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 South Atlantic Ocean, and

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

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

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ACRONYMS AND ABBREVIATIONS

AMAPPS-Atlantic Marine Assessment Program for Protected Species

BOEM-Bureau of Ocean Energy Management

CETAP-Cetacean and Turtle Assessment Program

CFR-Code of Federal Regulations

CI-Confidence interval

CV-Coefficient of variation

dB-decibel

DDE-Dichlorodiphenyldichloroethylene

DDT-Dichlorodiphenyltrichloroethane

DPS-Distinct population segment

EEZ-Exclusive economic zone

ESA-Endangered Species Act

EZ-Exclusion zone

HCB-Hexachlorobenzene

HMS FMP-Highly migratory species fisheries management plan

Hz-Hertz

IHA-Incidental harassment authorization

IPCC-Intergovernmental Panel on Climate Change

IWC-International Whaling Commission

kHz-kilohertz

kg-kilogram

L-DEO-Lamont Doherty Earth Observatory

MBES-Multibeam echosounder

MCS-Multichannel seismic

MMPA-Marine Mammal Protection Act

ms-millisecond

NAO-North Atlantic oscillation

NMFS-National Marine Fisheries Service

NOAA-National Oceanic and Atmospheric Administration

NSF-National Science Foundation

OBS-Ocean bottom seismometer

PAM-Passive acoustic monitoring

PCB-Polychlorinated biphenyl

PFOA-Perfluorooctanoic acid

PFOS-Perfluorooctanesulfonic acid

PSVO-Protected species visual observer

PTS-Permanent threshold shift

RMS-Root mean squared

SEL-Sound exposure level

SERDP SDSS- Strategic Environmental Research and Development Program Spatial Decision Support System

SBP-Sub-bottom profiler

TEWG-Turtle Expert Working Group

TTS-Temporary threshold shift

U.S.-United States

U.S.C.-United States Code

USFWS-United States Fish and Wildlife Service

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 US 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 South Atlantic Ocean near the Mid-Atlantic Ridge during the austral summer of 2016, in support of an NSF-funded collaborative research project led by Texas A&M University and the University of Texas. 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' Office of Protected Resources, ESA Interagency Cooperation Division.

The biological opinion (opinion) and incidental take statement were prepared by NMFS Endangered Species Act 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 NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The NSF is proposing to fund a seismic survey for the austral summer (January-March) 2016 in the South Atlantic Ocean near the Mid-Atlantic Ridge, at approximately 30°S. Although the NSF has funded similar seismic surveys in the past, this is the first such survey that would take place within this particular action area. In conjunction with this action, the NMFS Permits and Conservation Division would issue an IHA under the MMPA for marine mammal takes that could occur during the NSF seismic survey. This document represents NMFS's ESA Interagency Cooperation Division's opinion on the effects of the two proposed federal actions on threatened and endangered species, and has been prepared in accordance with section 7 of the ESA.

1.2 Consultation History

On July 23, 2015, 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 October 28, 2015, 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.

A revised draft Environmental Analysis from NSF was received on October 30, 2015. On November 13, 2015, the NMFS' ESA Interagency Cooperation Division sent additional questions to NSF. NSF responded on November 19th. Information was sufficient to initiate consultation with the NSF on this date.

On December 1, 2015, 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, *Marcus G. Langseth* (*Langseth*), operated by the L-DEO, to conduct a seismic survey in the South Atlantic Ocean near the Mid-Atlantic Ridge during the austral summer 2016, in support of an NSF-funded collaborative research project led by Texas A&M University and the University of Texas. 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 Action

The NSF proposes to allow the use the *Langseth*, to conduct a seismic survey in the South Atlantic Ocean near the Mid-Atlantic Ridge during the austral summer 2016 over an approximate 42 day period from January through March 2016. An array of thirty-six airguns will be deployed as an energy source.

The survey would entail a total of 3,263 km of transect lines, with 2,127 km of primary transect lines and 1,136 km of contingency transect lines. The receiving system for the survey would consist of seven ocean bottom seismographers (OBSs) and a single 8 km hydrophone streamer. The OBSs would be deployed at five sites along each vertical transect line (Figure 3). In addition, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) will continuously operate from the *Langseth*, except during transit to the survey site (LGL 2015).

The purpose of the proposed activities is to collect and analyze reflection and refraction seismic data from the Mid-Atlantic Ridge to the Rio Grande Rise to study the evolution of the South Atlantic Ocean crust. The seismic portion of the study would collect reflection data, and the OBS profiles would collect refraction data. The seismic operations would image changes in crustal structures from the Mid-Atlantic Ridge to aging crust to the west. The OBS profiles would acquire refraction data to characterize the structure of the crust and upper mantle (LGL 2015). A secondary purpose of the proposed activities would be to provide seismic data for five sites proposed for future drilling by the International Ocean Discovery Program.

2.1.1 Schedule

The NSF proposes to allow the use of the *Langseth* by L-DEO during roughly 22 days of seismic operations and an additional 10 days of non-airgun operations (e.g., OBS deployment and retrieval, hydrophone streamer deployment and retrieval). The proposed action is comprised of two main components: the multi-channel seismic activities, and the OBS operations. The hydrophone streamer and airgun array would be used in the multi-channel seismic operations, along the seismic line transect, east to west. The OBS operations would occur along the five vertical lines shown in the map (Figure 3). It is proposed that the multi-channel seismic activities would happen before the OBS operations (LGL 2015).

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. The round-trip transit from the port at Cape Verde to the survey site would take ~10 days. During an approximate 42-day period starting in January through March 2016, 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 (Figure 3). 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 m. The airgun array will fire roughly every 65 seconds for OBS lines (~150 m) and about every 22 seconds (~50 m) for the multi-channel seismic lines. 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 R/V *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 Seismometers Deployment

The *Langseth* would deploy a total of 7 OBSs before beginning the tracklines for the five OBS profiles; the OBSs would be recovered after the line is completed, and then placed at the site of the next line. OBSs from two sources would be used during the proposed activities—Woods Hole Oceanographic Institution and Scripps Institution of Oceanography. The OBSs differ slightly in their configurations (Table 2). The five OBS profile tracklines would most likely be completed before the seismic line transect.

Table 2 Specifications for the OBSs to be used during the proposed seismic activities in the South Atlantic 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 $\mu\text{Pa}\cdot\text{m}_{\text{rms}}$. 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 R/V *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	30º
Pulse duration	1, 2, or 4 ms

2.1.6 Proposed Exclusion Zones

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

2.1.6.1 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 (Figure 1) as well as a 40 in^3 single 1900LLX airgun used during power-downs (Figure 2). 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 EZ radii (>1000m) were obtained from L-DEO model results (to a water depth of 2000m). The EZ radii for intermediate water depths (100-1000m) were derived from the deep-water ones by applying a 1.5 correction factor. Figures 1-2 show predicted distances of the various configurations of the airguns.

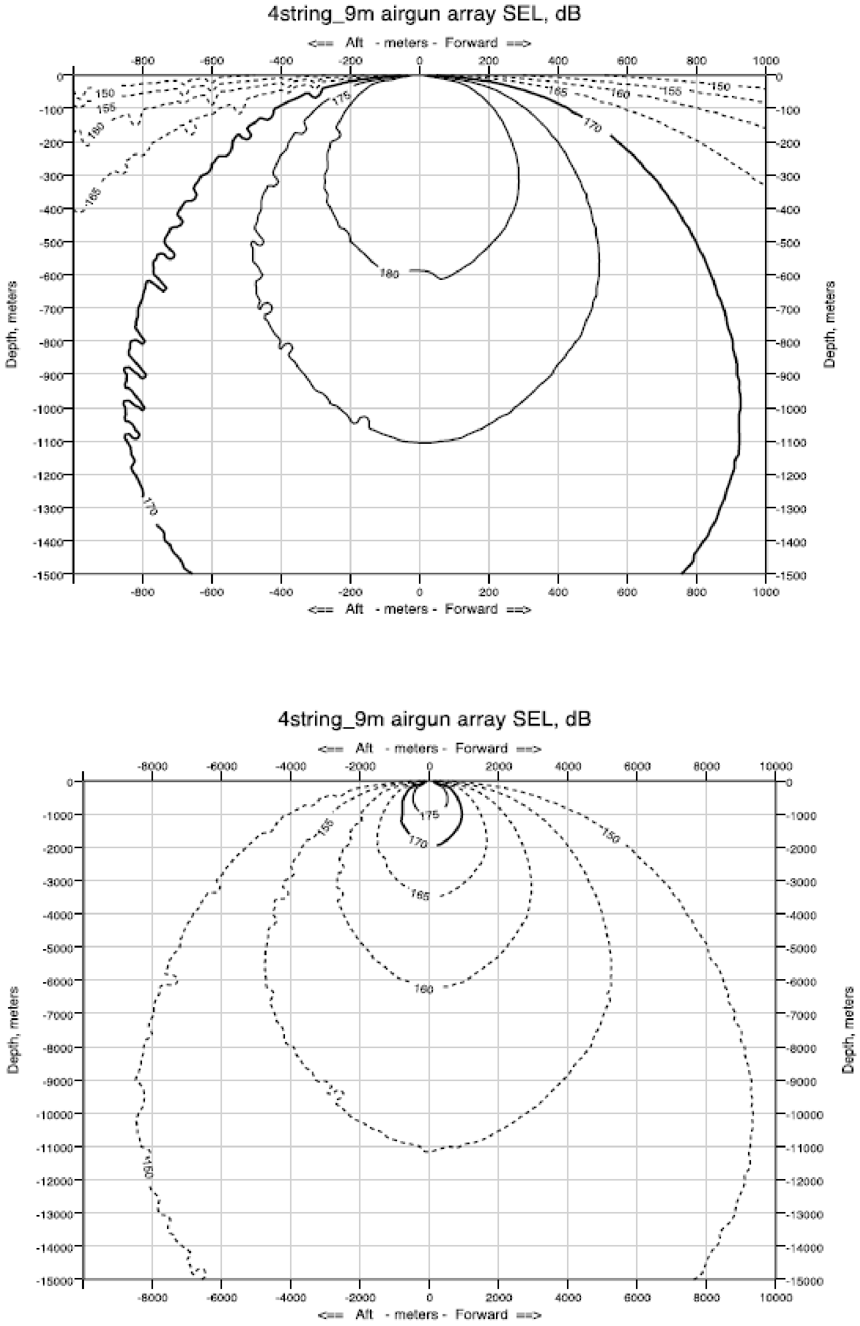

Figure 1. Modelled distances for the 36-airgun array at nine meter tow depth in deep water; top plot provides the radius to the 170-dB SEL isopleth, bottom plot provides the radius to the 150-dB SEL isopleth. From LGL 2015.

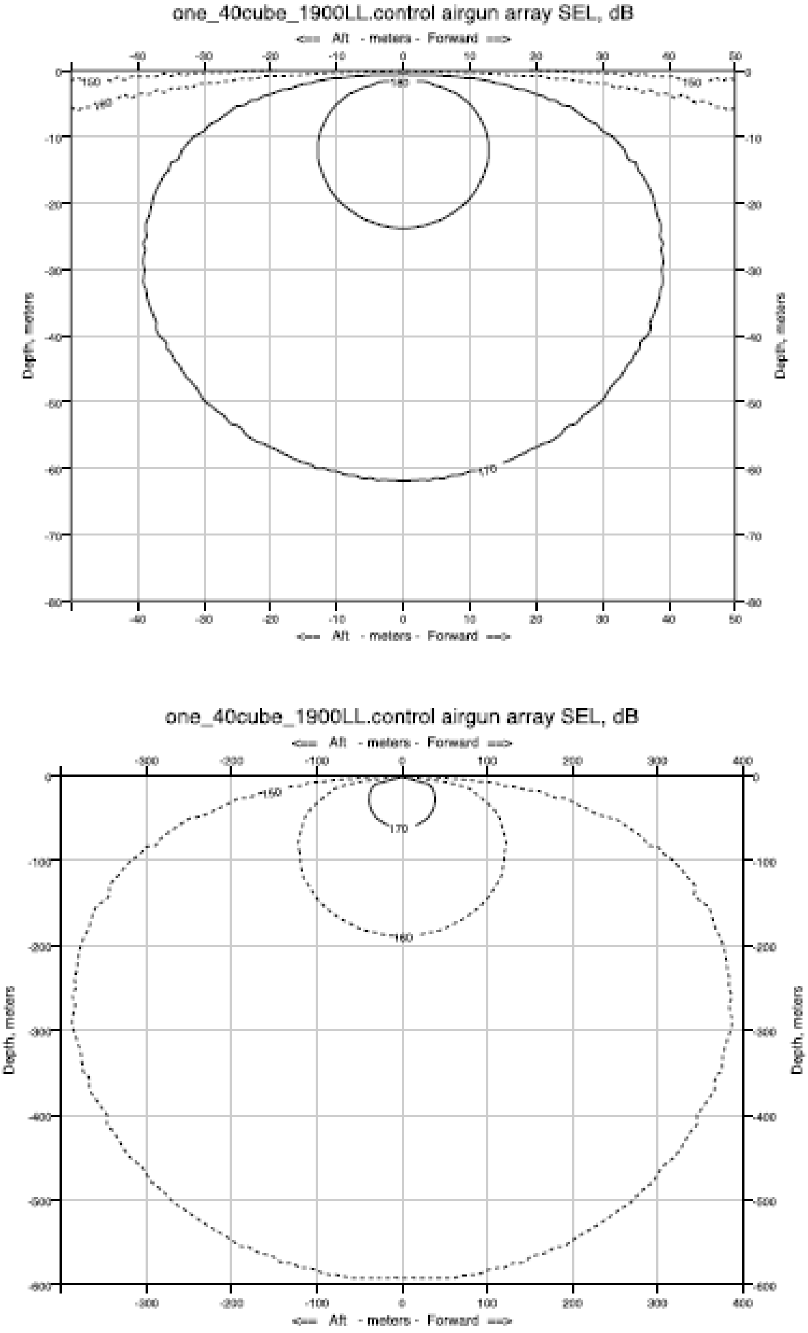

Figure 2. Modelled distances for the single 40-in^3 airgun array at nine meter tow depth in deep water; top plot provides the radius to the 170-dB SEL isopleth, bottom plot provides the radius to the 150-dB SEL isopleth. From LGL 2015.

