National Marine Fisheries Service
Endangered Species Act Section 7 Consultation
Biological Opinion FPR-2014-9089

Agencies: Division of Polar Programs, National Science Foundation and Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, NOAA

Activities Considered: Geophysical survey in the Scotia Sea and South Atlantic Ocean and issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act

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

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Date: SEP 19 2014

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ABBREVIATIONS AND ACRONYMS

ASC	Antarctic Support Contract
dB	Decibel
ESA	Endangered Species Act
GI	generator-injector
Hrs	Hours
IHA	Incidental Harassment Authorization
IWC	International Whaling Commission
kHz	Kilohertz
Kts	Knots
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
Opinion	this biological opinion
Permits Division	NMFS Office of Protected Resources, Permits and Conservation Division
PSO	protected species observer
PTS	permanent threshold shift
p-p	peak-to-peak
Rms	root mean square
TTS	temporary threshold shift
μPa	Micropascal
0-p	Peak

A Note on Sound Measurements Used in This Opinion

This section includes a brief explanation of the sound measurements frequently used in the discussions of acoustic effects in this Opinion.

Sound pressure is the sound force per unit micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. *Sound pressure level* is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in underwater acoustics is 1 μPa, and the units for sound pressure levels are decibels (dB) re 1 μPa. Sound pressure level (in dB) = 20 log (pressure/reference pressure).

Sound pressure level is an instantaneous measurement and can be expressed as *peak* (0-p), *peak-to-peak* (p-p), or *root mean square* (rms). Root mean square, which is the square root of the arithmetic average of the squared instantaneous pressure values, is typically used in discussions of the effects of sounds on vertebrates. All references to sound pressure level in this document are expressed as root mean square. In instances where sound pressure levels for airguns were originally expressed as peak or peak-to-peak, we used the following rough conversions in order to express those values in root mean square:

- root mean square is approximately 10 dB lower than peak
- root mean square is approximately 16 dB lower than peak-to-peak

We reported the original peak or peak-to-peak measurements in footnotes. It should also be noted that sound pressure level does not take the duration of a sound into account.

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1536(a)(2)), requires Federal agencies to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat. When a Federal agency's action may affect ESA-listed species or critical habitat, formal consultation with National Marine Fisheries Service (NMFS) and/or the U.S. Fish and Wildlife Service is required (50 CFR 402.14(a)). The National Science Foundation (NSF), Division of Polar Programs and the National Oceanic and Atmospheric Administration (NOAA) NMFS Office of Protected Resources, Permits and Conservation Division (hereafter referred to as "the Permits Division") are the Federal action agencies for activities described in this document.

The NSF proposes to allow the use of U.S. Antarctic Program's research vessel, *Nathaniel B. Palmer*, (operated by Lockheed Martin Antarctic Support Contract [ASC]) to conduct a geophysical survey in the Scotia Sea and South Atlantic Ocean from September to October, 2014. The NSF would fund the project, and the research would be conducted by University of Texas at Austin and University of Memphis. The Permits Division proposes to issue an Incidental Harassment Authorization (IHA), pursuant to section 101 (a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA) (16 U.S.C. § 1361 et seq.), to NSF for harassment of marine mammals during the proposed survey (79 FR 45591).

NMFS's Office of Protected Resources, ESA Interagency Cooperation Division consulted with NSF and the Permits Division on their actions. This document represents our biological opinion (Opinion) of their actions and the effects on ESA-listed species. We based our Opinion on the items included in NSF's consultation initiation package, the Permits Division's proposed IHA, and the best scientific and commercial data available, as found in: recovery plans, status reviews, scientific publications, past biological opinions, and other sources of information. We prepared our Opinion in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536(a)(2)), associated implementing regulations (50 CFR 402), and agency policy and guidance (USFWS and NMFS 1998).

2 CONSULTATION HISTORY

Our communication with NSF and the Permits Division regarding this consultation is summarized as follows:

- January to February 2014
    - provided technical assistance to NSF in the form of marine mammal density recommendations
- April 17, 2014
    - received an email requesting initiation of formal section 7 consultation
- June 20, 2014
    - initiated consultation and asked NSF clarifying questions about its proposed action
    - informed NSF we will attempt to issue a final biological opinion by September 20, 2014
- June 24, 2014
    - received draft proposed IHA from the Permits Division
- June to July 2014
    - requested additional information from NSF about its proposed action
- July 24, 2014

    - received memo from the Permits Division requesting initiation of formal section 7 consultation
    - Permits Division requested a final biological opinion be issued by September 19, 2014
- August 11, 2014
    - NSF requested a draft of the Opinion
- August 14, 2014
    - sent NSF a draft of the Description of the Actions
- August 18, 2014
    - incorporated NSF's suggested edits into the Description of the Actions

3 Description of the Actions

The proposed action for this consultation consists of two related actions:

1. NSF's proposed geophysical (seismic) research activities; and
2. the Permits Division's proposed issuance of an IHA.

3.1 NSF Geophysical Research

The NSF proposes to use a U.S. Antarctic Program research vessel to conduct the following research activities in the Scotia Sea and South Atlantic Ocean:

- low-energy seismic surveys
- bathymetric profiling, imaging surveys, and magnetometry of the seafloor
- dredge sampling around the edges of seamounts or ocean floor

Transit to and from the research areas is also considered part of the action.

Installation of three continuous Global Navigation Satellite Systems on the South Georgia microcontinent is also proposed. However, because this action is entirely land-based and would have no effect on ESA-listed marine species, it will not be discussed further in this Opinion.

3.1.1 Research Vessel

The U.S. Antarctic Program research vessel/icebreaker *Nathaniel B. Palmer* would be used to conduct the proposed research activities. The *Palmer's* specifications are:

- length: 93.9 m
- beam: 18.3 m
- draft: 6.8 m
- gross tonnage: 6,174
- four Caterpillar Model 3608 diesel engines provide propulsion
    - each engine is rated at 3,300 brake horsepower at 900 revolutions per minute
- four Caterpillar 3512, 1,050-kilowatt diesel generators provide electrical power
- one 1,050-kilowatt water jet azimuthing bow thruster provides 1,400 break horsepower
- two generator-injector Borsig-LMF seismic air compressors
    - compress air at 1,200 cubic feet per minute at 2,000 pounds per square inch
- maximum speed: 26.9 km/hr (14.5 knots [kts])
- average speed: 18.7 km/hr (10.1 kts)
- operating range: 27,780 km (approximately 70 to 75 days)

- accommodation capacity: 22 crew and 37 scientists

The *Nathaniel B. Palmer* would depart from Punta Arenas, Chile on or around September 22, 2014 and return to Punta Arenas on or around October 22, 2014. It is expected that transit to and from the project area would take six days each (approximately 12 days total transit time). Estimates in NSF's proposed itinerary are based primarily on a transit speed of 18.7 km/hr (10.1 kts), though NSF states that actual speed is usually slightly greater. The maximum speed of the *Palmer* is 26.9 km/hr (14.5 kts).

During seismic activities, cruising speed would vary between 7.4 to 11.1 km/hr, for an average of 9.3 km/hr (4 to 6 kts; average of 5 kts). Cruising speed during dredging activities would be less than 3.7 km/hr (2 kts).

The *Palmer* would also serve as the platform from which protected species observers (PSOs) would watch for marine mammals before and during seismic activities.

3.1.2 Seismic Survey

The seismic survey would be conducted with a two-generator injector (GI) airgun array and either one or two 100-m solid-state hydrophone streamer(s) towed behind the *Palmer*. A third airgun would serve as a "hot spare"[1] to be used as a backup in the event that one of the airguns malfunctions.

The airguns would be deployed in one string at a depth of 3 to 4 m below the surface, spaced approximately 3 m apart and between 15 and 40 m astern. The generator and injector of each airgun would have displacement volumes of 1,721 cm^3 (105 in^3) and approximate firing pressures of 2,000 pounds per square inch. The airguns would be operated in "harmonic mode"[2] to maximize data resolution by minimizing noise created by bubble oscillations.

Weather conditions permitting, it is anticipated that the length of the seismic survey would not exceed 2,950 km and the duration of operation would not exceed 325 hours (hrs), total. Table 1 summarizes the proposed seismic survey activities and specifics of the airgun array.

Table 1. Geophysical survey activities and airgun array of the Scotia Sea and South Atlantic Ocean proposed by the National Science Foundation.

Length (km)	Speed (km/hr)	Duration[1] (hr)	Airguns (number)	Airgun Volume (cm^3)	Airgun Firing Frequency (sec)	Streamer Length (m)
2,950	9.3	≤ 325	2	1,721	5-10	100

[1] Seismic surveys will not exceed 40 hrs at a time.

During the seismic survey, the vessel would attempt to maintain a constant cruise speed of approximately 9.3 km/hr (5 kts). At this cruising speed, the airguns would fire between 360 and 720 shots per hr (i.e. the *Palmer* would travel approximately 12.9 to 25.8 m between shots). The airguns would be operated for no more than 40 hrs at a time, and the cumulative duration of airgun operation would not exceed 325 hrs. The hours and survey length would include equipment testing, ramp-up, line changes, and repeat coverage of lines, if needed.

[1] An airgun that is primed and ready for use, but is not firing.

[2] "Harmonic mode" is when the volume of the generator chamber (which introduces bubble into the ocean) equals the volume of the injector chamber (which injects air into the bubble created by the generator chamber to maintain the bubble's shape) for each gun.

3.1.2.1 Airgun Acoustic Modeling

The Lamont-Doherty Earth Observatory of Columbia University modeled the acoustic output of the airguns proposed for use (see Appendix A in NSF 2014) . Though the modeling software (Nucleus) used at Lamont-Doherty Earth Observatory does not include GI guns as part of its airgun library, signatures and mitigation models were obtained for two 1,721-cm^3 (105-in^3) generator guns[3] at 3 m tow depth. Because generator guns lack the injector that stabilizes the generator-produced bubble in a GI gun, acoustic modeling outputs for generator guns are greater (by approximately 10 percent) than the actual acoustic output of GI guns.

The Lamont-Doherty Earth Observatory further compared the modeled result to empirical measurements of received sound from a two-1,721-cm^3 (105-in^3) GI airgun array acoustic verification study conducted by Lamont-Doherty Earth Observatory in the northern Gulf of Mexico in 2003 (Tolstoy et al. 2004). Because measurements for the two-airgun array were obtained in water depths less than 1,000 m, correction factors for received sound levels in water greater than 1,000 in depth (i.e., the depth at which the proposed project would occur) were developed. Table 2 summarizes estimates of maximum distances to received sound levels[4] based on modeling and empirical measurements (with correction factors applied).

Table 2. Estimated radial distances of received sound levels of 190, 180, and 160 dB re 1 µPa$_{rms}$ resulting from the proposed seismic activities in the Scotia Sea and South Atlantic Ocean.

