blue whales in the Southern Hemisphere (Yochem and Leatherwood 1985). However, a recent estimate of population growth for Antarctic blue whales throughout the region was 7.3 percent (Branch et al. 2007b). Punt (2010) estimated the rate of increase for blue whales in the Southern Hemisphere to be 8.2 percent annually (3.37 SE) between 1978 and 2004. Branch et al. (2007b) also included an estimate of 1,700 individuals south of 60°. Antarctic blue whales remain severely depleted with the 1996 estimate only 0.7 percent of pre-whaling levels (IWC 2005). Between 1929 and 1967, 2,852 blue whales were killed along Chile due to whaling (Aguayo 1974b). Blue whales along Chile have been estimated to number between 7 and 9 percent of historical abundance (Williams et al. 2011).

Blue whales were the mainstay of whaling in the region once the explosive harpoon was developed in the late nineteenth century (Shirihai 2002). During the early 1900s, the species became a principal target of the whaling industry throughout the world, with the majority killed in the Southern Hemisphere. Approximately 330,000–360,000 blue whales were harvested from 1904 to 1967 in the Antarctic alone, reducing their abundance to less than 3 percent of their original numbers (Perry et al. 1999; Reeves et al. 2003). Blue whales were protected in portions of the Southern Hemisphere beginning in 1939, and received full protection in the Antarctic in 1966. Branch et al. (2007c) estimated 452 blue whales within 22 km of the central Chilean coast, although the survey's design was not ideal to estimate abundance. Another set of surveys conducted in 1997 and 1998 estimated 267 blue whales along an area betweeb 18° and 38° S (Williams et al. 2009). Vernazzani et al. (2011) estimated blue whales along Chile to number between 682 and 1,151 individuals (best estimate 917) based upon more robust survey techniques, making Chilean blue whales the smallest population of blue whales in the Southern Hemisphere (Vernazzani 2011).

4.2.4.8 Critical habitat

NMFS has not designated critical habitat for blue whales.

4.2.5 Humpback Whale

4.2.5.1 Species description and distribution

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed) (Gendron and Urban 1993). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985).

Humpback whales are frequently observed in the Corcovado Gulf in southern Chile, which is a feeding and nursing ground (Cuevas 2009). Humpbacks are being sighted in increasing numbers off the coast of northern Chile (41.5°-44°S) (Hucke-Gaete et al. 2013).

4.2.5.2 Population structure

Populations have been relatively well defined for humpback whales, and currently include the North Atlantic, North Pacific, Arabian Sea, and Southern Hemisphere. NMFS has proposed to revise the ESA listing for the humpback whale to identify 14 distinct population segments, with two as threatened, two as endangered, and the remaining 10 as not warranted for listing (80 FR 22304) (Figure 4). Currently, humpback whales are listed as endangered rangewide. Under the proposed rule, individual humpback whales in the action area would likely be from the proposed Southeastern distinct population segment, and identified as not warranted for listing.

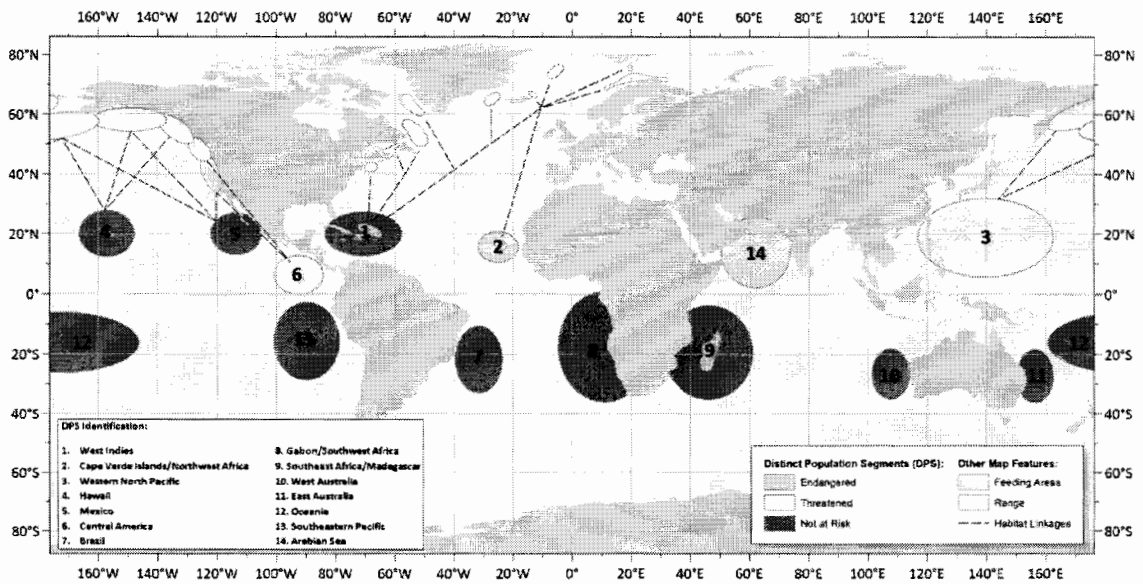

Figure 4. Worldwide distribution of the 14 identified humpback whale distinct population segments.

Eight stocks, or populations, of humpback whales occur in waters of the Southern Hemisphere (Figure 5). Individuals from these stocks winter and breed in separate areas and are known to return to the same areas. However, the degree (if any) of gene flow (i.e., adult individuals wintering in different breeding locations) is uncertain (Carvalho et al. 2011). Individuals from breeding grounds in Ecuador are somewhat heterogeneous from individuals in other breeding areas, but appear to maintain a genetic linkage (Felix et al. 2009). Based upon recent satellite telemetry, a revision of stocks A and G may be warranted to reflect stock movements within and between feeding areas separated east of 50° W (Dalla Rosa et al. 2008). In addition to being a breeding area, the west coast of South Africa also appears to serve as a foraging ground due to upwelling of the Benguela Current (Barendse et al. 2010). Females appear in this area in large numbers well before their male counterparts, frequently accompanied by calves (Barendse et al. 2010). Female movement between breeding locations across years has been documented, bringing into question the genetic discreteness of at least Southern Hemisphere populations (Stevick et al. 2011). However, mixing between some populations has not been found (such as between B2 and C1 groups). Sao Tome appears to be primarily a resting, nursing, and calving area with very little breeding occurring (Carvalho et al. 2011).

Individuals within the action area are part of a group that breeds along Columbia and Ecuador during the austral winter (June-November, peaking in August-October) and feeds in the Strait of Magellan and/or Antarctic Peninsula during the austral summer (December-June) (Capella et al. 2008; Florez-Gonzalez et al. 1998; Sabaj et al. 2004; Vernazzani et al. 2008b). Capella et al. (1999) reported individual humpback whale near Chaparal, Chile (approximately 500 km north and east of the action area) during March. Humpback whales occur along the Peruvian coast (approximately 4° S, the likely southernmost extent of breeding grounds) from at least late-July

to late-September, peaking in August (Pacheco et al. 2011; Pacheco et al. 2009). Migratory routes between feeding and breeding locations are unknown (Capella et al. 2008; Florez-Gonzalez et al. 1998). Humpback whales are feeding along Chiloe Island (approximately 41-42° S) during February-April in groups of one to four individuals (Galletti Vernazzani et al. 2006; Vernazzani et al. 2008b). Further south, in Patagonian fjords, humpback whales are fairly common from January into May (Gibbons et al. 1998). This area, as well as the Straits of Megellan, are a frequently-used foraging location for humpback whales during this time period; prey species inclide Galatheid crabs and herring (Gibbons et al. 1998; Gibbons et al. 2003; Hucke-Gaete et al. 2006b). High levels of primary productivity in the area likely support humpback whale occurrence in the area (Viddi et al. 2010). Group sizes here averages 1.9-2.8, with a maximum of five individuals (Gibbons et al. 2003)(Viddi et al. 2010). Fishermen consider humpback whales to occur year round in the Cordova Gulf (Hucke-Gaete et al. 2006b). Aerial surveys conducted from 35° to 44° S along the Chilean coast during February -April, found a single humpback whale in 2007 and another in 2009 (Maritime Affairs Department Environmental- Antarctic Maritime Affairs Division Ministry of Foreign Affairs 2007).

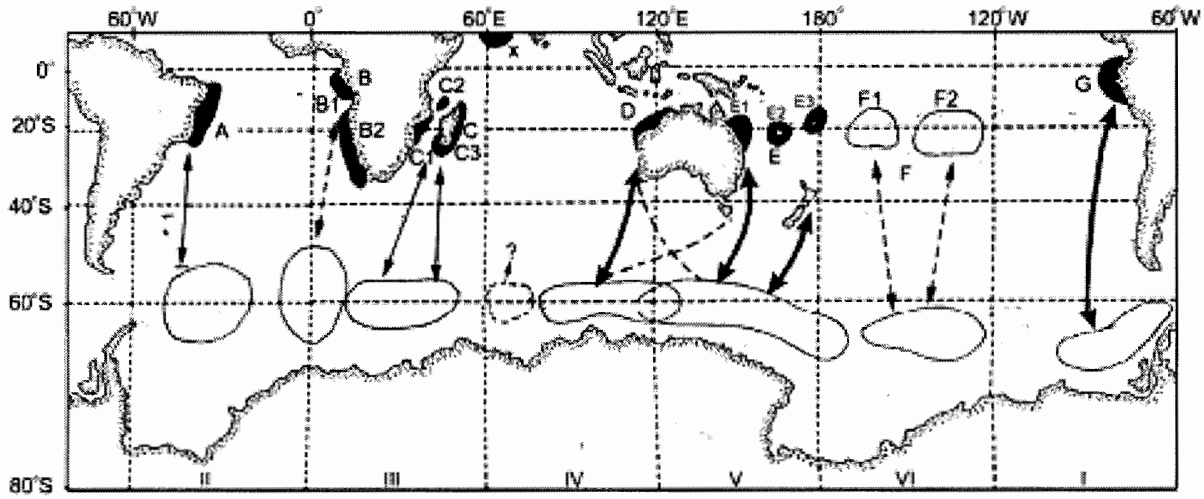

Figure 5. Southern Hemisphere humpback stocks (populations) (IWC 2005).

4.2.5.3 Movement

Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed; (Constantine et al. 2007; Garrigue et al. 2000; Gendron and Urban 1993) (Garrigue et al. 2010). Individuals in the action area would likely belong to IWC management area II and III and breeding stock A, B, (1 and/or 2) (Constantine et al. 2007; Dawbin 1956). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985). Some individuals may not migrate, or species occurrence in foraging areas may extend beyond summer months (Murray et al. 2014; Van Opzeeland et al. 2013).

4.2.5.4 Reproduction

Humpback whale calving and breeding generally occurs during winter at lower latitudes. Gestation takes about 11 months, followed by a nursing period of up to 1 year (Baraff and Weinrich 1993). Sexual maturity is reached at between 5-7 years of age in the western North Atlantic, but may take as long as 11 years in the North Pacific, and perhaps over 11 years (e.g., southeast Alaska, Gabriele et al. 2007). Females usually breed every 2-3 years, although consecutive calving is not unheard of (Clapham and Mayo 1987; 1990; Glockner-Ferrari and Ferrari 1985 as cited in NMFS 2005b; Weinrich et al. 1993). Males appear to return to breeding grounds more frequently than do females (Herman et al. 2011). Larger females tend to produce larger calves that may have a greater chance of survival (Pack et al. 2009). In some Atlantic areas, females tend to prefer shallow nearshore waters for calving and rearing, even when these areas are extensively trafficked by humans (Picanco et al. 2009).

In calving areas, males sing long complex songs directed towards females, other males, or both. The breeding season can best be described as a floating lek or male dominance polygamy (Clapham 1996). Calving occurs in the shallow coastal waters of continental shelves and oceanic islands worldwide (Perry et al. 1999). Males "court" females in escort groups and compete for proximity and presumably access to reproduce females (particularly larger females) (Pack et al. 2009). Although long-term relationships do not appear to exist between males and females, mature females do pair with other females; those individuals with the longest standing relationships also have the highest reproductive output, possibly as a result of improved feeding cooperation (Ramp et al. 2010). The sex ratio of humback whales occurring along Chile is even (Sabaj et al. 2004).

4.2.5.5 Feeding

During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992; Witteveen et al. 2011). The principal fish prey in the western North Atlantic are sand lance, herring, and capelin (Kenney et al. 1985). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best. 1995). Additional evidence, such as songs sung in northern latitudes during winter, provide additional support to plastic seasonal distribution (Smith and G.Pike 2009). Relatively high rates of resighting in foraging sites in Greenland suggest whales return to the same areas year after year (Kragh Boye et al. 2010). Herring and krill are important prey species for humpback whales along Chile (Capella et al. 2008). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively

shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

4.2.5.6 Vocalization and hearing

We understand humpback whale vocalization much better than we do hearing. Humpback whales produce different sounds that correspond to different functions: feeding, breeding, and other social calls. Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (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 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986a; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack and Whitehead 1983). Other social sounds from 50 Hz to 10 kHz (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 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m; (Au 2000b; Erbe 2002a; Payne and Payne 1985; Richardson et al. 1995c; Thompson et al. 1986). Humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c). Recently, humpback whales were reported to use echolocation-type clicks that were associated with feeding (Stimpert et al. 2009). The authors suggest that a primitive echoranging capability may exist.

4.2.5.7 Status and trends

Three human activities widely and significantly threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), NMFS has proposed a revision to the humpback whale listing, designating DPS, (80 FR 22709). Individuals from the the proposed Southeastern Pacific DPS are likely to be in the action area.

(Winn and Reichley 1985) argued that the global humpback whale population consisted of at least 150,000 whales in the early 1900s, mostly in the Southern Ocean. In 1987, the global population of humpback whales was estimated at about 10,000 (NMFS 1987). Although this estimate is outdated, it appears that humpback whale numbers are increasing. Table 10 provides estimates of historic and current abundance for ocean regions.

Table 10. Summary of past and present humpback whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	1,000,000	--	--	--	(Roman and Palumbi 2003)
North Atlantic	Basinwide	240,000	156,000-401,000*	11,570	10,005-13,135*	(Roman and Palumbi 2003) (Stevick et al. 2001) *in* (Waring et al. 2004)
	Basinwide - Females	--	--	2,804	1,776-4,463	(Palsbøll et al. 1997)
	Basinwide - Males	--	--	4,894	3,374-7,123	(Palsbøll et al. 1997)
	Western North Atlantic from Davis Strait, Iceland to the West Indies	>4,685*	--	--	--	*circa 1865; (Mitchell and Reeves 1983)
	NMFS - Gulf of Maine stock	--	--	847	CV=0.55	(Waring et al. 2009)
	NMFS - Gulf of Maine stock, including a portion of Scotian Shelf	--	--	902	177-1,627*	(Clapham et al. 2003)
	Northeast Atlantic - Barents and Norwegian Seas	--	--	889	331-1,447*	(Øien 2001) *in* (Waring et al. 2004)
North Pacific	Basinwide	15,000	--	6,000-8,000	--	(Calambokidis et al. 1997)
	NMFS - Western North Pacific stock	--	--	394	329-459*	(Angliss and Allen 2007)
	NMFS - Central North Pacific stock	--	--	5,833	CV=0.30	(Angliss and Outlaw 2009)
	NMFS - Eastern North Pacific stock	--	--	1,391	1,331-1,451*	(Carretta et al. 2009)
Indian Ocean	Arabian Sea	--	--	56	35-255	Minton et al. (2003) *in* (Bannister 2005)
Southern Hemisphere	Basinwide	100,000	--	19,851	--	(Gambell 1976; IWC 1996)
	South of 60°S	--	--	4,660	2,897-6,423	(IWC 1996)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

The IWC compiled population data on humpback whales in the Southern Hemisphere. Approximately 42,000 Southern Hemisphere humpbacks can be found south of 60° S during the austral summer feeding season (IWC 2007). However, humpback whales in this region experienced severe whaling pressure. Based upon whaling logs, particularly by Soviet vessels, at least 75,542 humpback whales were harvested from Antarctic waters from 1946 through 1973, largely from management areas IV, V, and VI (Clapham et al. 2009). One-third of these catches occurred from 1959-1961 in Area V. These numbers support Southern Hemisphere humpbacks being well below their carrying capacities (Clapham et al. 2009). Between 1929 and 1966, 319 humpback whales were harvested from Chilean waters (Aguayo 1974b). Towards the end of the whaling period, observation cruises did not detect humback whales in Chilean offshore waters between 33° and 48° S (Aguayo 1974b) . Recent surveys off the Brazilian breeding grounds suggests a population of 6,404 individuals in this area (Andriolo et al. 2010). Modeling efforts to bound the number of individuals within Oceania have estimated 2,300-3,500 individuals divided amongst various populations/subpopulations (Constantine et al. 2010). A 2009 spike in calf mortality along western Australia brings into question whether carrying capacity has been

reached by this population or other factors have increased mortality (Coughran and Gales 2010). Some vital rates of the humpback whale population summering off eastern Australia (E1) were recently estimated, including adult annual survival of 0.925, subadult survival of 0.70 (Hoffman et al. 2010). Growth rates for certain age classes included 10.7 percent for adult females and 12.4 percent for juveniles (Hoffman et al. 2010). Punt (2010) estimated the rate of increase for humpback whales off eastern and western Australia to be 10.9 and 10.1 percent annually, respectively (0.23 and 4.69 SE, respectively). The estimate of abundance for the southeast Pacific stock is about 2,900 individuals and appears to be increasing in numbers by about 5 percent annually (Felix et al. 2005; Pacheco et al. 2009).

4.2.5.8 Critical habitat

NMFS has not designated critical habitat for humpback whales.

4.2.6 Sperm Whale

4.2.6.1 Species description and distribution

Sperm whales are distributed in all of the world's oceans, from equatorial to polar waters, and are highly migratory. Mature males range between 70° N in the North Atlantic and 70° S in the Southern Ocean (Perry et al. 1999; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50° N or S (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring et al. 1993) where adult males join them to breed.

4.2.6.2 Population structure

There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawaii; (Perry et al. 1999; Waring et al. 2004). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead et al. 2008).

All sperm whales of the Southern Hemisphere are treated as a single stock with nine divisions, although this designation has little biological basis and is more in line with whaling records (Donovan 1991). Sperm whales that occur off the Galapagos Islands, mainland Ecuador, and northern Peru may be distinct from other sperm whales in the Southern Hemisphere (Dufault and

Whitehead 1995; Rice 1977; Wade and Gerrodette 1993). Gaskin (1973) found females to be absent in waters south of 50° and decrease in proportion to males south of 46-47°.

Few sighting data are available for sperm whales along central Chile, or in other locations along the country. A total of 13 sightings were made along northern and central Chile during winter surveys between 1993 and 1995 (Aguayo et al. 1998). Aerial surveys conducted from 35° to 44° S along the Chilean coast in February through April found five sperm whales groups composed of 12 individuals in 2007 and one sighting in 2009 (Maritime Affairs Department Environmental- Antarctic Maritime Affairs Division Ministry of Foreign Affairs 2007; Maritime Affairs Department Environmental- Antarctic Maritime Affairs Division Ministry of Foreign Affairs 2010).

4.2.6.3 Movement

Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead et al. 2008). No sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred miles are common, (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. General transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Gaskin (1973) proposed a northward population shift of sperm whales off New Zealand in the austral autumn based on reduction of available food species and probable temperature tolerances of calves. Stomach content analysis of two female sperm whales harvested off Peru indicate these individuals likely engaged in extensive movement from water south of 40° S prior to being killed (Clarke et al. 1976). This is also likely for adult males, with a sperm whale reportedly marked off Chile and killed in Antarctic waters (Clarke et al. 1978).