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 >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 (EZ) 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 EZ 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 >1,000m. Adapted from LGL 2015.

Source, volume, and tow depth	Water Depth (m)	Predicted RMS radii (m)		
		180 dB	166 dB	160 dB
36-airgun array 6600 in^3 @ 9 m	>1000 m	927	3,740	5,780
single Bolt airgun, 40 in^3 @ 9m	>1000 m	100	185	388

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 January 4, 2016 through March 31, 2016. The Permits and Conservation Division proposes to issue the IHA by January 4, 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 Marine Mammal Protection Act. The proposed IHA identifies the following requirements that L-DEO must comply with as part of its authorization.

- Visual Observers
    - Utilize 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

civil twilight-dawn to civil twilight-dusk) and before and during start-ups of airguns day or night.

        - At least one visual observer will be on watch during meal times and restroom breaks.
        - Observer shifts will last no longer than four hours at a time.
        - Visual observers will also conduct monitoring while the *Langseth* crew deploy and recover the airgun array and streamers from the water.
        - 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.
        - The *Langseth*'s vessel crew will also assist in detecting marine mammals, when practicable.
        - Visual observers will have access to reticle binoculars (7x50 Steiner) and big-eye binoculars (25x150) optical range finders, and night vision devices.

- Exclusion Zones
    - Establish a 180-decibel (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 (attached).
- Visual Monitoring at the Start of Airgun Operations
    - 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.
    - Delay airgun operations if the visual observer sees a cetacean within the 180-dB exclusion zone (as defined in Table 2) 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) until the marine mammal(s) has left the area.
        - 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 (as defined in Table 2).

        - If, for any reason the visual observer cannot see the full relevant exclusion zone (as defined in Table 2) 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.
        - 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)).
- Passive Acoustic Monitoring
    - 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.
    - Do and record the following when an observer detects an animal by the PAM:
        - Notify the visual observer immediately of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;
        - 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, etc.), 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
    - 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
    - Visual observers must record the following information when they detect a marine mammal:

        - 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
        - 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
        - The data listed under 6(h)(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
    - 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
    - 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). 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
    - Following a power-down, if the marine mammal approaches the smaller exclusion zone (as defined in Table 2), 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 pinnipeds) or 30 minutes for species with longer dive durations (*i.e.*, mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).
    - 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). 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
  - 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). A shutdown means that the *Langseth* turns off all operating airguns.
- Resuming Airgun Operations after a Shutdown
  - 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.
  - 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 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).
- Survey Operations
  - 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.
  - 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
  - The *Langseth* may operate a small-volume airgun (*i.e.*, mitigation airgun) during turns, brief transits between seismic tracklines, and maintenance at approximately one shot per minute. The *Langseth* would not operate the small-volume airgun for longer than three hours in duration.
- Special Procedures for Large Whale Concentrations
  - The *Langseth* will avoid concentrations of large whales (*i.e.*, mysticetes and/or sperm whales [*Physeter microcephalus*]) if possible (*i.e.*, *i.e.*, avoid exposing concentrations of these animals to sounds greater than 160 dB re: 1 μPa), and power-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) for resuming operations after a power down.

2.2.1 Schedule

To correspond with NSF's proposed seismic survey (section 2.1), the NMFS' Permits and Conservation Division proposes to issue an authorization that is effective from January 4, 2016 to March 31, 2016.

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 within the area ~10-35°W, 27-33°S (Figure 3). Water depths range from ~1,150 to 4,800 m. The proposed survey would take place in the international waters of the South Atlantic Ocean (LGL 2015).

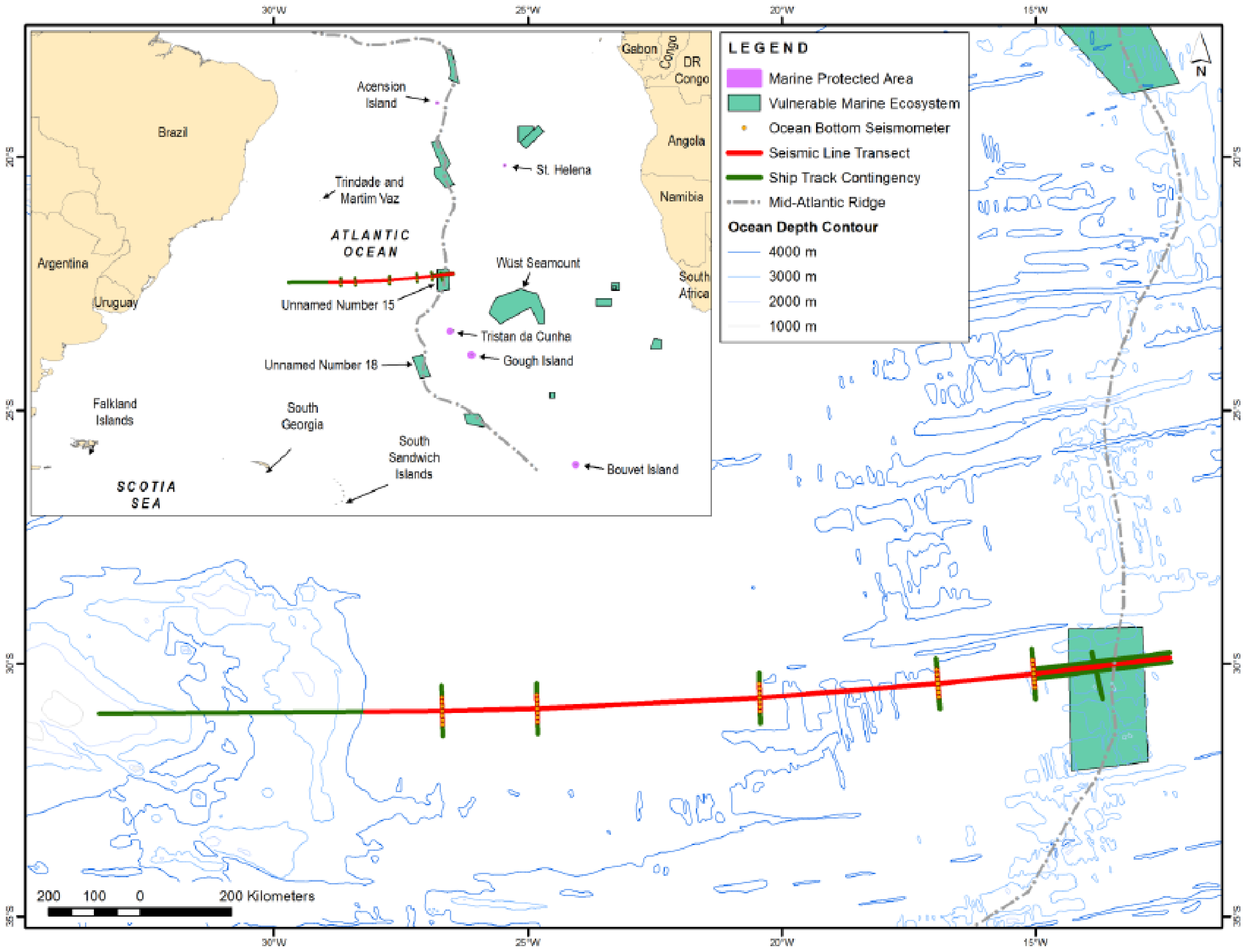

Figure 3. Map of the proposed action area for NSF's seismic survey in the South Atlantic Ocean during austral summer, 2016. From LGL 2015.

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

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.[1]

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.

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[1] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

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 from NMFS Science Centers; 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, Conference Papers Index, First Search (Article First, ECO, WorldCat), Web of Science, Oceanic Abstracts, 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 in 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). Toothed whales (such as 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. 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 ESA-listed in Table 5, along with their regulatory status.

Table 5. Threatened and endangered species that may be affected by NSFs proposed action of seismic activities in the South Atlantic Ocean.

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	-- --	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

Species	ESA Status	Critical Habitat	Recovery Plan
Fishes			
Scalloped Hammerhead Shark (Sphyrna lewini) – Eastern Atlantic DPS	E – 79 FR 38213	-- --	-- --
Scalloped Hammerhead Shark (Sphyrna lewini) – Central and Southwest Atlantic DPS	T – 79 FR 38213	-- --	-- --
Sea Turtles			
Green Turtle (*Chelonia mydas*) South Atlantic DPS (Proposed T)	E – 43 FR 32800	63 FR 46693	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693	57 FR 38818
Leatherback Turtle (*Dermochelys coriacea*)	E – 61 FR 17	44 FR 17710	63 FR 28359
Loggerhead Turtle (*Caretta caretta*) – South Atlantic Ocean DPS	T – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (Lepidochelys olivacea)	T – 43 FR 32800	-- --	-- --

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 5 and we summarize our results below.

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

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

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

4.1.1.1 Scalloped Hammerhead Shark

The action area encompasses the range of two DPSs of scalloped hammerhead shark: Central and Southwest Atlantic DPS, and the Eastern Atlantic DPS. Scalloped hammerhead sharks occur worldwide from 46°N to 36°S, in waters warmer than 22°C (Miller et al. 2013). Juveniles occur in shallow coastal waters, while adults can be found over continental shelves in waters up to 275 m deep (Clarke 1971; Compagno 1984; Miller et al. 2013), although dives up to depths of nearly 1,000 m have been documented (Jorgensen et al. 2009). Scalloped hammerheads are captured in the gillnet fishery in the equatorial Atlantic off the coast of northeastern Brazil within 150 km of shore (Hazin et al. 2001). In a summary of tagging efforts off the coast of the eastern United States, scalloped hammerheads were most often tagged and recaptured within 200 m from shore (Kohler et al. 1998). Off the east coast of South Africa, tagged scalloped hammerheads moved an average distance of about 148 km (Diemer et al. 2011).

The proposed action would take place in waters from about 1,150 to 4,800 m deep, and the western end of the trackline is approximately 2,000 km from shore. Because the action would take place in waters deeper than scalloped hammerheads typically inhabit, and farther from shore than they typically travel, we do not expect scalloped hammerheads to be adversely affected by the proposed action. We therefore conclude that the effects of the proposed action to the Eastern Atlantic and Central and Southwest Atlantic DPSs are discountable, and will not be considered further in this opinion.

4.1.1.2 Green turtle

Currently, green turtles are listed as threatened under the ESA, but there is a proposed rule to establish green turtle DPSs and revise the listing status (80 FR 15271). Green turtles in the action area would be included in the proposed South Atlantic DPS.

Known nesting and foraging sites for green turtles in the region occur on the east coast of South America and the western coast of Africa, as well as islands in the South Atlantic like Ascension Island and Trindade and Martim Vaz (Seminoff 2015). The largest nesting area in the South Atlantic is Guinea-Bissau, composed of three nesting sites; post-nesting females traveled north or south off western Africa (Godley et al. 2003a). Ascension Island (7°57’S, 14°22’W) is the location of the second largest nesting colony in the South Atlantic, and its population is well-studied (Seminoff 2015). The nesting season lasts from January to July, peaking in March (Godley et al. 2001). The southern-most green turtle nesting site in the South Atlantic is Trindad Island (located at approximately 20°31’ S, 29°19” W), about 1,300 km north of the proposed action area (Seminoff 2015). Nesting occurs from January to March (Moreira et al. 1995).

Other green turtle nesting sites in the South Atlantic occur in Brazil, Equatorial Guinea, and São Tomé and Principe; populations at these locations are estimated to have 850 or fewer nesting females. Despite data gaps, the available information indicates that populations of green turtles are increasing at many of the nesting sites in the South Atlantic (Seminoff 2015).

There is evidence for trans-Atlantic dispersal for green turtles in the South Atlantic. Records of post-nesting females traveling from Ascension Island west to coastal Brazil (~8°S) are well-documented (Luschi et al. 1998; Papi et al. 2000). Genetic evidence also indicates that populations from Ascension Island and Aves Island contribute to foraging groups found off of Arvordeo Island in southern Brazil (~27°16’S, 48°21’W) (Proietti et al. 2009) (Seminoff 2015). The coastal waters of Brazil, Uruguay and Argentina serve as foraging grounds for adult and juvenile green turtles. Although some tagged individuals travelled <100 km, juveniles generally stayed within waters >10 km deep (Godley et al. 2003b). There are no records in the OBIS database of green turtles in or near the action area.

The proposed action will take place over a 42 day period from January to March 2016. The information available indicates that green turtles will be nesting during this time, in locations far north and well outside of the proposed action area. At the time the survey would occur, we expect that juvemile green turtles would foraging or traveling to foraging grounds, but they would be in coastal areas >1,000 km away from the action area. It is unlikely that hatchlings could be exposed to the proposed activities, as incubation takes about two months, and they would most likely be emerging from their nests after the proposed action is complete. We therefore conclude that the effects of the proposed action to the green turtles of the proposed South Atlantic DPS are discountable, and will not be considered further in this opinion.