				Estimated Radial Distances of Received Sound Levels (m)		
Airgun Type	**Airguns (number)**	**Airgun Volume (cm^3)**	**Water Depth (m)**	**190 dB**	**180 dB**	**160 dB**
GI	2	1,721	> 1,000	20	69	670

The NSF used the estimated radial distances of the received sound level for 160 dB re 1 µPa$_{rms}$ to develop a 670-m "buffer zone"[5] for the proposed project. Typically, estimated radial distance of received sound level for 180 dB re 1 µPa$_{rms}$ is used to determine the size of the "exclusion zone"[6]. However, because the estimated radial distance of received sound level at 180 dB 1 µPa$_{rms}$ was modeled at 69 m for the proposed project, NSF would use the 100-m exclusion zone that was defined for all low-energy acoustic sources in water depths greater than 100 m in NMFS's *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (NSF and USGS 2011).

Please see Section 8 of this document for further discussion of the rationale behind the development of the exclusion zone and buffer zone.

3.1.2.2 Monitoring and Mitigation

Monitoring and mitigation measures for the seismic survey would include:

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[3] Generator guns are often referred to as "G guns".

[4] Sound levels expressed in decibels referenced to one micropascal, root mean square (dB re 1 µPa$_{rms}$).

[5] The "buffer zone" is defined as the area expected to be ensonified to at least 160 dB re 1 µPa$_{rms}$, the received sound level at which the Permits Division assumes Level B harassment will occur in cetaceans. See Section 8 of this document for further discussion about harassment.

[6] The "exclusion zone" is defined as the area expected to be ensonified to at least 180 dB re 1 µPa$_{rms}$, the received sound level at which the Permits Division assumes Level A harassment will occur in cetaceans. See Section 8 of this document for further discussion about harassment.

- establishing the exclusion zone and buffer zone
- employing protected species observers (PSOs)
- ramp-ups
- shut-downs

These measures are discussed in greater detail in Section 3.2 of this document.

3.1.3 Bathymetric Profiling, Imaging Surveys, and Passive Instrumentation

In addition to the seismic surveys, geophysical measurements would be made for the following purposes:

- bathymetric profiling
- imaging surveys
- magnetometry

In addition to their use for the above purposes, some transducer-based instruments would be used continuously during the cruise for operational and navigational purposes.

The following are the instruments that would be used and their specifications:

- **single beam echo sounder**
  - hull-mounted Compressed High-Intensity Radiated Pulse (CHIRP) sonar
  - sonar emits energy in a 30° beam from the bottom of the ship at frequencies of
    - 12 kHz for bottom-tracking purposes
    - 3.5 kHz in the sub-bottom profiling mode
  - has an estimated maximum source energy level of 222 dB re 1 μPa_{rms}
  - would be operated continuously during all phases of the cruise
  - one of the following two echo sounders would be used (specific model would be selected by the researchers)
    - Knudsen 3260
    - Bathy 2000
      - preferred echo sounder during many previous *Palmer* surveys
- **multi-beam sonar**
  - Simrad EM120
    - hull-mounted
    - emits a narrow (less than 2°) beam fore to aft and 150° in cross-track
    - emits a series of nine consecutive 15 millisecond pulses
    - operates at a frequency of 12 kHz
    - has an estimated maximum source energy level of 242 dB re 1 μPa_{rms}
    - would be operated continuously during the cruise
- **acoustic Doppler current profiler**
  - Teledyne RDI VM-150
    - hull-mounted
    - would be operated continuously during the cruise
    - energy is emitted as a 30° conically-shaped beam
    - operates at a frequency of 150 kHz
    - estimated acoustic output level at the source is 223.6 dB re 1 μPa_{rms}
  - Ocean Surveyor OS-38

        - specifications are similar to the Teledyne RDI VM-150
        - would serve as a backup
- **passive instruments**
    - precession magnetometer
    - air-sea gravity meter
    - expendable bathythermographs
        - approximately 60 expendable bathythermographs would be released (and would not be recovered) over the course of the cruise to obtain temperature data necessary to calculate sound velocity profiles used by multi-beam sonar

3.1.4 Dredge Sampling

Dredge sampling would be conducted to acquire in situ rock samples from deep marine rises (escarpments) at 1,000 to 4,000 m depth to determine composition and age of the seafloor. Multibeam and seismic data obtained during the cruise would be used to locate submarine outcrops. Dredging would be conducted upslope along ledges. No dredging would occur along the top of seamounts. Final selection of dredge sites would include a review to ensure that seamounts or corals in the area are avoided.

It is anticipated that researchers would survey and dredge two deep marine rises and one topographic high (see areas A and B in Figure 2; page 17). No more than three samples would be collected in each area. Dredge buckets would measure less than 1 m across and each sample area to be dredged would be no longer than 1,000 m; therefore, approximately 1,000 m^2 of seafloor would be disturbed by each deployment of the dredge. A total of approximately 6,000 m^2 of seafloor would be disturbed for the entire project. Each dredge effort would require approximately 6 hrs; therefore, dredges would be in the water a total of approximately 36 hrs. During dredging efforts, the vessel speed would be less than 3.7 km/hr (2 kts). NSF assumes that noise associated with the mechanical actions of the dredging would be below 120 dB.

Dredging would be performed with a Scripps Institution of Oceanography-style deep sea rock dredge. The dredge would be attached to the *Palmer's* deep sea trawl winch's (Markey DUSH-9-11) 1.4-cm mechanical wire using a chain bridle. The dredge would be lowered slowly to the sea floor and the *Palmer* would move down the dredge line while slowly paying out on the winch at a speed of about 31 m/min (1 kt). The vessel would hold station while slowly paying in the dredge to obtain the sample. Using this method would allow the crew to maintain tension evenly in the event the dredge is caught on or skips along the ocean bottom.

The NSF has obtained a permit from the Government of South Georgia and South Sandwich Islands for dredging and sampling of the seafloor within the Marine Protected Area in the South Georgia and South Sandwich Islands Maritime Zone. Additionally, the Commission for the Conservation of Antarctic Marine Living Resources has adopted conservation measures to protect vulnerable marine ecosystems, including seamounts, hydrothermal vents, cold water corals, and sponge fields. Though vulnerable marine ecosystems would be avoided during dredging activities, researchers would follow the Commission for the Conservation of Antarctic Marine Living Resources conservation measures if any vulnerable marine ecosystems would be encountered.

3.2 NMFS's Incidental Harassment Authorization

The Permits Division proposes to issue an IHA for non-lethal "takes"[7] of marine mammals by Level B harassment (as defined by the MMPA) incidental to NSF's proposed action (79 FR 45591). The IHA would be valid from September 20 to December 1, 2014 and would authorize the incidental harassment of six ESA-listed whale species as well as 21 non-ESA-listed whale, dolphin, porpoise, and pinniped species. Table 3 shows the amount of take for the six ESA-listed species that would be authorized under the IHA.[8] Section 8.2.1 of this document contains more information about the methods used to calculate these take numbers.

Table 3. Amount of incidental harassment (takes) of ESA-listed whales authorized under the proposed IHA.

Common Name	Scientific Name	MMPA-authorized Takes
Blue whale	*Balaenoptera musculus*	1
Fin whale	*B. physalus*	72
Humpback whale	*Megaptera novaeangliae*	3
Sei whale	*B. borealis*	25
Southern right whale	*Eubalaena australis*	31
Sperm whale	*Physeter macrocephalus*	8

The proposed IHA would include the following mitigation, monitoring, and reporting requirements applicable to ESA-listed species:

- buffer and exclusion zones
  - prior to operation of the airgun array, a 160 dB re 1 μPa_{rms} buffer zone and 180 dB re 1 μPa_{rms} exclusion zone for cetaceans must be established
- PSOs and visual monitoring
  - three PSOs shall be based onboard the vessel
  - one NMFS-qualified, vessel-based PSO would visually 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 ramp-ups of airguns, day or night
    - PSOs shall
      - have shifts lasting no longer than 4 hrs at a time
      - have access to reticle binoculars (7 x 50 Fujinon) equipped with a built-in daylight compass and range reticles
      - make observations during daytime periods when seismic airguns are not operating for comparison of animal abundance and behavior, when feasible
      - conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water

[7] By regulation, "take" under the MMPA means "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal". This includes, without limitation, any of the following: the collection of dead animals, or parts thereof; the restraint or detention of a marine mammal, no matter how temporary; tagging a marine mammal; the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; and feeding or attempting to feed a marine mammal in the wild. Under the ESA, "take" means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to do any of the preceding".

[8] Please see proposed IHA for MMPA-authorized takes of whale, dolphin, porpoise, and pinniped species not listed under the ESA (79 FR 45591).

        - record the following information when a marine mammal is sighted
            - 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
                - this information shall also be recorded 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
            - time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, and sun glare
    - PSOs would visually observe the entire extent of the exclusion zone for at least 30 min prior to starting the airgun array (day or night)
        - if the PSO(s) see a marine mammal within the exclusion zone, the seismic survey would be delayed until the marine mammal(s) has left the area
            - if the PSO(s) sees a marine mammal that surfaces, then dives below the surface, the PSO(s) would wait 30 min
                - if the PSO sees no marine mammals during that time, they would assume that the animal has moved beyond the exclusion zone
    - the *Palmer*'s crew shall also assist in detecting marine mammals, when practicable
    - if, for any reason (i.e., rough seas, fog, darkness), the entire radius cannot be seen for the entire 30 min, or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be ramped-up
        - if one airgun is already running at a source level of at least 180 dB re 1 μPa_{rms}, the second airgun could be started without observing the entire exclusion zone for 30 min prior, provided no marine mammals are known to be near the exclusion zone (in accordance with the ramp-up procedures described below)
- ramp-up procedures
    - "ramp-up"[9] procedures would be implemented when beginning seismic operations or any time the entire array has been shut-down[10] for more than 15 min
        - during ramp-up, PSOs shall monitor the exclusion zone, and if marine mammals are sighted, a shut-down shall be implemented as though the full array (both GI airguns) were operational
        - initiation of ramp-up procedures from shut-down would require that PSOs be able to view the full exclusion zone
- shut-down procedures
    - airgun(s) would be shut down if a marine mammal is detected within, approaches, or enters the exclusion zone
        - following a shut-down, airgun activity shall not resume until the PSO(s) either:

[9] For this survey, a "ramp-up" would consist of firing one GI airgun for five min before starting the second airgun.
[10] "Shut-down" means all operating airguns are turned off.