Sperm whales are probably the deepest and longest diving mammalian species, with dives to 3 km and durations in excess of 2 hours (Clarke 1976; Watkins et al. 1993; Watkins et al. 1985). However, dives are generally shorter (25- 45 min) and shallower (400-1,000 m). Dives are separated by 8-11 min rests at the surface (Gordon 1987; Jochens et al. 2006; Papastavrou et al. 1989; Watwood et al. 2006; Würsig et al. 2000). Sperm whales typically travel approximately 3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet and Whitehead 1996; Jaquet et al. 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000a; Davis et al. 2000b; Davis et al. 2000c; Davis et al. 2002; Wormuth et al. 2000). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet et al. 1996; Waring et al. 1993). Sperm whale over George's Bank were associated with surface temperatures of 23.2-24.9°C (Waring et al. 2003).

4.2.6.4 Reproduction

Female sperm whales become sexually mature at an average of 9 years or 8.25-8.8 m (Kasuya 1991). Males reach a length of 10 to 12 m at sexual maturity and take 9-20 years to become sexually mature, but require another 10 years to become large enough to successfully breed (Kasuya 1991; Würsig et al. 2000). Mean age at physical maturity is 45 years for males and 30 years for females (Waring et al. 2004). Adult females give birth after roughly 15 months of gestation and nurse their calves for 2-3 years (Waring et al. 2004). The calving interval is estimated to be every 4-6 years between the ages of 12 and 40 (Kasuya 1991; Whitehead et al. 2008). Pregnancy rates in the southeasrern Pacific along Chile were higher than in other areas of the wolrd (0.28) from 1959-1962, but this declined to 0.23 from 1975-1977, possibly due to demographic shifts associated with large, sexually mature males being targeted by whalers (Clarke et al. 1980). In 2000, only 4 percent of individuals were considered to be large males and was greater from July-September (Coakes and Whitehead 2004). Female groups were not accompanied by large males from March through June 2000, but almost all females groups had at least one male associated with them during the month of July (Coakes and Whitehead 2004). Male density along northern Chile was roughly twice that as has been found off the Galapagos Islands. In the North Pacific, female sperm whales and their calves are usually found in tropical and temperate waters year round, while it is generally understood that males move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters off of the Aleutian Islands (Kasuya and Miyashita 1988). It has been suggested that some mature males may not migrate to breeding

grounds annually during winter, and instead may remain in higher latitude feeding grounds for more than 1 year at a time (Whitehead and Arnbom 1987).

Sperm whale age distribution is unknown, but sperm whales are believed to live at least 60 years (Rice 1978). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (IWC 1980). In addition to anthropogenic threats, there is evidence that sperm whale age classes are subject to predation by killer whales (Arnbom et al. 1987; Pitman et al. 2001).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals) versus the Pacific (25-30 individuals) (Jaquet and Gendron 2009). Groups may be stable for long periods, such as for 80 days in the Gulf of California (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997). Mean group size of female groups along Chile was 23.6 individuals (Coakes and Whitehead 2004).

4.2.6.5 Feeding

Sperm whales appear to feed regularly throughout the year (NMFS 2006c). It is estimated they consume about 3-3.5 percent of their body weight daily (Lockyer 1981). They seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Rice 1989). A large proportion of a sperm whale's diet consists of low-fat, ammoniacal, or luminescent squids (Clarke 1996; Clarke 1980b; Martin and Clarke 1986). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopi, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Angliss and Lodge 2004; Berzin 1972; Clarke 1977; Clarke 1980a; Rice 1989). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989). In some areas of the North Atlantic, however, males prey heavily on the oil-rich squid *Gonatus fabricii*, a species also frequently eaten by northern bottlenose whales (Clarke 1997).

4.2.6.6 Vocalization and hearing

We understand sound production and reception by sperm whales better than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (200-236 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 2-4 kHz and 10-16 kHz (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). These long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). 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 Hz to 20 kHz (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 2.5-60 kHz. 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).

4.2.6.7 Status and trends

Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959-1983). Whaling in the Southern Hemisphere averaged roughly 20,000 whales between 1956-1976 (Perry et al. 1999). Other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). All of these estimates are likely underestimates due to illegal and inaccurate killings by Soviet whaling fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov and Zemsky 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, large-scale commercial whaling pressures on sperm whales ended. However, Japan maintains an active whaling fleet, killing up to 10 sperm whales annually (IWC 2008). In 2009, one sperm whale was killed during western North Pacific surveys (Bando et al. 2010).

Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales

is unknown, several studies and estimates of abundance are available. Table 11 contains historic and current estimates of sperm whales by region. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead 2003). Population size appears to be stable (Whitehead 2003). Whitehead (2002b) estimated 12,069 sperm whales south of 60° S.

Table 11. Summary of past and present sperm whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
Global	--	--	--	900,000	--	(Würsig et al. 2000)
	--	1,100,000	670,000-1,512,000	360,000	105,984-614,016*	(Whitehead 2002)
North Atlantic	Basinwide	224,800	--	22,000	--	(Gosho et al. 1984; Würsig et al. 2000)
	Northeast Atlantic, Faroes-Iceland, and U.S. East coast	--	--	13,190	--	(Whitehead 2002)
	NMFS-North Atlantic stock (Western North Atlantic)	--	--	4,804	1,226-8,382*	(NMFS 2008)
	Eastern North Atlantic-Iceland	--	--	1,234	823-1,645*	(Gunnlaugsson and Sigurjónsson 1990)
	Eastern North Atlantic-Faroe Islands	--	--	308	79-537*	(Gunnlaugsson and Sigurjónsson 1990)
	Eastern North Atlantic-Norwegian Sea	--	--	5,231	2,053-8,409*	(Christensen et al. 1992b)
	Eastern North Atlantic-Northern Norway to Spitsbergen	--	--	2,548	1,200-3,896*	(Øien 1990)
Gulf of Mexico	NMFS-Gulf of Mexico stock	--	--	1,665	CV=0.2	(Waring et al. 2009)
	Northern Gulf of	--	--	398	253-607	(Jochens et al. 2006)

in (Perry et al. 1999)

Region	Population, stock, or study area	Pre-exploitation estimate	95% C.I.	Current estimate	95% C.I.	Source
	Mexico – off the Mississippi River Delta between 86° and 91° W					
	North-central and northwestern Gulf of Mexico	--	--	87	52-146	(Mullin et al. 2004)
North Pacific	Basinwide	620,400	--	472,100930,000	--	(Gosho et al. 1984)
		--	--	930,000	--	(Rice 1989)
	Eastern tropical Pacific	--	--	26,053	13,797-38,309*	(Whitehead 2003)
	Off Costa Rica	--	--	1,360	823-2,248*	(Gerrodette and Palacios 1996)
	Off Central America north of Costa Rica	--	--	333	125-890*	(Gerrodette and Palacios 1996)
	Eastern temperate North Pacific	--	--	26,300	0-68,054	(Barlow and Taylor 2005)
		--	--	32,100	9,450-54,750*	(Barlow and Taylor 2005)
	NMFS-California/ Oregon/Washington stock	--	--	2,853	CV=0.25*	(Carretta et al. 2008)
	NMFS-Hawaii stock	--	--	7,082	2,918-11,246*	(Carretta et al. 2008)
	Western North Pacific	--	--	102,000	75,000-148,000	Kato and Miyashita (2000)
Southern Hemisphere	Basinwide	547,600	--	299,400	--	(Gosho et al. 1984; IWC 1988; Perry et al. 1999)
	South of 60°S	--	--	14,000	8,786-19,214	(Butterworth et al. 1995) as cited in (Perry et al. 1999)
	South of 30°S	--	--	128,000	17,613-238,687	(Butterworth et al. 1995) as cited in (Perry et al. 1999)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

4.2.6.8 Critical habitat

NMFS has not designated critical habitat for sperm whales.

4.2.7 Green Sea Turtle—East Pacific Distinct Population Segment

4.2.7.1 Species description and distribution

The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 lb (159 kg) and a straight carapace length of greater than 3.3 ft (1 m). Green sea turtles have a circumglobal distribution, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters.

Green turtles appear to prefer waters that usually remain around 20° C in the coldest month, but may occur considerably north of these regions during warm-water events, such as El Niño. Stinson (1984a) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18° C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998a). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal and Bolten 2000). Strong site fidelity appears to be a characteristic of juvenile green sea turtles along the Pacific Baja coast (Senko et al. 2010b).

The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA (Figure 6) (81 FR 20057). Eight DPSs are listed as threatened: Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific. Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean. Individuals from the East Pacific DPS are likely to be affected by the proposed action.

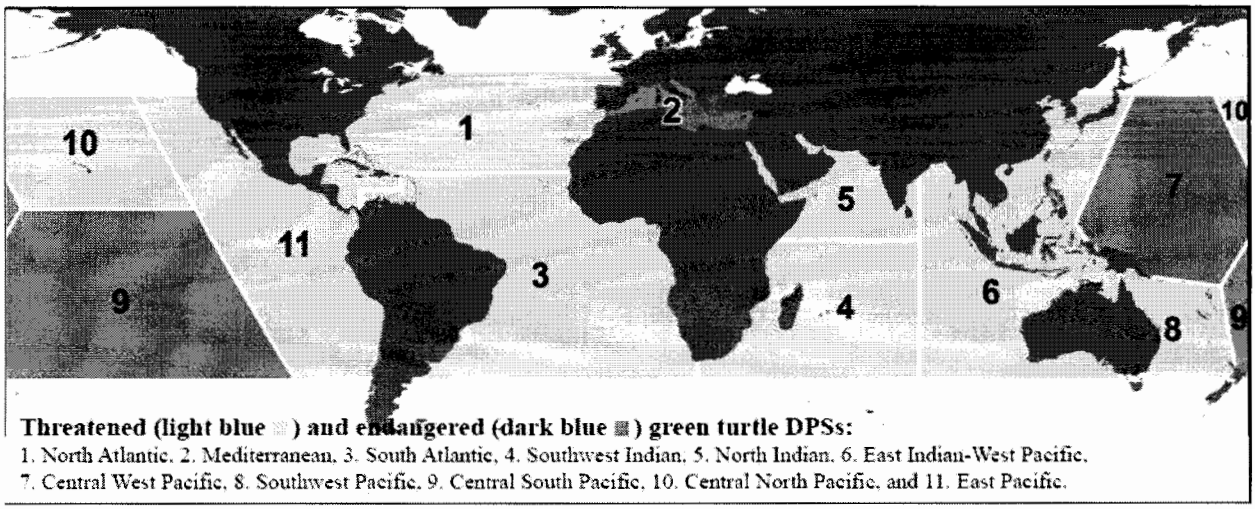

Figure 6. Map depicting DPS boundaries for green turtles.

Individuals from the East Pacific DPS range generally from California (approximately 42°N) to central Chile (approximately 40°S), with significant neseting beaches in Mexico and the Galapagos Islands, Ecuador (Seminoff 2015). Green turtles have been reported off the Chilean coast from 21°S-26°S, particularly around an area of warm water discharge from a power plant (23.7°S); green turtles seem to be more prevalent in the area from Decemeber through February (Donoso and Dutton 2010b; Sarmiento-Devia et al. 2015).

4.2.7.2 Population structure

Populations are distinguished generally by ocean basin and more specifically by nesting location (Table 12).

Based upon genetic differences, two or three distinct regional clades may exist in the Pacific: western Pacific and South Pacific islands, eastern Pacific, and central Pacific, including the rookery at French Frigate Shoals, Hawaii (Dutton and Balazs In review; Dutton et al. 1996). In the eastern Pacific, green sea turtles forage from San Diego Bay, California to Mejillones, Chile. Individuals along the southern foraging area originate from Galapagos Islands nesting beaches, while those in the Gulf of California originate primarily from Michoacán.

Genetic analysis of green sea turtles captured from shore along northern Chile indicate individuals here originate from the Galapagos Islands (Donoso and Dutton 2002). Sightings of green sea turtles have also been made up to 70 km offshore near Isla Santa Maria (Donoso and Dutton 2002) and a few green sea turtles have been captured via longlines in the high seas off Chile, some very near the action area (Donoso and Dutton 2010a). Occurrence has also been documented up to 500 km offshore of Chile (34 °S) (Chandler 1991). Occurrence along coastal Chile appears to be year round in areas where algal growth is abundant (Frazier 1990). El Niño years have been associated with high green sea turtle abundances along Chile, possibly due to the influx of warm equatorial water into regions that would otherwise be influenced by colder waters (Frazier 1990).

Table 12. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF), annual nests (AN), annual egg production (EP), and annual egg harvest (EH).

Location	Most recent abundance	Reference
Western Atlantic Ocean		
Tortuguero, Costa Rica	17,402-37,290 AF	(Troëng and Rankin 2005)
Aves Island, Venezuela	335-443 AF	(Vera 2007)
Galibi Reserve, Suriname	1,803 AF	(Weijerman et al. 1998)
Isla Trindade, Brazil	1,500-2,000 AF	(Moreira and Bjorndal 2006)
Central Atlantic Ocean		
Ascension Island, UK	3,500 AF	(Broderick et al. 2006)
Eastern Atlantic Ocean		
Poilao Island, Guinea-Bissau	7,000-29,000 AN	(Catry et al. 2009)
Bioko Island, Equatorial Guinea	1,255-1,681 AN	(Tomas et al. 1999)
Mediterranean Sea		
Turkey	214-231 AF	(Broderick et al. 2002)
Cyprus	121-127 AF	(Broderick et al. 2002)
Israel / Palestine	1-3 AF	(Kuller 1999)
Syria	100 AN	(Rees et al. 2005)
Western Indian Ocean		
Eparces Islands	2,000-11,000 AF	(Le Gall et al. 1986)
Comoros Islands	5,000 AF	S. Ahamada, pers. comm. 2001
Seychelles Islands	3,535-4,755 AF	J. Mortimer, pers. comm. 2002
Kenya	200-300 AF	(Okemwa and Wamukota 2006)
Northern Indian Ocean		
Ras al Hadd, Oman	44,000 AN	S. Al-Saady, pers. comm. 2007
Sharma, Yemen	15 AF	(Saad 1999)
Karan Island, Saudi Arabia	408-559 AF	(Pilcher 2000)
Jana and Juraid Islands, Saudi Arabia	643 AN	(Pilcher 2000)
Hawkes Bay and Sandspit, Pakistan	600 AN	(Asrar 1999)
Gujarat, India	461 AN	(Sunderraj et al. 2006)
Sri Lanka	184 AF	(Kapurisinghe 2006)
Eastern Indian Ocean		
Thamihla Kyun, Myanmar	<250,000 EH	(Thorbjarnarson et al. 2000)
Pangumbahan, Indonesia	400,000 EH	(Schulz 1987)
Suka Made, Indonesia	395 AN	C. Limpus, pers. comm. 2002
Western Australia	3,000-30,000 AN	R. Prince, pers. comm. 2001
Southeast Asia		
Gulf of Thailand	250 AN	Charuchinda pers. comm. 2001
Vietnam	239 AF	(Hamann et al. 2006)
Berau Islands, Indonesia	4,000-5,000 AF	(Schulz 1984)
Turtle Islands, Philippines	1.4 million EP	(Cruz 2002)
Sabah Turtle Islands, Malaysia	8,000 AN	(Chan 2006)
Sipadan, Malaysia	800 AN	(Chan 2006)
Sarawak, Malaysia	2,000 AN	(Liew 2002)
Enu Island (Aru Islands)	540 AF	Dethmers, in preparation
Terengganu, Malaysia	2,200 AN	(Chan 2006)
Western Pacific Ocean		
Heron Island, Australia	560 AF	(Limpus et al. 2002)
Raine Island, Australia	25,000 AF	(Limpus et al. 2003)
Guam	45 AF	(Cummings 2002)
Ogasawara Islands, Japan	500 AF	(Chaloupka et al. 2007)

Location	Most recent abundance	Reference
Central and Eastern Pacific Ocean		
French Frigate Shoals, Hawaii	400 AF	(Balazs and Chaloupka 2006)
Michoacán, Mexico	1,395 AF	C. Delgado, pers. comm. 2006
Central American Coast	184-344 AN	(López and Arauz 2003)
Galapagos Islands, Ecuador	1,650 AF	(Zárate et al. 2006)

4.2.7.3 Movement

Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. After departing as hatchlings and residing in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), green sea turtles make their way back to the same beach from which they hatched (Carr et al. 1978; Meylan et al. 1990). Green sea turtles spend the majority of their lives in coastal foraging grounds. These areas include both open coastline and protected bays and lagoons. While in these areas, green sea turtles rely on marine algae and seagrass as their primary dietary constituents, although some populations also forage heavily on invertebrates. There is some evidence that individuals move from shallow seagrass beds during the day to deeper areas at night (Hazel 2009). However, avoidance of areas of greater than 10 m when moderate depths of 5-10 m with sea grass beds has been found, with speed and displacement from capture locations being similar at night as during the daytime (Senko et al. 2010a).

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, we presume that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (Hazel et al. 2009; NMFS and USFWS 1998a). Recent data from Australia indicate green sea turtles rarely dive deep, staying in upper 8 m of the water column (Hazel et al. 2009). Here, daytime dives were shorter and shallower than were nighttime dives. Also, time spent resting and dive duration increased significantly with decreases in seasonal water temperatures. The maximum recorded dive depth for an adult green turtle was just over 106 m (Berkson 1967), while subadults routinely dive to 20 m for 9-23 min, with a maximum recorded dive of over 1 h (Brill et al. 1995; I-Jiunn 2009). Green sea turtles along Taiwan may rest during long, shallow dives (I-Jiunn 2009). Dives by females may be shorter in the period leading up to nesting (I-Jiunn 2009).

4.2.7.4 Reproduction

Most green sea turtles exhibit particularly slow growth rates, which have been attributed to their largely plant-eating diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from less than 1 cm/year (Green 1993) to greater than 5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka et al. 2004), and density of turtles in foraging areas (Balazs and Chaloupka 2004; Bjorndal et al. 2000; Seminoff et al. 2002b). If individuals do not feed

sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark et al. 2009). In general, there is a tendency for green sea turtles to exhibit monotonic growth (declining growth rate with size) in the Atlantic and non-monotonic growth (growth spurt in mid size classes) in the Pacific, although this is not always the case (Balazs and Chaloupka 2004; Chaloupka and Musick 1997; Seminoff et al. 2002b). It is estimated that green sea turtles reach a maximum size just under 100 cm in carapace length (Tanaka 2009). A female-bias has been identified from studies of green sea turtles (Wibbels 2003).