4.1.1.3 Hawksbill turtle

Hawksbill sea turtles nest in Bahia, Brazil (~11°-16°S), comprising the largest nesting grounds in the South Atlantic. Nesting occurs from November to March, with a peak from December to February (Marcovaldi et al. 2012; Marcovaldi et al. 2007). Hatchlings emerge from their nests after about two months, and are believed to occupy ocean waters greater than 200 m deep (NMFS 2013). Female hawksbill turtles were fitted with telemetry tags to track their inter-nesting and post-nesting movements; all movements occurred within 24 km of shore (Marcovaldi et al. 2012). After nesting, hawksbill turtles migrate to foraging grounds, typically coral reefs, where they eat sponges and other invertebrates (USFWS 1993). An individual was tagged in Brazil, and then was recovered in Sengal off the west coast of Africa seven months later (Marcovaldi and Filippini 1991); this appears to be an unusual occurrence, however, in light of more recent telemetry data (Marcovaldi et al. 2012).

The proposed action will take place over a 42 day period from January to March 2016. The information available indicates that hawksbill turtles will be nesting during this time, in a location well outside of the proposed action area. Furthermore, the data show that post-nesting movement of adult females occurs close to shore, and the proposed action would occur over 2,000 km from shore. Hatchlings could be emerging from their nests during the time that the survey would take place; however the nesting sites in Bahia, Brazil are ~2,400 km north of the proposed action area, making it unlikely that they would be in the area while the survey took place. There are no coral reefs in the action area where we might expect hawksbill turtles to forage. 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.

4.1.1.4 Loggerhead turtles

The proposed action falls within the range of the South Atlantic DPS of loggerhead turtles. There are two nesting sites in the region: Bahia and Espirito Santo, Brazil. Nesting occurs from September through February, with a peak in November (BAPTISTOTTE 2003) (Marcovaldi and Chaloupka 2007). Post-nesting females tagged with telemetry tags in Bahia migrated up to 2,400 km to foraging grounds, staying within 26 km from the coast in waters less than 50 m deep (Lima et al. 2014; Marcovaldi et al. 2010). However, this is not always the case, as a juvenile tagged in Brazil was later sighted in the Azores (Bolten 1990). Largely though, loggerheads are considered a neritic species, with adults and sub-adults occupying nearshore habitat (Conant 2009).

The proposed action would occur during a time that would overlap with the end of the loggerhead nesting season in Brazil. At the time the survey would occur, we expect that loggerheads would either be nesting or traveling to foraging grounds, and hatchlings could possibly be emerging from their nests. The survey trackline is approximately 2,300 km long, with its western edge about 2,000 km off the coast of southern Brazil, and roughly 2,000 km south of known loggerhead nesting sites. The eastern end of the trackline is approximately 3,200 km from the coast of South Africa. Because the proposed action would take place in an area offshore where loggerheads are not known to typically occur, we do not expect them to by adversely affected by the proposed action. We therefore conclude that the effects of the proposed action to loggerhead turtles are discountable, and will not be considered further in this opinion.

4.1.1.5 Olive Ridley turtles

Olive ridley turtles have been known to occupy waters from 43°N to 34°S, but are most commonly found in tropical waters (NMFS and USFWS 2014). In the southwestern Atlantic Ocean, they typically occur along the northeastern coast of South America (Guyana, Suriname, French Guiana, and Brazil). There are two nesting beaches located in northeastern Brazil (da Silva et al. 2007), and in Suriname and French Guiana (Marcovaldi 2001). Peak nesting occurs from November to January in Brazil (da Silva et al. 2007). In the eastern Atlantic, olive ridley turtles occur in high densities from the Gulf of Guinea to the Ivory Coast in West Africa. Olive ridley turtles are not believed to cross ocean basins (NMFS and USFWS 2014). Olive ridley turtles have been incidentally captured in longline fisheries off the coast of southern Brazil (29-35°S), near the shelf edge break (approximately 220 km from shore) (Pinedo and Polacheck 2004).

The proposed action would occur during a time that would overlap with the end of the olive ridley nesting season in South America. The survey trackline is approximately 2,300 km long, with its western edge about 2,000 km off the coast of southern Brazil, and roughly 2,400 km south of known olive ridley nesting sites. Because the proposed action would take place in an area offshore where olive ridley turtles are not known to typically occur, we do not expect them to by adversely affected by the proposed action. We therefore conclude that the effects of the proposed action to olive ridley turtles 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 is likely to be adversely 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 this NMFS website: [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, humpback, Southern right and sperm whales, leatherback sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in each following section throughout the status of the species.

4.2.1 Sei whale

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.

4.2.1.1 Population designation

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 30º 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).

4.2.1.2 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).

4.2.1.3 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).

4.2.1.4 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).

4.2.1.5 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).

4.2.1.6 Status and trends

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 6 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).

Table 6. 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).

4.2.1.7 Natural threats

Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008).

Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

4.2.1.8 Anthropogenic threats

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.

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

4.2.1.9 Critical Habitat

No critical habitat has been designated for sei whales.

4.2.2 Fin whale

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).

4.2.2.1 Subspecies

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.

4.2.2.2 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).

4.2.2.3 Distribution

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).

4.2.2.4 Age distribution

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 Reproduction

Fin whales reach sexual maturity between 5-15 years of age (COSEWIC 2005; Gambell 1985b; Lockyer 1972). Mating and calving occurs primarily from October-January, gestation lasts ~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. 1992). 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).

4.2.2.6 Habitat and movement

Fin whales along Southern California were found to be traveling 87% of the time and milling 5% 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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4.2.2.7 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. 1992; 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).

4.2.2.8 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 1998). 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 1997a; 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).

4.2.2.9 Status and trends

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 7). 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 1989a; Cherfas 1989b).

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 7. 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).

4.2.2.10 Natural threats

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04 to 0.06 for northeast Atlantic fin whales. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1992). Adult fin whales engage in a flight responses (up to 40 km/h) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999).

4.2.2.11 Anthropogenic threats

Increased noise in the ocean stemming from shipping seems to alter the acoustic patterns of singing fin whales, possibly hampering reproductive parameters across wide regions (Castellote et al. 2012). The vast majority of ship strike mortalities are never identified, and actual mortality is higher than currently documented.

The organochlorines DDE, DDT, and PCBs have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997a; Gauthier et al. 1997b). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

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 ear for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit NMFS (2006a). 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).

4.2.2.12 Critical Habitat

No critical habitat has been designated for fin whales.

4.2.3 Blue whale

Blue whales are the largest whale, reaching lengths up to 110 feet and weighing as much as 330,000 pounds.

4.2.3.1 Subspecies

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 live 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), although these whales are frequently referred to as *B. m. brevicauda* (Anderson et al. 2012). Inbreeding between *B. m. intermedia* and

B. m. brevicauda does apparently occur (Attard et al. 2012). Both pygmy and true blue whales occur in New Zealand waters (Branch et al. 2007a).

4.2.3.2 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 that 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. 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). Here, blue whales are treated as four distinct populations as outlined by Conway (2005).

During the austral summer, blue whales range from the edge of the Antarctic pack ice (40°-78° S) and during the austral winter, north to Ecuador, Brazil, South Africa, Australia, and New Zealand (Shirihai 2002). Occurrence in Antarctic waters appears to be highest from February to 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 on sonobuoy deployments. Pygmy blue whales were also frequently heard in Antarctic waters, further south than previously 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 or western Pacific Ocean (Cerchio et al. 2010; Mccauley and Jenner 2010). A strong male bias may exist in true blue whales (Double et al. 2013).

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

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"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 neighboring 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.

(Aguayo 1974; Clarke 1980b; Donovan 1984; LGL Ltd. 2007; Mate et al. 1999; Palacios 1999; 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). Other individuals are linked via song comparisons to blue whales foraging along southern Chile (Buchan et al. 2014).

4.2.3.3 Age distribution

Blue whales may reach 70–80 years of age (COSEWIC 2002; Yochem and Leatherwood 1985).

4.2.3.4 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). The mean intercalving interval in the Gulf of California is roughly two and half years (Sears et al. 2014). Once mature, females return to the same areas where they were born to give birth themselves (Sears et al. 2014).

4.2.3.5 Movement

In the Southern Ocean, blue whales travel long distances, but frequently concentrate in small areas, presumably searching for or feeding on prey, particularly along the ice edge (Andrews-Goff et al. 2013). Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). In fall, blue whales migrate toward the warmer waters of the subtropics to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998a). In the eastern Central Atlantic, blue whales appear to migrate from areas along Greenland and Iceland to the Azores over and east of the Mid-Atlantic Ridge, apparently engaging in some random movement along the way (Anil et al. 2013).

Blue whales occur singly, or in groups of two or three (Aguayo 1974; 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).

4.2.3.6 Vocalization and hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hertz (Hz), with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see Cummings and Thompson 1971; Cummings and Thompson 1977; Edds-Walton 1997b; Edds 1982; McDonald et al. 1995a; Thompson and Friedl 1982). Non-song vocalization are also low-frequency in nature (generally below 200 Hz, but one of six types up to 750 Hz) between 0.9 and 4.4 s long (Redalde-Salas et al. 2014). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. 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). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re: 1 μPa_{rms} at 1 m in the 17-30 Hz range and pygmy blue whale calls at 175± 1 dB re: 1 μPa_{rms} at 1 m in the 17-50 Hz range. Source levels around Iceland have been 158-169 dB re: 1 μPa_{rms} (Rasmussen et al. 2013). Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

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

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources (Edds-Walton 1997a; Payne and Webb 1971; Thompson et al. 1992a). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently during summer in high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based on call seasonality and structure.

4.2.3.7 Status and trends

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 8 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).

Estimates of 4-5% 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% (Branch et al. 2007b). Punt (2010) estimated the rate of increase for blue whales in the Southern Hemisphere to be 8.2% annually (3.37 standard error) between 1978 and 2004. Antarctic blue whales remain severely depleted with the 1996 estimate only 0.7% of pre-whaling levels (IWC 2005). Blue whales along Chile have been estimated to number between 7 and 9% of historical abundance (Williams et al. 2011). Genetic diversity remains reasonable to high here considering the extreme bottleneck that the population experienced (Sremba et al. 2012; Torres-Florez et al. 2014).

Table 8 Summary of past and present blue whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Current estimate	95% CI	Source
Global	~~	200,000	~~	11,200-13,000	~~	(DOC 1983; Maser et al. 1981)
	~~	~~	~~	5,000-12,000	~~	(COSEWIC 2002)
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)
	~~	10,000	~~	5,000	~~	(Gambell 1976)
	~~	13,000	~~	6,500	~~	(Zemsky and Sazhinov 1982)
				2,300 true		IWC (2014)
				1,500 pygmy		Boyd (2002)
	South of 60° S			1,700		(Branch et al. 2007b)

**Note: CIs not provided by the authors were calculated from CVs where available, using the computation from Gotelli and Ellison (2004).*

After the explosive harpoon was developed in the late nineteenth century, blue whales were the mainstay of whaling in the region (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 <3% 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.

4.2.3.8 Natural threats

As the world's largest animals, blue whales are only occasionally known to be killed by killer whales (Sears et al. 1990; Tarpy 1979). Blue whales engage in a flight response to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Blue whales are known to become infected with the nematode *Carricauda boopis*, which are believed to have caused mortality in fin whale due to renal failure (Lambertsen 1986).

4.2.3.9 Anthropogenic threats

Blue whales have faced threats from several historical and current sources. Blue whale populations were severely depleted originally due to historical whaling activity. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983).

Increasing oceanic noise may impair blue whale behavior. Although available data do not presently support traumatic injury from sonar, the general trend in increasing ambient low-frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006). Blue whales off California altered call levels and rates in association with changes in local vessel traffic (McKenna 2011). Either due to ship strike, vessel noise, whale watching, or a combination of these factors displacement from preferred habitat may be occurring off Sri Lanka (Ilangakoon 2012).

There is a paucity of contaminant data regarding blue whales. Available information indicates that organochlorines, including dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCB), benzene hexachloride (HCH), hexachlorobenzene (HCB), chlordane, dieldrin, methoxychlor, and mirex have been isolated from blue whale blubber and liver samples (Gauthier et al. 1997b; Metcalfe et al. 2004). Contaminant transfer between mother and calf occurs, meaning that young often start life with concentrations of contaminants equal to their mothers, before accumulating additional contaminant loads during life and passing higher loads to the next generation (Gauthier et al. 1997a; Metcalfe et al. 2004). This is supported by ear plug data showing maternal transfer of pesticides and flame retardants in the first year of life (Trumble et al. 2013). These data also support pulses of mercury in body tissues of the male studied (Trumble et al. 2013).

4.2.3.10 Critical Habitat

No critical habitat has been designated for the blue whale.

4.2.4 Humpback whale

Humpback whales are gray with white patches, and can be up to 60 feet in length. They have distinctive long, pectoral fins.

4.2.4.1 Population designations and distribution

Populations have been relatively well defined for humpback whales. In the Southern Hemisphere, eight proposed stocks, or populations, of humpback whales occur in waters off Antarctica (Figure 4). 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). Genetic relatedness is high between eastern and western Australian breeding populations, but significantly different (Schmitt et al. 2014). 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 on 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 50º W (Dalla Rosa et al. 2008). In addition to being a breeding area, the west coast of South Africa and Namibia also appears to serve as a foraging ground due to upwelling of the Benguela Current (Barendse et al. 2010; Elwen et al. 2013). North of this, along Gabon, a separate breeding group also occurs (Elwen et al. 2013). Females appear in this area in large numbers well before their male counterparts, frequently accompanied by calves (Barendse et al. 2010). Low-level movement between breeding locations across years has been documented, bringing into question the genetic discreteness of at least Southern Hemisphere populations (particularly between Oceania groups and Australia) (Garrigue et al. 2011a; Garrigue et al. 2011b; 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). At least two stop over sites along Madagascar for the C stock (Fossette et al. 2014). Another breeding area may exist along the Kenya and Somali coasts, with females moving more directly along migratory corridors while males potentially searching for and intercepting females along the way (Cerchio et al. 2013). Movement between several locations, either islands or bathymetric features, in the southwestern Indian Ocean appears to be frequent (Dulau et al. 2014).