        - have visually observed the marine mammal exiting the exclusion zone and it is not likely to return; or
        - have not seen the marine mammal within the exclusion zone for 30 min
    - following a shut-down and subsequent animal departure, airgun operations could be resumed, following ramp-up procedures described above
- speed or course alteration
    - if, based on its position and relative motion, a marine mammal appears likely to enter the exclusion zone, the *Palmer's* speed or course would be altered
        - further mitigation measures, such as a shut-down shall be taken if speed or course alteration is not safe or practicable or, if after alteration, the marine mammal still appears likely to enter the exclusion zone
- survey operations at night
    - survey operations would be scheduled during daylight hours, to the maximum extent practicable
    - survey operations may continue into night and low-light hours if the survey is initiated when the entire exclusion zone is visible and can be effectively monitored
    - no initiation of airgun operations is permitted at night or during low-light hours (such as in dense fog or heavy rain) when the entire exclusion zone cannot be effectively monitored by the PSO(s)
- reporting requirements
    - within 90 days of the completion of the cruise, the NSF and ASC are required to submit a draft report to the Permits Division containing and summarizing the following information:
        - 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
        - species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (e.g., number of shut-downs), observed throughout all monitoring activities
        - an estimate of the number (by species) of marine mammals that
            - are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa_{rms} (for seismic airgun operations), and/or 180 dB re 1 μPa_{rms}
                - including a discussion of any specific behaviors those individuals exhibited
            - may have been exposed (based on modeled values for the two GI airgun array) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa_{rms} (for seismic airgun operations), and/or 180 dB re 1 μPa_{rms}
                - including a discussion of the nature of the probable consequences of exposure on the individuals that have been exposed
        - a description of the implementation and effectiveness of the
            - Terms and Conditions of the biological opinion's Incidental Take Statement (Section 12.4)
                - the report shall 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 ESA-listed marine mammals

- mitigation measures of the IHA

- within 30 days after receiving comments from NMFS on the draft report, submit a final report to the Chief, Permits Division
  - if the Permits Division decides that the draft report needs no comments, the draft report shall be considered to be the final report

- reporting prohibited take
  - in the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA (i.e. injury [Level A harassment][11] or serious injury or mortality [e.g., ship-strike, gear interaction, and/or entanglement]), NSF and ASC shall immediately cease the specified activities and immediately report the incident to the Chief, Permits Division and include the following information:
    - time, date, and location (latitude/longitude) of the incident
    - the name and type of vessel involved
    - the vessel's speed during and leading up to the incident
    - description of the incident
    - status of all sound source use in the 24 hrs preceding the incident
    - water depth
    - environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility)
    - description of marine mammal observations in the 24 hrs preceding the incident
    - species identification or description of the animal(s) involved
    - fate of the animal(s)
    - photographs or video footage of the animal (if equipment is available)
  - activities shall not resume until NMFS is able to review the circumstances of the prohibited take
    - NMFS shall work with NSF and ASC to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance
    - NSF and ASC may not resume their activities until notified by NMFS via letter, email, or telephone
- reporting an injured or dead marine mammal with an unknown cause of death
  - in the event that NSF and ASC discover an injured or dead marine mammal, and the lead PSO 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 described in the next paragraph), NSF and ASC shall immediately report the incident to the Chief, Permits Division and include the same information listed above
  - activities may continue while NMFS reviews the circumstances of the incident
    - NMFS shall work with NSF and ASC to determine whether modifications in the activities are appropriate
- reporting an injured or dead marine mammal not related to the activities
  - in the event that NSF and ASC discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to authorized project activities (e.g., previously wounded animal, carcass with moderate to

[11] For additional information about Level A harassment, please refer to Section 8 of this Opinion.

advanced decomposition, or scavenger damage), NSF and ASC shall report the incident to the Chief, Permits Division within 24 hrs of the discovery

- NSF and ASC shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS
- activities may continue while NMFS reviews the circumstances of the incident

4 Action Area

Proposed project activities would occur in the Scotia Sea and South Atlantic Ocean between 53 to 58º South and 33 to 40º West (Figure 1). The majority of the proposed surveys would be within the Exclusive Economic Zone of the Government of the South Georgia and South Sandwich Islands (United Kingdom), though a portion would be conducted in International Waters.

Figure 1. General study area overview.

The seismic survey track lines would total approximately 2,950 km (estimate includes an overage of about 25% to account for equipment testing, ramp-up, line changes, or repeat coverage of acoustic sources before the start of the survey track) and would occur only in water depths greater than 1,000 m (Figure 2). Dredging activities would occur in Areas A and B (see Figure 2).

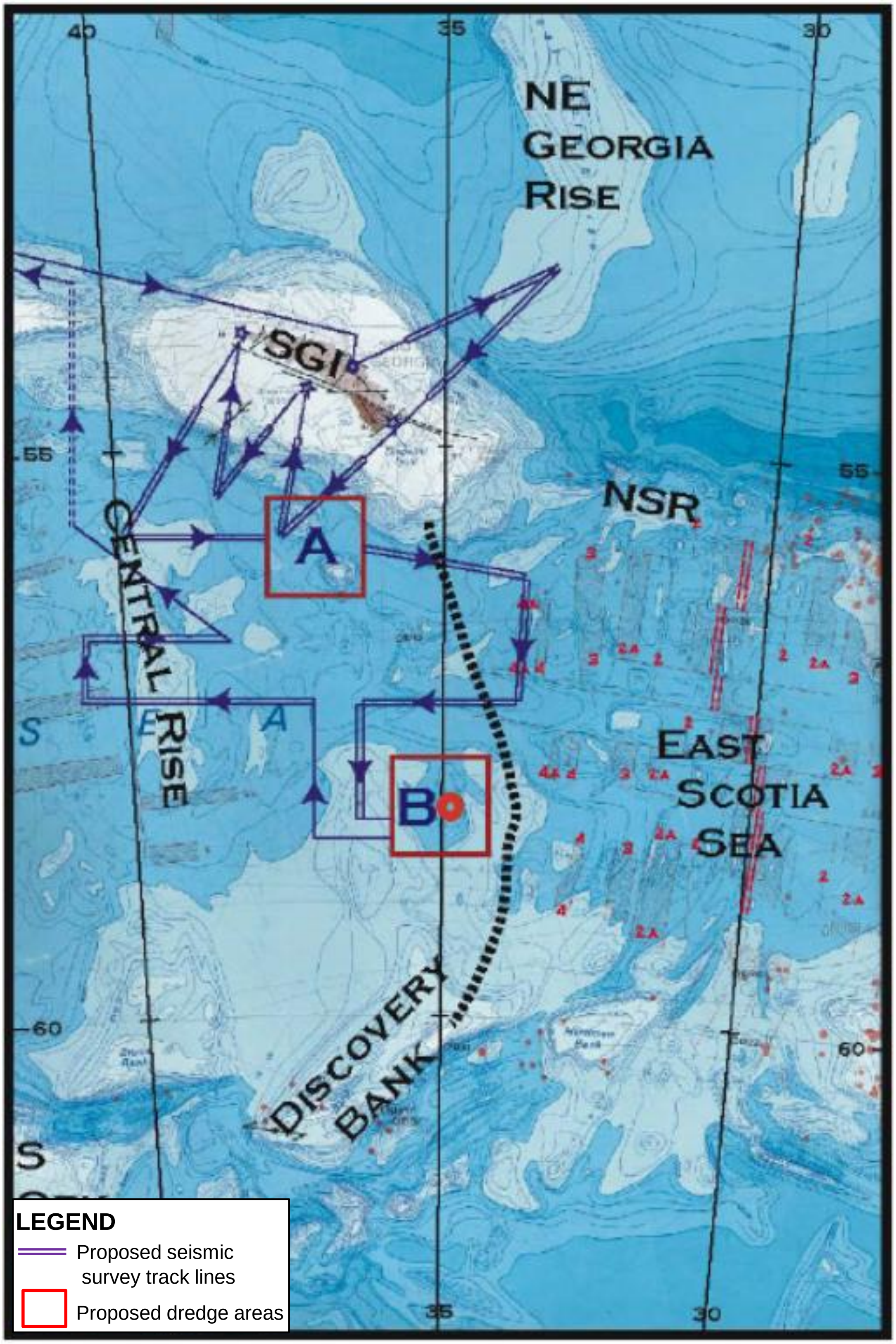

Figure 2. Proposed seismic and dredge areas.

The NSF estimates that the maximum area ensonified during the seismic surveys would be approximately 3,953 km^2. This estimate was calculated by multiplying the maximum number of kilometers estimated for the seismic survey (2,950 km) by the modeled area ensonified to 160 dB on either side of the planned seismic lines (0.670 km x 2 [1.34 km]). A total of 6,000 m^2 of sea floor would be disturbed during dredging.

The NSF estimates the study area is approximately 2,693 km from Punta Arenas. Transit to and from Punta Arenas would take approximately six days each way. Total transit length (excluding travel during project activities) is estimated to be 5,386 km (2,693 km x 2).

5 APPROACH TO THE ASSESSMENT

Section 7(a)(2) requires every Federal agency, in consultation with and with the assistance of NMFS, to insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any ESA-listed species or result in the destruction or adverse modification of critical habitat. This consultation was initiated because ESA-listed whales **may be affected** by the proposed activities.

During the consultation, we first reviewed information provided by NSF and the Permits Division to describe the proposed actions. We also described the Action Area, which includes all areas affected directly and indirectly by the actions.

Second, we evaluated the current status of ESA-listed species that occur within the Action Area. We did not evaluate critical habitat in the Action Area because no critical habitat has been designated for species considered in this Opinion. We also evaluated the environmental baseline (i.e., past and present anthropogenic impacts within the Action Area) to determine how species and critical habitat are likely to be affected by the action.

Third, we evaluated the direct and indirect effects of the action on ESA-listed species. Indirect effects are those that could be caused by the proposed action later in time, but still are reasonably certain to occur. We assessed:

1. the exposure to physical, chemical, or biotic stressors produced by the proposed actions;
2. whether such exposure would be likely to reduce the survival and reproduction of individuals; and
3. whether fitness reductions would threaten the viability of populations and species.

For all analyses, we used the best available scientific and commercial data. For this consultation, we relied on:

- information submitted by the action agency
- government reports
- past survey reports for similar research activities
- general scientific literature

During the consultation, we conducted electronic searches of the general scientific literature using the following search engines:

- BioOne Abstracts and Indexes

- Google Scholar
- ScienceDirect
- Web of Science

6 Status of the Species

This Opinion examines the status of each species that would be affected by the proposed actions. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This section describes the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02.

We identified six ESA-listed species that may be affected by the proposed action (Table 4).

Table 4. ESA-listed species that may be affected by the proposed action in the Scotia Sea and South Atlantic Ocean.