Consistent with slow growth, age-to-maturity for green sea turtles appears to be the longest of any sea turtle species and ranges from approximately 20-40 years or more (Balazs 1982; Chaloupka et al. 2004; Chaloupka and Musick 1997; Frazer and Ehrhart 1985b; Hirth 1997; Limpus and Chaloupka 1997; Seminoff et al. 2002b; Zug et al. 2002; Zug and Glor 1998). Estimates of reproductive longevity range from 17 to 23 years (Carr et al. 1978; Chaloupka et al. 2004; Fitzsimmons et al. 1995). Considering that mean duration between females returning to nest ranges from 2 to 5 years (Hirth 1997), these reproductive longevity estimates suggest that a female may nest 3 to 11 seasons over the course of her life. Each female deposits 1-7 clutches (usually 2-3) during the breeding season at 12-14 day intervals. Mean clutch size is highly variable among populations, but averages 110-115 eggs/nest. Females usually have 2-4 or more years between breeding seasons, whereas males may mate every year (Balazs 1983). Based on reasonable means of three nests per season and 100 eggs per nest (Hirth 1997), a female may deposit 9 to 33 clutches, or about 900 to 3,300 eggs, during her lifetime. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Once hatched, sea turtles emerge and orient towards a light source, such as light shining off the ocean. They enter the sea in a "frenzy" of swimming activity, which decreases rapidly in the first few hours and gradually over the first several weeks (Ischer et al. 2009; Okuyama et al. 2009). Factors in the ocean environment have a major influence on reproduction (Chaloupka 2001; Limpus and Nicholls 1988; Solow et al. 2002). It is also apparent that during years of heavy nesting activity, density dependent factors (beach crowding and digging up of eggs by nesting females) may impact hatchling production (Tiwari et al. 2005; Tiwari et al. 2006). Precipitation, proximity to the high tide line, and nest depth can also significantly affect nesting success (Cheng et al. 2009). Precipitation can also be significant in sex determination, with greater nest moisture resulting in a higher proportion of males (Leblanc and Wibbels 2009). Green sea turtles often return to the same foraging areas following nesting migrations (Broderick et al. 2006; Godley et al. 2002). Once there, they move within specific areas, or home ranges, where they routinely visit specific localities to forage and rest (Godley et al. 2003; Makowski et al. 2006; Seminoff and Jones 2006; Seminoff et al. 2002a; Taquet et al. 2006). It is also apparent that some green sea turtles remain in pelagic habitats for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier et al. 2003). Hatching success in the Galapagos is 46 percent (Zárate et al. 2013).

In general, survivorship tends to be lower for juveniles and subadults than for adults. Adult survivorship has been calculated to range from 0.82-0.97 versus 0.58-0.89 for juveniles (Chaloupka and Limpus 2005; Seminoff et al. 2003; Troëng and Chaloupka 2007), with lower values coinciding with areas of human impact on green sea turtles and their habitats (Bjorndal et al. 2003; Campbell and Lagueux 2005).

4.2.7.5 Feeding

While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley et al. 1998; Hatase et al. 2006; Heithaus et al. 2002; Parker and Balazs in press; Seminoff et al. 2002a). A shift to a more herbivorous diet occurs when individuals move into neritic habitats, as vegetable matter replaces an omnivorous diet at around 59 cm in carapace length off Mauritania (Cardona et al. 2009). This transition may occur rapidly starting at 30 cm carapace length, but animal prey continue to constitute an important nutritional component until individuals reach about 62 cm (Cardona et al. 2010). Foraging within seagrass ecosystems by green sea turtles can be significant enough to alter habitat and ecological parameters, such as species composition (Lal et al. 2010).

4.2.7.6 Hearing

Although very limited information is available regarding green turtle hearing, it is one of the few sea turtle species that have been studied. Based upon auditory brainstem responses of three green sea turtles in air, these individuals had maximum sensitivity to sound in the 300-400 Hz range. A similar study by Bartol and Ketten (2006) found a range of 100-500 Hz as being sensitive to sound, with maximum sensitivity from 200-400 Hz. These same authors also reported a pair of juvenile green turtles to be generally sensitive between 100-800 Hz and most sensitive between 600-700 Hz. Outside of this limited range, green turtles are much less sensitive to sound (Ridgway et al. 1969). This is similar to estimates for loggerhead sea turtles, which have most sensitive hearing between 250-1,000 Hz, with rapid decline above 1,000 Hz (Moein Bartol et al. 1999).

4.2.7.7 Status and trends

No trend data are available for almost half of the important nesting sites, where numbers are based on recent trends and do not span a full green sea turtle generation, and impacts occurring over four decades ago that caused a change in juvenile recruitment rates may have yet to be manifested as a change in nesting abundance. The numbers also only reflect one segment of the population (nesting females), who are the only segment of the population for which reasonably good data are available and are cautiously used as one measure of the possible trend of populations.

In the East Pacific DPS, mitochondrial DNA analysis has indicated three key nesting populations: Michoacán, Mexico; Galapagos Islands, Ecuador; and Islas Revillagigedos, Mexico (Dutton 2003). The number of nesting females per year exceeds 1,000 females at each site

(NMFS and USFWS 2007a). The Galapagos nesting beaches is the second largest nesting aggregation in the East Pacific DPS, with 3,603 nesters from 2001-2002. This figure is an increase from an estimated 1,283 females from 1979-1980 (Seminoff 2015). However, historically, greater than 20,000 females per year are believed to have nested in Michoacán alone (Clifton et al. 1982; NMFS and USFWS 2007a). Thus, the current number of nesting females is still far below historical levels.

4.2.7.8 Critical habitat

On September 2, 1998, critical habitat for green sea turtles was designated in coastal waters surrounding Culebra Island, Puerto Rico (63 FR 46693). Aspects of these areas that are important for green sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for green sea turtle prey. This designated critical habitat unit is relevant to the North Atlantic DPS green turtle, and is outside the proposed action area.

4.2.8 Leatherback Sea Turtle

4.2.8.1 Species description and distribution

Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. They have a distinctive appearance from other sea turtles, with dark, leathery skin covering their carapace. Leatherbacks range farther than any other sea turtle species, having evolved physiological and anatomical adaptations that allow them to exploit cold waters (Frair et al. 1972; Greer et al. 1973; USFWS 1995). High-latitude leatherback range includes in the Atlantic includes the North and Barents Seas, Newfoundland and Labrador , Argentina, and South Africa (Goff and Lien 1988; Hughes et al. 1998; Luschi et al. 2003; Luschi et al. 2006; Márquez 1990; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998b; Gill 1997; Hodge and Wing 2000).

Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Grant and Ferrell 1993; Schroeder and Thompson 1987; Shoop and Kenney 1992; Starbird et al. 1993). 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; Collard 1990; Davenport and Balazs 1991; Frazier 2001; HDLNR 2002). Aerial surveys off the western U.S. support continental slope waters as having greater leatherback occurrence than shelf waters (Bowlby et al. 1994; Carretta and Forney 1993; Green et al. 1992; Green et al. 1993).

Associations exist with continental shelf and pelagic environments and sightings occur in offshore waters of 7-27° C (CETAP 1982). Juvenile leatherbacks usually stay in warmer, tropical waters greater than 21° C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James et al. 2005). Most records of leatherbacks in the action area occur south of 33°S, from January to March (Sarmiento-Devia et al. 2015).

Leatherback sea turtles are considered the most abundant sea turtle along Chile (particularly the central and southern sections of the country) (Brito 1998a; Chandler 1991; Donoso and Dutton 2006). Hundreds of leatherbacks are estimated to be bycaught and die in gill netting operations along central Chile near the action area (Brito 1998a; Frazier 1990; Frazier and Brito Montero 1990; Marquez M. and Villanueva O. 1993). More recent reviews of the literature indicate that green turtles are more frequently reported than leatherbacks (765 records versus 607), although leatherbacks are still more frequently caught incidentally in fisheries (Sarmiento-Devia et al. 2015). Longline bycatch is most prevalent in waters between 24° and 38° S (Donoso and Dutton 2010a). Tags and genetic samples of some bycaught individuals indicate they originate from Central American and Mexican beaches (Brito 1998a; Donoso and Dutton 2010a; Donoso et al. 2000; Marquez M. and Villanueva O. 1993).

4.2.8.2 Population structure

Leatherbacks break into four nesting aggregations: Pacific, Atlantic, and Indian oceans, and the Caribbean Sea. Detailed population structure is unknown, but is likely dependent upon nesting beach location.

Leatherbacks are found from tropical waters north to Alaska within the North Pacific and is the most common sea turtle in the eastern Pacific north of Mexico (Eckert 1993; Stinson 1984b; Wing and Hodge 2002). The west coast of Central America and Mexico hosts nesting from September-March, although Costa Rican nesting peaks during April-May (Chacón-Chaverri and Eckert 2007; LGL Ltd. 2007). Leatherback nesting aggregations occur widely in the Pacific, including China, Malaysia, Papua New Guinea, Indonesia, Thailand, Australia, Fiji, the Solomon Islands, and Central America (Dutton et al. 2007; Limpus 2002). Significant nesting also occurs along the Central American coast (Márquez 1990). There are no known leatherback nesting beaches in the action area.

In Costa Rica, leatherbacks nest at Playa Naranjo in Santa Rosa National Park, the second-most important nesting beach on the Pacific coast (Yañez et al. 2010), Rio Oro on the Osa Peninsula, and at various beaches in Las Baulas National Park, which includes Playa Langosta and Playa Grande and contains the largest colony of leatherbacks in the Pacific (Spotila 2004b). The number of leatherback turtles nesting in Las Baulas National Park declined steadily during the 1990s, from anout 1,500 females during the 1988–1989 nesting season, to about 800 in 1990–1992, 193 in 1993–1994 (Williams et al. 1996b). Females typically lay six clutches per season (average nine days between nests), which incubate for 58–65 days (Lux et al. 2003). Limited nesting also occurs along Nicaragua, Panama, El Salvador, Vanuatu, and Guatemala.

Leatherbacks within Chilean waters are believed to belong to the East Pacific subpopulation, which is regarded as having been severely depleted (Dutton et al. 2010).

4.2.8.3 Movement

Leatherback sea turtles migrate throughout open ocean convergence zones and upwelling areas, along continental margins, and in archipelagic waters (Eckert 1998; Eckert 1999; Morreale et al.

1994). In a single year, a leatherback may swim more than 9,600 km to nesting and foraging areas throughout ocean basins (Benson et al. 2007a; Benson et al. 2007b; Eckert 1998; Eckert 2006; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; Sale et al. 2006). Much of this travel may be due to movements within current and eddy features, moving individuals along (Sale and Luschi 2009). Return to nesting beaches may be accomplished by a form of geomagnetic navigation and use of local cues (Sale and Luschi 2009). Leatherback females will either remain in nearshore waters between nesting events, or range widely, presumably to feed on available prey (Byrne et al. 2009; Fossette et al. 2009a). Leatherbacks are known to pass by the Japanese coast during developmental, foraging, and reproductive migrations (Sea Turtle Association of Japan 2010; Uchida and Nishiwaki 1995).

Fossette et al. (2009b) identified three main migratory strategies in leatherbacks in the North Atlantic (almost all of studied individuals were female). One involved 12 individuals traveling to northern latitudes during summer/fall and returning to waters during winter and spring. Another strategy used by six individuals was similar to this, but instead of a southward movement in fall, individuals overwintered in northern latitudes (30-40° N, 25-30° W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10° in winter, where they remained or returned to the northwest Atlantic. A third strategy, which was followed by three females remaining in tropical waters for the first year subsequent to nesting and moving to northern latitudes during summer/fall and spending winter and spring in latitudes of 40-50° N.

Satellite tracking data reveal that leatherback females leaving Mexican and Central American nesting beaches migrate towards the equator and into Southern Hemisphere waters, some passing the Galápagos Islands, and disperse south of 10°S (Dutton et al. 2006; Shillinger et al. 2010). Post-nesting females travel from Costa Rica and Mexico to forage off the South American coast (Dutton et al. 2010).

Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave exposure, possibly as a means to aid hatchling dispersal (Garcon et al. 2010). Individuals nesting in Malaysia undergo migrations to tropical feeding areas, taking 5-7 months to arrive there from nesting locations (Benson et al. 2011). Additional foraging occurs in temperate locations, including across the Pacific basin along the U.S. west coast; individuals take 10-12 months to migrate here (Benson et al. 2011). Individuals nesting during the boreal summer move to feeding areas in the North China Sea, while boreal winter nesters moved across the Equator to forage in the Southern Hemisphere (Benson et al. 2011).

Leatherbacks are deep divers among sea turtles with a maximum- recorded dive of over 4,000 m (Eckert et al. 1989; López-Mendilaharsu et al. 2009). Dives are typically 50-84 m and 75-90 percent of time duration is above 80 m (Standora et al. 1984). Leatherbacks off South Africa were found to spend less than 1 percent of their dive time at depths greater than 200 m (Hays et al. 2009). Dive durations are impressive, topping 86 min, but routinely 1-14 min (Eckert et al. 1989; Eckert et al. 1996; Harvey et al. 2006; López-Mendilaharsu et al. 2009). Most of this time is spent traveling to and from maximum depths (Eckert et al. 1989). Dives are continual, with

only short stays at the surface (Eckert et al. 1989; Eckert et al. 1986; Southwood et al. 1999). Off Playa Grande, Costa Rica, adult females spent 57–68 percent of their time underwater, diving to a mean depth of 19 m for 7.4 min (Southwood et al. 1999). Off St. Croix, adult females dove to a mean depth of 61.6 m for an average of 9.9 min, and spent an average of 4.9 min at the surface (Eckert et al. 1989). During shallow dives in the South China Sea, dives averaged 6.9–14.5 min, with a maximum of 42 min (Eckert et al. 1996). Off central California, leatherbacks dove to 20–30 m with a maximum of 92 m (Harvey et al. 2006). This corresponded to the vertical distribution of their prey (Harvey et al. 2006). Leatherback prey in the Gulf of Alaska are frequently concentrated in the deep-scattering layer (Hodge and Wing 2000). Mean dive and surface durations were 2.9 and 2.2 min, respectively (Harvey et al. 2006). In a study comparing diving patterns during foraging versus travelling, leatherbacks dove shallower (mean of 53.6 m) and moved more slowly (17.2 km/day) while in foraging areas while travelling to or from these areas (81.8 m and 51.0 km/day) (Fossette et al. 2009b).

4.2.8.4 Reproduction

It has been thought that leatherbacks reach sexual maturity somewhat faster than other sea turtles (except Kemp's ridley), with an estimated range of 3-6 years (Rhodin 1985) to 13-14 years (Zug and Parham 1996). However, recent research suggests otherwise, with western North Atlantic leatherbacks possibly not maturing until as late as 29 years of age (Avens and Goshe 2007). Female leatherbacks nest frequently (up to 10 nests per year and about every 2-3 years). During each nesting, females produce 100 eggs or more per clutch and 700 eggs or more per nesting season (Schultz 1975). However, up to approximately 30 percent of the eggs can be infertile. Thus, the actual proportion of eggs that can result in hatchlings is less than this seasonal estimate. The eggs incubate for 55-75 days before hatching.

A significant female bias exists in all leatherback populations thus far studied. An examination of strandings and in-water sighting data from the U.S. Atlantic and Gulf of Mexico coasts indicates that 60 percent of individuals were female. Studies of Suriname nesting beach temperatures suggest a female bias in hatchlings, with estimated percentages of females hatched over the course of each season at 75.4, 65.8, and 92.2 percent in 1985, 1986, and 1987, respectively (Plotkin 1995). Binckley et al. (1998) found a heavy female bias upon examining hatchling gonad histology on the Pacific coast of Costa Rica, and estimated male to female ratios over three seasons of 0:100, 6.5:93.5, and 25.7:74.3. James et al. (2007) also found a heavy female bias (1.86:1) as well as a primarily large sub-adult and adult size distribution. Leatherback sex determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell et al. 2005).

4.2.8.5 Feeding

Leatherbacks may forage in high-invertebrate prey density areas formed by favorable features (Eckert 2006; Ferraroli et al. 2004). Although leatherbacks forage in coastal waters, they appear to remain primarily pelagic through all life stages (Heppell et al. 2003). The location and abundance of prey, including medusae, siphonophores, and salpae, in temperate and boreal

latitudes likely has a strong influence on leatherback distribution in these areas (Plotkin 1995). Leatherback prey are frequently found in the deep-scattering layer in the Gulf of Alaska (Hodge and Wing 2000). North Pacific foraging grounds contain individuals from both eastern and western Pacific rookeries, although leatherbacks from the eastern Pacific generally forage in the Southern Hemisphere along Peru and Chile (Dutton 2005-2006; Dutton et al. 2000; Dutton et al. 1998). Mean primary productivity in all foraging areas of western Atlantic females is 150 percent greater than in eastern Pacific waters, likely resulting in twice the reproductive output of eastern Pacific females (Saba et al. 2007). Leatherbacks have been observed feeding on jellyfish in waters off Washington State and Oregon (Eisenberg and Frazier 1983; Stinson 1984b). Suprisingly, occurrence off Chile is not associated with jellyfish blooms as in other locations worldwide (Frazier 1990).

4.2.8.6 Hearing

Information on the hearing capabilities of sea turtles is limited, but the information that is available suggests auditory capabilities are centered in the low-frequency range (less than 1 kHz), with hearing thresholds at about 132-140 dB (Lenhardt 1994; Lenhardt et al. 1983; Moein Bartol and Ketten 2006; Moein Bartol et al. 1999; O'Hara and Wilcox 1990; Ridgway et al. 1969). There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz (L-DEO 2006).

4.2.8.7 Status and trends

Leatherback sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA, but declines in nesting have continued worldwide. Breeding females were initially estimated at 29,000-40,000, but were later refined to approximately 115,000 (Pritchard 1971; Pritchard 1982). Spotila et al. (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004a). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001b).

Heavy declines have occurred at all major Pacific basin rookeries, as well as Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. This includes a nesting decline of 23 percent between 1984-1996 at Mexiquillo, Michoacán, Mexico (Sarti et al. 1996). According to reports from the late 1970s and early 1980s, three beaches on the Pacific coast of Mexico supported as many as half of all leatherback turtle nests for the eastern Pacific. Since the early 1980s, the eastern Pacific Mexican population of adult female leatherback turtles has declined to slightly more than 200 individuals during 1998-1999 and 1999-2000 (Sarti et al. 2000). Spotila et al. (2000) reported the decline of the leatherback turtle population at Playa Grande, Costa Rica, which had been the fourth largest nesting colony in the world. Between 1988 and 1999, the nesting colony declined from 1,367 to 117 female leatherback turtles. Based on their models, Spotila et al. (2000) estimated that the colony could fall to less than 50 females by 2003-2004. Fewer than 1,000 females nested on the Pacific coast of Mexico from 1995-1996 and fewer than 700 females are estimated for Central America (Spotila et al. 2000). The number

of leatherback turtles nesting in Las Baulas National Park declined rapidly during the 1990s, from about 1,500 females during the 1988–89 nesting season, to about 800 in 1990–91 and 1991–92 to 193 in 1993–94 (Williams et al. 1996a) and 117 in 1998–99 (Spotila et al. 2000). Spotila (2004b) reported that between 59 and 435 leatherbacks nest at Las Baulas each year depending on the El Niño–La Niña cycle. Only an Indonesian nesting assemblage has remained relatively abundant in the Pacific basin. The largest extant leatherback nesting assemblage in the Indo-Pacific lies on the northern Vogelkop coast of Irian Jaya (West Papua), Indonesia, with roughly 3,000 nests recorded annually (Dutton et al. 2007; Putrawidjaja 2000; Suárez et al. 2000). The Western Pacific leatherback metapopulation harbors the last remaining nesting aggregation of significant size in the Pacific with approximately 2700–4500 breeding females (Dutton et al. 2007; Hitipeuw et al. 2007). The total number of nests per year for the Jamursba-Medi leatherback nesting population ranged between a high of 6,373 nests in 1996 and a low of 1,537 nests in 2010 (Hitipeuw et al. 2007).

Declines in the western Pacific are equally severe. Nesting at Terengganu, Malaysia is 1 percent of that in the 1950s (Chan and Liew 1996). The South China Sea and East Pacific nesting colonies have undergone catastrophic collapse. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000). The number of nesting leatherbacks has declined by an estimated 95 percent over the past 20 years in the Pacific (Gilman 2009). Drastic overharvesting of eggs and mortality from fishing activities is likely responsible for this tremendous decline (Eckert 1997; Sarti et al. 1996).

4.2.8.8 Critical habitat

On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, U.S.V.I. from the 183 m isobath to mean high tide level between 17° 42'12" N and 65°50'00" W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. However, studies do not currently support significant critical habitat deterioration.