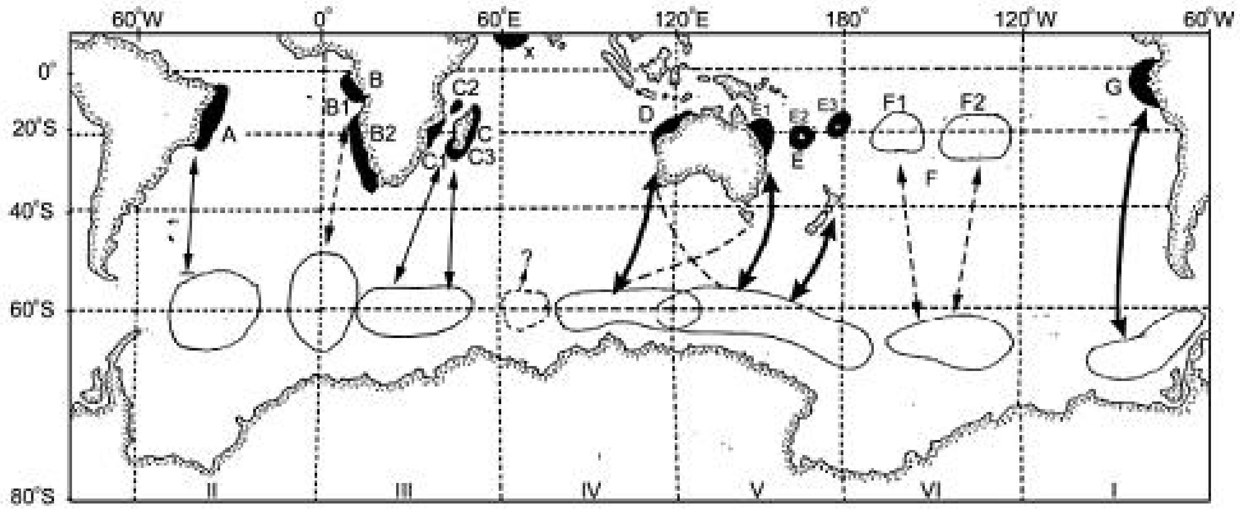

Figure 4 Southern Hemisphere humpback stocks (populations) (IWC 2005).

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 5).

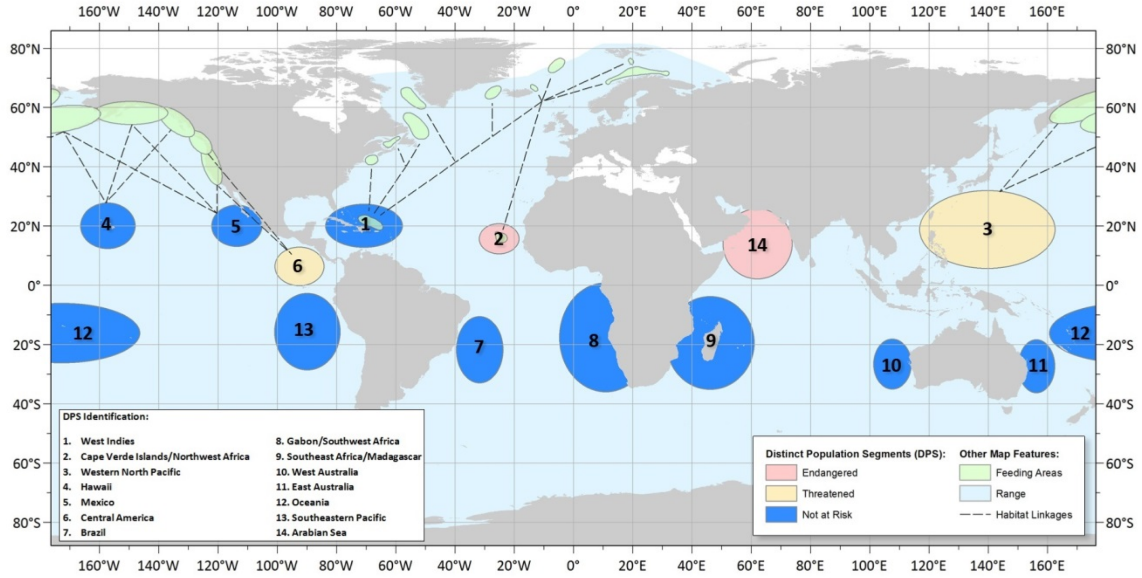

Figure 5 Worldwide distribution of the 14 identified humpback whale distinct population segments.

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) (Figure 4). 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).

4.2.4.2 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).

4.2.4.3 Diving

In Hawaiian waters, humpback whales remain almost exclusively within the 1,800 m isobath and usually within water depths of less than 182 m. Maximum diving depths are approximately 170 m (but usually <60 m), with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1-5.1 min in the North Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). In the Gulf of California, humpback whale dive durations averaged 3.5 min (Strong 1990). 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).

4.2.4.4 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).

Average group size near Kodiak Island is 2-4 individuals, although larger groups are seen near Shuyak and Sitkalidak islands and groups of 20 or more have been documented (Wynne et al. 2005).

4.2.4.5 Vocalization and hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency 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). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

4.2.4.6 Status and trends

Humpback whales were originally listed as endangered rangewide in 1970 (35 FR 18319), and this status remains under the ESA. There are DPSs currently proposed for listing under the ESA; see Section 4.2.4.1. 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 (Table 9). 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.

The IWC recently compiled population data on humpback whales in the Southern Hemisphere. However, humpback whales in this region experienced severe whaling pressure. Based on 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 (Figure 4) (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). 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% for adult females and 12.4% 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% annually, respectively (0.23 and 4.69 standard error, respectively). Kent et al. (2012) provided an even high estimate of 13% from 2000-2008. Humpback whales off Mozambique appear to be more numerous now than when surveyed in the 1990s (Findlay et al. 2011). Population growth of humpback whales along Brazil showed a growth rate of 7.4% annually between 1995-1998 (Ward et al. 2011).

Two separate surveys recorded 150 (Pinkerton et al. 2010) and 27 (Ensor et al. 2003) animals. It is estimated that fewer than 5% (150 animals) of the Southern Ocean population (3,000 animals) are present in the Ross Sea for only two months per year (Pinkerton et al. 2010). The current population in the Scotia Sea and Antarctic Peninsula region was estimated to be approximately 9,484 animals (Reilly et al. 2004). However, a small number of late- or early-migrating whales may pass further south of the area during early or late austral summer, based on the species' typical migration patterns.

Table 9 Summary of past of 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	--	--	845	CV=0.55	(NMFS 2008)
	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	--	--	4,005	3,259-4,751*	(Angliss and Allen 2007)
	NMFS - Eastern North Pacific stock	--	--	1,391	1,331-1,451*	(Carretta et al. 2008)
Indian Ocean	Arabian Sea	--	--	56	35-255	Minton et al. (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)

4.2.4.7 Natural threats

Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period. One-quarter of humpback whales of the Arabian Sea population show signs of tattoo skin disease, which may reduce the fitness of afflicted individuals (Baldwin et al. 2010).

4.2.4.8 Anthropogenic threats

Three human activities are known to 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 are also killed or injured during interactions with commercial fishing gear. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). 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. 2005c; Nelson et al. 2007d). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Between 30 and 40% of humpback whales in the Arabian Sea show scarring from entanglements, with fishing effort on the rise (Baldwin et al. 2010).

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005c; Nelson et al. 2007d). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9%. The first estimate of population-level effects of entanglement were recently produced, with over 12% of the Gulf of Maine population of humpbacks acquiring new scars from entanglement interactions annually (Mattila and Rowles 2010).

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997a). Higher PCB levels have been observed in Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

4.2.4.9 Critical Habitat

No critical habitat has been designated for humpback whales.

4.2.5 Southern Right whale

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.

4.2.5.1 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).

4.2.5.2 Distribution

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 ~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).

4.2.5.3 Habitat

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).

4.2.5.4 Migration and 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 (~71 days) in calving grounds off southern Australia than do females without calves (~20 days)(Burnell and Bryden 1997). Southern right whales have been seen in these waters from mid-May to late October, with 100% 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 2002a). 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).

4.2.5.5 Reproduction

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as long as those whose calves were born early in the season (80 versus 40 days) (Burnell and Bryden 1997).

4.2.5.6 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).

4.2.5.7 Status and trends

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% 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% annually (Bannister 2001). Southern right whale populations in Argentina and South Africa are increasing at about 6.9% 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% of historic levels (Patenaude 2003b). 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 2015).

Some evidence suggests that, due to historical shore whaling, southern right whales have not reoccupied former calving or nursery habitat, particularly in northern areas of the species' historical range (Kemper and Samson. 1999; Richards 2009). Whaling records indicate that southern right whales formerly inhabited waters much further north than presently known relatively late in spring, such as the Kermadec Islands (29˚ S) 1,000 km to the north-northeast of New Zealand (Richards 2002b). Southern right whales were not sighted at all in New Zealand from 1927-1963, but roughly 70 sightings (30-50 individuals) per year have been documented since 2003 (Richards 2009).

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).

Southern right whales regularly winter in Campbell Island south of New Zealand and have been seen with increasing frequency along the mainland (Carroll et al. 2011a; Carroll et al. 2011b; Childerhouse et al. 2010; Patenaude 2003a; Patenaude and Baker 2001; Patenaude et al. 2001; Stewart and Todd 2001). Their numbers seem to be increasing and the latest estimate of population size is 2,169 (Carroll et al. 2013).

4.2.5.8 Natural threats

The only natural predator of southern right whales are killer whales (Sironi et al. 2008). In some cases, such as off Peninsula Valdes, Argentina, southern right whales appear to have abandoned habitat where the highest concentrations of killer whales also occur (Sironi et al. 2008). When attacked, southern right whales attempt to turn their tails towards attacking killer whales and use their flukes as a weapon (Ford and Reeves. 2008; Sironi et al. 2008). Right whale females will also attempt to protect their calves, move into shallower water, increase group size, and form a rosette formation (circle with tails facing outward, younger individuals in the center; this activity was formerly only known for sperm whales being attacked by killer whales) (Ford and Reeves. 2008; Sironi et al. 2008). Southern right whale aggregations in calving areas have been suggested to be a result of predator defense (Ford and Reeves. 2008; Sironi et al. 2008).

4.2.5.9 Anthropogenic threats

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).

Southern right whales are currently subject to many of the same anthropogenic threats as other large whales face. 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 ~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% of records for Australia involve ship strike versus 16% in South Africa and 35% for North Atlantic right whales (Kemper et al. 2008). Additional threats identified in Australian waters include water quality and pollution and near shore habitat degradation due to development (NHT 2005).

4.2.5.10 Critical Habitat

No critical habitat has been designated for southern right whales.

4.2.6 Sperm whale

Sperm whales are the largest of the toothed whales, reaching between 36-52 feet in length, and weighing up to 46 tons. Sperm whales have a large, distinctive head and are dark gray in color.

4.2.6.1 Population designations

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). Chemical analysis also suggests significant differences in diet for animals captured in different regions of the North Atlantic. However, vocal dialects indicate parent-offspring transmission that support differentiation in populations (Rendell et al. 2011). Vocal differences exist not only across ocean basins, but also over much smaller spatial scales (Amano et al. 2014). Therefore, population-level differences may be more extensive than are currently understood.

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). Matrilineal groups in the eastern Pacific share nuclear DNA within broader clans, but North Atlantic matrilineal groups do not share this genetic heritage (Whitehead et al. 2012).

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 50º and decrease in proportion to males south of 46-47º.

4.2.6.2 Movement and distribution

Mature males range between 70º N in the North Atlantic and 70º 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 50º 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. 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). However, 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 kilometers 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. However, 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.

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 1989b). 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 may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet et al. 1996; Waring et al. 1993).

4.2.6.3 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 every four to six years between the ages of 12 and 40 (Kasuya 1991; Whitehead et al. 2008). 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 one 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; 7-9 along Dominica) versus the Pacific (25-30 individuals)(Gero et al. 2013; 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).

4.2.6.4 Feeding

Sperm whales appear to feed regularly throughout the year (NMFS 2006b). It is estimated they consume about 3-3.5% 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 1989b). 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 1989b). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989b). 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).

4.2.6.5 Vocalizations and hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 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; Norris and Harvey. 1972). Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intragroup interactions (Weilgart and Whitehead 1993). They may also aid in intra-specific communication. Another class of sound, “squeals”, are produced with frequencies of 100 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. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999).

4.2.6.6 Status and trends

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. Consideration of the status of populations outside of the action area is important under the present analysis to determine the how risk the risk to the affected population(s) bears on the status of the species as a whole. Table 10 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).

Table 10 Summary of past and present sperm whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	~~	~~	900,000	~~	(Würsig et al. 2000)
	~~	1,110,000	672,000-1,512,000	360,000	105,984-614,016*	(Whitehead 2002)
Southern Hemisphere	Basinwide	547,600	~~	299,400	~~	(Gosho et al. 1984; IWC 1988; Perry et al. 1999)
				30,000		Boyd (2002)
	South of 60°S	~~	~~	14,000	8,786-19,214*	(Butterworth et al. 1995) as cited in (Perry et al. 1999)
	South of 60°S	~~	~~	12,069	~~	(Whitehead 2002b)
	South of 30°S	~~	~~	128,000	17,613-238,387*	(Butterworth et al. 1995) as cited in (Perry et al. 1999)

**Note: CIs not provided by the authors were calculated from CVs where available, using the computation from Gotelli and Ellison (2004).*

Whaling in the Southern Hemisphere averaged roughly 20,000 whales between 1956-1976 (Perry et al. 1999). Population size appears to be stable (Whitehead 2003). Populations of sperm whales in the Ross Sea are estimated to range between 88 (Ensor et al. 2003) and 800 (Pinkerton et al. 2010) animals.