Common Name	Scientific Name	Status[1]
Cetaceans		
Blue whale	*Balaenoptera musculus*	E
Fin whale	*B. physalus*	E
Humpback whale	*Megaptera novaeangliae*	E
Sei whale	*B. borealis*	E
Southern right whale	*Eubalaena australis*	E (F)
Sperm whale	*Physeter macrocephalus*	E

[1] *ESA status: E = endangered species, F = foreign species*

No critical habitat has been designated for these species.

6.1 Blue Whale

We used information available in the recovery plan (NMFS 1998) and recent stock assessments (Waring et al. 2010, Carretta et al. 2013), the status report (COSEWIC 2002), and recent biological opinions (NMFS 2014a, b, USFWS and NMFS 2014) to summarize the status of the species, as follows.

6.1.1 Distribution

Blue whales can be found in coastal and pelagic waters in all oceans. Though often found in coastal waters, blue whales generally occur in offshore waters, from subpolar to subtropical latitudes.

Three subspecies of blue whales have been identified, based on body size and geographic distribution:

- Antarctic (or "true") blue whale, *B. m. intermedia*
  - occurs in high latitudes of the Southern Ocean
- pygmy blue whale, *B. m. brevicauda*
  - occurs in mid-latitude waters of the southern Indian Ocean and north of the Antarctic convergence
- Northern Hemisphere blue whale, *B. m. musculus*
  - occurs throughout the Northern Hemisphere

A fourth subspecies, *B. m. indica*, may exist in the northern Indian Ocean (McDonald et al. 2006b), although these whales are frequently referred to as *B. m. brevicauda* (Anderson et al. 2012). This consultation will focus on the Antarctic and pygmy blue whale subspecies, because the Northern Hemisphere blue whale does not occur in the action area.

6.1.2 Life History

Blue whales are the largest animals on Earth. They are baleen whales distinguished by their large size, long body, and mottled gray skin that appears light blue when seen through water.

The lifespan of blue whales is estimated to be 70 to 80 years. Sexual maturity is reached at five to 15 years of age. The gestation period of blue whales is approximately 10 to 12 months, and calves are nursed for six to seven months. The average calving interval is two to three years. Birthing and mating occur in lower latitudes during winter months, and weaning probably occurs in or en route to summer feeding areas in higher, more productive latitudes.

Blue whales feed almost exclusively on krill and can consume approximately 3,600 kg per day. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m.

Blue whales typically occur alone or in groups of up to five, though larger foraging groups of up to 50 have been reported, occasionally in mixed-species groups with fin whales (Corkeron et al. 1999).

Blue whales dive five to 20 times at 12 to 20 sec intervals before a deep dive of three to 30 min (Mackintosh 1965, Leatherwood et al. 1976, Maser et al. 1981, Yochem and Leatherwood 1985, Strong 1990, Croll et al. 1999). Foraging dives average a depth of 140 m and a duration of 7.8 min; non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001). Dives of up to 300 m are known (Calambokidis et al. 2003).

Blue whales produce the following vocalizations (Cummings and Thompson 1971, Cummings and Thompson 1977, Edds 1982, Thompson and Friedl 1982, McDonald et al. 1995, Edds-Walton 1997):

- prolonged, low-frequency moans
  - frequencies between 0.0125 to 0.4 kHz (dominant frequencies between 0.016 to 0.025 kHz)
- songs
  - between 0.016 to 0.060 kHz
  - last up to 36 sec, repeated every 1 to 2 min

Source levels have been described as:

- generally ranging between 180 to 188 dB re 1µPa at 1 m
  - may reach 195 dB re 1µPa at 1 m (Aburto et al. 1997, Ketten 1998, McDonald et al. 2001, Clark and Ellison 2004)
- in the Indian Ocean
  - Antarctic blue whale calls
    - 179 ± 5 dB re 1 μPa_{rms} at 1 m (Samaran et al. 2010)
    - between 0.017 to 0.03 kHz
  - pygmy blue whale calls
    - 175 ± 1 dB re 1 μPa_{rms} at 1 m
    - between 0.017 to 0.05 kHz

The function of blue whale vocalization is unknown, though authors (Payne and Webb 1971, Thompson et al. 1992, Edds-Walton 1997) have hypothesized the following reasons:

- maintaining spacing between individuals
- recognition
- socialization
- navigation
- contextual information transmission
- location of prey resources

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 and Thompson 1971, Cummings and Thompson 1977, 1994, Thompson et al. 1996, Rivers 1997). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur, though less frequently, while in summer high-latitude feeding areas.

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 (Richardson et al. 1995, Ketten 1997).

6.1.3 Population Dynamics

Little is known about population and stock structure[12] of blue whales. Studies suggest a wide range of alternative population and stock scenarios based on movement, feeding, and acoustic data. Under the MMPA, NMFS recognizes four stocks of blue whales:

- western North Pacific Ocean
- eastern North Pacific Ocean
- Northern Indian Ocean
- Southern Hemisphere

For the purposes of this consultation, we will focus on whales in the Southern Hemisphere, which includes whales of both Antarctic and pygmy blue whale subspecies.

The worldwide population of all blue whales can be plausibly estimated to be between 10,000 to 25,000 individuals, a population 3 to 11 percent of pre-exploitation levels (Reilly et al. 2013). The IWC estimated the population of Southern Hemisphere blue whales (excluding pygmy blue whales) to be approximately 2,300 individuals for years 1997/98, with an estimated rate of population increase of 8.2 percent per year between years 1978/79 to 2003/04. No reliable figures exist for pygmy whale populations throughout their range, though it is generally assumed that pygmy blue whales are more abundant than Antarctic whales.

Though all populations of blue whales are depressed relative to pre-exploitation levels, population growth appears to be positive. Growth rates for various populations worldwide vary between 3 to 9 percent (Yochem and Leatherwood 1985, Sigurjónsson and Gunnlaugsson 1990, Branch et al. 2007, Pike et al. 2009).

“ We define populations as 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. In some cases, the term “stock” is synonymous with this definition of “population” while other usages of “stock” are not.

6.1.4 Status

The species was ESA-listed as endangered on December 2, 1970 (35 FR 18319). The blue whale is endangered as a result of past commercial whaling. Approximately 330,000 to 360,000 blue whales were killed from 1904 to 1967 in the Antarctic alone (Perry et al. 1999, Reeves et al. 2003). Commercial whaling no longer occurs, but blue whales are threatened by:

- ship strikes
- entanglement in fishing gear
- pollution
- noise

Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, it has not recovered to pre-exploitation levels.

6.2 Fin Whale

We used information available in the recovery plan (NMFS 2010a), the five-year review (NMFS 2011a), recent stock assessment reports (NMFS 2012b, Allen and Angliss 2013, Carretta et al. 2013), the status report (COSEWIC 2005), and recent biological opinions (NMFS 2014a, b, USFWS and NMFS 2014) to summarize the status of the species, as follows.

6.2.1 Distribution

Fin whales are distributed widely in deep, offshore waters of every ocean except the Arctic Ocean. They range from near 40° S (Brazil, Madagascar, Western Australia, New Zealand, Colombia, Peru, and Chile) during the austral winter southward to Antarctica in the austral summer (Rice 1998). The distribution of fin whales during the austral summer ranges from 40 to 60° S in the southern Indian and South Atlantic oceans. Fin whales migrate north before the end of austral summer toward breeding grounds in and around the Fiji Sea.

Two subspecies of fin whale are recognized:

- *B. p. physalus*
  - occurs in the North Atlantic
- *B. p. quoyi* (commonly called the Antarctic fin whale)
  - occurs in the Southern Hemisphere

Though not formally recognized as subspecies, a third population of fin whale in the North Pacific is generally considered a separate, unnamed subspecies and a fourth subspecies, *B. p. patachonica* (as described by Dr. H. Burmeister [Gray 1865]), may exist in the mid-latitudes of the Southern Hemisphere (Clarke 2004).

6.2.2 Life History

Fin whales are large baleen whales distinguished by a sleek, streamlined body and distinctive coloration pattern of black or dark brownish-gray back and sides with a white underside.

The lifespan of fin whales is estimated to be 70 to 80 years (Kjeld et al. 2006). Sexual maturity is reached at six to 10 years of age. Their gestation period is less than one year, and calves are nursed for six to seven months. The average calving interval is two to three years. Birthing and mating occur in lower latitudes during the winter months.

Fin whales eat pelagic crustaceans (primarily krill) and schooling fish such as capelin, herring, and sand lance. Intense foraging occurs at high latitudes during the summer.

Like blue whales, fin whales make a series of shallow dives followed by a deep dive. The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll et al. 2001). Foraging dives in excess of 150 m are known (Panigada et al. 1999).

Fin whales are most often sighted alone or in groups of less than five individuals (Hain et al. 1992, Barlow 2003).

Fin whales produce a variety of low-frequency sounds in the 0.01 to 0.2 kHz range (Watkins 1981, Watkins et al. 1987, Edds 1988, Thompson et al. 1992). Typical vocalizations include:

- long, patterned pulses (Patterson and Hamilton 1964)
  - range between 0.018 to 0.035 kHz range
  - duration of 0.5 to 2.0 sec
  - only males are known to produce these (Croll et al. 2002)
- short series (Richardson et al. 1995)
  - about 0.2 kHz
  - 1 sec duration
  - produced in spring, summer, and fall, and in repeated stereotyped patterns during winter

Source levels have been described as:

- between 140 to 200 dB re 1μPa at 1 m (Erbe 2002, Clark and Ellison 2004, Weirathmueller et al. 2013)
- 189 dB re 1 μPa at 1m in the Southern Ocean (Širović et al. 2007)

The function of fin whale vocalization is unknown and hypotheses are similar to those discussed for blue whales (Section 6.1.2). 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 (Clark and Charif 1998). Vocalizations of 40Hz in irregular sequence have been associated with feeding (Širović et al. 2013). The 1-sec vocalization described above has been associated with social groups (McDonald et al. 1995). During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002).

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 and are likely most sensitive to this frequency range (Richardson et al. 1995, Ketten 1997).

6.2.3 Population Dynamics

Globally, fin whales are sub-divided into three major groups:

- Atlantic
- Pacific
- Southern Hemisphere

The two subspecies described above (see Section 6.2.1) appear to be organized into separate populations within these groups, though there is a lack of consensus in the published literature as to population structure. Within the Atlantic and Pacific groups, the IWC and NMFS recognize different “stocks” and “populations” of fin whales. Within the Antarctic group, both organizations consider fin whales to belong to the subspecies *B. p. quoyi*.