On January 26, 2012, the NMFS designated critical habitat for leatherback sea turtles in waters along Washington State and Oregon (Cape Flattery to Cape Blanco; 64,760 km^2) and California (Point Arena to Point Arguello; 43,798 km^2). The primary constituent element of these areas includes (1.) the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*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. Both of these units of designated critical habitat are outside of the action area.

4.2.9 Loggerhead Sea Turtle-South Pacific Distinct Population Segment

4.2.9.1 Species description and distribution

Loggerheads are circumglobal occurring throughout the temperate and tropical regions. Adult loggerhead sea turtles have relatively large heads, which support powerful jaws. They have a reddish-brown, slightly heart-shaped top shell with pale yellowish bottom shell. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. They weigh 250 pounds (113 kg) and measure 3 feet (approximately 1 m) in length. Hatchlings are brown to dark gray with a yellowish to tan bottom shell. Their flippers are dark gray to brown above with white to white-gray margins. They weigh 0.05 pounds (20 g) and are 2 inches (4 cm) long.

4.2.9.2 Population structure

As with other sea turtles, populations are frequently divided by nesting aggregation (Hutchinson and Dutton 2007). The species was first listed as threatened under the Endangered Species Act in 1978 (43 FR 32800). In 2011, the listing was revised, and nine DPSs were designated under the ESA (Figure 7) (76 FR 58868). Four DPSs were listed as threatened: Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and the Southwest Indian Ocean. Five DPSs were listed as endangered: Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean. We expect only the South Pacific DPS would be exposed during the proposed activities.

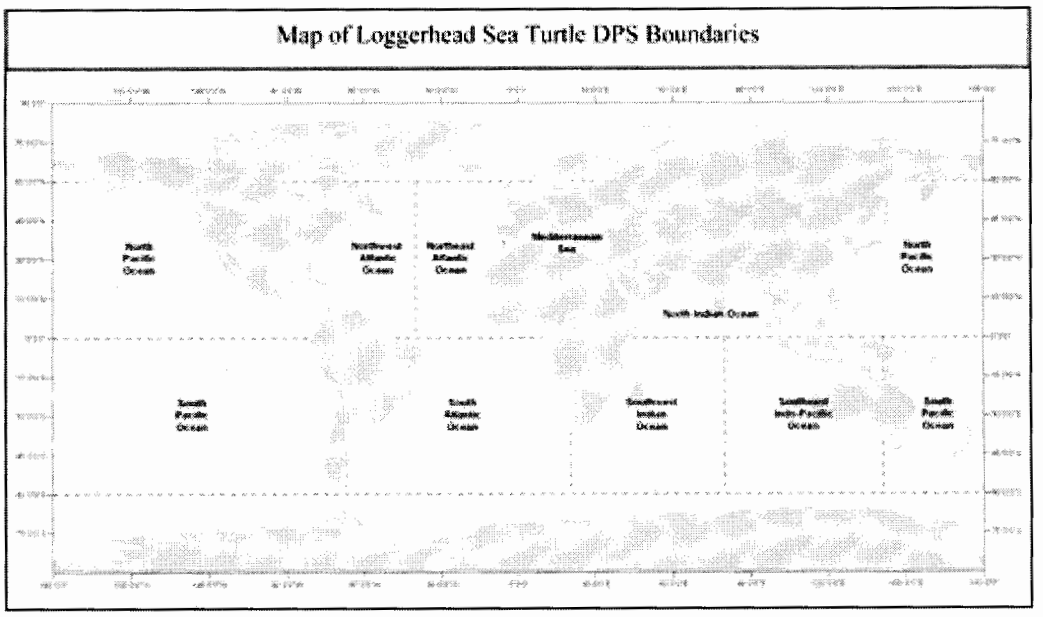

Figure 7. Map depicting the loggerhead sea turtle DPS boundaries.

Pacific Ocean rookeries are limited to the western portion of the basin. These sites include Australia, New Caledonia, and New Zealand. Index beaches for the South Pacific Ocean DPS are in eastern Australia (Limpus 2009).

Loggerheads are unusual in Chilean waters and have been reported as the rarest sea turtle species in the country (Brito 1998a). However, they appear to be present offshore of northern Chile year round south to at least 32° S (Donoso and Dutton 2006) and seem to form feeding aggregations along the northern potion of the country that are driven by locally enhanced productivity (15-25° S) (Donoso and Dutton 2010a). Loggerheads are reported in the warm water discharge from a coastal power plant at 23°S, and are reported as bycatch in Chilean fisheries (Sarmiento-Devia et al. 2015). Genetic samples from bycaught individuals indicate an Australian origin (Donoso and Dutton 2007; Donoso and Dutton 2010a; Donoso et al. 2000).

4.2.9.3 Movement

Loggerhead hatchlings migrate offshore and become associated with *Sargassum* spp. habitats, driftlines, and other convergence zones (Carr 1986). After 14-32 years of age, they shift to a benthic habitat, where immature individuals forage in the open ocean and coastal areas along continental shelves, bays, lagoons, and estuaries (Bowen et al. 2004; NMFS 2001a). Adult loggerheads make lengthy migrations from nesting beaches to foraging grounds (TEWG 1998).

Individuals in the western Pacific also show wide-ranging movements. Loggerheads hatched on beaches in the southwest Pacific travel have been found to range widely in the southern portion of the basin, with individuals from populations nesting in Australia found as far east as Peruvian coast foraging areas still in the juvenile stage (Boyle et al. 2009). Individuals hatched along Japanese coasts have been found to migrate to waters off Baja California via the North Pacific Subtropical Gyre to feed for several years before migrating back to western Pacific waters to breed (Bowen et al. 1995; Nichols 2005; Polovina et al. 2006; Polovina et al. 2000; Resendiz et al. 1998). Adult loggerheads also reside in oceanic waters off Japan (Hatase et al. 2002a). Habitat use off Japan may further be partitioned by sex and size (Hatase et al. 2002a; Hatase and Sakamoto 2004; Hatase et al. 2002b). Loggerheads returning to Japanese waters seem to migrate along nutrient-rich oceanic fronts (Kobayashi et al. 2008; Nichols et al. 2000; Polovina et al. 2000). Individuals bycaught and satellite tracked in Hawaii longline fisheries show individual movement north and south within a thermal range of 15-25° C, or 28-40° N, with juveniles following the 17-20° C isotherm (Kobayashi et al. 2008; Nichols et al. 2000; Polovina et al. 2004).

Loggerhead diving behavior varies based upon habitat, with longer surface stays in deeper habitats than in coastal ones. Off Japan, dives were shallower than 30 m (Sakamoto et al. 1993). Routine dives can last 4–172 min (Byles 1988; Renaud and Carpenter 1994; Sakamoto et al. 1990). The maximum-recorded dive depth for a post-nesting female was over 230 m, although most dives are far shallower (9-21 m(Sakamoto et al. 1990). Loggerheads tagged in the Pacific over the course of 5 months showed that about 70 percent of dives are very shallow (less than 5 m) and 40 percent of their time was spent within 1 m of the surface (Polovina et al. 2003; Spotila 2004b). During these dives, there were also several strong surface temperature fronts that individuals were associated with, one of 20° C at 28° N latitude and another of 17° C at 32° N latitude.

4.2.9.4 Reproduction

Loggerhead nesting is confined to lower latitudes temperate and subtropic zones but absent from tropical areas (NMFS and USFWS 1991b; NRC 1990; Witherington et al. 2006b). The life cycle of loggerhead sea turtles can be divided into seven stages: eggs and hatchlings, small juveniles, large juveniles, subadults, novice breeders, first year emigrants, and mature breeders (Crouse et al. 1987b). Hatchling loggerheads migrate to the ocean (to which they are drawn by near ultraviolet light Kawamura et al. 2009), where they are generally believed to lead a pelagic existence for as long as 7-12 years (NMFS 2005a). As adults, individuals may experience a secondary growth pulse associated with shifting into neritic habitats, although growth is generally monotypic (declines with age Casale et al. 2009a; Casale et al. 2009b). Individually-based variables likely have a high impact on individual-to-individual growth rates (Casale et al. 2009b). At 15-38 years, loggerhead sea turtles become sexually mature, although the age at which they reach maturity varies widely among populations (Casale et al. 2009b; Frazer and Ehrhart 1985a; Frazer et al. 1994; NMFS 2001a; Witherington et al. 2006). However, based on new data from tag returns, strandings, and nesting surveys, NMFS (2001a) estimated ages of maturity ranging from 20-38 years and benthic immature stage lasting from 14-32 years.

Loggerhead mating likely occurs along migration routes to nesting beaches, as well as offshore from nesting beaches several weeks prior to the onset of nesting (Dodd 1988; NMFS and USFWS 1998d). Females usually breed every 2-3 years, but can vary from 1-7 years (Dodd 1988; Richardson et al. 1978). Females lay an average of 4.1 nests per season (Murphy and Hopkins 1984) , although recent satellite telemetry from nesting females along southwest Florida support 5.4 nests per female per season, with increasing numbers of eggs per nest during the course of the season (Tucker 2009). The authors suggest that this finding warrants revision of the number of females nesting in the region. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Although information on males is limited, several studies identified a female bias, although a single study has found a strong male bias to be possible (Dodd 1988; NMFS 2001a; Rees and Margaritoulis 2004).

Additionally, little is known about longevity, although Dodd (1988) estimated the maximum female life span at 47-62 years. Heppell et al. (2003) estimated annual survivorship to be 0.81 (southeast U.S. adult females), 0.78-0.91 (Australia adult females), 0.68-0.89 (southeast U.S. benthic juveniles, and 0.92 (Australia benthic juveniles). Survival rates for hatchlings during their first year are likely very low (Heppell et al. 2003).

4.2.9.5 Feeding

Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker et al. 2005). Hatchling loggerheads feed on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991b). Pelagic and benthic juveniles forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988; Wallace et al. 2009).

Loggerheads in the deep, offshore waters of the western North Pacific feed on jellyfish, salps, and other gelatinous animals (Dodd Jr. 1988b; Hatase et al. 2002a). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998d). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich et al. 2010; Vander Zanden et al. 2010). Loggerheads that nested in Australia were found foraging in Chile and Peru (Conant et al. 2009b).

4.2.9.6 Hearing

Information on the hearing capabilities of sea turtles is limited, but available information suggests auditory capabilities are centered in the low-frequency range (less than 1 kHz), with hearing thresholds at about 132-140 dB (Lenhardt 1994; Lenhardt et al. 1983; Moein Bartol and Ketten 2006; Moein Bartol et al. 1999; O'Hara and Wilcox 1990; Ridgway et al. 1969). There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz (L-DEO 2006).

4.2.9.7 Status and trends

There is general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are doubts about the ability to estimate the overall population size (Bjorndal et al. 2005). An important caveat for population trends analysis based on nesting beach data is that this may reflect trends in adult nesting females, but it may not reflect overall population growth rates well. Adult nesting females often account for less than 1 percent of total population numbers. The global abundance of nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004a).

Eastern Australia supported one of the major global loggerhead nesting assemblages until recently (Limpus 1985). Now, less than 500 females nest annually, an 86 percent reduction in the size of the annual nesting population in 23 years (Limpus and Limpus 2003). Overall, Gilman (2009) estimated that the number of loggerheads nesting in the Pacific has declined by 80 percent in the past 20 years. Nesting for the South Pacific DPS occurs mostly in eastern Australia and New Caledonia. For many years, the nesting population at Queensland was in decline; there were approximately 3,500 females in the 1976-1977 nesting season, and less than 500 in 1999. From 2000 to 2009, there has been an increasing number of females nesting (Conant et al. 2009a).

4.2.9.8 Critical habitat

NMFS has designated critical habitat for the Northwest Atlantic Ocean DPS loggerhead sea turtles. On July 10, 2014, NMFS and FWS designated critical habitat for the Northwest Atlantic Ocean DPS loggerhead sea turtles along the U.S. Atlantic and Gulf of Mexico coasts from North Carolina to Mississippi (79 FR 39856). These areas contain one or a combination of nearshore reproductive habitat, winter area, breeding areas, and migratory corridors. The critical habitat is

categorized into 38 occupied marine areas and 685 miles of nesting beaches. This area is outside the proposed action area.

4.2.10 Olive Ridley Sea Turtle

4.2.10.1 Species description and distribution

Olive ridleys are globally distributed in tropical regions (greater than 20° C) of the Pacific (southern California to Peru, and rarely in the Gulf of Alaska Hodge and Wing 2000), Indian (eastern Africa and the Bay of Bengal), and Atlantic oceans (Foley et al. 2003; Fretey et al. 2005; Stokes and Epperly 2006). Olive ridleys are uncommon in the western Pacific and western Indian Oceans, and most of the North Atlantic (Spotila 2004a). Olive ridley sea turtles have been reported in Chilean waters, in particular near the warm water discharge area from a power plant at 23.7°S (Sarmiento-Devia et al. 2015)

4.2.10.2 Population structure

Population designations are poorly known. Populations likely correspond somewhat to nesting beach location (Table 13 and Table 14). Most olive ridleys nest synchronously in huge events called "arribadas", with hundreds to thousands of females nesting over the course of three to seven days; other individuals nest alone, out of sequence with the arribada (Aprill 1994; Kalb and Owens 1994).

Table 13 Recent estimates of olive ridley arribada size.

Country	Beach	Estimates of arribada size from one-time, most recent counts	References
Western Atlantic Ocean			
Suriname	Galibi Nature Reserve*	335 nests	(Hoekert et al. 1996)
French Guiana		1,716-3,257 females	(Kelle et al. 2009)
Eastern Pacific Ocean			
Nicaragua	Chacocente	42,541 nests	(López Carcache et al. in press)
Nicaragua	La Flor	1,300-9,000 turtles per arribada	(Ruiz 1994)
Nicaragua	Masachapa	No estimate available	(Cornelius 1982; Margaritoulis and Demetropoulos 2003)
Nicaragua	Pochomil	No estimate available	(Cornelius 1982; Margaritoulis and Demetropoulos 2003)
Nicaragua	Boquita	No estimate available	(Cornelius 1982)***
Costa Rica	Nancite	200-20,000 turtles per arribada	(Fonseca et al. 2009)
Costa Rica	Ostional	Average 50,000-200,000 turtles per arribada	(Chaves et al. 2005)
Panama	Isla Cañas	5,000-12,000 turtles per arribada	(Evans and Vargas 1998)
Northern Indian Ocean			
India	Gahirmatha	1,000-100,000+ turtles per arribada	(Shanker et al. 2003)
India	Devi River	No estimate available	(Shanker et al. 2003)
India	Rushikulya	10,000-200,000 turtles per arribada	(Shanker et al. 2003)

* Large arribadas once occurred at these beaches but no longer do (Cliffton et al. 1982; Hoekert et al. 1996).
** These data represent total nests for season.
*** Masachapa, Pochomil, and Boquita were extant at the time of the Cornelius (1982) article. The status for Boquita is unknown.

Table 14. Locations of olive ridley arribada and solitary nesting beaches in the eastern Pacific and estimates of arribada sizes.

Country	Beach	Estimates of arribada size from one-time, most recent counts	References
Arribada			
Mexico	Mismaloya*	1,000-5,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007b)
Mexico	Tlacoyunque*	500-1,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007b)
Mexico	Chacahua*	10,000-100,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007b)
Mexico	La Escobilla	1,000,000+ nests	(Márquez et al. 2005)
Mexico	Moro Ayuta*	10,000-100,000 nests	(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007b)
Solitary			
Mexico	Entire Pacific coast		(R. Briseño and A. Abreu, pers. comm. in NMFS and USFWS 2007b)

* Large arribadas once occurred at these beaches but no longer do (Cliffton et al. 1982; Hoekert et al. 1996).

In the Pacific Ocean, typical distribution of olive ridley sea turtles is from Peru to California, with rare Alaskan sightings. Peak arribada nesting in the eastern Pacific occurs at several beaches in Mexico, Nicaragua, Costa Rica, and Panama (NMFS and USFWS 2007f). Tagged Costa Rican nesters have been recovered as far south as Peru, as far north as Oaxaca, Mexico, and offshore to a distance of 2,000 km (Kelez et al. 2009). Olive ridleys are the most common sea turtle in oceanic waters of the eastern tropical Pacific but move into nearshore waters prior to breeding (Pitman 1990). This species frequently basks at the surface, is accompanied by seabirds, and associates with floating debris, from logs to plastic debris to dead whales (Arenas and Hall 1991a; Pitman 1992 as cited in NMFS 2004a).

Brito (1998a) reported several instances of olive ridley sea turtles along the Chilean coast, including to the south of the action area, but the species is considered rare here (Brito Montero 1995; Kelez et al. 2010). Reports of olive ridleys may be low due to local confusion with green sea turtles, which are reported to be abundant in northern Chile (Chandler 1991; Frazier 1990). Three olive ridleys in poor health stranded in south-central Chile (36°S) in June and July 2001; the authors supposed that water temperatures were too cold for this species and resulted in hypothermia (Miranda and Ortiz 2003). Frazier (1990) suggested that olive ridleys along Chile originate from Costa Rican and Mexican nesting groups.

4.2.10.3 Movement

Olive ridleys are highly migratory and may spend most of their non-breeding life cycle in deep-ocean waters, but occupy the continental shelf region during the breeding season (Arenas and Hall 1991b; Beavers and Cassano 1996; Cornelius and Robinson 1986; Pitman 1991; Pitman 1993; Plotkin 1994; Plotkin et al. 1994a; Plotkin et al. 1995). Reproductively active males and females migrate toward the coast and aggregate at nearshore breeding grounds near nesting beaches (Cornelius 1986; Hughes and Richard 1974; Kalb et al. 1995; Plotkin et al. 1991; Plotkin et al. 1996; Plotkin et al. 1997; Pritchard 1969). Other males and females may not migrate to nearshore breeding aggregations at all (Kopitsky et al. 2000; Pitman 1991). Some males appear to remain in oceanic waters, are non-aggregated, and mate opportunistically as they intercept females *en route* to near shore breeding grounds and nesting beaches (Kopitsky et al. 2000; Plotkin 1994; Plotkin et al. 1994b; Plotkin et al. 1996). Their migratory pathways vary annually (Plotkin 1994), there is no spatial and temporal overlap in migratory pathways among groups or cohorts of turtles (Plotkin et al. 1994a; Plotkin et al. 1995), and no apparent migration corridors exist. Olive ridleys may use water temperature more than any other environmental cue during migrations (Spotila 2004a). Post-nesting migration routes from Costa Rica traverse more than 3,000 km out into the central Pacific (Plotkin et al. 1994a). Olive ridleys from different populations may occupy different oceanic habitats (Polovina et al. 2004; Polovina et al. 2003). Unlike other marine turtles that migrate from a breeding ground to a single feeding area, where they reside until the next breeding season, olive ridleys are nomadic migrants that swim hundreds to thousands of kilometers over vast oceanic areas (Plotkin 1994; Plotkin et al. 1994a; Plotkin et al. 1995). Olive ridleys may associate with flotsam, which could provide food, shelter, and/or orientation cues (Arenas and Hall 1991b).

Diving behavior remains somewhat of a mystery, but several studies have highlighted general insights. The average dive length for an adult female and male were reported to be 54.3 and 28.5 min, respectively (Plotkin 1994 in Lutcavage and Lutz 1997, as cited in NMFS and USFWS 2007f). McMahon et al. (2007) reported a maximum dive duration of 200 min (± 20 min) in northern Australia. In the eastern tropical Pacific, diving rate is greater during daytime than at night (Beavers and Cassano 1996; Parker et al. 2003). During nighttime however, dives are longer (up to 95 min).

Olive ridleys can dive and feed at considerable depths (80–300 m), although approximately 90 percent of their time is spent at depths less than 100 m (Polovina et al. 2003). At least 25 percent of their total dive time is spent in the permanent thermocline, located at 20–100 m (Parker et al. 2003). In the North Pacific Ocean, two olive ridleys tagged with satellite-linked depth recorders spent about 20 percent of their time in the top meter and about 10 percent of their time deeper than 100 m; 70 percent of the dives were no deeper than 5 m (Polovina et al. 2003).