4.2.6.7 Natural threats

Sperm whales are known to be occasionally preyed on by killer whales (Jefferson and Baird 1991; Pitman et al. 2001) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989a; Weller et al. 1996; Whitehead 1995). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes of strandings remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

4.2.6.8 Anthropogenic threats

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). However, other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). However, all of these estimates are likely underestimates due to illegal and inaccurate killings by Soviet whaling fleets between 1947-1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998). 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, significant whaling pressures on sperm whales were eliminated.

Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

Contaminants have been identified in sperm whales, but vary widely in concentration based on life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and HCHs in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 µg Cr/g tissue, with the mean (8.8 µg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals do not appear to accumulate chromium at higher levels.

Small changes in reproductive parameters, such as the loss of adult females, can significantly alter the population trajectory of sperm whale populations (Chiquet et al. 2013).

4.2.6.9 Critical Habitat

No critical habitat has been designated for sperm whales.

4.2.7 Leatherback sea turtle

Leatherback sea turtles are the largest of the sea turtles, with adults reaching up to 6.5 feet in length, and weighing up to 2,000 pounds. Instead of a hard carapace like other sea turtles, leatherbacks have thick, black, leathery skin covering the dermal bones of its top shell.

4.2.7.1 Population designations

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.

Previous genetic analyses of leatherbacks using only mitochondrial DNA (mtDNA) resulted in an earlier determination that within the Atlantic basin there are at least three genetically different nesting populations: the St. Croix nesting population (U.S. Virgin Islands), the mainland nesting Caribbean population (Florida, Costa Rica, Suriname/French Guiana), and the Trinidad nesting population (Dutton et al. 1999). Further genetic analyses using microsatellite markers in nuclear DNA along with the mtDNA data and tagging data has resulted in Atlantic Ocean leatherbacks now being divided into seven groups or breeding populations: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean/Guianas, West Africa, South Africa, and Brazil (TEWG 2007c).

4.2.7.2 Distribution

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. 2003b; Luschi et al. 2006; Márquez 1990; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998; Gill 1997; Hodge and Wing 2000). 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 >21˚ C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James et al. 2005).

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. 2011b; 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). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Areas above 30º N in the Atlantic appear to be popular foraging locations (Fossette et al. 2009b). Northern foraging areas were proposed for waters between 35º and 50º N along North American, Nova Scotia, the Gulf of Saint-Laurent, in the western and northern Gulf Stream, the Northeast Atlantic, the Azores front and northeast of the Azores Islands, north of the Canary Islands. Southern foraging was proposed to occur between 5º and 15º N in the Mauritania upwelling, south of the Cape Verde islands, over the Guinea Dome area, and off Venezuela, Guyana and Suriname.

4.2.7.3 Reproduction and growth

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 (Rhodin 1985) or 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; Avens and Goshe 2008; Avens et al. 2009). Female leatherbacks nest frequently (up to 13, average of 5-7 nests per year and about every 2-3 years) (Eckert et al. 2012). The average number of eggs per clutch varies by region: Atlantic Ocean (85 eggs), western Pacific Ocean (85 eggs), eastern Pacific Ocean (65 eggs) and Indian Ocean (>100 eggs (Eckert et al. 2012)). However, up to ~30% 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. Information on leatherback nesting in Gabon indicates that there are 30,000 nests per season, making it one of the largest rookeries in the Atlantic (Fossette et al. 2008).

4.2.7.4 Migration and 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 11,000 km to nesting and foraging areas throughout ocean basins (Benson et al. 2007a; Benson et al. 2011b; 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 (generally within 100-300 km) (Benson et al. 2011a; Eckert et al. 2012), or range widely, presumably to feed on available prey (Byrne et al. 2009; Fossette et al. 2009a).

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 (30-40º N, 25-30º W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10º 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 40-50º N. Individuals nesting in Caribbean Islands migrate to foraging areas off Canada (Richardson et al. 2012).

Genetic studies support the satellite telemetry data indicating a strong difference in migration and foraging fidelity between the breeding populations in the northern and southern hemispheres of the Atlantic Ocean (Dutton et al. 2013; Stewart et al. 2013). Genetic analysis of rookeries in

Gabon and Ghana confirm that leatherbacks from West African rookeries migrate to foraging areas off South America (Dutton et al. 2013). Foraging adults off Nova Scotia, Canada, mainly originate from Trinidad and none are from Brazil, Gabon, Ghana, or South Africa (Stewart et al. 2013).

4.2.7.5 Sex ratio

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% 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% 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).

4.2.7.6 Feeding

Leatherbacks may forage in high-invertebrate prey density areas formed by favorable oceanographic 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).

4.2.7.7 Vocalization and hearing

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

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

4.2.7.8 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. 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. Breeding females were initially estimated at 29,000-40,000, but were later refined to ~115,000 (Pritchard 1971; Pritchard 1982). Spotila et al. (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001a; NMFS 2001b) (Table 11).

Florida (March-July) and U.S. Caribbean nesting since the early 1980s has increased ~0.3% and 7.5% per year, respectively, but lags behind the French Guiana coast and elsewhere in magnitude (NMFS/SEFSC 2001). This positive growth was seen within major nesting areas for the stock, including Trinidad, Guyana, and the combined beaches of Suriname and French Guiana (TEWG 2007a). Trinidad supports an estimated 7,000 to 12,000 leatherbacks nesting annually (Stewart et al. 2013), which represents more than 80% of the nesting in the insular Caribbean Sea (Fournillier and Eckert 1999). Using both Bayesian modeling and regression analyses, the TEWG (2007a) determined that the Southern Caribbean/Guianas stock had demonstrated a long-term, positive population growth rate (using nesting females as a proxy for population).

Table 11 Leatherback nesting population site location information where multiple-year surveys were conducted or trends are known (data type, years surveyed, annual number (nests, females, trend). Nesting population trend symbols: ▲ = increasing; ▼ = decreasing.

Location	Data: Nests, Females	Years	Annual number	Trend	Reference
Atlantic					
United States (Florida)	Nests	1979-2008	63-754	▲	Stewart et al. (2011)
Puerto Rico (Culebra)	Nests	1993-2012	395-32	▼	Diez et al. (2010; Ramírez-Gallego et al. 2013)
Puerto Rico (other)	Nests	1993-2012	131-1,291	▲	C. Diez, Department of Natural and Environmental Resources of Puerto Rico, unpublished data in// NMFS and

					USFWS (2013)
United States Virgin Islands (Sandy Point National Wildlife Refuge, St. Croix)	Nests	1986 - 2004	143-1,008	▲[1]	Dutton et. al. (2005); Turtle Expert Working Group (2007b)
British Virgin Islands	Nests	1986 - 2006	0-65	▲	McGowan et al. (2008) ;Turtle Expert Working Group (2007b)

[1] A more recent trend analysis was not found in the literature. However, trends since 2001 suggest the population may be declining, possibly due to a decrease in the number of new nesters, lowered productivity (number of clutches per season and lower hatch success), and an increase in remigration intervals (Garner 2012; Garner et al. 2012).

The Caribbean coast of Costa Rica and extending through Chiriquí Beach, Panama, represents the fourth largest known leatherback rookery in the world (Troeng et al. 2004). Examination of data from three index nesting beaches in the region (Tortuguero, Gandoca, and Pacuare in Costa Rica) using various Bayesian and regression analyses indicated that the nesting population likely was not growing during 1995-2005 (TEWG 2007a). Other modeling of the nesting data for Tortuguero indicates a 67.8% decline between 1995 and 2006 (Troëng et al. 2007).

In Puerto Rico, the primary nesting beaches are at Fajardo and on the island of Culebra. Nesting between 1978 and 2005 ranged between 469-882 nests, and the population has been growing since 1978, with an overall annual growth rate of 1.1% (TEWG 2007a). At the primary nesting beach on St. Croix, the Sandy Point National Wildlife Refuge, nesting has fluctuated from a few hundred nests to a high of 1,008 in 2001, and the average annual growth rate has been approximately 1.1% from 1986-2004 (TEWG 2007a). Overall increases are recorded for mainland Puerto Rico and St. Croix, as well as the U.S. Virgin Islands (Ramírez-Gallego et al. 2013). Trends since 2001 suggest the population may be declining, possibly due to a decrease in the number of new nesters, lowered productivity (number of clutches per season and lower hatch success), and an increase in remigration intervals (Garner 2012; Garner et al. 2012).

The Florida nesting stock comes ashore primarily along the east coast of Florida. This stock is of growing importance, with total nests between 800-900 per year in the 2000s following nesting totals fewer than 100 nests per year in the 1980s (NMFS 2011). Using data from the index nesting beach surveys, the TEWG (2007a) estimated a significant annual nesting growth rate of 1% between 1989 and 2005. Stewart et al. (2011) evaluated nest counts from 68 Florida beaches over 30 years (1979-2008) and found that nesting increased at all beaches with trends ranging from 3.1%-16.3% per year, with an overall increase of 10.2% per year. In 2007, a record 517 leatherback nests were observed on the index beaches in Florida, with 265 in 2008, and then an increase to a new record of 615 nests in 2009, and a slight decline in 2010 back to 552 nests

(FWC Index Nesting Beach database). This up-and-down pattern is thought to be a result of the cyclical nature of leatherback nesting, similar to the biennial cycle of green turtle nesting.

The most recent population estimate for leatherback sea turtles from the North Atlantic as a whole is between 34,000-90,000 adult individuals (20,000-56,000 adult females) (TEWG 2007a). In the Atlantic, the largest rookeries are in northeastern South America and west Africa (primarily Gabon), and there is evidence that these colonies are either stable or increasing (Fossette et al. 2008).

Annual survival probability (ca. 0.85) was constant over the 10-year period. Annual survival was lower than those estimated for Atlantic rookeries (Dutton et al. 2005; Rivalan et al. 2005). For the St. Croix, U.S. Virgin Islands population, the annual survival rate was approximately 0.893 (confidence interval = 0.87-0.92) for adult female leatherbacks at St. Croix (Dutton et al. 2005). Annual juvenile survival rate for St. Croix was estimated to be approximately 0.63, and the total survival rate from hatchling to first year of reproduction for a female hatchling was estimated to be between 0.004 and 0.02, given assumed age at first reproduction between 9 and 13 (Eguchi et al. 2006). In Florida, annual survival for nesting females was estimated to be 0.956 (Stewart 2007). Spotila et al. (1996) estimated the first year (from hatching) of survival for the global population to be 0.0625.

4.2.7.9 Natural threats

Sea turtles face predation primarily by sharks and to a lesser extent by killer whales (Pitman and Dutton 2004). Hatchlings are preyed upon by herons, gulls, dogfish, and sharks. Leatherback hatching success is particularly sensitive to nesting site selection, as nests that are overwashed have significantly lower hatching success and leatherbacks nest closer to the high-tide line than other sea turtle species (Caut et al. 2009b). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* can kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

4.2.7.10 Anthropogenic threats

Leatherback nesting and marine environments are facing increasing impacts through widespread development and tourism along nesting beaches (Hamann et al. 2006; Hernandez et al. 2007; Maison 2006; Santidrián Tomillo et al. 2007). Structural impacts to beaches include building and piling construction, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997b). 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). Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Bourgeois et al. 2009; Cowan et al. 2002; Deem et al. 2007; Witherington 1992; Witherington and Bjorndal 1991). Leatherbacks are much more likely to emerge and not nest on developed beaches and much more likely to emerge and nest on undeveloped stretches

(Roe et al. 2013). Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). Along the coast of Peru, 13% of 140 leatherback carcasses were found to contain plastic bags and film (Fritts 1982). A leatherback found stranded along the northern Adriatic had been weakened by plastic ingestion, likely leading to an infection that ultimately killed the individual (Poppi et al. 2012). Although global warming may expand foraging habitats into higher latitude waters, increasing temperatures may increase feminization of nests (Hawkes et al. 2007; James et al. 2006; McMahon and Hays 2006; Mrosovsky et al. 1984). Rising sea levels may also inundate nests on some beaches. Egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of females along nesting beaches is of concern worldwide.

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). Wallace et al. (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace et al. 2010); many of these turtles are expected to be leatherbacks. Currently, the U.S. tuna and swordfish longline fisheries managed under the HMS FMP are estimated to capture 1,764 leatherbacks (no more than 252 mortalities) for each 3-year period starting in 2007 (NMFS 2004). While 2010 total estimates are not yet available, in 2009, 285.8 (95% CI: 209.6-389.7) leatherback sea turtles are estimated to have been taken in the longline fisheries managed under the HMS FMP based on the observed takes (Garrison and Stokes 2010). Observer coverage for this period ranged from 54 to 92%. Trinidad and Tobago's Institute for Marine Affairs estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000. Half or more of the gravid turtles in Trinidad and Tobago waters may be killed (Lee Lum 2003), though many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS 2001a).

We know little about the effects of contaminants on leatherback sea turtles. The metals arsenic, cadmium, copper, mercury, selenium, and zinc bioaccumulate, with cadmium in highest concentration in leatherbacks versus any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). Along with these, lead has also been reported in high concentrations, potentially to the detriment of the individual (Perrault et al. 2013; Poppi et al. 2012). A diet of primarily jellyfish, which have high cadmium concentrations, is likely the cause (Caurant et al. 1999). Organochlorine pesticides have also been found (Mckenzie et al. 1999). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight Davenport et al. 1990; Oros et al. 2009).

4.2.7.11 Critical Habitat

Critical habitat for leatherback sea turtles has been designated in the U.S. Virgin Islands (44 FR 17710), and off the West Coast of the United States (77 FR 4170). There is no leatherback critical habitat within the action area.

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 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. As we better understand responses to climate change, we will address these effects in the relevant species-specific section.