While abundance estimates are not available for all populations or stocks worldwide, some abundance estimates are available for stocks within U.S. waters:

- North Atlantic
    - best estimate of abundance is 3,985 whales
- Pacific
    - Alaska
        - provisional minimum population estimate of abundance west of the Kenai peninsula is 5,700
    - Hawaii
        - best estimate of abundance is 174
    - California/Oregon/Washington
        - best estimate of abundance is 3,269

Abundance data for stocks and populations in the Southern Hemisphere are limited and there are no reliable estimates available. The IWC (1979) estimated the Southern Hemisphere population to be 85,200 whales in 1978/1979; however, NMFS considers this a poor estimate because of the calculation methods used.

Abundance appears to be increasing in Alaska (4.8 percent annually) and possibly in California/Oregon/Washington, though not to a statistically significant degree. Trends are not available for other stocks, due to insufficient data.

6.2.4 Status

The species was ESA-listed as endangered on December 2, 1970 (35 FR 18319). The fin whale is endangered as a result of past commercial whaling. Historical commercial harvests in the North Atlantic, North Pacific, and Southern Hemisphere are as follows:

- North Atlantic
    - at least 55,000 fin whales killed between 1910 and 1989
- North Pacific
    - at least 74,000 whales killed between 1910 and 1975
- Southern Hemisphere
    - approximately 704,000 whales killed between 1904 to 1975

Whaling does still occur for fin whales, though at a reduced level compared to historical numbers. In the Antarctic Ocean, fin whales were killed by Japanese whalers for scientific research under an Antarctic Special Permit. Between 2005/2006 and 2012/2013, 18 fin whales were killed (IWC 2014d). In 2014, the International Court of Justice issued a judgment ordering Japan to suspend its whaling activities, after ruling that Japan’s activities could not be considered scientific. Iceland killed 292 fin whales from 1986 to 1989 under a special permit (IWC 2014d).

There is currently no legal commercial whaling for fin whales in the Northern Hemisphere by IWC Member Nations party to the moratorium on whaling; however, fin whales are still killed commercially by countries that filed objections to the moratorium (i.e. Iceland and Norway) and for subsistence purposes. Iceland returned to commercial whaling of fin whales in 2006 and has killed 280 fin whales since that time (IWC 2014b). Norway has not returned to commercial whaling of fin whales. Denmark has killed 335 fin whales since 1985 for subsistence purposes (IWC 2014a).

In summary, since the moratorium on commercial whaling in 1985, 925 fin whales have been killed.

Additional threats to the species include:

- ship strikes
- reduced prey availability due to overfishing or climate change
- noise

Though whaling does continue, the number of whales killed has been significantly reduced. The recovery plan concluded the severity of the threat of whaling as medium, with a medium level of uncertainty, and ranked the relative impact of direct harvest to recovery as medium. It is assumed large population size may provide some resilience to current threats, but trends are largely unknown.

6.3 Humpback Whale

We used information available in the recovery plan (NMFS 1991), recent stock assessment reports (Allen and Angliss 2013, Carretta et al. 2013, NMFS 2013b), the status report (COSEWIC 2011), and recent biological opinions (NMFS 2014a, b, USFWS and NMFS 2014) to summarize the status of the species, as follows.

6.3.1 Distribution

Humpback whales are widely distributed in the Atlantic, Indian, Pacific, and Southern Oceans. Individuals generally migrate seasonally between warmer, tropical and sub-tropical waters in winter months (where they reproduce and give birth to calves) and cooler, temperate and sub-Arctic waters in summer months (where they feed). In their summer foraging areas and winter calving areas, they tend to occupy shallower, coastal waters; though during seasonal migrations they disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

6.3.2 Life History

Humpback whales are large baleen whales that are primarily dark grey in appearance, with variable areas of white on their fins, bellies, and flukes. The coloration of flukes is unique to individual whales.

The lifespan of humpback whales is estimated to be 80 to 100 years. Sexual maturity is reached at five to 11 years of age. The gestation period of humpback whales is 11 months, and calves are nursed for 12 months. The average calving interval is two to three years. Birthing occurs in low latitudes during winter months.

Humpback whale feeding occurs in high latitudes during summer months. They exhibit a wide range of foraging behaviors and feed on a range of prey types, including:

- small schooling fishes
- krill
- other large zooplankton

In a review of humpback whale social behavior, Clapham (1996) reported that they form small, unstable social groups during the breeding season and form small groups that occasionally aggregate on concentrations of food during the feeding season. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996).

Maximum dive depths average 170 m (but usually less than 60 m), though a 240 m dive was recorded off Bermuda (Hamilton et al. 1997). Feeding dives of humpback whales in the Northern Hemisphere average 2.1 to 5.1 min, though dives can last for up to 21 min (Dolphin 1987, Strong 1990). Because most humpback prey is generally found within 300 m of the surface, most humpback dives are probably relatively shallow.

Humpback whale vocalizations are highly variable and produced for a variety of reasons:

- breeding vocalizations
    - songs
        - sung by mature and immature males (Herman et al. 2013)
        - range in frequency from 0.02 kHz to 4 kHz
        - estimated source levels from 144 to 174 dB re 1 μPa at 1 m (Winn et al. 1970, Richardson et al. 1995, Au 2000, Frazer and Mercado III 2000, Au et al. 2006)
    - other social sounds
        - range from 0.05 kHz to 10 kHz (mostly below 3 kHz) (Tyack and Whitehead 1983, Richardson et al. 1995)
- feeding vocalizations of both sexes (Payne and Payne 1985, Thompson et al. 1986, Richardson et al. 1995, Au 2000, Erbe 2002, Vu et al. 2012)
    - grunts
        - range from 0.025 kHz to 1.9 kHz
    - pulses
        - range from 0.025 to 0.089 kHz
    - songs
        - range from 0.030 kHz to 8 kHz (dominant frequencies 0.012 kHz to 4 kHz)
        - source levels between 175 to 192 dB re 1 μPa at 1 m
- other social vocalizations
    - sounds associated with aggression in males
        - generally between 0.05 kHz to 10 kHz (mostly energy below 3 kHz) (Tyack and Whitehead 1983, Silber 1986)
        - can be heard up to 9 km away (Tyack and Whitehead 1983)
    - social vocalizations during migration
        - source levels between 123 to 183 dB re 1 μPa at 1 m (median of 158 dB re 1 μPa at 1 m) (Dunlop et al. 2013)

Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz.

6.3.3 Population Dynamics

Humpback whale populations can be generally sub-divided into four major groups:

- North Atlantic
- North Pacific
- Arabian Sea
- Southern Hemisphere

Populations within these groups are relatively well-defined. NMFS recognizes five stocks of humpback whale in the Atlantic and Pacific Oceans:

- Atlantic
    - Gulf of Maine stock
- Pacific
    - Western North Pacific stock
    - Central North Pacific stock
    - California/Oregon/Washington stock
    - American Samoa stock

The IWC recognizes seven stocks in the Southern Hemisphere.

Humpback whale abundance pre-exploitation cannot be known, but various estimates have been proposed:

- global (though mostly representative of the Southern Ocean)
    - at least 150,000 whales in the early 1900s (Winn and Reichley 1985)
- North Atlantic
    - estimates range from 40,000 to 250,000 (Smith and Pike 2009)
- North Pacific
    - 15,000 humpback whales prior to 1905 (Rice 1978)

Currently, there are over 60,000 humpback whales worldwide, occurring primarily in the North Atlantic, North Pacific, and Southern Hemisphere. Though abundance estimates are not available for all populations or stocks worldwide, estimates are available for some major groups:

- North Atlantic
    - total population between 7,698 and 11,570 (Palsbøll et al. 1997, Smith et al. 1999, Stevick et al. 2003), though all are considered to be underestimates
- North Pacific
    - total population is estimated to be 20,800 (Barlow et al. 2011), though this is likely an underestimate
- Southern Hemisphere
    - total population estimated by IWC in 1997/98 was 42,000

Though all populations of humpback whales are depressed relative to pre-exploitation levels, population growth appears to be positive. Growth rates for populations worldwide vary between 3.1 to 10.0 percent (Katona and Beard 1990, Barlow 1997, Stevick et al. 2003, Angliss and Outlaw 2005, Calambokidis et al. 2008, Punt 2010, Barlow et al. 2011, Hendrix et al. 2012, NMFS 2013b, Saracco et al. 2013)

6.3.4 Status

The species was ESA-listed as endangered on December 2, 1970 (35 FR 18319). On June 26, 2014, NMFS issued a 90-day finding concluding that a petition to identify the Central North Pacific population as a distinct population segment and delist it had presented substantial scientific or commercial information and that the petitioned action may be warranted. NMFS is continuing a humpback whale status review to determine whether the population is a DPS and whether delisting is warranted (79 FR 36281).

The humpback whale is endangered as a result of past commercial whaling. Historical commercial harvests in the North Atlantic, North Pacific, and Southern Hemisphere are as follows:

- North Atlantic
  - approximately 31,000 whales killed since the 1600s (Smith and Reeves 2010)
- North Pacific
  - nearly 28,000 whales killed between 1905 and 1965 (Perry et al. 1999)
- Southern Hemisphere
  - more than 200,000 whales killed in the 20th century (Findlay 2001)

Whaling for subsistence purposes does still occur for humpback whales, though at a reduced level compared to historical numbers. Since 1985, 83 humpback whales have been killed for subsistence purposes; Denmark has killed 49 whales and St. Vincent and the Grenadines has killed 34 whales (IWC 2014a).

Additional threats to the species include:

- ship strikes
- fisheries interactions (including entanglement)
- noise

Though whaling does continue, the number of whales killed has been significantly reduced. The species' large population size and increasing trends indicate that it is resilient to current threats, and one population (Central North Pacific) is currently being considered for delisting.

6.4 Sei Whale

We used information available in the recovery plan (NMFS 2011b), the five-year review (NMFS 2012a), and recent stock assessment reports (Carretta et al. 2013, NMFS 2013a) to summarize the status of the species, as follows.

6.4.1 Distribution

Individuals generally migrate seasonally between warm, temperate or subtropical waters at low latitudes in winter months to feeding areas in higher latitudes in summer months. In general, sei whales do not migrate as far south as blue or fin whales. Sei whales are usually observed in deep oceanic areas far from the coastline.

Two subspecies have been identified:

- northern sei whale (*B. borealis borealis*)
- southern sei whale (*B. b. schleglii*)

However, this classification has not yet been confirmed with empirical evidence. Perrin et al. (2009) noted that evidence for sei whale subspecies is weak, though the ranges of these populations are not known to overlap (Rice 1998).

6.4.2 Life History

Sei whales are baleen whales with long, sleek bodies with dark bluish-gray to black skin on their backs and sides and pale undersides. They are similar in appearance to Bryde's whales and distinguished from them by a single ridge on the rostrum.

The lifespan of sei whales is estimated to be 50 to 70 years. Sexual maturity is reached at eight to 10 years of age. The gestation period is 10 to 12 months, and calves are nursed for six to nine months. The average calving interval is two to three years. Birthing and mating occur in lower latitudes during the winter months, and weaning probably occurs in or en route to summer feeding areas in higher, more productive latitudes.