4.2.10.4 Reproduction

Little is known about olive ridley growth or reproduction. However, some beaches, such as Ostional Beach on the Pacific coast of Costa Rica, are known to have extremely low hatching success, particularly at the onset of the dry season onward, at least partly due to the high temperatures of nests (Valverde et al. 2010).

4.2.10.5 Feeding

Olive ridleys typically forage offshore and feed on a variety of benthic and pelagic species, such as jellyfish, squid, salps, red crabs, acorn and gooseneck barnacles, mollusks, and algae (Márquez 1990; Deraniyagala 1939, Carr 1961, Caldwell 1969, Fritts 1981, Cornelius and Robinson 1986, Mortimer 1982 - as cited in NMFS 2004a).

4.2.10.6 Hearing

Information on the hearing capabilities of sea turtles is limited, but available information supports low-frequency hearing centered below 1 kHz and a hearing threshold at 132-140 dB (Lenhardt 1994; Lenhardt et al. 1983; Moein Bartol and Ketten 2006; Moein Bartol et al. 1999; O'Hara and Wilcox 1990; Ridgway et al. 1969).

4.2.10.7 Status and trends

Collection of eggs as well as adult turtles has historically led to species decline (NMFS and USFWS 2007b). Except for the Mexico breeding stock, olive ridley sea turtles were listed as threatened under the ESA on July 28, 1978 (43 FR 32800). The olive ridley is the most abundant sea turtle in the world (Pritchard 1997). Worldwide, abundance of nesting female olive ridleys is estimated at two million (Spotila 2004a).

The eastern Pacific population of olive ridley sea turtles is believed to number roughly 1.39 million (Eguchi et al. 2007; Eguchi et al. in preperation). Abundance estimates in recent years indicate that the Mexican Mismaloya and Moro Ayuta nesting populations appear to be stable and the nesting population at La Escobilla is increasing, although less than historical levels, which was roughly 10 million adults prior to 1950 (Cliffton et al. 1982; NMFS and USFWS 2007b). By 1969, after years of adult harvest, the estimate was just over one million (Cliffton et al. 1982). Olive ridley nesting at La Escobilla rebounded from approximately 50,000 nests in 1988 to over 700,000 nests in 1994, and more than a million nests by 2000 (Márquez et al. 2005; Márquez et al. 1996). The largest known arribadas in the eastern Pacific are on the coast of Costa Rica (approximately 475,000-650,000 females estimated nesting annually) and in southern Mexico (approximately 800,000 nests per year at La Escobilla, in Oaxaca, Mexico). Along Costa Rica, 25,000-50,000 olive ridleys nest at Playa Nancite and 450,000-600,000 turtles nest at Playa Ostional annually (NMFS and USFWS 1998b). At a nesting site in Costa Rica, an estimated 0.2 percent of 11.5 million eggs laid during a single arribada produced hatchlings (NMFS and USFWS 1998b). Two of the five arribada beaches in Nicaragua have available estimates – Chacocente at over 42,000 nests and La Flor at 1,300 to 9,000 turtles per arribada (NMFS 2004a;

NMFS 2004b). Analysis of bycatch data off Costa Rica suggest a female-biased sex ratio of roughly two females for every male (Arauz 2001).

4.2.10.8 Critical habitat

NMFS has not designated critical habitat for olive ridley sea turtles.

5 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 CFR 402.02).

5.1 Physical and Oceanographic Features

The oceanography of the action area is dominated by the Humboldt Current (Figure 8), which is the world's most productive marine ecosystem, including two dozen major estuaries and numerous seamounts (Sea Around Us 2007). The Humboldt Current Large Marine Ecosystem supports the world's largest fisheries, amounting to 12 million tonnes caught in 1994 by Peru and Chile alone, (16-20 percent of global fish catch), and 15 million tonnes (19 percent total global catch) in 2000 (Heileman et al. 2008; FAO 2002 in UNEP 2005). Noteworthy is the extremely high level of fishing effort found here; even with the high level of productivity in the 2.5 million km^2 area of the large marine ecosystem, 80 percent of exploited fish stocks have collapsed (especially anchovy and sardine stocks) (Heileman et al. 2008). This level of fishing effort also produces very high levels of bycatch; Little and Herrera (1991 in UNEP 2005) estimated between 8,178 and 11,064 tonnes of sea turtles were bycaught annually. Large numbers of exploited marine predators are also drawn to the area by the sardine, anchovy, and mackerel (potentially including humpback, fin, and sei whales) that feed on the high levels of productivity found in these waters (UNIDO 2003 in Heileman et al. 2008).

Along the coasts of Chile and Peru, southerly trade winds interact with the northerly current that, through Ekman offshore divergence, produces coastal upwelling and establishes the basis for nutrient rich waters to rise and allow for high levels of primary productivity (Heileman et al. 2008). As a result of coastal upwelling, productivity is particularly high in coastal waters versus offshore areas; overall productivity averages 150-300 gCm^2/yr (Heileman et al. 2008). The current system is complex and marked by coastal currents that can export waters up to 1,000 km offshore, with subsequent effects on the biological populations of species with planktonic dispersal (Miloslavich et al. 2011). Anchovies, sardines, and mackerel are strong controlling organisms of plankton within the ecosystem (Heileman et al. 2008). Increased sperm whale abundance has been associated with particularly productive upwelling features in the Humboldt Current (Rendell et al. 2004).

Figure 8. Overview of the Humboldt Current along South America. From UNEP (2005).

Oceanic frontal systems also add to the productivity of the Humboldt Current system. The largest occurs off Peru (5-19° S) due to wind-induced coastal upwelling (Heileman et al. 2008). The coastline further south is not conducive to wind-induced upwelling (Heileman et al. 2008). However, the presence of the underwater Nasca Ridge also induces a summertime (especially March) upwelling front northwestward from 23-25° S off the Chilean coast, supporting top marine predators (Belkin and Cornillon 2003). Additional major frontal systems include the

North and South Subtropical Fronts that traverse the South Pacific along 35-40° S up to the Chilean coast, where they diverge poleward (Heileman et al. 2008). In between these, several associated fronts enhance coastal upwelling year-round (Heileman et al. 2008).

5.2 Fisheries Interactions

Fisheries interactions represent a significant threat to ESA-listed whales throughout their range. Whales are often killed or injured during interactions with commercial fishing gear. Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Several humpback whales are also known to have become entangled in the North Pacific (Angliss and Outlaw 2007; Hill et al. 1997). Sperm whales are also known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004). Sperm whales are also killed incidentally by gill nets at a rate of roughly nine per year (data from 1991 to 1995) in U.S. Pacific waters (Barlow et al. 1997). Sperm whales interact with (i.e., remove fish from) longline fisheries in the Gulf of Alaska and entanglement has rarely been recorded (Hill and DeMaster 1999; Rice 1989; Sigler et al. 2008).

Sea turtles are also vulnerable to threats from fishing gear. Wallace et al. (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide; many of these turtles are expected to be leatherbacks. Bycatch, particularly by longline fisheries, is a major source of mortality for leatherback sea turtles (Crognale et al. 2008; Fossette et al. 2009a; Gless et al. 2008; Petersen et al. 2009). Japanese research and training vessels are estimated to have bycaught large numbers of sea turtles historically (21,200 bycaught, 12,296 killed) (Nishimura and Nakahigashi 1990). An estimated 20,000-40,000 leatherbacks were captured as longline bycatch in the Pacific during 2000, with 1,000-1,300 of these dying (Lewison et al. 2004).

Donoso and Dutton (2010) found that 284 leatherbacks were bycaught between 2001 and 2005 as part of the Chilean longline fishery, with two individuals observed dead; leatherbacks were the most frequently bycaught sea turtle species. About 500 leatherback turtles are estimated to die annually in Chilean and Peruvian fisheries.

Incidental bycatch in fisheries poses a significant threat for green turtles of the East Pacific DPS (Seminoff 2015). Significant green turtle bycatch has been reported in the gill net and longline shark fisheries in Peru (and to a lesser extent in Chile) (Donoso and Dutton 2010b). Although turtle excluder devices are a requirement for shrimp fisheries in all countries from Mexico to Ecuador so that they may export shrimp to the U.S., it is believed that the fishermen are not using the devices properly, or taking them off the gear entirely (Seminoff 2015). In the Pacific, loggerhead turtles are captured, injured, or killed in numerous fisheries including commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru. Olive ridleys in the

eastern Pacific are also incidentally caught by purse seine fisheries and gillnet fisheries (Frazier et al. 2007).

5.3 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.

In general, based on forecasts made by the Intergovernmental Panel on Climate Change, climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the near future (IPCC 2000; IPCC 2001a; IPCC 2001b; IPCC 2002). From 1906 to 2006, global surface temperatures have risen 0.74° C and continues at an accelerating pace; 11 of the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown. Species that are shorter-lived, larger body size, or generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is most likely to have its most pronounced affects on species whose populations are already in tenuous positions (Isaac 2008). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming.

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for whale calving and rearing, the distribution and abundance of prey and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated to prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). Climate change can influence reproductive success by altering prey availability, as evidenced by low-success of northern elephant seals during El Niño periods, when cooler, more productive waters are associated with higher first year pup survival (McMahon and Burton. 2005). Reduced prey availability resulting from increased sea temperatures has also been suggested to explain reductions in Antarctic fur seal pup and harbor porpoise survival (Forcada et al. 2005; Macleod et al. 2007). Polygamous marine mammal mating systems can also be perturbated by rainfall levels, with the most competitive grey seal males being more successful in wetter years than in drier ones (Twiss et al. 2007). Sperm whale females were observed to have lower rates of conception following

unusually warm sea surface temperature periods (Whitehead 1997). Marine mammals with restricted distributions linked to water temperature may be particularly exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, 47 percent would be negatively affected, and 21 percent would be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters and preferences for shelf habitats (Macleod 2009). Kaschner et al. (2011) modeled marine mammal species richness, overlaid with projections of climate change and found that species in lower-latitude areas would likely be more affected than those in higher-latitude regions. Variations in the recruitment of krill and the reproductive success of krill predators correlate to variations in sea-surface temperatures and the extent of sea-ice cover age during winter months. Although the IPCC (2001b) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran et al. (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20 percent since the 1950s.

Roughly 50 percent of the Earth's marine mammal biomass occurs in the Southern Ocean, with all baleen whales feeding largely on a single krill species, *Euphausia superba*, here and feeding virtually nowhere else(Boyd 2002). However, Atkinson et al. (2004) found severe decreases in krill populations over the past several decades in some areas of the Antarctic, linked to sea ice loss. Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators (Antarctic fur seals, gentoo penguins, macaroni penguins, and black-browed albatrosses) that depend on krill for prey and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50 percent in the 1990s, although incidental mortalities from longline fisheries probably contributed to the decline of the albatross. However, these declines resulted, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older krill age classes, which lowered the number of predators krill could sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s. By 2055, severe reductions in fisheries catch due to climate change have been suggested to occur in the Indo-Pacific, Red Sea, Mediterranean Sea, Antarctic, and tropical areas worldwide while increased catches are expected in the Arctic, North Pacific, North Atlantic, and northern portions of the Southern Ocean (Cheung et al. 2010).

Similarly, Sims et al. (2001) found the timing of squid peak abundance in the English Channel advanced by 120-150 days in the warmest years compared with the coldest. Bottom water temperatures correlated with the extent of squid movement, and temperature increases over the 5 months before and during the month of peak squid movement did not differ between early and late years. These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which climatic changes association with the North Atlantic Oscillation mediate. Cephalopods dominate the diet of sperm whales,

who would likely re-distribute following changes in the distribution and abundance of their prey. If, however, cephalopod populations collapse or decline dramatically, sperm whales would likely decline as well.

Climate change has been linked to changing ocean currents as well. Rising carbon dioxide levels have been identified as a reason for a poleward shift in the Eastern Australian Current, shifting warm waters into the Tasman Sea and altering biotic features of the area (Johnson et al. 2011; Poloczanska et al. 2009). Similarly, the Kuroshio Current in the western North Pacific (an important foraging area for juvenile sea turtles) has shifted southward as a result of altered long-term wind patterns over the Pacific Ocean (Poloczanska et al. 2009).

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. If sea ice extent decreases, then larval krill may not be able to survive without access to underice algae to feed on. This may be a cause of decreased krill abundance in the northern western Antarctic Peninsula during the last decade (Fraser and Hofmann 2003). Meltwaters have also reduced surface water salinities, shifting primary production along the Antarctic Peninsula (Moline et al. 2004). Blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990). If they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations would likely experience declines similar to those observed in other krill predators, including dramatic declines in population size and increased year-to year variation in population size and demographics. These outcomes would dramatically increase the extinction probability of baleen whales. Edwards et al. (2007) found a 70 percent decrease in one zooplankton species in the North Sea and an overall reduction in plankton biomass as warm-water species invade formerly cold-water areas. However, in other areas, productivity may increase, providing more resources for local species (Brown et al. 2009). In addition, reductions in sea ice may alleviate "choke points" that allow some marine mammals to exploit additional habitats (Higdon and Ferguson 2009).

Foraging is not the only potential aspect that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott. 2009). It has also been suggested that

increases in harmful algal blooms could be a result from increases in sea surface temperature (Simmonds and Eliott. 2009).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half degree Celsius increase in temperatures during hurricane season from 1965-2005 correlated with a 40 percent increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of ocean water; this rate will likely increase. Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). The loss of nesting beaches, by itself, would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtle nests and reduce hatching success (Caut et al. 2009). Storms may also cause direct harm to sea turtles, causing "mass" strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchling), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009b; Fuentes et al. 2010; Fuentes et al. 2009c). Smaller individuals likely experience increased predation (Fuentes et al. 2009b)Climatic anomalies influencing the Marianas Islands include El Niño/Southern Oscillation and La Niña events (Giese and Carton 1999; Mantua and Hare 2002a; NOAA 2005a; NOAA 2005b; Sugimoto et al. 2001; Trenberth 1997). Although Guam and the Southern Marianas Islands do not appear to experience altered rainfall patterns during El Niño events, the Northern Marianas tend to experience drier dry seasons and wetter wet seasons (Pacific ENSO Applications Center 1995). Sea surface temperature in the regions also increases due to a weakening of a high pressure system over the western Pacific, potentially influencing the distribution of fish (Kubota 1987; Lehodey et al. 1997). Although typhoons tend to be more frequent during El Niño events (likely occurring at present), their tracks tend to be more to the northwest, away from the action area (Elsner and Liu 2003; Saunders et al. 2000).

Unlike El Niño and La Niña events, Pacific Decadal Oscillation events can persist for 20-30 years, but are more prominent outside the tropics, and mechanisms controlling them are relatively unknown (Hare and Mantua 2000; Mantua and Hare 2002b; Minobe 1997; Minobe 1999). PDO events should not strongly influence the action area.

Climactic variability, such as El Nino and La Nina oscillations, have significant impacts on the Humboldt Current Large Marine Ecosystem (Heileman et al. 2008; UNEP 2005). El Nino conditions result in intrusions of warm water, low nutrient waters from the west and north into the current's usual cold, nutrient rich southern waters (Wolff et al. 2003, GTE IMARPE 2003, Klyashtorin 2001, Bouchon et al. 2000 in Alheit and Niquen 2004; Heileman et al. 2008;

Klyashtorin 2001; Serra et al. 2002; UNEP 2005). The northern portion of the Humboldt large marine ecosystem is strongly affected by El Nino/La Nina conditions, whereas the southern portion of the large marine ecosystem is not directly impacted (NWS/CPC 2007). However, even in the northern region, some oscillations are barely noticeable (Heileman et al. 2008). A multidecadal shift in temperatures of this large marine ecosystem as well as a similar large marine ecosystem (California Current) support long term increases in upwelling and subsequent primary productivity (Heileman et al. 2008). Projections of the impacts of global warming in the Humboldt Current indicate increased upwelling along Chile, particularly to the south of the country, leading to increased fisheries exploitation, introductions of more tropical species, and altered food webs (Aguilera et al. 1992).

Sea level rise may have significant impacts upon green turtle nesting on Pacific atolls. These low-lying, isolated locations could be inundated by rising water levels associated with global warming, eliminating nesting habitat (Baker et al. 2006; Fuentes et al. 2010). Fuentes et al. (2010) predicted that rising temperatures would be a much greater threat in the long term to the hatching success of sea turtle turtles in general and green sea turtles along northeastern Australia particularly. Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). Predicted temperature rises may approach or exceed the upper thermal tolerance limit of sea turtle incubation, causing widespread failure of nests (Fuentes et al. 2010). Although the timing of loggerhead nesting depends upon sea-surface temperature, green sea turtles do not appear to be affected (Pike 2009). Although global warming may expand foraging habitats into higher latitude waters, increasing temperatures may increase feminization of nests (Hawkes et al. 2007b; James et al. 2006; McMahon and Hays 2006; Mrosovsky et al. 1984). Rising sea levels may also inundate nests on some beaches. Climate change may also have significant implications on loggerhead populations worldwide. In addition to potential loss of nesting habitat due to sea level rise, loggerhead sea turtles are very sensitive to temperature as a determinant of sex while incubating. Ambient temperature increase by just 1°-2° C can potentially change hatchling sex ratios to all or nearly all female in tropical and subtropical areas (Hawkes et al. 2007a). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin et al. 2009). Sea surface temperatures on loggerhead foraging grounds correlate to the timing of nesting, with higher temperatures leading to earlier nesting (Mazaris et al. 2009a; Schofield et al. 2009). Increasing ocean temperatures may also lead to reduced primary productivity and eventual food availability. This has been proposed as partial support for reduced nesting abundance for loggerhead sea turtles in Japan; a finding that could have broader implications for other populations in the future if individuals do not shift feeding habitat (Chaloupka et al. 2008). Warmer temperatures may also decrease the energy needs of a developing embryo (Reid et al. 2009).

5.4 Harvest

Commercial harvest of whales (i.e., whaling) was placed under moratorium by the IWC in 1986, although Iceland and Norway still hunt minke and fin whales within their respective exclusive economic zones.

Harvest of sea turtle eggs or turtles themselves is a serious threat. Directed harvests of green sea turtle eggs constitute a "major problem" for the East Pacific DPS in Costa Rica, Mexico, Guatemala, El Salvador, and Nicaragua (Blanco 2010; Seminoff 2015). Deliberate hunting of loggerheads for their meat, shells, and eggs has declined from previous exploitation levels, but still exists and hampers recovery efforts (Lino et al. 2010). Green turtles are hunted on foraging grounds, particularly in northwest Mexico (Seminoff 2015). Leatherback egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of female leatherbacks along nesting beaches is of concern worldwide. Harvests remain a concern for olive ridley recovery. In some locations, takes are now regulated or banned (with varying compliance), while harvests remain uncontrolled in other areas. Adult harvests are now largely banned, except along African coasts.

High levels of adult mortality due to harvesting are believed to be the reason why rapid and large nesting population declines occurred in Mexico (Cornelius et al. 2007). The nationwide ban on commercial sea turtle harvest in Mexico, enacted in 1990, has greatly aided olive ridley conservation, but the population is still seriously decremented and threatened with extinction (Groombridge 1982). Several solitary and arribada nesting beaches experience (although banned) egg harvesting, which is causing declines (Cornelius et al. 2007). Approximately 300,000-600,000 eggs were seized each year from 1995-1998 (Trinidad and Wilson 2000).

5.5 Habitat Degradation

Habitat degradation impacts whales on a broad scale through impaired water quality and exposure to contaminants, oil spills, and run-off from coastal areas; see section 5.8 and 5.9 for more detailed discussion.