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 2002). From 1906 to 2006, global surface temperatures have risen 0.74º C and continue 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). North Atlantic and Pacific sea surface temperatures have shown trends in being anomalously warm in recent years (Blunden and Arndt 2013). The ocean along the U.S. eastern seaboard is also much saltier than historical averages (Blunden and Arndt 2013).

The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. As described in the *Status of Listed Resources* for each sea turtle species, temperature regimes are generally leading towards female-biased nests. This can result in heavily feminized populations incapable of fertilization of available females (Laloë et al. 2014). This is not considered to be an imminent threat and presently has the advantage of shifting the natural rates of population growth higher (Laloë et al. 2014). Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe as well as an increase in the mass of the Antarctic and Greenland ice sheets, 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 effects 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.

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 with 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). With warming temperatures and decreasing sea ice, humpback and fin whales have been found in increasing numbers at the northern extreme of their Pacific range and are regularly found now in the southern Chukchi Sea (Clarke et al. 2013). We do not know if this is due to range expansion owing to species recovery, or due to altered habitat associated with climate change (Clarke et al. 2013). Climate change can influence reproductive success by altering prey availability, as evidenced by high 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 perturbed 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% of cetaceans would be affected by climate change, 47% would be negatively affected, and 21% 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). Modeling of North Atlantic cetacean species found that three of four odontocete species would likely undergo range contraction while one would expand its range (Lambert et al. 2014). 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 during winter months. Although the IPCC (2001) 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% since the 1950s.

Roughly 50% 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% 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).

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 under ice algae to feed on. This may be a cause of decreased krill abundance in the northwestern 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% 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). This has been proposed to be the case in the eastern North Pacific, where a poleward shift in the North Pacific Current that would likely continue under global warming conditions would enhance nutrient and planktonic species availability, providing more prey for many higher trophic level species (Sydeman et al. 2011). Species such as gray whales may experience benefits from such a situation (Salvadeo et al. 2013). 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 (Schumann et al. 2013; 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).

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 five 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. Long-term shifts of sperm whale prey in the California Current have also been attributed to the re-distribution of their prey resulting from climate-based shifts in oceanographic variables (Salvadeo et al. 2011). Similar changes have also been suggested for sardines and anchovy in the California Current (Salvadeo et al. 2011), which are important prey for humpback and fin whales, among others.

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 (Blunden and Arndt 2013; Poloczanska et al. 2009). Ocean temperatures around Iceland are linked with alterations in the continental shelf ecosystem there, including shifts in minke whale diet (Víkingsson et al. 2014).

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% 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. The current pace is nearly double this, with a 20-year trend of 3.2 mm/year (Blunden and Arndt 2013). This is largely due to thermal expansion of water, with minor contributions from melt water (Blunden and Arndt 2013). 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). In addition, flatter beaches preferred by smaller sea turtle species would be inundated sooner than would steeper beaches preferred by larger species (Hawkes et al. 2014). 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. 2009a). 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).

Climactic shifts also occur due to natural phenomena. In the North Atlantic, this primarily concerns fluctuations in the NAO, which results from changes in atmospheric pressure between a semi-permanent high pressure feature over the Azores and a subpolar low pressure area over Iceland (Curry and McCartney 2001; Hurrell 1995; Stenseth et al. 2002). This interaction affects sea surface temperatures, wind patterns, and oceanic circulation in the North Atlantic (Stenseth et al. 2002). The NAO shifts between positive and negative phases, with a positive phase having persisted since 1970 (Hurrell 1995). North Atlantic conditions experienced during positive NAO phases include warmer than average winter weather in central and eastern North America and Europe and colder than average temperatures in Greenland and the Mediterranean Sea (Visbeck 2002). Effects are most pronounced during winter (Taylor et al. 1998). The NAO is significant for North Atlantic right whales due to its influence on the species primary prey, zooplankton of the genus *Calanus*, which are more abundant in the Gulf of Maine during positive NAO years (Conversi et al. 2001; Greene and Pershing 2004; Greene et al. 2003). This subsequently impacts the nutritional state of North Atlantic right whales and the rate at which sexually mature females can produce calves (Greene et al. 2003).

5.2 Habitat Degradation

A number of factors may be directly or indirectly affecting listed species in the action area by degrading habitat. These include ocean noise and fisheries impacts.

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), among other effects (Eriksen and Pakkenberg 2013; Francis and Barber 2013). For species inhabiting Arctic waters, vessel and industrial noise may become much more problematic as oil and gas development and commercial shipping lanes through ice-free areas expand and intensify (Reeves et al. 2014). Vessels pose not only a risk of ship strike, but also impede the ability of whales to communicate. Hatch et al. (2012) estimated that roughly two-thirds of a right whales' communication space may be lost due to current ocean noise levels, which have greatly increased due to shipping noise. Shipping noise is also linked with increased stress levels in right whales (Rolland et al. 2012b).

Marine debris is another significant concern for listed species and their habitats. Marine debris has been discovered to be accumulating in gyres throughout the oceans. Law et al. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 to 2008. More than 60% of 6,136 surface plankton net tows collected small, buoyant plastic pieces. The data identified an accumulation zone east of Bermuda that is similar in size to the accumulation zone in the Pacific Ocean. Over half of cetacean species (including humpback, fin, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22% of individuals found stranded on shorelines (Baulch and Perry 2014). Microplastics have been detected in whale feeding grounds in the Mediterranean, placing baleen whales at risk of ingesting microplastics; the impacts of ingestion remain unknown (Deudero and Alomar 2015; Fossi 2015).

Ingestion of marine debris can have fatal consequences even for large whales as well as sea turtles. In 1989, a stranded sperm whale along the Mediterranean was found to have died from ingesting plastic that blocked its' digestive tract. A sperm whale examined in Iceland had a lethal disease thought to have been caused by the complete obstruction of the gut with plastic marine debris (Lambertsen 1990). Further incidents may occur but remain undocumented when carcasses do not strand.

For sea turtles, marine debris is a problem due primarily to individuals ingesting debris and blocking the digestive tract, causing death or serious injury (Laist et al. 1999; Lutcavage et al. 1997a). Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives; this figure is supported by data from Lazar and Gracan (Lazar and Gračan 2010), who found 35% of loggerheads had plastic in their gut. One study found 37% of dead leatherback turtles had ingested various types of plastic (Mrosovsky et al.

2009). A Brazilian study found that 60% of stranded green sea turtles had ingested marine debris (primarily plastic and oil; (Bugoni et al. 2001)). Loggerhead sea turtles had a lesser frequency of marine debris ingestion. Plastic is possibly ingested out of curiosity or due to confusion with prey items; for example, plastic bags can resemble jellyfish (Milton and Lutz 2003). Marine debris consumption has been shown to depress growth rates in post-hatchling loggerhead sea turtles, elongating the time required to reach sexual maturity and increasing predation risk (McCauley and Bjorndal 1999). Sea turtles can also become entangled and die in marine debris, such as discarded nets and monofilament line (Laist et al. 1999; Lutcavage et al. 1997a; NRC 1990; O'Hara et al. 1988). This fundamentally reduces the reproductive potential of affected populations, many of which are already declining.

5.3 Seismic Surveys

Seismic surveys occur off the coast of Brazil and west Africa for the purposes of oil and gas exploration and geological studies (IONGEO 2015b) (IONGEO 2015a). These surveys are generally confined to coastal waters, and do not extend out into the waters of the proposed action area.

5.4 Vessel Traffic

Vessel noise could affect marine animals in the study area. Shipping 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). 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. Masking of acoustic information can result (Simard et al. 2013); an important issue for marine mammals that rely primarily on sound as a sense. 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. Other coping mechanisms include shifting the frequency or amplitude of calls, increasing the redundancy or length of calls, or waiting for a quieter period in which to vocalize (Boness et al. 2013; Holt et al. 2013; Parks et al. 2013). Increases in vessel traffic and marine industrial construction is associated with decreases in the presence of minke whales and gray seals, presumably due to increased noise in the area (Anderwald et al. 2013). Sonars and small vessels also contribute significantly to mid-frequency ranges (Hildebrand 2009).

5.5 Entrapment and Entanglement in Fishing Gear

Fisheries interactions are a significant problem for several marine mammal species and particularly so for humpback whales, as well as sea turtles. Between 1970 and 2009, two-thirds of mortalities of large whales in the northwestern Atlantic were attributed to human causes, primarily ship strike and entanglement (Van der Hoop et al. 2013). In excess of 97% of entanglement is caused by derelict fishing gear (Baulch and Perry 2014). Aside from the potential of entrapment and entanglement, there is also concern that many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to accurately determine the frequency of mortalities. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). 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. 2005c; Nelson et al. 2007c). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Waring et al. (2007) reported four fin whales in the western North Atlantic having died or were seriously injured in fishing gear.

Fishery interaction remains a major factor in sea turtle recovery and, frequently, the lack thereof. Wallace et al. (2010) estimated that worldwide, 447,000 turtles are killed each year from bycatch in commercial fisheries. NMFS (2002a) estimated that 62,000 loggerhead sea turtles have been killed as a result of incidental capture and drowning in shrimp trawl gear. Although turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch to sea turtles and other marine species in U.S. waters, mortality still occurs.

5.6 Invasive Species

Invasive species have been referred to as one of the top four threats to the world's oceans consistently ranked behind habitat degradation and alteration (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). In most cases, habitat is directly affected by human alterations, such as hydromodification, mining, dredging, drilling, and construction. However, invasive species, facilitated by human commerce, have the ability to directly alter ecosystems upon which listed species rely.

Invasive species are a major threat to many ESA-listed species. For species listed by the United States Fish and Wildlife Service (USFWS), 26% were listed partially because of the impacts of invasive species and 7% were listed because invasive species were the major cause of listing (Anttila et al. 1998). Pimentel et al. (2004) found that roughly 40% of listed species are at risk of becoming endangered or extinct completely or in part due to invasive species, while Wilcove et al. (1998) found this to be 49%, with 27% of invertebrates, 37% of reptiles, 53% of fishes, and 57% of plants imperiled partly or wholly due to non-native invasions. In some regions of the world, up to 80% of species facing extinction are threatened by invasive species (Pimentel et al. 2004; Yan et al. 2002). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the International Union for the Conservation of Nature database; invasive species were the only cited cause in 20% of those cases. Richter et al. (1997) identified invasive species as one of three top threats to threatened and endangered freshwater species in the U.S. as a whole.

5.7 Diseases

The impacts of introduced pathogens in the aquatic environment has been poorly explored and we likely know very little about the true frequency and significance of pathogen invasions (Drake et al. 2001). Pathogens are known to have adverse effects to invertebrate communities. Molluscs such as black and white abalone seem to be particularly sensitive to pathogens. Various species of the genus *Vibrio*, known to cause cholera in humans, white pox and white plague type II diseases in corals, and mortality in abalone of the same genus as black and white abalone, have been identified in ports and ballast water of vessels (Aguirremacedo et al. 2008; Anguiano-Beltrán et al. 1998; Ben-Haim and Rosenberg 2002). Oyster species have sustained several outbreaks from invasive pathogens, including *Haplosporidium nelsoni* (the cause of MSX disease, which Chesapeake Bay eastern oysters have shown 75-92% mortality to) and *Perkinsus marinus* (the cause of Dermo disease) in California, eastern North America, and Europe (Andrews 1984; Burreson and Ford 2004; Burreson et al. 2000; Ford and Haskin 1982; Renault et al. 2000), Bonamia ostreae in Europe (Ciguarria and Elston 1997; Van Banning 1987), and in the northeastern U.S., respectively (Ford 1996). Although specific instances of sea turtle pathogen transference via invasive species are not documented, their spread into new areas are easily possible, particularly given environmental perturbations and naïve individuals in receiving habitats.

5.8 Ship Strikes

Ship-strike is a significant concern for the recovery of listed whales and, to a lesser degree, sea turtles. Between 1970 and 2009, two-thirds of mortalities of large whales in the northwestern Atlantic were attributed to human causes, primarily ship strike and entanglement (Van der Hoop et al. 2013). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada’s Maritime Provinces (Cole et al. 2005c; Nelson et al. 2007c). Two of these ship strikes were reported as having resulted in death. An update (unpublished data 1995–2011) ship strike inventory for the eastern seaboard indicates the following percentage of strikes by species: North Atlantic right whale (19%), humpback whale (28%), sei whale (6%), fin whale (17%), sperm whale (2%), and unknown species (16%). Based on the records available, large whales have been struck by ships off almost every coastal state in the U. S., although ship strikes are most common along the Atlantic Coast. More than half (56%) of the recorded ship strikes from 1975-2002 occurred off the coasts of the northeastern U.S. and Canada, while the mid-Atlantic and southeastern areas each accounted for 22% (Jensen and Silber 2003). According to Waring et al. (2007), five fin whales were killed or injured as a result of ship strikes between January 2000 and December 2004. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005a; Nelson et al. 2007a). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist et al. 2001).

In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9%, fin whales by 42%, right whales by 62%, and sei whales by 17%; the same rule applies from November through April from Brunswick, Georgia to Jacksonville, Florida, where North Atlantic right whales go for calving and breeding. Speed rules also apply to medium and large ports along the eastern seaboard during this time frame when right whales migrate to and from northern feeding and southern breeding areas. Nearly a dozen shipping lanes transect through coastal waters of the southeastern U.S. from the North-South Carolina to Cape Canaveral, Florida. Modeling efforts suggest voluntary changes in “areas to be avoided” suggested by the International Maritime Organization will reduce right whale strikes over the Scotian Shelf from one lethal strike every 0.78-2.07 years to one every 41 years (Hoop et al. 2012). Part of the susceptibility of North Atlantic right whales to ship strike may be its propensity to remain just below the surface, invisible to vessels, but at significant risk to ship strike (Parks et al. 2011).