Sei whales in the North Atlantic reportedly feed primarily on copepods, with a secondary preference for krill. In the Pacific, they also feed on fish (e.g., anchovies, saury, whiting, lamprey, and herring). Less is known about the prey selection for sei whales in the Southern Hemisphere, but it is assumed habits are similar to their Northern Hemisphere counterparts.

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 1985).

Little information is published about the diving behavior of sei whales. It is assumed diving behavior is similar to that of other baleen whales, though they may not dive as deeply as other species (Gambell 1985).

Data on sei whale vocal behavior is limited, and differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007). Vocalizations have been described in different areas:

- off the Antarctic Peninsula (McDonald et al. 2005)
  - broadband sounds
    - range between 0.1 to 0.6 kHz
    - duration of 1.5 sec
  - tonal and upsweep calls
    - between 0.2 to 0.6 kHz
    - 1 to 3 sec durations
- northeastern Pacific
  - source levels of 189 ±5.8 dB re 1 µPa at 1m (Weirathmueller et al. 2013)
- Hawaiian Islands (Rankin and Barlow 2007)
  - sweeps
    - between 0.039 to 0.021 kHz
      - 1.3 sec duration
    - between 0.1 to 0.044 kHz
      - 1.0 sec duration
- North Atlantic (Thomson and Richardson 1995)
  - sweeps
    - between 1.5 to 3.5 kHz
    - paired sequences lasting 0.5 to 0.8 sec, separated by 0.4 to 1.0 sec
    - each sequence contained 10 to 20 short (4 millisecond) sweeps

The function of sei whale vocalization is unknown and hypotheses are similar to those discussed for blue whales (Section 6.1.2). Like other baleen whales, it is assumed sei whales can hear the same frequencies that they produce.

6.4.3 Population Dynamics

Globally, sei whales are sub-divided into three major groups:

- North Atlantic
- North Pacific
- Southern Hemisphere

The two subspecies described above (see Section 6.4.1) appear to be organized into separate populations within these groups, though population structure of sei whales is largely unknown because there are so few data on this species. Population structure is assumed to be discrete by ocean basin, though the IWC and NMFS recognize different stocks and populations in the Atlantic and Pacific groups. Whales in the Southern Ocean may consist of one population or several discrete populations.

While abundance estimates are not available for all populations or stocks worldwide, some abundance estimates are available for stocks within U.S. waters:

- North Atlantic
  - Nova Scotia
    - best estimate of abundance (conservative) is 357 whales
- Pacific
  - Eastern North Pacific
    - best estimate of abundance is 126
  - Hawaiian
    - best estimate of abundance for summer/fall is 77

While there is currently no accepted recent abundance estimate for sei whales in the Southern Ocean, the best available information indicates that there were approximately 9,700 sei whales in the 1980s (IWC 1996).

Population trends are not available, due to insufficient data. It is unknown whether populations are stable or fluctuating.

6.4.4 Status

The species was ESA-listed as endangered on December 2, 1970 (35 FR 18319). The sei whale is endangered as a result of past commercial whaling. Historical commercial harvests are as follows:

- North Atlantic
  - approximately 825 sei whales killed between 1966 and 1972 on the Nova Scotia shelf (Mitchell and Chapman 1977)
- North Pacific
  - approximately 74,215 whales killed between 1910 to 1975 (Horwood 1987, Perry et al. 1999)
- Southern Hemisphere
  - approximately 152, 233 whales killed between 1910 and 1979 (Horwood 1987)

Whaling does still occur for sei whales, though at a reduced level compared to historical numbers. In the Northwest Pacific Ocean, sei whales are killed by Japanese whalers for scientific research under a special permit. Between 2001/2002 and 2012/2013, 989 sei whales were killed (IWC 2014d). Iceland killed 70 sei whales from 1986 to 1988 under a special permit (IWC 2014d).

There is currently no legal commercial whaling for fin whales in the Northern Hemisphere by IWC Member Nations party to the moratorium on whaling; however, sei whales have been killed for subsistence purposes. Denmark has killed three sei whales (two in 1989 and one in 2006) for subsistence purposes (IWC 2014a).

In summary, since the moratorium on commercial whaling in 1985, 1,062 sei whales have been killed.

Additional threats to the species include:

- ship strikes
- fisheries interactions (including entanglement)
- habitat loss and reduced prey availability from climate change
- noise

Though whaling does continue, the number of whales killed has been significantly reduced. The recovery plan concluded the severity of the threat of whaling as medium, with a medium level of uncertainty, and ranked the relative impact of direct harvest to recovery as medium. It is assumed large population size may provide some resilience to current threats, but trends are largely unknown.

6.5 Southern Right Whale

We used information available in status reviews (Perry et al. 1999, NMFS 2007) to summarize the status of the species, as follows.

6.5.1 Distribution

The southern right whale is generally distributed between 20° and 60°S, though they have been recorded at lower latitudes. During winter months, southern right whales calve and nurse in temperate latitudes and in sub-Antarctic New Zealand. In summer, they migrate south to feeding areas in lower latitudes. Wintering (feeding) grounds have been identified off of:

- South America
- Australia
- New Zealand
- South Africa

Less is known about summer feeding grounds; however, feeding right whales have been recorded around 45°S south of Western Australia, around South Georgia, and near the Antarctic Peninsula.

6.5.2 Life History

Southern right whales are baleen whales distinguished by a stocky body, generally black coloration (although some individuals have white patches on their undersides), no dorsal fin, and callosities (raised patches of roughened skin) on the head region.

The lifespan of southern right whales is assumed to be at least 50 years. Sexual maturity is reached around nine years of age. The gestation period is about one year, and calves are weaned at about one year of age. Adult females typically calve every three years. Little is known about the mating habits of southern right whales, but Best et al. (2003) suggested courtship behavior may occur during winter in coastal waters off South Africa. It is assumed birthing and mating occur in the wintering grounds identified above (see Section 6.5.1).

Southern right whales primarily feed on copepods and krill. The location of summer feeding grounds is not well known; however, feeding right whales have been recorded around 45°S south of Western Australia, around South Georgia, and near the Antarctic Peninsula. The IWC has also identified five feeding areas:

- Brazil, False Banks, and Falkland Islands
  - 30° to 55°S
- South Georgia and Shag Rocks
  - around 53°S
- Tristan da Cunha
  - around 40°S
- Antarctic Peninsula
  - 60° to 70°S
- South of 50°S

Little is known about the social structure of southern right whales and the few behavioral observations that have been made are limited to cow-calf pairs on calving grounds.

Published information about the diving behavior of southern right whales is limited. It is assumed diving behavior is similar to that of other baleen whales, though they may not dive as deeply as some other species.

Data are scarce on southern right whale vocalizations. A summary of vocalizations from Cummings (1985) is as follows:

- belchlike utterance
  - duration of 1.4 sec
  - below 0.5 kHz
  - source levels ranging from 172 to 187 dB re 1 µPa at 1m
- moans
  - simple
    - narrow band of frequencies, centered at 0.160 kHz
    - little frequency shift
  - complex
    - wide-band of frequencies, centered around 0.235 kHz
    - extensive frequency shifts
- pulses
  - 0.03 to 2.1 kHz
  - in bursts of 0.06 sec
- other sounds
  - below 1.9 kHz
  - duration from 0.3 to 1.3 sec

The function of southern right whale vocalization is unknown and hypotheses are similar to those discussed for blue whales (Section 6.1.2). Like other baleen whales, it is assumed southern right whales can hear the same frequencies that they produce.

6.5.3 Population Dynamics

Little is known about population and stock structure of southern right whales. The IWC recognizes four breeding stocks associated with the wintering/feeding grounds described in Section 6.5.1. In addition to the four major breeding areas, the IWC recognizes the following areas where significant numbers of right whales are seen:

- Tristan de Cunha
- Brazil
- Namibia
- Mozambique
- South Georgia

While abundance estimates are not available for all populations worldwide, the most recent worldwide population estimate for southern right whales was about 7,000 individuals in 1997, a population about 12 percent of pre-exploitation levels (IWC 2001).

Trends in all populations are not known, but where data are available, trends are or appear to be increasing. Wintering populations at three primary calving grounds (South Africa, Argentina and Australia) are increasing at annual rates of about seven percent (Bannister 2001, Best et al. 2001, Cooke et al. 2001, Patenaude 2003). There is evidence that the New Zealand sub-Antarctic population may also be increasing. Population trends for breeding groups are largely unknown.

6.5.4 Status

The species was ESA-listed as endangered on June 2, 1970 (35 FR 106). The southern right whale is endangered as a result of past commercial whaling. Approximately 35,335 southern right whales were killed from 1784 to 1912 (Best and Ross 1986, Dawbin 1986, du Pasquier 1986). Commercial whaling no longer occurs, but southern right whales are threatened by:

- ship strikes
- entanglement in fishing gear
- habitat degradation
- chemical pollution
- increased vessel traffic
- kelp gull harassment

Because populations appear to be increasing in size (where data are available), the species appears to be somewhat resilient to current threats; however, it has not recovered to pre-exploitation levels.

6.6 Sperm Whale

We used information available in the recovery plan (NMFS 2010b), the five-year review (NMFS 2009, 2011a), recent stock assessment reports (Allen and Angliss 2013, Carretta et al. 2013, NMFS 2013b, a,), and recent biological opinions (NMFS 2014a, b) to summarize the status of the species, as follows.

6.6.1 Distribution

The distribution of sperm whales extends to all deep ice-free marine waters from the equator to the edges of polar pack ice (Rice 1989). Sperm whales appear to prefer waters deeper than 1,000 m (Reeves and Whitehead 1997).

Migratory behavior differs between males and females. All age classes and both sexes range throughout tropical and temperate seas year-round, while adult males will typically migrate to higher latitudes in summer months. Mature males range between 70º N in the North Atlantic and 70º S in the Southern Ocean (Reeves and Whitehead 1997, Perry et al. 1999), whereas mature females and immature individuals of both sexes are seldom found higher than 50º N or S (Reeves and Whitehead 1997). However, at least some individual males and females are present year-round at higher latitudes (Mellinger et al. 2004). In some areas, whales are present in warm water throughout the year, and such areas may have discrete “resident” populations (Gordon et al. 1998, Drouot 2003, Jaquet et al. 2003, Engelhaupt 2004).

6.6.2 Life History

Sperm whales are large toothed whales distinguished by a mostly dark gray body (though some whales have white patches on the belly) and an extremely large head (about one-third of its total body length).