Habitat degradation impacting sea turtles takes several forms, including: coastal development and construction, placement of erosion control structures, beachfront lighting, vehicular and pedestrian traffic, sand extraction, beach erosion, beach nourishment, beach pollution, removal of native vegetation, and planting of non-native vegetation (Baldwin 1992; Margaritoulis et al. 2003; Mazaris et al. 2009b; USFWS 1998). Surprisingly, beach nourishment also hampers nesting success, but only in the first year post-nourishment before hatching success increases (Brock et al. 2009). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water, with up to 50 percent of some olive ridley hatchlings

disoriented upon emergence in some years (Karnad et al. 2009; Witherington 1992; Witherington and Bjorndal 1991).

Major anthropogenic impacts causing habitat degradation affect green sea turtle survival and recovery. At nesting beaches, green sea turtles rely on intact dune structures, native vegetation, and normal beach temperatures for nesting (Ackerman 1997). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to nesting females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington et al. 2003; Witherington et al. 2007). In some areas, timber and marine debris accumulation as well as sand mining reduce available nesting habitat (Bourgeois et al. 2009; Chacón Chaverri 1999; Formia et al. 2003; Laurance et al. 2008).

In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, particularly areas rich in seagrass and marine algae. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005). The introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996).

5.6 Noise

Vessel noise could affect marine animals in the proposed study area. Shipping and seismic noise generally dominates ambient noise at frequencies from 20 to 300 Hz (Andrew et al. 2002; Hildebrand 2009; Richardson et al. 1995c). Background noise has increased significantly in the past 50 years as a result of increasing vessel traffic, and particularly shipping, with increases of as much as 12 dB in low frequency ranges; background noise may be 20 dB higher now versus preindustrial periods (Hildebrand 2009; Jasny et al. 2005; McDonald et al. 2006; NRC 1994; NRC 2003; NRC 2005; Richardson et al. 1995a). Over the past 50 years, the number of commercial vessels has tripled, carrying an estimated six times as much cargo (requiring larger, more powerful vessels) (Hildebrand 2009). Roughly two dozen ports occur along western South America; major Chilean ports include Valparaiso, San Antonio, San Vicente, and Concepcion (CPPS 2000 in NSF 2012; UNEP 2005). Seismic signals also contribute significantly to the low frequency ambient sound field (Hildebrand 2009). Baleen whales may be more sensitive to sound at those low frequencies than are toothed whales. Dunlop et al. (2010) found that humpback whales shifted from using vocal communication (which carries relatively large amounts of information) to surface-active communication (splashes; carry relatively little information) when low-frequency background noise increased due to increased sea state. Sonars and small vessels also contribute significantly to mid-frequency ranges (Hildebrand 2009). Whale watching is a rapidly-growing activity in Japan, with over 45 businesses operating 185

vessels in 30 communities (Hoyt 1993; Hoyt 2001). Humpback whales are targeted in several locations (Hoyt 1993; Hoyt 2001; Mori 1999; Uchida 1997). Peak season is in winter through summer, depending upon location and target species (Hoyt 1993). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

Natural sources of ambient noise include: wind, waves, surf noise, precipitation, thunder, and biological noise from marine mammals, fishes, and crustaceans. Anthropogenic sources of ambient noise include: transportation and shipping traffic, dredging, construction activities, geophysical surveys, and sonars. In general, it has been asserted that ocean background noise levels have doubled every decade for the last six decades in some areas, primarily due to shipping traffic (IWC 2004). The acoustic noise that commercial traffic contributes to the marine environment is a concern for listed species because it may impair communication between individuals (Hatch et al. 2008).

Seamounts are sensitive to fishery impacts due to the high level of endemism characteristic of this habitat. Species that inhabit seamounts tend to be long-lived and do not move widely between seamounts, meaning that their recovery can be very slow (Johnston and Santillo 2004; Richer de Forges 2000). Listed species may associate with seamounts, apparently due to prey availability here, and the deterioration of the habitat can have significant effects on listed species.

5.7 Ship Strike

Ship strikes pose a significant threat to several whale species throughout their range. The vast majority of ship strike mortalities are never identified, and actual mortality is higher than currently documented. More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific U.S. coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997). One sei whale was killed in a collision with a vessel off the coast of Washington in 2003 (Waring et al. 2008a). Two whales have been struck offshore of Japan (Jensen and Silber 2003).

Ship strike is presently a concern for blue whale recovery. Dive data support a surface-oriented behavior during nighttime that would make blue whales particularly vulnerable to ship strikes. There are concerns that, like right whales, blue whales may surface when approached by large vessels; a behavior that would increase their likelihood of being struck.

In the Southern Hemisphere, southern right whales are by far the most ship struck cetacean, with at least 56 reported instances; nearly four-fold higher than the second most struck large whale (Van Waerebeek et al. 2007). Over the past approximately 68 years in Australia, one whale was documented to have been shot (non-fatal), one fatal and 12 non-fatal entanglements (most frequently by lines, nets, and buoys) have been documented, and three non-fatal and two fatal ship strikes have been documented out of 44 mortalities or non-fatal anthropogenic interactions (Kemper et al. 2008). Two-thirds of these events occurred from July to October, but occurrences in every month except January are known (Kemper et al. 2008). The incidence of human interactions of this type has increased four-fold since the mid-1970s (Kemper et al. 2008).

Overall, 11 percent of records for Australia involve ship strike versus 16 percent in South Africa and 35 percent for North Atlantic right whales (Kemper et al. 2008).

There have not been any recent documented ship strikes involving sperm whales in the eastern North Pacific, although there are a few records of ship strikes in the 1990s. Two whales described as "possibly sperm whales" are known to have died in U.S. Pacific waters in 1990 after being struck by vessels (Barlow et al. 1997). More recently in the Pacific, two sperm whales were struck by a ship in 2005, but it is not known if these ship strikes resulted in injury or mortality (NMFS 2009). The lack of recent evidence should not lead to the assumption that no mortality or injury from collisions with vessels occurs as carcasses that do not drift ashore may go unreported, and those that do strand may show no obvious signs of having been struck by a ship (NMFS 2009). Worldwide, sperm whales are known to have been struck 17 times out of a total record of 292 strikes of all large whales; 13 resulted in mortality (Jensen and Silber 2003; Laist et al. 2001). Given the current number of reported cases of injury and mortality, it does not appear that ship strikes are a significant threat to sperm whales (Whitehead 2003).

A female sei whale was struck by a cruise ship off the southern Chile coast (41°33'S –74°11W) in January 2009. There are published records of three other possible vessel strikes of large whales (sei, fin and sperm whales) within the area (approximately 32°-34°S, 71°-72°W) (Brownell et al. 2009).

Propeller and collision injuries from boats and ships are common in sea turtles. From 1997 to 2005, 14.9 percent of all stranded loggerheads in the U.S. Atlantic and Gulf of Mexico were documented as having sustained some type of propeller or collision injuries although it is not known what proportion of these injuries were post or ante-mortem. The incidence of propeller wounds has risen from approximately 10 percent in the late 1980s to a record high of 20.5 percent in 2004 (NMFS, unpublished data).

5.8 Pollution

Within the action area, pollution poses a significant threat to ESA-listed whales and sea turtles. Whales are impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear. 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.

Contaminants cause adverse health effects in whales. Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Garrett 2004; Grant and Ross 2002; Hartwell 2004). 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.

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.

5.11.1 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 et al. 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 believed 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, in all likelihood, in the action area itself. These two factors are the greatest known source of mortality and impairment to recovery for ESA-listed whales in the action area. Reductions in vessel speed as well as seasonal or brief closings of areas to fishing can reduce these impacts, but data are not yet available to demonstrate the long-term effectiveness of these strategies. However, such measures would 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.

Other researchers have noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels (Bauer 1986; Bauer and Herman 1986). These stimuli are probably stressful to the humpback whales in the Action Area, but the consequences of this stress on the individual whales remains unknown (Baker and Herman 1987; Baker et al. 1983). Studies of other baleen whales, specifically bowhead and gray whales, document similar patterns of behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel's engine was turned on even at a distance of about 900 m (3,000 ft). Jahoda et al. (2003) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They concluded that close vessel approaches caused these whales to stop feeding and swim away from the approaching vessel. The whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed for hours after the exposure ended. They recommended keeping vessels more than 200 meters from whales and having approaching vessels move at low speeds to reduce visible reactions in these whales.

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 or biopsy work) occur on a regular basis.

5.11.2 Sea Turtles

Several of the activities described in this *Environmental Baseline* have significant and adverse consequences for nesting sea turtle aggregations whose individuals occur in the action area. In particular, the commercial fisheries annually capture substantial numbers of leatherback sea turtles.

Climate change has and will continue to impact sea turtles throughout the action area as well as throughout the range of the populations. Sex ratios of several species 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 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 sea turtle recovery. Turtle mortality associated with shrimp trawls was estimated to be 10 times greater than that of all other human-related factors combined (Smith 1990). Most bycaught turtles were neritic juveniles, the life stage most critical to the stability and recovery of sea turtle populations (Crouse et al. 1987a; Crowder et al. 1994). Sea turtles 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 poundnets (Dutton and Squires 2008). Since sea turtle takes are directly linked to fishery effort, these takes are expected to decrease proportionately. However, hundreds to a possible few thousand sea turtle interactions are expected annually, with hundreds of deaths (NMFS 2012). 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.

6 EFFECTS OF THE ACTION ON ESA-LISTED SPECIES AND CRITICAL HABITAT

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 CFR 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.

As was stated in section 3, this biological opinion includes a jeopardy analysis. 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 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

6.1 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.

6.1.1 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 *Langseth* 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 marine mammals or sea turtles.

6.1.2 Ship Strike

We are not aware of a ship-strike by a seismic survey vessel. The *Langseth* 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 *Langseth* has traveled without a ship strike, general expected movement of marine mammals away or parallel to the *Langseth*, as well as the generally slow movement of the *Langseth* 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 marine mammals or sea turtles.

6.1.3 Disturbance from Engine Noise

We expect that the *Langseth* will add significantly 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 *Langseth*'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 *Langseth* will be traveling at slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a shipstrike 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 marine mammals or sea turtles.

6.1.4 Gear Entanglement

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 et al. 2008; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). To the best of our knowledge, sea turtles do not occur in high densities in the action area. Instances of such entanglement events with ESA-listed marine mammals 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.

Deployment of oceanographic and bottom sampling equipment is standard practice aboard deep-water research vessels, including those used by Scripps under NSF-funded activities (Haley and Koski 2004; MacLean and Koski 2005), and entanglements with ESA-listed species are rare. However, we are unaware of entanglements or other interactions since the event in 2011 between the equipment used for this research and listed species or critical habitat. The taut cables used to raise and lower equipment would prevent entanglement. Based upon extensive deployment and the impractical nature of entanglement, we find the probability of adverse impact to listed species to be 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 sonars.

6.2 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 as 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.

6.3 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 sea turtles in the action area.

6.3.1 Exposure Analysis

Although there are several acoustic and non-acoustic stressor associate 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 FR 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 3** and section 2.1.5), 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 that was informed by comments received during the public comment period that was required on the proposed IHA and a draft environmental assessment prepared pursuant to NEPA. 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.

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. The NSF and NMFS analyses for each ESA-listed species are described below.

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 166 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"[3] 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.

Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

The exposure analysis for this opinion is concerned with the number of fin, sei, southern right, blue, humpback, and sperm whales, as well as green, leatherback, loggerhead, and olive ridley sea turtles likely to be exposed to received levels greater than 160 dB re 1 μPa_{rms} (166 for sea turtles), which constitute the best estimate of adverse response by listed whales and sea turtles. The NSF and NMFS' Permits and Conservation Division estimated the expected number of

[3] 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)

ESA-listed whales exposed to received levels ≥160 dB re 1 μPa_{rms}. The NMFS' Permits and Conservation Division'sdata 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.

6.3.2 NSF Exposure Estimates

The NSF applied acoustic thresholds to determine at what point during exposure to seismic airguns marine mammals are "harassed," based on definitions provided in the MMPA (65 FR 16374). The NSF concluded that ESA-listed whales would be exposed to the seismic activities. The NSF did not provide estimates of sea turtle exposure. These thresholds were also used to develop exclusion radii around the acoustic source to determine appropriate power-down and shut-down procedures. The acoustic thresholds are described in Table 4. The NSF provided the predicted distances to which sound levels ≥ 180 and 160 dB re 1 μPa_{rms} would be received (Level A and Level B harassment under the MMPA for whales) are described above in Table 4.

The exposure analysis from NSF estimates the number of ESA-listed marine mammals likely to be exposed to received levels greater than 160 dB re 1 μPa_{rms}, which is a level that an adverse response by ESA-listed marine mammals is reasonable to expect. NSF provided estimates of marine mammal exposure based on the potential exposures to sound levels received at the 160 dB re 1 μPa_{rms}. The rationale was that if exposed to sound levels from the proposed seismic activities, animals would move away from the comparatively larger 160 dB radius before received levels reached the higher sound levels of the 180 or 190 dB radii (LGL 2016).

Following a methodology similar to the NMFS' Permits and Conservation Division, NSF calculated the distance of trackline that could be surveyed in a single day (160 km). NSF calculated the ensonified area for each of the survey areas: northern (84,913 km^2), central (12,213 km^2), and southern (80,976 km^2), including a 25 percent contingency for each study area. Expected species density was multiplied by the ensonified area to arrive at numbers of animals exposed.

NSF calculated takes estimates for each of the proposed survey areas. There are no definitive density estimates available for the action area in the waters off of Chile, so NSF used their judgment to select the source that was most appropriate to develop estimates of the number of individuals that could be exposed. NSF applied species density information from the NMFS Southwest Fisheries Science Center's research cruises, which took place in the eastern Pacific Ocean (Barlow 2003; Barlow 2010; Ferguson et al. 2003; Ferguson and Barlow 2001). NSF provided the rationale that the California Current Coastal Province is sufficiently alike to the Humboldt Current Coastal Province in the action area in estimating take for the proposed action. The two currents share similar oceanographic features, bathymetry, productivity and fishery resources. NSF applied correction factors for detectability and availability bias to their density estimates (Barlow 2010). To estimate exposure for blue whales, NSF used a study conducted by (Galletti Vernazzani et al. 2012) off the coast of southern Chile. See Table 15 for a summary of NSF's take request.

6.3.3 NMFS Exposure Estimates

The NMFS' Permits and Conservation Division developed a daily ensonified area to apply to the species density estimates. Assuming that the *Langseth* was traveling at its fastest speed (4.5 kts) and a sea state at Beaufort 3 or less, the maximum amount of line kilometers that could be traveled in 24 hours is 160 km. They selected the first grouping of consecutive tracklines that had a total length of 160 km to represent the daily area that could be ensonified during seismic activities.

The survey tracklines for the proposed action consist of three areas: the northern, central and southern survey areas (Figure 3). When calculating exposure, the NMFS' Permits and Conservation Division calculated an ensonified area for the survey areas separately. Each survey area is made up of a different amount of tracklines (owing to different research objectives), and thus would vary in the number of days needed to complete each survey area. To account for additional contingency effort, the NMFS' Permits and Conservation Division included a 25 percent increase in the number of days.The number of survey days (including contingency) for each survey area are: 35 (northern), 6 (central), and 34 (southern).

An exclusion zone representing the predicted RMS distances (27.1 km) was applied to the trackline ensonified areas; this buffer distance was provided by L-DEO (Table 4). The NMFS' Permits and Conservation Division estimated the daily ensonified area to be 2,047 km^2 for the northern tracklines, 1,655 km^2 for the central tracklines, and 2,061 km^2 for the southern tracklines. Since the depth strata are different in each of the survey areas, the received sound level distances would vary for different survey areas, leading to the different calculations of ensonified areas. These estimates do not account for overlap of ensonified areas.

Exposure for each species for a single day was calculated by multiplying available species density by the daily ensonified areas, and then the sum of those exposures over 75 days. This figure resulted in the final NMFS' Permits and Conservation Division estimated take numbers. This calculation assumes 100 percent turnover of individuals within the ensonified area on a daily basis—that is, each individual exposed to the seismic activities is a unique individual.

The NMFS' Permits and Conservation Division used the species density information from the NMFS' Southwest Fisheries Science Center's research cruises (the same used as NSF) to estimate species density in the survey area in the Pacific Ocean for all species except blue whales (see below). For species where the instance of exposure was less than one (sei whales), or no density information was available (sei whales and southern right whale), the number of individuals exposed was increased to the mean group size based upon the NMFS Atlantic Marine Assessment Program for Protected Species surveys in 2010, 2011, and 2013. Density information taken from Galletti Vernazzani et al. (2012) was used to calculate exposure numbers for blue whales. The results of the NMFS' Permits and Conservation Division's calculations and their proposed take numbers is in Table 15.

As described above, there is very little information available on the population abundance or density of the ESA-listed species within the action area. Throughout the consultation, we worked with the NMFS' Permits and Conservation Division to develop exposure estimates. We agreed with and adopted the NMFS' Permits and Conservation Division's methodology for estimating exposure of ESA-listed marine mammals to the proposed action. Given the the general lack of species density information, and that there are oceanographic similarities between the two regions, it is acceptable to use species density information from the NMFS' Southwest Fisheries Science Center's research cruises. However, because there is blue whale density information specific to the action area, it is more appropriate to use that to estimate exposure for the proposed action, than to rely on information from a different part of the Pacific as NSF did.

Fin, sei, humpback, blue and southern right whales of all age classes are likely to be exposed. During austral summer (January through March), we expect that most whales at this time will be on the summer feeding grounds (south of 50 or 55°S, generally), or migrating to or from the feeding grounds (Branch 2007; Clapham 2009; Gambell 1985b; Horwood 2009; Kenney 2009). However, we expect that blue whales are more likely to be exposed to the proposed action during the months of February-April in the waters off the coast of Chile around 39°-44°S (in the southern survey area), because of feeding aggregations are known to occur there at that time (Galletti Vernazzani et al. 2012). Whales are expected to be feeding, traveling, or migrating in the area and some females would have young-of-the-year accompanying them. Humpback whales are known to breed and rear calves in the nearshore waters of Columbia (2-6°S) from June through November (Capella Alzueta et al. 2001). These individuals could be exposed to the proposed seismic activities while they are transiting from the feeding grounds to their breeding grounds.

We would normally assume that sex distribution is even for fin, sei, humpback, blue and southern right 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 15. Comparisons of the proposed take estimates calculated by the NMFS' Permits and Conservation Division and the NSF for ESA-listed marine mammals.

Species	Survey Area	NSF Exposure Estimate	NMFS Exposure Estimate
Humpback Whale	Northern	42	35
	Central	42	18
	Southern	99	102

	Total	183	143
Fin Whale	Northern	119	105
	Central	24	18
	Southern	196	170
	Total	339	368
Sei Whale	Northern	10	105
	Central	10	18
	Southern	10	3
	Total	30	126
Sperm Whale	Northern	101	70
	Central	15	12
	Southern	107	102
	Total	223	184
Southern right Whale	Northern	12	105
	Central	12	18
	Southern	12	102
	Total	36	225
Blue Whale	Northern	45	35
	Central	26	24
	Southern	387	247
	Total	458	306

6.3.4 Exposure Estimates in the Action Area

As discussed in section 2.3.1, we must estimate the amount of ESA-listed species which could be exposed throughout the entire action area; in this case, that means the entire ensonified area for each of the survey areas in the proposed action. The numbers presented in the NMFS' Permit and Conservation Division's take request represent the amount of take expected in the non-territorial waters of Chile. To account for take that might occur as a result of the proposed action in territorial seas, NMFS applied the proportion of the survey area inside the territorial seas to outside the territorial seas to the take numbers for each species (northern: 23 percent; central: 2.7 percent; southern: 32 percent) (Table 16).