We believe the vast majority of ship-strike mortalities go unnoticed, and that actual mortality is higher than currently documented; Kraus et al. (2005) estimated that 17% of ship strikes are actually detected. The magnitude of the risks commercial ship traffic pose to large whales in the proposed action areas has been difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the U.S. EEZ and have virtually no information on interactions between ships and commercial vessels outside of U.S. waters. With the information available, we know those interactions occur but we cannot estimate their significance to whale species.

Various types and sizes of vessels have been involved in ship strikes with large whales, including container/cargo ships/freighters, tankers, steamships, U.S. Coast Guard vessels, Navy vessels, cruise ships, ferries, recreational vessels, fishing vessels, whale-watching vessels, and other vessels (Jensen and Silber 2004). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. There have been 18 reports of North Atlantic right whales being struck by vessels between 1999 and 2005 (Cole et al. 2005b; Nelson et al. 2007b). Of the 17 reports that NMFS could confirm, right whales were injured in two of the ship strikes and killed in nine. Recent records show that from 2004-2008, there were 17 confirmed reports of North Atlantic right whales being struck with eight whales dying of their wounds and two additional right whales sustaining serious injuries (Glass et al. 2009). Deaths of females are especially deleterious to the ability of the North Atlantic right whale population to recover. For instance, in 2005, mortalities included six adult females, three of which were carrying near-term fetuses and four of which were just starting to bear calves, thereby representing a lost reproductive potential of as many as 21 individuals over the short term (Kraus et al. 2005). Between 1999 and 2006, ships are confirmed to have struck 22 North Atlantic right whales, killing 13 of these whales (Jensen and Silber 2003; Knowlton and Kraus 2001; NMFS 2005). From 1999 to 2003, an average of 2.6 right whales were killed per year from various types of anthropogenic factors, but mostly from ship-strike (Waring et al. 2010). From 2000 to 2004, this increased to 2.8 annually and increased again from 2001 to 2005 to an average of 3.2 right whales (Waring et al. 2010). The most recent estimate of anthropogenic mortality and serious injury available showed a rate of 3.8 right whales per year from 2002 to 2006. Of these, 2.4 were attributed to ship strikes (Glass et al. 2008). Based on records collected between 1970 and 1999, about 60% of the right whales struck by ships along the Atlantic Coast of the U. S., 20% occurred in waters off the northeast states and 20% occurred in waters off the mid-Atlantic or southeast states (Knowlton and Kraus 2001). Over the same time interval (1970 to 1999), these authors identified 25 (45%) unconfirmed serious injuries and mortalities from ship strikes. Of these, 16 were fatal interactions; two possibly fatal; and seven nonfatal. Based on these confirmed mortalities, ships are responsible for more than one-third (16 out of 45, or 36%) of all confirmed right whale mortalities (a confirmed mortality is one observed under specific conditions defined by NMFS).[3] Part of the susceptibility of this species to ship strike may be its propensity to remain just below the surface, invisible to vessels, but at significant risk to ship strike (Parks et al. 2011).

Another study conducted over a similar period – 1970 to 2002 – examined 30 (18 adults and juveniles, and 12 calves) out of 54 reported right whale mortalities from Florida to Canada (Moore et al. 2005). Human interaction (ship strike or gear entanglement) was evident in 14 of the 18 adults examined, and trauma, presumably from vessel collision, was apparent in 10 out of the 14 cases. Trauma was also present in four of the 12 calves examined, although the cause of death was more difficult to determine in these cases. In 14 cases, the assumed cause of death was vessel collision; an additional four deaths were attributed to entanglement. In the remaining 12 cases, the cause of death was undetermined (Moore et al. 2005). A more recent examination of 28 sperm whale strandings in Greece between 1992 and 2014 showed that 12 showed clear evidence of vessel collision, prompting the authors to recommend consideration of changes in shipping routes to reduce risk of sperm whale ship strike in the Hellenic Trench (Frantzis et al. 2015). Additional efforts have been made to identify critical areas for fin whales in the

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[3] There are four main criteria used to determine whether serious injury or mortality resulted from ship strikes: (1) propeller cut(s) or gashes that are more than approximately 8 cm in depth; (2) evidence of bone breakage determined to have occurred premortem; (3) evidence of hematoma or hemorrhaging; and (4) the appearance of poor health in the ship-struck animal

Knowlton, A. R., and S. D. Kraus. 2001. Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. Journal of Cetacean Research and Management Special Issue 2:193-208..

Mediterranean to mitigate effects of ship strikes (Panigada et al. 2015). Sound propagation modeling showed that the level of sound received by whales depends on season and dive cycles, and the speed of the vessel approaching the whale reducing its ability to out-maneuver the vessel (Gannier and Marty 2015).

Sea turtle ship strikes are a poorly-studied threat to sea turtles, but has the potential to be highly-significant (Work et al. 2010). All sea turtles must surface to breath and several species are known to bask at the surface for long periods, including loggerhead sea turtles. Although sea turtles can move rapidly, sea turtles apparently are not well able to move out of the way of vessels moving at more than 4 km/hr; most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). This, combined with the massive level of vessel traffic in the Gulf of Mexico and coastal Atlantic, has the potential to result in frequent injury and mortality to sea turtles in the region (MMS 2007). Hazel et al. (2007) suggested that green sea turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases. Overall, ship strike is likely highly underestimated as a source of injury or mortality to sea turtles in the action area.

5.9 Commercial Whaling

Large whale population numbers in the action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Between 1969-1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these, seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979).

5.10 Scientific and Research Activities

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

Authorized research on ESA-listed sea turtles includes capture, handling, and restraint, satellite, sonic, and passive integrated transponder tagging, blood and tissue collection, lavage, ultrasound, captive experiments, laparoscopy, and imaging. Research activities involve “takes” by harassment, with some resulting mortality. There have been numerous permits[4] issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles all over the world, including for research in the Mediterranean. The consultations which took place on the issuance of these ESA scientific research permits each

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

found that the authorized activities would have no more than short-term effects and would not result in jeopardy to the species or adverse modification of designated critical habitat.

Additional "take" is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below represent the maximum number of "takes" authorized in a given year, monitoring and reporting indicate that the actual number of "takes" rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these "takes" will occur since they have been authorized. It is also noteworthy that these "takes" are distributed across the Atlantic Ocean, mostly from Florida to Maine, and in the eastern Gulf of Mexico. Although whales and sea turtles are generally wide-ranging, we do not expect many of the authorized "takes" to involve individuals who would also be "taken" under the proposed research.

5.11 Physical and Oceanographic Features

The presence of key habitat features, such as shelter or foraging opportunities, are the primary reasons why listed individuals occur where they do. In the marine environment, this is fundamentally built upon local physical and oceanographic features that influence the marine environment. As such, we describe the physical and oceanographic environment here to establish a rationale for why listed species occur in the action area at the levels we observe or expect. This does not represent a stressor, but is instead an underlying principle for establishing why effects are what we expect them to be.

5.12 Impacts of the Environmental Baseline on ESA-listed Species

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

5.12.1 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 North Atlantic right whales and humpback whales) and entanglement in fishing gear (right whales). Ship-strike and entanglement occur broadly along the U.S. East Coast, including (in all likelihood) in the action area itself. These two factors are the greatest known source of mortality and impairment to recovery for North Atlantic right whales and represent known mortality sources for all other ESA-listed whales in the action area. Reductions in speed through portions of the action area as well as seasonal or brief closings of areas to fishing are underway to reduce these impacts, but data are not yet available to demonstrate the long-term effectiveness of these strategies. However, these measures are likely reducing the severity and frequency of these interactions.

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

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

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.

5.12.2 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.

Although only small percentages of these sea turtles are estimated to have died as a result of their capture during research or incidental to fisheries, the actual number could be substantial if considered over the past 5 to 10 years. When we add the percentage of sea turtles that have suffered injuries or handling stress sufficient to have caused them to delay the age at which they reach maturity or the frequency at which they return to nesting beaches, the consequences of these fisheries on nesting aggregations of sea turtles would be greater than we have estimated.

Even with turtle excluder device measures in place, in 2002, NMFS (2002) expected these fisheries to capture about 323,600 sea turtles each year and kill about 5,600 (~1.7%) of the turtles captured. Leatherback sea turtle interactions were estimated at 3,090 captures with 80 (~2.6%) deaths as a result (NMFS 2002b). Since 2002, however, effort in the Atlantic shrimp fisheries has declined from a high of 25,320 trips in 2002 to approximately 13,464 trips in 2009, roughly 47% less effort. 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 leatherback 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.

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. acoustic interference from engine noise;
3. ship-strikes;
4. sound fields produced by airguns; and
5. sound fields produced by sub-bottom profiler or multibeam echosounder

Based on a review of available information, we 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 unlikely. Leaks 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* or its smaller counterparts 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 Disturbance from Engine Noise

The propulsion system of the *Langseth* and the chase vessel are designed to be very quiet compared to other vessels to reduce interference with seismic activities. Although noise originating from vessel propulsion will propagate into the marine environment, disturbance from this amount of noise generated by the *Langseth* would be highly improbable. 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). The chase vessel would also not generate sufficient noise to significantly disturb ESA-listed marine mammals or sea turtles. 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.

6.1.3 Ship Strike

The *Langseth* and the chase vessel 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). The same can be said for the chase vessel to be utilized. All factors considered, we have concluded the potential for ship strike from the research vessel or the chase 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.

Accordingly, this consultation focused on the following stressors likely to occur from the proposed seismic activities that may adversely affect ESA-listed species: 1) acoustic energy introduced into the marine environment by the airgun array and 2) acoustic energy introduced by the sub-bottom profiler and multibeam echosounder 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. NSF's and NMFS's measures are described in the description of the action, and exposure and response analysis were considered throughout our analysis.

6.3 Exposure and Response Analysis

Exposure Analyses identify the physical, chemical, and biotic stressors produced by a proposed action that co-occur in space and time with ESA-listed species within the action area. The stressors identified for this proposed action that warrant further analysis are sound fields produced by airguns, and sound field produced by sub-bottom profiler or multibeam echosounder.

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.

6.3.1 Exposure Analysis

Although there are several acoustic and non-acoustic stressors 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, the Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed that of the airgun array. The 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 1 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 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 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 Permits and Conservation Divisions 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 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 Permits and Conservation Division is proposing to issue take authorizations for marine mammals. The ESA does not define harassment nor has the NMFS defined the term pursuant to the ESA through regulation. The MMPA of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, "...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is similar to language in the USFWS's regulatory definition of "harass"[5] pursuant to the ESA. For this opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

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

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[5] An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)

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).

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 $\mu Pa_{rms,}$ 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 $\mu Pa_{rms.}$ 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 2015).

The ensonified area was calculated to be 41,406 km^2, including a 25% contingency for the South Atlantic study area (33,125 km^2 without the contingency). Expected species density was multiplied by the ensonified area to arrive at numbers of animals exposed. NSF predicted that the ensonified area including overlap is 1.2 times the area excluding overlap.

There are no definitive density estimates available for the action area in the waters of the South Atlantic, 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. For sperm, fin and sei whales, NSF used density estimates developed for a previous marine geophysical survey in 2014 which took place in the Scotia Sea and South Atlantic Ocean (~53-58°S, 30-40°W). NSF determined that humpback, blue and Southern right whales would be rarely encountered in the action area (LGL 2015). As a result, NSF increased the take request to 1% of the mean group size for these species. For southern right and humpback whales, the estimate was based on Williams et al. (2006) off the Antarctic Peninsula and South Georgia. To estimate exposure for blue whales, NSF used mean group size from a survey conducted by Waring et al. (2008) in the North Atlantic over the Mid-Atlantic Ridge (Waring et al. 2008). See Table 12 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 150 km. They selected the first grouping of consecutive tracklines that had a total length of 150 km to represent the daily area that could be ensonified during seismic activities.

The design of the proposed seismic activities influenced how NMFS estimated exposure. The survey tracklines for the proposed action consist of two main parts: the long, single multichannel seismic (MCS) trackline, and the OBS station tracklines running north and south, each ~110 km in length (Figure 3). NSF plans to conduct the survey by completing the OBS tracklines first, and then survey the MCS trackline. According to NSF, the OBS tracklines are estimated to take 5 days, and the MCS trackline to take 22 days to complete acquisition. When calculating exposure, the NMFS Permits and Conservation Division calculated an ensonified area for the OBS tracklines and the MCS tracklines separately.

An exclusion zone representing the predicted RMS distances (5.7 km) was then applied to the OBS and MSC trackline ensonified areas; this buffer distance was provided by L-DEO. The Permits and Conservation Division estimated the daily ensonified area to be 1,170 km^2 for the OBS tracklines, and 1,558 km^2 for the MCS trackline[6]; this estimate does not account for overlap of ensonified areas. To account for additional contingency effort, the Permits and Conservation Division included a 25% increase in the number of days (increasing from 5 to 6 for the OBS tracklines, and from 22 to 28 for the MCS trackline).

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 34 days. This figure resulted in the final Permits and Conservation Division estimated take numbers. This calculation assumes 100% 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 Permits and Conservation Division used the Navy's Atlantic Fleet Training and Testing Navy Marine Species Density Database maps to estimate species density in the survey area in the South Atlantic Ocean. For species where the instance of exposure was less than one (humpback and blue whales), or no density information was available (Southern right whale), the number of individuals exposed was increased to the mean group size based upon AMAPPS survey data. The results of the Permits and Conservation Division's calculations and their proposed take numbers is in Table 12.

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[6] The difference in daily ensonified areas is caused by the different lengths traveled in a single day on the OBS tracklines (110 km) and the MCS trackline (150 km). The Langseth would only be able to complete one OBS trackline in a single day.