Sperm whales live up to 80 years (Whitehead 2003). Female sperm whales become sexually mature at an average age of nine years (Kasuya 1991). Maturation in males usually begins around the same age, but most individuals do not become fully mature until their twenties. Sperm whale gestation lasts around 15 months, and calves are nursed for at least two years. The calving interval is estimated to be about four to six years (Best et al. 1984). Breeding in the South Atlantic is thought to occur in austral spring.

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. Males start leaving these family groups at about six years of age, after which they live in “bachelor schools”. The cohesion among males within a bachelor school declines with age and they are essentially solitary during their breeding prime and old age (Christal and Whitehead 1997).

Sperm whales feed primarily on large and medium-sized squids; however, other documented prey items include other cephalopods, medium- and large-sized rays and sharks, and many teleost fishes (Berzin 1972, Clarke 1977, Clarke 1980, Rice 1989). Sperm whales appear to feed regularly throughout the year.

Sperm whales are one of the deepest- and longest- diving mammals, with dives of up to 2 km deep and durations in excess of 2 hrs (Watkins et al. 1985, Watkins et al. 1993). However, dives are generally shorter (25 to 45 min) and shallower (400 to 1,000 m) and separated by 8 to 11 min rests at the surface (Papastavrou et al. 1989, Watwood et al. 2006). Differences in night and day diving patterns are not known, but sperm whales probably make relatively shallow dives at night, when prey is closer to the surface.

Vocalizations of sperm whales are summarized below:

- broad-band clicks (Weilgart and Whitehead 1993, Goold and Jones 1995, Møhl et al. 2003)
    - frequencies range between 0.1 kHz to 20 kHz
        - mostly between 2 to 4 kHz and 10 to 16 kHz
    - source levels as loud as 200 to 236 dB re 1μPa at 1 m

    - lower source levels around 171 dB re 1 μPa at 1 m have been suggested
- "squeals" (Weir et al. 2007)
  - frequencies of 0.1 to 20 kHz

Long, repeated clicks are associated with feeding and echolocation (Weilgart and Whitehead 1993, Goold and Jones 1995). Short patterns of clicks (codas) are associated with group social behavior (Weilgart and Whitehead 1993). They may also aid in intra-specific communication.

Like other cetaceans, we assume sperm whales can hear the same frequencies that they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded and indicated a hearing range of 2.5 to 60 kHz (Carder and Ridgway 1990). Sperm whales stop vocalizing for brief periods when codas are being produced by other individuals, possibly because they can hear better while not actively vocalizing (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).

6.6.3 Population Dynamics

Though sperm whales have a global distribution, their population structure is poorly understood. It is likely that population structuring exists in the species, but the extent to which it occurs is not yet known. The IWC recognizes four sperm whale stocks:

- North Atlantic
- North Pacific
- northern Indian Ocean
- Southern Hemisphere

NMFS recognizes five stocks in U.S. waters:

- North Atlantic
- northern Gulf of Mexico
- Pacific
  - Alaska
  - California/Oregon/Washington
  - Hawaii

While abundance estimates are not available for all stocks worldwide, the most recent worldwide population estimate for sperm whales was about 300,000 to 450,000 individuals in 2002, a population about 32 percent of pre-exploitation levels (Whitehead 2002). Using the methods of Whitehead (2002), abundance in the Atlantic Ocean in 2002 was approximately 90,000 to 134,000 sperm whales.

Population trends are not available, due to insufficient data. It is unknown whether populations are stable or fluctuating.

6.6.4 Status

The species was ESA-listed as endangered on December 2, 1970 (35 FR 18319). The sperm whale is endangered as a result of past commercial whaling. Worldwide, at least 1,305,000 sperm whales were killed from 1800 to 1973 (Best et al. 1984).

Whaling does still occur for sperm whales, though at a reduced level compared to historical numbers. In the Northwest Pacific Ocean, sperm whales are killed by Japanese whalers for scientific research under a special permit. Between 2001/2002 and 2012/2013, 55 sperm whales were killed (IWC 2014d). Japan also killed 388 sperm whales in the Antarctic during the 1986/1987 and 1987/1988 seasons under objection to the moratorium on whaling (IWC 2014b).

In summary, since the moratorium on commercial whaling in 1985, 443 sperm whales have been killed.

Though whaling does continue, the number of whales killed has been significantly reduced. The recovery plan concluded the severity of the threat of whaling as low, with a medium level of uncertainty, and ranked the relative impact of direct harvest to recovery as low.

Additional threats to the species include:

- ship strikes
- reduced prey availability from climate change
- contaminants and pollutants
- fisheries interactions (including entanglement)
- noise

Due to the lack of sufficient and reliable information on population structure, species abundance and population trends, and the severity of threats to the recovery of sperm whale populations, NMFS recommended the sperm whale remain endangered in the 2009 5-year status review. For these reasons, we assume sperm whales would have a low to moderate tolerance to additional disturbance.

7 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). For this Opinion, the Action Area consists of portions of the Scotia Sea and South Atlantic Ocean (see Section 4).

Focusing on the impacts of activities specifically within the Action Area allows us to assess the prior experience and condition of the whales that would be exposed to effects from the actions under consultation. This focus is important because individuals of ESA-listed species may commonly exhibit, or be more susceptible to, adverse responses to stressors in some life history states, stages, or areas within their distributions than they may be in others. These localized stress responses or baseline stress conditions may increase the severity of the adverse effects expected from the proposed actions.

7.1 Natural Mortality

We assume that possible sources of natural mortality for each species within the Action Area are similar across the range of the species. Natural sources of mortality in large whales include:

- predation by killer whales and/or large sharks
- parasites
- disease
- other and/or unknown causes

Calves of large whales are targeted by predators more commonly than adults. Though not often taken by killer whales or sharks, adult baleen whales may expend large amounts of energy by defending calves against predators and/or evading predators (Ford and Reeves 2008).

Mortality associated with parasitic infections has been documented or suspected in whales:

- the nematode *Crassicauda boopis* is believed to have caused renal failure in blue, fin, and humpback whales (Lambertsen 1986, 1992)
- parasites and biotoxins from red-tide blooms are potential causes of mortality in humpback whales (Perry et al. 1999)
- endoparasitic helminths (worms) commonly found in sei whales can result in pathogenic effects when liver and kidney infestations occur (Rice 1977)

Disease may reduce fitness in whales and further contribute to mortality. Disease has been documented in humpback and sperm whales:

- tattoo skin disease has been identified in one-quarter of the Arabian Sea humpback whale population (Baldwin et al. 2010)
- calcivirus and papillomavirus are known pathogens of sperm whales (Smith and Latham 1978, Lambertsen et al. 1987)

Strandings and mortality in low numbers from unknown causes are fairly common in large whale species; however, strandings with large numbers of mortalities also have been documented:

- in 2009, 46 humpback whales (mostly calves and juveniles) were found dead or dying along Western Australia beaches due to unknown causes (Coughran et al. 2013)
- stranded dead southern right whales (mostly calves) have been found at Península Valdés due to unknown causes (Uhart et al. 2009)
    - 83 in 2007
    - 96 in 2008

Two additional factors may affect southern right whale survival: El Niño events and kelp gull harassment. Sea surface anomalies caused by El Niño events have been shown to impact calving success (Leaper et al. 2006, Valenzuela et al. 2009). Kelp gulls feed on the skin and blubber of whales, particularly calves, at Península Valdés. These kelp gull attacks have increased in the past 30 years. Currently, more than three-quarters of whales at Península Valdés show scars from gull attacks (Sironi et al. 2009, Fazio et al. 2012). Though these attacks do injure whales, it is uncertain how they may contribute to southern right whale survival (Fazio et al. 2012).

7.2 Climate Change

Climate change (i.e. warming) has, is, and will continue to impact marine species in the following ways (IPCC 2014):

- shifting abundances
- distribution
- migration patterns
- timing of seasonal activities

These changes have and will lead to interspecific competition for resources and changes in predator-prey dynamics (IPCC 2014). Of particular concern to baleen whales are shifts in krill abundance.

Warming is occurring in the waters around South Georgia. Water temperatures around South Georgia are cold year-round, ranging from 0°C in austral winter to 4°C in late austral summer (GSGSSI 2013). Between 1925 and 2006, the average annual temperature within the upper 100 m of waters around South Georgia increased by approximately 1.54°C (0.9°C in January and 2.3°C in August) (Whitehouse et al. 2008).

In addition to warming water temperatures around South Georgia, the island's glaciers are retreating (Cook et al. 2010). This influx of glacial meltwater can affect physical dynamics and biological properties of waters up to 100 km offshore (Dierssen et al. 2002).

Roughly 50 percent of the Earth's marine mammal biomass occurs in the Southern Ocean, where all baleen whales feed primarily on a single species of krill (Boyd 2002). Krill feed on algae on the underside of sea ice. Though the 2013 Antarctic sea ice coverage was above average compared to the 1981 to 2010 average (Blunden et al. 2014), there is concern that there will be a net loss of Antarctic sea ice in the future. In areas of the Antarctic that have experienced sea ice loss, there have been severe decreases in krill populations (Atkinson et al. 2004). Reid and Croxall (2001) proposed that krill predators are operating near the limits of krill availability in the Scotia Sea. If krill availability declines in the waters around South Georgia due to sea ice loss and/or warmer temperatures, it is likely that baleen whales would move away to feed in areas with higher krill availability. The GSGSSI (2013) proposes that if krill are scarce, the ecosystem could become more like that around the Kerguelen Plateau, where the system is driven by lanternfish abundance. Lanternfish are fed upon by squid, the primary prey of sperm whales (Kozlov 1995). The large whale abundance in a lanternfish-driven system would likely shift toward sperm whales and away from baleen whales.

7.3 Whaling and Fisheries

More than two million whales were killed in the Southern Hemisphere between 1904 and 2000 and the majority of these whales were killed at South Georgia. This depletion pushed some whale species close to extinction and others to levels that threatened their recovery. To protect whales from commercial whaling, the IWC issued the following moratoria on whaling:

- blue and humpback whales in 1966
- fin whales in 1976
- sei whales in 1978
- sperm whales in 1988

Southern right whales first received protection from commercial whaling in 1935, prior to the formation of the IWC.

Though there has been no further commercial whaling in the Action Area since the moratoria, commercial harvest of whale prey (krill for baleen whales, toothfish and squid for sperm whales) has occurred. All fishing south of the Antarctic Convergence is governed by the Commission for the Conservation of Antarctic Marine Living Resources under the Antarctic Treaty System. The Antarctic Treaty System allows fishing as long as practices are managed for conservation of fisheries and the ecosystem (including whales). The Commission for the Conservation of Antarctic Marine Living Resources determines catch levels to allow for the conservation of all Antarctic species. The majority of the Action Area falls within the Commission for the Conservation of Antarctic Marine Living Resources statistical area 48.3, but a small portion also falls within 48.2. The catch of all species in statistical areas 48.2 and 48.3 from 1970 to 2013 equaled 6,903,229 metric tons (t) (CCAMLR 2014). Krill has dominated the catch in these areas. Of the total catch, krill accounted for 4,840,864 t. From 2003 to 2013, the krill catch totaled 1,037,419 t. Mackeral icefish, toothfish, and rockcod are also important fisheries in the area.