Table 16. Exposure estimates of ESA-listed species in the entire action area and in non-territorial seas.

Species	Survey Area	Exposure Numbers (entire action area)	ITS Take Numbers (non-territorial seas, >12 nmi)
Humpback Whale	Northern	44	35
	Central	19	18
	Southern	135	102
	Total	198	143
Fin Whale	Northern	130	105
	Central	19	18
	Southern	225	170
	Total	374	368
Sei Whale	Northern	130	105
	Central	19	18
	Southern	4	3
	Total	153	126

Sperm Whale	Northern	87	70
	Central	13	12
	Southern	135	102
	Total	284	184
Southern right Whale	Northern	130	105
	Central	19	18
	Southern	135	102
	Total	284	225
Blue Whale	Northern	44	35
	Central	25	24
	Southern	327	247
	Total	396	306

6.3.4.1 Exposure of ESA-listed whales to multibeam echosounder and sub-bottom profiler.

Two additional acoustic systems will operate during the proposed *Langseth* cruise: the multibeam echosounder and the sub-bottom profiler. These systems have the potential to expose listed species to sound above the 160 dB re 1 μPa_{rms} threshold. All systems operate at generally higher frequencies than airgun operations (10.5-13 kHz for the multibeam echosounder, and 3.5 kHz for the sub-bottom profiler). As such, their frequencies will attenuate more rapidly than those from airgun sources. ESA-listed individuals would experience higher levels of airgun sound well before either multibeam echosounder or sub-bottom profiler sound of equal amplitude would reach them.

While airguns are not operational, marine mammal observers will remain on duty to collect sighting data. If listed whales closely approached the vessel, the *Langseth* would take evasive actions to avoid a ship-strike and simultaneously avoid exposure to very high source levels. Ship strike has already been ruled out as a discountable effect, and we also rule out high-level ensonification of listed whales (multibeam echosounder source level = 242 dB re 1 μPa_{rms}; sub-bottom profiler source level = 204 dB re 1 μPa_{rms}). Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multibeam echosounders and sub-bottom profilers similar to those to be

used during the proposed activities presented a low risk for auditory damage or any other injury. An individual would require exposure to 250–1,000 consecutive pulses from a sub-bottom profiler to be at risk for a temporary threshold shift (TTS). To be susceptible to TTS, a marine mammal would have to pass at very close range and match the vessel's speed; we expect a very small probability of this during the proposed study. An individual would have to be well within 100 m of the vessel to experience a single multibeam echosounder pulse that could result in TTS (LGL Ltd. 2008). The same result could only occur at even closer ranges for sub-bottom profiler signals, because the signals are weaker. Furthermore, we expect both multibeam echosounder and sub-bottom profiler systems to operate continuously with duty cycles of 1-20 s. It is possible, however, that some small number of ESA-listed marine mammals (fewer than those exposed to airguns) could experience low-level multibeam echosounder and/or sub-bottom profiler sound exposure. We are unable to quantify the level of exposure from these secondary sound sources, but do not expect any exposure at levels sufficient to cause more than behavioral responses in some species capable of hearing frequencies produced by these systems. As discussed earlier, the sound levels produced by the airgun array are of primary concern in terms of exposure, due to their greater power.

6.3.5 Sea Turtles

NSF did not provide estimates of the expected number of ESA-listed turtles exposed to received levels ≥166 dB re 1 μPa_{rms}. To the best of our knowledge, there are no reliable estimates of sea turtle populations in the action area. After examining the best available information in scientific publications and reports on turtle densities in the action area, we relied on a planned ensonified area of approximately 12.6 km^2 along survey track lines, including areas of repeated exposure from adjacent track lines and turning legs to estimate exposure of sea turtles. Based upon information presented in the *Response analysis*, we expect all exposures at the 166 dB re 1 μPa_{rms} level and above to constitute "take."

6.3.5.1 Exposure of ESA-listed sea turtles to airguns

NSF presented estimated distances for the 166 dB re 1 μPa_{rms} sound levels generated by the 36 6600 in^3 GI-guns. When the array is towed at 12 m, in deep water (greater than 1000 m), the predicted established distance at received levels is 4,411 m. In shallow water (less than 100 m), the predicted established distance at received levels is 12,630 m, and 6,617 m at depths between 100-1000m. These are the distances at which sea turtles could experience fitness consequences as a result of the sound created by the airguns.

As discussed in the *Status of listed resources* section, there are four ESA-listed sea turtle species that are likely to be affected by the proposed action: leatherback, loggerhead, green and olive ridley sea turtles.

Estimating exposure for sea turtles in the action area was challenging, as there is scant information on sea turtle density or population estimates specific to the waters near the Chilean coast. To estimate exposure for sea turtles, we relied on recent status reviews, reports and

scientific literature focusing on sea turtles in the area. To summarize the status of sea turtles in Chile, Sarmiento-Devia et al. (2015) reviewed grey and scientific publications from 1956 to 2013. This is one of the more comprehensive and recent sources of information regarding sea turtles in Chile.

Four sea turtle species are found in Chile: green, leatherback, olive ridley and loggerhead. According to reports of bycatch, stranding and encounters, green turtles were observed most frequently, followed by leatherbacks, olive ridleys and loggerheads (Sarmiento-Devia et al. 2015). Sea turtle encounters were not distributed evenly throughout the Chilean coast. The majority of reported sea turtle sightings occurred between 18.5 and 23.6°S, and were mostly green turtles (greater than 200). About 40 olive ridley sea turtles were reported in the same area. No loggerheads or leatherback sea turtles were reported in this region. The authors point out that the thermal discharge from a power plant in Mejillones Bay (approximately 23°S) may be responsible for sea turtle sightings (especially green turtles) in the area (Sarmiento-Devia et al. 2015).

The proposed action will take place in three distinct survey areas: the northern (19.5-22.5°S), the central (approximately 30-31°S), and the southern (approximately 34-44°S).

According to the reported turtle encounters, we would expect olive ridley sea turtles likely to be exposed to the proposed action in the northern and central survey areas. We do not expect olive ridley sea turtles in the southern survey area because there are no reports of this species south of 32°S.

There are reports of green turtles throughout each of the three proposed survey areas (Donoso and Dutton 2010b; Guerra-Correa et al. 2008; Sarmiento-Devia et al. 2015). Therefore, we expect that green turtles may be exposed to the proposed action.

We do not expect leatherback sea turtles to be exposed in the northern or central survey areas as the species rarely occurs north of 33°S (Sarmiento-Devia et al. 2015). The available information indicates that leatherbacks are more common in southern Chile, with telemetry tagged leatherbacks found as far south as 37.6°S (Bailey et al. 2012; Shillinger et al. 2008; Shillinger et al. 2011). Therefore, we expect that leatherbacks may be exposed to the proposed action in the southern survey area.

Of the reports compiled by Sarmiento-Devia et al., (2015), only one loggerhead sea turtle was reported in the Valparaiso region of Chile (33°S). However, further offshore, loggerhead sea turtles comprise the majority of turtle bycatch in commercial fisheries off the coast of Peru and northern Chile (8-25°S), with an estimated 3200 captured annually in the region based on observer records (Alfaro-Shigueto et al. 2011). Loggerhead sea turtles were also reported as bycatch in fisheries in the region (24.3-25.2°S) (Donoso and Dutton 2010b). From these studies, we expect that loggerheads may be exposed to the proposed action in the northern survey area. There are no records of loggerhead sea turtles in or near the central or southern survey areas. We cannot entirely rule out the possibility of loggerhead exposure to the proposed action in the

central and southern survey areas, as loggerhead sea turtles are reported at southern latitudes in other parts of the world [e.g., Brazil (30-35°S), Tasmania (40°S), and New Zealand (42°S)] (Dodd Jr. 1988a; Pinedo and Polacheck 2004). However, based on the available records for the action area, we believe that it is more likely that loggerhead sea turtles would be exposed to the proposed action in the northern survey area than in the central or southern areas.

The likelihood of sea turtle exposure to the proposed action also depends on when each of the three study areas will be surveyed. There was no clear temporal pattern of distribution of sea turtle encounters among the records compiled by Sarmiento-Devia et al. (2015), but there were some general trends. Most records of leatherback encounters were from January through March. Most green turtle records were from February. Olive ridleys were encountered most frequently in March. Loggerheads were incidentally captured in long-line fisheries off Chile most often in March (Donoso and Dutton 2010b).

There is no evidence of any sea turtle nesting in the action area. Nesting occurs to the north (in Costa Rica and Mexico for olive ridleys and leatherbacks, Mexico and the Galapagos Islands for East Pacific green turtles, and Australia for South Pacific loggerheads). Therefore, we do not expect that hatchlings or nesting females to be exposed to the proposed action. The size of sea turtles captured in fisheries indicates that juveniles, sub-adults and adult sea turtles are present in the area, and consequently we expect these life stages to be exposed to the proposed action.

We are unable to quantify the level of sea turtle exposure. As discussed earlier, there are no reliable sea turtle population estimates for Chilean waters. Thus, it is not possible to quantify the proportion of the overall population that may be exposed to the proposed activity. However, we do not expect sea turtle exposure to occur at high levels because the available information indicates that sea turtles are not reported to be highly abundant in the action area. Sea turtles are still expected to be present in the action area, and thus could be exposed to the seismic operations.

We are relying on the extent of the ensonified area as a surrogate to estimate sea turtle exposure. The 166 dB exclusion zone (12.6 km^2) represents the distance to which sound levels will extend and be in the hearing threshold of sea turtles. If a sea turtle is within this exclusion zone during seismic operations, it would be exposed to the stressor (i.e., the sound field produced by the airguns) and be taken by harassment.

6.3.5.2 Exposure of ESA-listed sea turtles to multibeam echosounder and sub-bottom profiler

Sea turtles hear in the low frequency range. The multibeam echosounder and the operate at 10.5-13 kHz, 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.

6.3.6 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.

6.3.6.1 Potential response of marine mammals 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 TTS results in a temporary hearing change (Finneran and Schlundt 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. Either of these conditions can result 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 et al. 2005; Ketten 2012; Schlundt et al. 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. For pinnipeds in water, data are limited to measurements of TTS in harbor seals (*Phoca vitulina*), an elephant seal (*Mirounga angustirostris*), and California sea lions (*Zalophus californianus*) (Kastak et al. 199, 2005; Kastelein et al. 2012 b). The functional hearing frequency range for pinnipeds in air is 75 Hz to

30 kHz, and from 75 Hz to 75 kHz (Southall et al. 2007a). Baleen whales (e.g., sei, fin, and humpback) have an estimated functional hearing frequency range of 7 Hz to 22 kHz (Southall et al. 2007a). 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 196-201 dB re 1 μPa_{rms} in order to produce a low-level TTS from a single pulse (Southall et al. 2007c). 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. 2007c). In terms of exposure to the *Langseth'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 m of the *Langseth'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 or pinniped as a result 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 be 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 and Barber 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson et al. 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 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 2 to 4 kHz and 10 to 16 kHz, 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 Hz (0-188 Hz for the *Langseth* 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 s pulse when fired every 5 sec. 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 as a result 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 (Richardson et al., 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin, 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 (Penner et al., 1986; Dubrovskiy, 1990; Bain et al., 1993; Bain and Dahlheim, 1994). 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 et al., 1974, 1985; Moore and Pawloski, 1990; Thomas and Turl, 1990; Romanenko and Kitain, 1992; Lesage et al.,

1999). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim, 1987; Au, 1993; Lesage et al., 1993, 1999; Terhune, 1999; Foote et al., 2004; Parks et al., 2007, 2009; Di Iorio and Clark, 2010; Holt et al., 2009).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kHz, in contrast to the pronounced effect at higher frequencies. Studies have noted directional hearing at frequencies as low as 0.5-2 kHz in several marine mammals, including killer whales (Richardson et al., 1995a). This ability may be useful in reducing masking at these frequencies. In summary, high levels of sound generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking 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 and Barber 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 et al. 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 and Barber 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 et al. 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 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 and Hernandez (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 (Wilcock et al. 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Sperm whales, 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 $\mu Pa_{p\text{-}p}$ (Madsen et al. 2002; McCall Howard 1999). Some exposed individuals may cease calling in response to the *Langseth's* airguns. If individuals ceased calling in response to the *Langseth'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 et al. 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 et al. 2013). Migrating bowhead whales show strong avoidance reactions to received 120–130 dB re 1 μPa_{rms} exposures at distances of 20-30 km, but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152–178 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 116-129 dB re 1

μPa (possibly but not knowingly due to whale movement away from the airguns), but did not change at received levels of 99-108 dB re 1 μPa (Blackwell et al. 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 140-160 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 7-12 km 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 3-4 km, although some individuals (mainly males) approached to within 100 m on occasion where sound levels were 179 dB re 1 μPa_{rms}. Changes in course and speed generally occurred at estimated received level of 157–164 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 et al. 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 $20in^3$ 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 et al. 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 et al. 2014b).

Feeding humpbacks appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150–169 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. 2000b; 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 130-162 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 2003; Jochens and Biggs 2004; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re 1 μPa. 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 (Winsor and Mate 2013). However, no tagged whales within five kilometers were available to assess potential displacement within five kilometers (Winsor and Mate 2013). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 188 Hz) pulses produced by seismic airguns (Richardson et al. 1995c). Sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold and Fish 1998), so even though this

species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re 1 μPa lower at 1 kHz and 60 dB re 1 μPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. 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 *Langseth*'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.

Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources proposed for use. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. Monitoring work in the Alaskan Beaufort Sea during 1996-2001 provided considerable information regarding the behavior of Arctic ice seals exposed to seismic pulses (Harris et al. 2001; Moulton and Lawson 2002). These seismic projects usually involved arrays of 6 to 16 airguns with total volumes of 560 to 1,500 in^3. The combined results suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal (*Phoca hispida*) sightings tended to be farther away from the seismic vessel when the airguns were operating than when they were not (Moulton and Lawson 2002). However, these avoidance movements were relatively small, on the order of 100 m (328 ft) to a few hundreds of meters, and many seals remained within 100-200 m (328-656 ft) of the trackline as the operating airgun array passed by the animals. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey 1987; Jefferson and Curry 1994; Richardson et al. 1995). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998).

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 and Hayward 2009; Gregory and Schmid 2001; Gulland et al. 1999; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Cattet et al. 2003; Dickens et al. 2010; Dierauf and Gulland 2001b; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia et al. 2008; Noda et al. 2007; Thomson and Geraci 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly-stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan and Curry 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 2001a). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008; St. Aubin et al. 1996). Stress is lower in immature right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud noises generally increase stress indicators in mammals (Kight and Swaddle 2011). Romano et al. (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 U.S.; this decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to baseline after 24 hours of traffic resuming. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities 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 2003). 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 and Swaddle 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. 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 and Swaddle 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 and Swaddle 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 and Jurado 1997; André et al. 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 (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). 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-in^3 airgun array 22 km 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 et al., 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos, 2000; Creel, 2005; DeVries et al., 2003; Fair and Becker, 2000; Foley et al., 2001; Moberg, 2000; Relyea, 2005a; 2005b, Romero, 2004; Sih et al., 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 and pinnipeds to strand as a result of the proposed seismic survey.

Responses of marine mammal prey. Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for listed whales and pinipeds. Unfortunately, species-specific information on the prey of listed whales and pinnipeds is not generally available. Until more specific information 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; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996b; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen 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 (220-242 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 10-15 dB of hearing loss with recovery within 1 day (Popper et al. 2005). Caged pink snapper have experienced PTS when exposed over 600 times to received seismic sound levels of 165-209 dB re 1 $\mu Pa_{p\text{-}p}$. 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 et al. 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 momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column. Although received sound levels were not reported, caged *Pelates* spp., pink snapper, and trevally generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (McCauley and Fewtrell 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (McCauley and 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 20-60 minutes after seismic firing ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186–191 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 et al. 1992). These fish also showed a startle response when the survey vessel was as much as 2.5 km 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 185-192 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. 1996b). Lesser sandeels 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 156–161 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 195–218 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 20–50 m 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 142–186 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 160–180 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 163–191 dB re 1 μPa_{0-p} (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a 4-5 month seismic survey (Pickett et al. 1994). La Bella et al. (1996a) 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 (McCauley and 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 156–161 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 3 to 11 minutes. Andre et al. (2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50-400 Hz at 157 +/- 5 dB re 1 μPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 +/- 5 dB re 1 μPa, with peak levels at 175 dB re 1 μPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the surveys in time and space, as well as pathological information from the carcasses. Another laboratory story observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013). Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Payne et al. 2013). However, feeding did increase in exposed individuals (Payne et al. 2013).

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 10.5-13 kHz, and 3.5 kHz, respectively. These frequencies are within the functional hearing range of baleen whales, such as the ESA-listed humpback, blue, southern right, fin and sei whales.[4] We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng et al. 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80-90 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 3.5-4.0 kHz mid-frequency sonar at received levels below 90 dB re 1 μPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen et al. 2013). Hearing is poorly understood for 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 {Oleson, 2007 #66461}(Ketten 1997; 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 3.5-12.6 kHz 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 kHz sonar supports this species ability to hear this signal as well (Goldbogen et al. 2013). Maybaum (1990; 1993) observed that Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1-3.6 kHz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal 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 6-13 kHz pingers, but did not respond to 12 kHz echo-sounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975). Sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding, but not while traveling (Andre and Jurado 1997; André et al. 1997).

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kHz multibeam echosounder, similar in operating characteristics as that proposed for use aboard the *Langseth*, suggest that this sonar played a significant role in the mass stranding of a large group

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

of melon-headed whales (*Peponocephala electra*) (Southall et al. 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 et al. 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Langseth*'s 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 and Barber 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 L-DEO 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 navigational sonars are operated routinely by thousands of vessels around the world, strandings have 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, 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 3 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. Also, 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.

6.3.6.2 Potential responses of sea turtles to acoustic sources

As with marine mammals, 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. O'Hara and Wilcox (1990) found loggerhead sea turtles exhibited an avoidance reaction at an estimated sound level of 175–176 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 1994; Lenhardt et al. 1983). However, loggerheads resting at the ocean surface were observed to startle and dive as active seismic source approached them (DeRuiter and Larbi Doukara 2012). Responses decreased with increasing distance of closest approach by the seismic array (DeRuiter and Larbi Doukara 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 10 m (Holst et al. 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006e; NMFS 2006h).

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 166 dB re 1 μPa. This corresponds with previous reports of sea turtle hearing thresholds being generally higher than for marine mammals (DFO 2004). At 166 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 *Langseth* 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 and Martin 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 166 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 166 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.

6.4 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 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that those aspects described in the *Environmental baseline* will continue to impact listed resources into the foreseeable future. We expect climate change, ship-strikes, bycatch, and habitat degradation to continue into the future. Movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring through the Pacific Ocean, which may aid in abating the downward trajectory of sea turtle populations.

6.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 6.4) 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 4).

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.

ESA-Listed marine mammals. The NSF proposes to allow the use of its vessel, the *Langseth*, to conduct a seismic survey by L-DEO that could incidentally harass several ESA-listed marine mammal species; and the NMFS' Permits and Conservation Division proposes to authorize the incidental take of marine mammals. These species include: blue whales, southern right whales, fin whales, humpback whales, sei whales, and sperm whales, all of which are endangered throughout their ranges.