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

Fin, sei, humpback, blue and Southern right whales of all age classes are likely to be exposed. Given that the survey will take place 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 (Gambell 1985a; Horwood 2009) (Branch 2007; Clapham 2009; Kenney 2009). Whales are expected to be feeding, traveling, or migrating in the area and some females would have young-of-the-year accompanying them. We would normally assume that sex distribution is even for fin, sei, humpback, 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 12. Comparisons of the proposed take estimates calculated by the NMFS Permits and Conservation Division and the NSF for ESA-listed marine mammals.

Species	NSF Exposure Estimate	NMFS Exposure Estimate
Humpback Whale	2	3
Fin Whale	754	134
Sei Whale	263	134
Sperm Whale	86	50
Southern right Whale	2	18
Blue Whale	1	2

6.3.3.1 Exposure of ESA-listed marine mammals 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.

6.3.4 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}. Exposure estimates stem from the best available information on turtle densities and a predicted RMS radius of approximately 3.7 km along survey track lines, including areas of repeated exposure from adjacent track lines and turning legs. 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."

6.3.4.1 Exposure of ESA-listed turtles to airguns

NSF presented estimated distances for the 166 dB re 1 μPa_{rms} sound levels generated by the 36 45 in^3 GI-guns. When the array is towed at 9 m, in deep water (>1000 m), the predicted established distance at received levels is 3,740 m. 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 is one ESA-listed sea turtle species that is likely to be affected by the proposed action: leatherback sea turtles.

Estimating exposure for leatherback sea turtles in the action area was challenging, as there is scant information on sea turtle density or population estimates specific to the waters in the South Atlantic near the Mid-Atlantic Ridge. To estimate exposure for sea turtles, we relied on recent status reviews, reports and scientific literature focusing on sea turtles in the area.

Significant nesting beaches occur on both sides of the South Atlantic; on the west coast of Africa centered around Gabon, and in South America in Guyana, French Guiana, Suriname and southern Brazil. Nesting in Gabon occurs from September to April and from September to February in Brazil (Thomé et al. 2007).

Leatherbacks are well-known to undergo long-distance migrations (up to 11,000 km) (Benson et al. 2011a), and show different dispersal patterns after nesting. Adult females tagged in Gabon either traveled 1) in the equatorial Atlantic (10°S), 2) towards Southern Africa (~8-30°S), or across the Atlantic to Brazil, Uruguay, and Argentina (Witt et al. 2011). Other individuals tagged in Gabon were later recovered in South America (Billes et al. 2006). An adult female tagged in Brazil traveled east across the Atlantic Ocean to Angola (Almeida et al. 2011).

The information available indicates that leatherbacks do transit the South Atlantic Ocean after nesting, and although a single migratory corridor is not well-defined, tagged leatherbacks have traveled near and around the action area. According to the OBIS database, there is at least one record of a leatherback sea turtle in the action area. Based on the timing of the proposed action (January through March), it is possible that adult female leatherbacks could be transiting the area during their post-nesting movements. Leatherbacks nesting season lasts from 5 to 8 months, and this broad span of time means that it is possible that a female could nest and begin migrating across the South Atlantic during the time the proposed seismic activities occur. Movements of hatchling and juvenile leatherback sea turtles are not well known, but they are thought to rely on ocean currents after leaving the nesting beaches (Luschi et al. 2003a). It is likely that hatchlings could emerge from their nests during the survey, since hatchlings take about 2 months to emerge from their nests (Fossette et al. 2008). We do not think it is likely that leatherback hatchlings will be exposed to the proposed seismic activities, because the ocean currents in the area do not travel directly through the action area.

We are unable to quantify the level of leatherback sea turtle exposure. However, we do not expect leatherback sea turtle exposure to occur at high levels because the available information indicates that the species not reported to be highly abundant in the action area. As discussed earlier, there are no reliable leatherback sea turtle population estimates for the South Atlantic. Thus, it is not possible to quantify the proportion of the overall population that may be exposed to the proposed activity.

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

Sea turtles hear in the low frequency range. The multibeam echosounder and the SBP 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.

6.3.5 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.

6.3.5.1 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 temporary threshold shift (TTS) results in a temporary hearing change (Finneran and Schlundt 2013). TTSs 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. 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 ~186 dB SEL or ~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 ~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 >230 dB re 1 μPa peak (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of ~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 ~198 dB re 1 μPa^{2}s.

Overall, we do not expect TTS or PTS to occur to any ESA-listed whale 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 μPa_{p-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 ~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. 2007a; 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 ~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. (2007b) 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 ~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 <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 <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 ~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 – e.g., 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.

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 µPa · 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. 2012a). 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. 1996a; 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). TTS was not found in whitefish at received levels of ~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 μPa_{p-p}. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish and capelin eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne et al. 2009). Salmonid swim bladders were reportedly damaged by received sound levels of ~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 μPa_{0-p} and alarm responses at >177 dB re 1 μPa_{0-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 μPa_{0-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 μPa_{0-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. 1996a). 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 $\mu Pa_{0\text{-}p}$ (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. (1996b) 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 ~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 and pinnipeds to experience ensonification from not only airguns, but also seafloor and ocean current mapping systems. Multibeam echosounder and sub-bottom profiler frequencies are much higher than frequencies used by all ESA-listed marine mammals except humpback and sperm whales. We expect that these systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng et al. 2014). However, we do not expect these sub-harmonic frequencies in these systems to be audible to these species. 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 (Ketten 1997; Richardson et al. 1995c). Thus, if fin or sei whales are exposed, they are unlikely to hear these frequencies well (if at all) and a response is not expected.

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 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 Southern right, blue, fin, sei, sperm, or humpback whale communications to appreciably occur due to multibeam echosounder or sub-bottom profiler signal directionality, low duty cycle, and the brief period when an individual could be within its beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multibeam echosounder was less than 3% 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.

6.3.5.2 Potential Response of Sea turtles to Acoustic Sources

As with marine mammals, sea turtles may experience

- hearing threshold shifts
- behavioral responses
- 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 (Nelms et al. 2016). 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 $_{\mathrm{rms}}$ (or slightly less) in a shallow canal. Green and loggerhead sea turtles avoided airgun sounds at received sound levels of 166 dB re 1 µPa and 175 dB re 1 µPa, respectively (McCauley et al. 2000a; McCauley et al. 2000b). Sea turtle swimming speed increased and becomes more erratic at 175 dB re 1 µPa, with individuals becoming agitated. Loggerheads also appeared to move towards the surface upon airgun exposure (Lenhardt 1994b; Lenhardt et al. 1983). However, loggerheads resting at the ocean surface were observed to startle and dive as active seismic source approached them (DeRuiter 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 (~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 ~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.

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 0) 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 0).

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 PR1 proposes to authorize the incidental take of marine mammals. These species include: Southern right whales, blue 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 South Atlantic 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 18 Southern right, 2 blue, 134 fin, 134 sei, 3 humpback, and 50 sperm whales could be exposed to airgun sounds which will elicit a behavioral response of temporarily moving out of the area. We expect a low-level, transitory stress response to accompany this behavior. 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.

ESA-Listed turtles. ESA-listed turtles that are expected to occur within the action area include leatherback sea turtles which are endangered. The *Status of Listed Resources* section found that leatherback 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 leatherback 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 leatherback sea turtles. Overall, we do not expect any individual leatherback 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 leatherback sea turtle to experience fitness reductions, we also do not expect reductions in the viability of the populations to which these individuals belong or the viability of the species those populations comprise.

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 sea turtles. There is no critical habitat in 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 or "the extent of land or marine area that may be affected by an action" may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953).

Section 7(b)(4)(C) of the ESA specifies that in order to provide an incidental take statement for an endangered or threatened species of marine mammal, the taking must be authorized under section 101(a)(5) of the MMPA. One of the Federal actions considered in this opinion is NMFS's Permits and Conservation Division's proposed authorization of the incidental taking in the form of harassment of blue, fin, sei, humpback, sperm and Southern right whales pursuant to section 101(a)(5)(D) of the MMPA. The final authorization would be issued and its mitigation and monitoring measures incorporated in this incidental take statement as terms and conditions. With this authorization, the incidental take of ESA-listed whales would be exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA as long as such take occurs consistent with this statement.

The NMFS anticipates the proposed seismic survey in the South Atlantic Ocean is likely to result in the incidental take of ESA-listed species by harassment (Table 13). We expect up to 2 blue, 18 southern right, 134 fin, 134 sei, 3 humpback, and 50 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. Additional exposures to the same individuals sufficient to elicit responses may also occur.

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 13. 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	2
Fin whale	134
Sei whale	134
Humpback whale	3
Southern right whale	18
Sperm whale	50

We also expect individual leatherback sea turtles could be exposed to airgun sounds during the course of the proposed seismic survey that will elicit a behavioral response that would constitute harassment. No death or injury is expected for individuals who are exposed to the seismic activities. Harassment for sea turtles is expected to occur at received levels above 166 dB re: 1

µPa, which includes a 3.74 km distance in the South Atlantic Ocean based upon the propagation and trackline estimates provided by the NSF. If these amounts change, then incidental take for marine mammals or sea turtles may be exceeded. As such, if more trackline, greater estimates of sound propagation, and/or increases in airgun source levels occur, re-initiation of consultation may be necessary. As we cannot determine the number of individuals to which harassment will occur (because there is scant information on sea turtle density or population estimates specific to the waters in the South Atlantic near the Mid-Atlantic Ridge) 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 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 leatherback sea turtles. In addition, the Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and to inform the 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 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 Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

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

1. The ITS limits the incidental taking of ESA-listed species by harassment only, to the species listed in Table 13.
    a. 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.
2. Reporting Prohibited Take
    a. 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, National Marine Fisheries Service, at 301-427-8401 and/ or by email to Jolie.Harrison@noaa.gov and to Cathy Tortorici ESA Interagency Cooperation Division Chief at Cathy.Tortorici@noaa.gov.
3. Cooperation
    a. We require the Holder of this Authorization to cooperate with the Office of Protected Resources, National Marine Fisheries Service, and any other Federal, state, or local agency monitoring the impacts of the activity on marine mammals.
4. Mitigation and Monitoring Requirements
    a. 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:

        i. 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.
        ii. At least one visual observer will be on watch during meal times and restroom breaks
        iii. Visual observer shifts will last no longer than four hours at a time.
        iv. 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.
        v. 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.
        vi. The *Langseth's* vessel crew will also assist in detecting marine mammals, when practicable.
        vii. Visual observers will have access to reticle binoculars (7×50 Steiner), and big-eye binoculars (25×150), optical range finders, and night vision devices.

5. Exclusion Zones
    a. Establish a 180-decibel (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).
6. Visual Monitoring at the Start of Airgun Operations
    a. 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.
    b. 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.
    c. 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 180-dB exclusion zone for cetaceans or 190-dB exclusion zone for pinnipeds (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).

7. Passive Acoustic Monitoring
   a. 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.
   b. 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, etc.), types and nature of sounds heard (*e.g.*, clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.
8. Ramp-Up Procedures
   a. 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.
9. Recording Visual Detections
   a. 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.

10. Speed or Course Alteration
    a. 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.
11. Power-Down Procedures
    a. 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). 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.
12. Resuming Airgun Operations after a Power-Down
    a. 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 pinnipeds) or 30 minutes for species with longer dive durations (*i.e.*, mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).
    b. 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.
13. Shutdown Procedures
    a. 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.
14. Resuming Airgun Operations after a Shutdown
    a. 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.
    b. 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 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.

15. Survey Operations
    a. 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.
    b. 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.
16. Mitigation Airgun
    a. The *Langseth* may operate a small-volume airgun (*i.e*., mitigation airgun) during turns, brief transits between seismic tracklines, and maintenance at approximately one shot per minute. The *Langseth* would not operate the small-volume airgun for longer than three hours in duration.
17. Special Procedures for Large Whale Concentrations
    a. The *Langseth* will avoid concentrations of large whales (*i.e*., mysticetes and/or sperm whales [*Physeter microcephalus*]) if possible (*i.e*., *i.e*., avoid exposing concentrations of these animals to sounds greater than 160 dB re: 1 µPa), and power-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.
18. Reporting Requirements
    a. This Authorization requires the Holder of this Authorization to:
        i. 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, National Marine Fisheries Service, within 90 days of the completion of the *Langseth's* cruise. This report must contain and summarize the following information:
            1. 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.
            2. 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.
            3. 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.

        4. 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.
        5. 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.
    - ii. Submit a final report to the Chief, Permits and Conservation Division, and the Chief, ESA Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, 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.

19. Reporting Prohibited Take
    - a. 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.
    - b. The report must include the following information:
        - i. Time, date, and location (latitude/longitude) of the incident;
        - ii. Name and type of vessel involved;
        - iii. Vessel's speed during and leading up to the incident;
        - iv. Description of the incident;
        - v. Status of all sound sources used in the 24 hours preceding the incident;
        - vi. Water depth;
        - vii. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);
        - viii. Description of all marine mammal observations in the 24 hours preceding the incident;
        - ix. Species identification or description of the animal(s) involved;
        - x. Fate of the animal(s); and
        - xi. Photographs or video footage of the animal(s) (if equipment is available).
    - c. 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.

20. Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death
    a. 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.
    b. The report must include the same information identified in Condition 8. 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.
21. Reporting an Injured or Dead Marine Mammal Unrelated to the Activities
    a. 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.
    b. Lamont-Doherty would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.
22. Endangered Species Act Biological Opinion and Incidental Take Statement
    a. 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' Office of Protected Resources, Permits and Conservation Division.
    b. 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).

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

We recommend the following conservation recommendations, which would provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorization that may affect endangered marine mammals as well as endangered or threatened sea turtles and fishes:

1) The NSF should promote and fund research examining the potential effects of seismic surveys on listed sea turtles 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.

10 REINITIATION OF CONSULTATION

This concludes formal consultation for the proposed seismic survey to be funded by the NSF and conducted by the L-DEO on board the *R/V Langseth* in the South Atlantic Ocean, and NMFS Permits and Conservation Division's 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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