The *Status of Listed Resources* section identified commercial whaling as the primary reason for reduced populations, many of whom are a small fraction of their former abundance. Although large-scale commercial harvests no longer occur for these species, some harvests from subsistence and scientific research in regional and worldwide populations still occur. Other worldwide threats to the survival and recovery of ESA-listed whale species include: altered prey base and habitat quality as a result of global warming, ship strike, entanglement in fishing gear, toxic chemical burden and biotoxins, ship noise, competition with commercial fisheries, and killer whale predation. Populations of whales inhabiting the Pacific Ocean face area-specific threats identified in the *Environmental Baseline*.

Despite these pressures, available trend information indicates most local populations of ESA-listed whales are stable or increasing. As previously mentioned, the *Cumulative Effects* section identifies actions in the *Environmental Baseline* we expect to generally continue for the foreseeable future.

The *Effects Analysis* supports the conclusion of harassment to ESA-listed marine mammals by proposed seismic activities. As discussed in the exposure analysis, we expect up to 225 southern right, 306 blue, 368 fin, 126 sei, 143 humpback, and 184 sperm whales could be exposed to airgun sounds which will elicit behavioral responses of temporarily moving out of the area, or temporarily suspending feeding or calling. We expect a low-level, transitory stress response to

accompany these behaviors. The number of individuals exposed is a small fraction of the populations, with some individual re-exposure and reactions. These exposures should not limit the fitness of any single individual. The other actions we considered in the opinion, the operation of multibeam echosounder and sub-bottom profiler systems, are not expected to be audible to fin or sei whales and consequently are not expected to have any direct effects on these species. However, humpback, and sperm whales could hear sounds produced by these systems. Responses could include cessation of vocalization by sperm whales and/or movement out of the survey area by these species. Behavioral harassment caused by exposure to sound sources associated with the proposed seismic survey are expected to cause some individuals to cease these activities temporarily and possibly move out of the immediate area. However, we expect that individuals will either resume foraging in a secondary location or reoccupy the habitat from which they were displaced within a period of days (or less). We do not expect these effects to have fitness consequences for any individual. The *Effects Analysis* also found that, although sperm whales may experience temporarily reduced feeding opportunities; this indirect effect would be transient and not reduce individual fitness of any whale. Based upon these findings, the risk of fitness consequences to any single individual is not expected to translate to population or species-level consequences. Overall, we do not expect a fitness reduction to any individual whale from the survey or IHA. As such, we do not expect fitness consequences to populations or listed whale species as a whole. Therefore, we do not expect that the proposed action would reduce appreciably the likelihood of both the survival and recovery of a ESA-listed marine mammal species in the wild by reducing their numbers, reproduction, or distribution.

ESA-Listed turtles. ESA-listed turtles that are expected to occur within the action area include East Pacific green sea turtles, leatherback sea turtles, South Pacific Ocean loggerhead sea turtles, and olive ridley sea turtles, which are either threatened or endangered. The *Status of Listed Resources* section found that most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and turtles, as well as severe bycatch pressure in worldwide fishing industries. As previously mentioned, the *Cumulative Effects* section identified actions in the *Environmental Baseline* to generally continue for the foreseeable future.

From the *Effects Analysis*, we expect that East Pacific green, leatherback, olive ridley and South Pacific Ocean loggerhead sea turtles could experience exposure to airgun sounds and be harassed by these sounds. These sounds may induce a temporary increase stress levels, swimming patterns, and movement out of the action area. Population size is not available to calculate the subset of all population affected. However, those that are available suggest a very small proportion of each population would be affected. We expect transient responses that do not affect the fitness of any one individual. We do not expect impairment of local nesting by the proposed survey. As we do not expect any sea turtle to be capable of hearing signals produced by the multibeam echosounder and sub-bottom profiler systems, we do not expect direct effects from these systems on sea turtle fitness. We do not anticipate any indirect effects from the proposed actions to influence sea turtles. Overall, we do not expect any individual sea turtle to undergo a fitness consequence. Based upon these findings, the risk of fitness consequences to any single

individual is not expected to translate to population or species-level consequences. Because we do not expect individual sea turtles to experience fitness reductions, we also do not expect reductions in the viability of the populations these individuals belong or the viability of the species those populations comprise. Therefore, we do not expect that the proposed action would reduce appreciably the likelihood of both the survival and recovery of a ESA-listed sea turtle species in the wild by reducing their numbers, reproduction, or distribution.

7 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 humpback, blue, sei, fin, sperm or southern right whales, or leatherback, olive ridley, South Pacific Ocean loggerhead or East Pacific green sea turtles. No critical habitat has been designated or proposed for these species within the action area; therefore, none will be affected.

8 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. 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. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

8.1 Amount or Extent of Take

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

As discussed previously, we have jurisdiction to authorize incidental take of ESA-listed species in areas outside the territorial seas of Chile (i.e., greater than 12 nautical miles). Earlier, we examined the probable exposure of ESA-listed species in the full extent of the action area

(Section 6.3) to make our jeopardy determination. Here, we describe the amount of incidental take authorized for the action area outside the territorial seas of Chile.

The NMFS anticipates the proposed seismic survey in the East Pacific Ocean off the coast of Chile is likely to result in the incidental take of ESA-listed marine mammals by harassment (

Table **17**). We expect up to 306 blue, 225 southern right, 368 fin, 126 sei, 143 humpback, and 184 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 17. 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	306
Fin whale	368
Sei whale	126
Humpback whale	143
Southern right whale	225
Sperm whale	184

We also expect individual green East Pacific DPS, olive ridley, leatherback, and loggerhead South Pacific DPS 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.

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 exent of the 166 dB exclusion zone as a surrogate for sea turtle take. Harassment for sea turtles is expected to occur at received levels above 166 dB re: 1 μPa, which includes a 12.6 km^2 area in the eastern Pacific based upon the propagation and trackline estimates provided by the NSF. A sea turtle within the 12.6 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 166 dB re: 1 μPa are received (see Table 4), so we are assuming the largest predicted established distance of 12.6 km^2 for the 166 dB exclusion zone so as not to underestimate the effect of the stressor.

If the amount or location of trackline 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 tracklines are surveyed, an increase in the number of survey days beyond the 25 percent percent contingency, greater estimates of sound propagation, and/or increases in airgun source levels occur, re-initiation of consultation will be necessary. As we cannot determine the number of individuals to which harassment will occur, we expect the extent of exposure will occur within the 166 dB isopleth of the *Langseth's* airgun array.

8.2 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.

8.3 Reasonable and Prudent Measures

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

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

- The NMFS' Permits and Conservation Division and the NSF must ensure that the L-DEO implements and monitors the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of southern right, blue, fin, sei, humpback, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA and as specified below for olive ridley, green East Pacific DPS, leatherback, and loggerhead

South Pacific DPS 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.

8.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the NSF, L-DEO, and NMFS' Permits and Conservation Division must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outlines the mitigation, monitoring and reporting measures required by the section 7 regulations (50 CFR 402.14(i)). These terms and conditions are non-discretionary. If NSF, L-DEO, and/or the 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.

This ITS does not cover incidental takes of marine mammals in the territorial seas of foreign nations, as neither the ESA nor the MMPA apply in those waters. Take coverage is only for the area outside Chilean territorial waters (i.e., outside of 12 nautical miles). The L-DEO is required to follow the requirements presented in the IHA.

To implement the reasonable and prudent measures, the L-DEO and the NMFS' Permits and Conservation Division shall ensure that:

a. The ITS limits the incidental taking of ESA-listed species by harassment only, to the species listed in Table 17.

   i. During the seismic activities, if the Holder of this ITS encounters any ESA-listed species that are not listed in the ITS for authorized taking and are likely to be exposed to sound pressure levels greater than or equal to 160 decibels (dB) re: 1 μPa, then the Holder of the ITS must alter speed or course or shut-down the airguns to avoid take.

b. In addition, the IHA prohibits the taking by serious injury or mortality of any of the species listed in Condition 3 of the IHA or the taking of any other kind of species of marine mammal. Thus, if this were to occur, it may result in the modification, suspension, or revocation of the IHA, and trigger a requirement for reinitiation under the ESA.

c. Both the action described in the opinion and the IHA limit the methods authorized for taking by harassment to the following acoustic sources without an amendment to the IHA or a request for reinitiation:

   i. An airgun array with a total capacity of 6,600 cubic inches (in^3) (or smaller).

d. Lamont-Doherty will not operate the multi-beam echosounder or the sub-bottom profiler during transit to or from the survey areas.

4. Reporting Prohibited Take

The Holder of the IHA must report the taking of any marine mammal in a manner prohibited under this Authorization immediately to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/ or by email to Jolie.Harrison@noaa.gov and

to Cathy Tortorici NMFS' ESA Interagency Cooperation Division Chief at Cathy.Tortorici@noaa.gov.

5. Cooperation

We require the Holder of this Authorization to cooperate with the Office of Protected Resources, NMFS, and any other Chilean and U.S. Federal agency requirements for monitoring the impacts of the activity on marine mammals.

6. Mitigation and Monitoring Requirements

We require the Holder of this ITS to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable adverse impact on affected marine mammal species or stocks:

Visual Observers

a. Use two, National Marine Fisheries Service-qualified, vessel-based Protected Species Visual Observers (visual observers) to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night.

   i. At least one visual observer will be on watch during meal times and restroom breaks.

   ii. Visual observer shifts will last no longer than four hours at a time.

   iii. Visual observers will also conduct monitoring while the *Langseth* crew deploy and recover the airgun array, ocean bottom seismometers, and hydrophone streamer from the water.

   iv. When feasible, visual observers will conduct observations during daytime periods when the seismic system is not operating for comparison of sighting rates and behavioral reactions during, between, and after airgun operations.

   v. The *Langseth's* vessel crew will also assist in detecting marine mammals, when practicable.

   vi. Visual observers will have access to reticle binoculars (7×50 Steiner), big-eye binoculars (25×150), optical range finders, and night vision devices.

Exclusion Zones

b. Establish a 180-dB and 190-dB exclusion zone for cetaceans and pinnipeds, respectively, before starting the airgun array (6,600 in^3 or smaller); and establish a 180-dB and 190-dB exclusion zone for cetaceans and pinnipeds, respectively, for the single airgun (40 in^3). Observers will use the predicted radius distance for the 180-dB and 190-dB exclusion zones for mitigation shown in Table 2 (of the IHA).

Visual Monitoring at the Start of Airgun Operations

c. Monitor the entire extent of the exclusion zones for at least 30 minutes (day or night) prior to the ramp-up of airgun operations after a shutdown.

d. Delay airgun operations if the visual observer sees a cetacean within the 180-dB exclusion zone (as defined in Table 2 of the IHA) until the marine mammal(s) has left the area.

   Delay airgun operations if the visual observer sees a pinniped within the 190-dB exclusion zone (as defined in Table 2 of the IHA) until the marine mammal(s) has left the area.

   i. If the visual observer sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes If the observer sees no marine mammals during that time, he/she should assume that the animal has moved beyond the relevant exclusion zone (as defined in Table 2 of the IHA).

   ii. If, for any reason the visual observer cannot see the full relevant exclusion zone (as defined in Table 2 of the IHA) for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or within zone, the *Langseth* may not resume airgun operations.

   iii. If one airgun is already running at a source level of at least 180 dB re: 1 μPa, the *Langseth* may start the second gun–and subsequent airguns–without observing relevant exclusion zones for 30 minutes, provided that the observers have not seen any marine mammals near the relevant exclusion zones (in accordance with Condition 6(b) of the IHA).

Passive Acoustic Monitoring

e. Utilize the PAM system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One visual observer and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

f. Do and record the following when an observer detects an animal by the PAM:

   i. Notify the visual observer immediately of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;

   ii. Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

Ramp-Up Procedures

g. Implement a ''ramp-up'' procedure when starting the airguns at the beginning of seismic operations or any time after the entire array has shutdown, which means starting the smallest gun first and adding airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the observers will monitor the exclusion zones, and if the observers sight

marine mammals, the *Langseth* will implement a course/speed alteration, power-down, or shutdown as though the full array were operational.

Recording Visual Detections

h. Visual observers must record the following information when they detect a marine mammal:

   i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

   ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, cloud cover, and sun glare; and

   iii. The data listed under 6(h)(ii) of the IHA at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

Speed or Course Alteration

i. Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant exclusion zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the relevant exclusion zone, Lamont-Doherty will implement further mitigation measures, such as a power-down or shutdown.

Power-Down Procedures

j. Power down the airguns if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zone (as defined in Table 2 of the IHA). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun. This would reduce the relevant exclusion zone to the degree that the animal(s) is/are outside of that zone. When appropriate or possible, power-down of the airgun array shall also occur when the vessel is moving from the end of one trackline to the start of the next trackline.

Resuming Airgun Operations after a Power-Down

k. Following a power-down, if the marine mammal approaches the smaller exclusion zone (as defined in Table 2 of the IHA), then the *Langseth* must completely shut down the airguns. Airgun activity will not resume until the observer has visually observed the marine mammal(s) exiting the exclusion zone and is not likely to return, or the observer has not seen the animal within the relevant exclusion zone for 15 minutes for species with shorter dive durations (i.e., small odontocetes) or 30 minutes for species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales) and pinnipeds.

l. Following a power-down and subsequent animal departure, the *Langseth* may resume airgun operations at full power. Initiation requires that the observers can effectively monitor the full exclusion zones described in Condition 6(b) of the IHA. If the observer

sees a marine mammal within or about to enter the relevant zones then the *Langseth* will implement a course/speed alteration, power-down, or shutdown.

Shutdown Procedures

m. Shutdown the airgun(s) if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zone (as defined in Table 2 of the IHA). A shutdown means that the *Langseth* turns off all operating airguns.

n. If an observer visually detects a pinniped, the *Langseth* will shut-down the airgun array regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 minutes after the last documented pinniped visual sighting.

Resuming Airgun Operations after a Shutdown

o. Following a shutdown, if the observer has visually confirmed that the animal has departed the relevant exclusion zone within a period of less than or equal to 8 minutes after the shutdown, then the *Langseth* may resume airgun operations at full power.

p. Else, if the observer has not seen the animal depart the relevant exclusion zone (with buffer), the *Langseth* shall not resume airgun activity until 15 minutes has passed for species with shorter dive times (i.e., small odontocetes) or 30 minutes has passed for species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales) and pinnipeds. The *Langseth* will follow the ramp-up procedures described in Conditions 6(g) of the IHA.

Survey Operations

q. The *Langseth* may continue marine geophysical surveys into night and low-light hours if the Holder of the Authorization initiates these segment(s) of the survey when the observers can view and effectively monitor the full relevant exclusion zones.

r. This Authorization does not permit the Holder of this Authorization to initiate airgun array operations from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the visual observers cannot view and effectively monitor the full relevant exclusion zones.

s. To the maximum extent practicable, the Holder of this Authorization should schedule seismic operations (i.e., firing the airguns) during daylight hours.

t. To the maximum extent practicable, the *Langseth* will conduct the seismic survey (especially when near land) from the coast (inshore) and proceed towards the sea (offshore) in order to avoid trapping marine mammals in shallow water.

Mitigation Airgun

t. The *Langseth* may operate a small-volume airgun (i.e., mitigation airgun) during turns and maintenance at approximately one shot per minute. During turns or brief transits between seismic tracklines, one airgun would continue to operate. The *Langseth* would not operate the small-volume airgun for longer than three hours in duration during turns.

Special Procedures for Large Whale Concentrations

u. The *Langseth* will avoid concentrations of fin and/or sperm whales if possible (i.e., exposing concentrations of animals to 160 dB re: 1 μPa), and powered-down the array. For purposes of the survey, a concentration or group of whales will consist of six or more individuals visually sighted that do not appear to be traveling (e.g., feeding, socializing, etc.). The *Langseth* will follow the procedures described in Conditions 6(k) of the IHA for resuming operations after a power down.

7. Reporting Requirements

This Authorization requires the Holder of this Authorization to:

a. Submit a draft report on all activities and monitoring results to the Chief, Permits and Conservation Division, and Chief, ESA Interagency Cooperation Division, Office of Protected Resources, NMFS, within 90 days of the completion of the *Langseth's* cruise. This report must contain and summarize the following information:

   i. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings.

   ii. Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of shutdowns), observed throughout all monitoring activities.

   iii. An estimate of the number (by species) of marine mammals with known exposures to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re: 1 μPa and/or 180 dB or 190-dB re: 1 μPa for cetaceans and pinnipeds, respectively and a discussion of any specific behaviors those individuals exhibited.

   iv. An estimate of the number (by species) of marine mammals with estimated exposures (based on modeling results) to the seismic activity at received levels greater than or equal to 160 dB re: 1 μPa and/or 180 dB or 190-dB re: 1 μPa with a discussion of the nature of the probable consequences of that exposure on the individuals.

   v. A description of the implementation and effectiveness of the: (A) Terms and Conditions of the Biological Opinion's Incidental Take Statement; and (B) mitigation measures of the Incidental Harassment Authorization. For the biological opinion, the report will confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on listed marine mammals under the Endangered Species Act.

b. Submit a final report to the Chief, Permits and Conservation Division, and the Chief, ESA Interagency Cooperation Division, Office of Protected Resources, NMFS, within 30 days after receiving comments from us on the draft report. If we decide that the draft report needs no comments, we will consider the draft report to be the final report.

8. Reporting Prohibited Take

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner not permitted by the Authorization, such as serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), Lamont-Doherty shall immediately cease the specified activities and immediately report the take to the Chief, Permits and Conservation Division, and the Chief, ESA Interagency Cooperation Division, Office of Protected Resources, NMFS, at 301-427-8400 and/or by email to Jolie.Harrison@noaa.gov and Cathy.Tortorici@noaa.gov.

The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound sources used 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) (if equipment is available).

Lamont-Doherty shall not resume its activities until we are able to review the circumstances of the prohibited take. We shall work with Lamont-Doherty to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. Lamont-Doherty may not resume their activities until notified by us via letter, email, or telephone.

9. Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death

In the event that Lamont-Doherty discovers an injured or dead marine mammal, and the lead visual observer determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as we describe in the next section), Lamont-Doherty will immediately report the incident to the Chief, Permits and Conservation Division, and the Chief, ESA Interagency Cooperation Division, Office of Protected Resources, NMFS, at 301-427-8400 and/or by email to Jolie.Harrison@noaa.gov and Cathy.Tortorici@noaa.gov.

The report must include the same information identified in Condition 8 in the IHA. Activities may continue while we review the circumstances of the incident. We would work with Lamont-Doherty to determine whether modifications in the activities are appropriate.

10. Reporting an Injured or Dead Marine Mammal Unrelated to the Activities

In the event that Lamont-Doherty discovers an injured or dead marine mammal, and the lead visual observer determines that the injury or death is not associated with or related to the

authorized activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Lamont-Doherty would report the incident to the Chief, Permits and Conservation Division, and the Chief, ESA Interagency Cooperation Division, Office of Protected Resources, NMFS, at 301-427-8400 and/or by email to Jolie.Harrison@noaa.gov and Cathy.Tortorici@noaa.gov.

Lamont-Doherty would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.

11. Endangered Species Act Biological Opinion and Incidental Take Statement

Lamont-Doherty must comply with the Terms and Conditions of the Incidental Take Statement corresponding to the Endangered Species Act biological opinion issued to the National Science Foundation and NMFS' Permits and Conservation Division.

A copy of this Authorization and the Incidental Take Statement must be in the possession of all contractors and protected species observers operating under the authority of this Incidental Harassment Authorization.

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

10 Reinitiation of Consultation

This concludes formal consultation on the proposed seismic survey to be funded by the NSF and conducted by L-DEO onboard the *Langseth* in the Southeast Pacific Ocean off Chile, and the issuance of an Incidental Harassment Authorization for the proposed studies pursuant to Section

101(a)(5)(D) of the MMPA. As 50 CFR 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 incidental take 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 considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat that was not considered in this opinion, or (4) a new species is ESA-listed or critical habitat designated that may be affected by the action.

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