In an effort to reduce competition between the krill fishery and krill-dependent predators (including whlales), the krill fishery in the Action Area is closed from November 1 to March 31.

Fisheries interactions are a significant problem for several marine mammal species, including all whale species considered in this Opinion. 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. 2013a, van der Hoop et al. 2013b). More than 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014). There is also concern that mortality from entanglement may be underreported for many large whales, as entangled whales tend to sink rather than strand ashore. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed. Though entanglement has been documented in all whale species considered in this consultation, the extent to which it has affected whales in the Action Area is unknown.

7.4 Ship Strike

Ship strikes are a serious concern for large whales in some areas of the world. In addition to documented mortality from ship strikes, it is assumed that additional mortality from ship strikes probably goes unreported because whales do not always strand or, if they do, they do not always have obvious signs of trauma. The IWC compiled a ship strike database that contains records of historical ship strikes from the mid-twentieth century to 2010 (IWC 2014c). Reporting of ship strikes to the IWC is only done by member nations and is not mandatory. Therefore, it can be assumed that the database represents the minimum number of dolphins and whales that have collided with vessels.

The database contains 538 records worldwide. The ESA-listed whales considered in this opinion represent 319 of the records. Those 319 collisions have resulted in:

- 98 deaths
- 13 severe external visible injuries
- 11 indeterminate visible injuries
- 13 apparently minor external injuries

The outcomes were reported as “not known” in 49 cases and outcomes were not reported in 135 cases.

Ship strikes around the Antarctic Peninsula and in the South Atlantic Ocean off the coast of South America make up a relatively small portion of the reported strikes discussed above. Thirteen whales (six southern right and seven humpback) experienced collisions with vessels from 1998 to 2009. The 13 incidents resulted in one known death of a southern right whale. Three humpback whales exhibited severe external injuries. The outcomes of the remaining nine incidents are not known or not reported.

7.5 Natural and Anthropogenic Noise

Marine mammals in the Action Area are exposed to several sources of natural and anthropogenic sounds. Natural sources of background underwater noise in the Action Area include (Scientific Committee on Antarctic Research 2004):

- movement and grinding of ice floes
- grounding of icebergs
- wind
- waves
- precipitation
- earthquakes

The area of the South Sandwich Islands is tectonically the most active zone in the Antarctic (Miller et al. 2004), with several earthquakes per day occurring in this region.

Anthropogenic sources of noise in the Action Area include:

- vessels
    - commercial fishing
    - tourism
    - shipping
    - research
- nearby seismic surveys

The combination of anthropogenic and natural noises can contribute to the total noise at any one place and time.

Many researchers have described behavioral responses of marine mammals to various anthropogenic sounds, such as boat traffic and airguns used in geophysical surveys (see Section 8.3.1). Because responses to anthropogenic noise vary among species and individuals within species, it is difficult to determine long-term effects. Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Clark et al. (2009) identified increasing levels of anthropogenic noise as a habitat concern for whales because of its potential effect on their ability to communicate (i.e. masking). Some research (Parks 2003, McDonald et al. 2006a, Parks 2009) suggests marine mammals, including blue and fin whales, compensate for masking by changing the following characteristics of their calls:

- frequency
- source level
- redundancy
- timing

However, the long-term implications of these adjustments, if any, are currently unknown.

7.6 Seismic Activities

Seismic surveys for research purposes have occurred in Antarctic waters since 1976/1977. Breitzke (2013) analyzed available data in the Seismic Data Library System for Cooperative Research from

1976/1977 to 2010/2011. In that 35 year span, 15 countries performed 128 multichannel seismic surveys[13] totaling 363,801 km of seismic data acquisition.

The Action Area is directly north of the Weddell Sea region of the eight Antarctic regions used in the Seismic Data Library System for Cooperative Research (below 60°S, roughly between 30° and 55°W). From 1976/1977 to 1996/1997, 19 surveys totaling 46,839 km were conducted in the region. Most were conducted in the northern portion of the Weddell Sea region (i.e. within a few degrees of the Action Area).

Because data sharing is not required for seismic exploration or geophysical surveys outside of the Antarctic Convention area, it is not known if seismic surveys have occurred in the Action Area.

Parente et al. (2007) suggested humpback whales have been displaced from feeding and breeding areas along the Brazilian coast as a result of increased seismic activity. It is not known if seismic surveys in or near the Action Area have affected whales in this manner.

7.7 Scientific Research

ESA-listed whales are exposed to research activities documenting their distribution and movements throughout the South Atlantic and Southern Oceans. Of the 18 active research permits authorizing takes of ESA-listed whales in the Atlantic Ocean and Southern Oceans, 13 have specific investigation areas far from the Action Area (NMFS 2014c). Activities associated with the remaining five permits could occur in the Action Area, but it is not known at this time if they would be occurring during the proposed project activities.

Currently permitted research activities include:

- counting/surveying
- opportunistic collection of sloughed skin
- behavioral and monitoring observations
- various types of photography and videography
- skin and blubber biopsy sampling
- passive acoustic recording
- active playback/broadcast
- tracking
- suction-cup, dart/barb, and satellite tagging

These research activities require close vessel and/or aircraft approach. Many permits also include “incidental harassment” takes to cover such activities as tagging, where the research vessel may come within 91.4 m (100 yds) of other whales while in pursuit of a target whale. These activities may cause stress to individual whales and cause behavioral responses, but harassment is not expected to rise to the level where injury or mortality would be expected to occur.

As discussed in Section 6.2.4, Japan suspended its lethal scientific research in the Antarctic for this year; however, Japan did kill 18 fin whales between 2005/2006 and 2012/2013.

[13] Seismic surveys using streamers capable of recording multiple reflections from the seafloor from airgun sounds.

Though it is not known if the Government of South Georgia and South Sandwich Islands has issued scientific research permits in the Action Area, we assume any permitted activities would be similar to those described above.

In order to reduce potential impacts of the proposed activity, crew of the *Palmer* would make efforts to coordinate with other scientific research vessels operating in the area.

7.8 Ecotourism and Whale Watching

The average annual number of tourists visiting Antarctica has ranged from a few hundred to more than 34,000 in 2013. Antarctic ecotourism is generally concentrated in the ice-free coastal zones during the austral spring and summer (November to March). Most tourism is focused in the Antarctic Peninsula region and islands, including South Georgia Island. Tourism expeditions to Antarctica started in 1966 and have been conducted almost every year since.

The International Association of Antarctica Tour Operators is "a member organization founded in 1991 to advocate, promote and practice safe and environmentally responsible private-sector travel to the Antarctic". There are currently 48 vessels registered with the International Association of Antarctica Tour Operators (IAATO 2014):

- 4 vessels can carry more than 500 passengers
- 4 vessels can carry 200 to 500 passengers
- 21 vessels can carry 13 to 200 passengers
- 19 vessels can carry up to 12 passengers

The International Association of Antarctica Tour Operators has developed viewing guidelines for all vessels engaged in wildlife watching activities, including photography, to minimize disturbance of wildlife. The guidelines for whales are similar to those developed by NMFS for humpback whales in Alaska and North Atlantic right whales in the Atlantic:

- vessel distance to whales
  - Zodiacs may not approach whales closer than 30 m
  - ships under 20,000 tons may not approach closer 100 m
  - ships over 20,000 tons may not approach closer than 150 m
  - if two ships are present, neither may approach closer than 200 m
- observation time is limited to 30 min
- vessels must
  - never chase or pursue animals
  - approach slightly to the side and rear of the animal
  - travel parallel to the animal(s)
  - avoid sudden changes in speed and direction (including putting vessel in reverse)
  - avoid loud noises, including conversation, whistling, etc.
  - keep radios at low volumes

Marine mammal watching is not without potential negative impacts. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic (Lusseau and Bejder 2007, Guzman et al. 2013). Another concern is that preferred habitats may be abandoned if disturbance levels are too high. Several investigators have studied the effects of whale watching vessels on marine mammals (Watkins 1986, Corkeron 1995, Felix 2001, Magalhaes et al. 2002, Richter et al. 2003, Scheidat et al. 2004, Amaral and Carlson 2005, Schaffar et al. 2009, Christiansen et al. 2013). Behavioral responses of whales to whale watching vessels in these studies were generally dependent upon the following vessel characteristics:

- distance to the whale
- speed
- direction
- noise

Whale responses generally changed with these vessel characteristics, though no response was found in some whales. Whales that did respond exhibited changes in the following behaviors:

- vocalization
- time at surface
- swimming speed, swimming angle, or direction
- respiration rates
- dive times
- feeding behavior
- social interactions

7.9 Protected Areas

The Government of South Georgia and South Sandwich Islands designated 1.07 million km^2 of its maritime zone north of 60°S to be a Marine Protected Area in February 2012, with additional protection added in June 2013. Activities conducted within the Marine Protected Area are subject to requirements of the Management Plan (GSGSSI 2013). The area was designated as a Marine Protected Area to ensure the protection and conservation of the resources and biodiversity and support important ecosystem roles, such as feeding areas for marine mammals, penguins, and other seabirds.

The Marine Protected Area also falls within the area managed by the Commission for the Conservation of Antarctic Marine Living Resources. The Commission for the Conservation of Antarctic Marine Living Resources has adopted conservation measures to protect vulnerable marine ecosystems, including:

- seamounts
- hydrothermal vents
- cold water corals
- sponge fields

These ecosystems are generally slow growing, with recovery rates from disturbance that could take decades.

Additionally, the area surrounding South Georgia Island was designated by the Commission for the Conservation of Antarctic Marine Living Resources as an Integrated Study Area to assist with the collection and management of information relating to the Commission for the Conservation of Antarctic Marine Living Resources Ecosystem Monitoring Program.

7.10 Environmental Baseline Summary

While a number of known and potential threats are discussed in the sections above, the actual levels of impact of these threats on ESA-listed whale species have not been determined. Though threats are discussed individually in the previous sections, individual whales may be affected by multiple threats at any given time, compounding the impacts of the threats. Given our limited knowledge of the impacts of known and potential threats, we have broadly addressed factors with the potential to impact ESA-listed whales in the Action Area.

Historically, commercial whaling in the Action Area caused large whale abundance to decline to the point of near-extinction, warranting their listing as endangered species. Commercial whaling has been eliminated; however, whale species have not recovered from historic exploitation. Researchers cannot determine if past exploitation continues to influence current populations of large whale species.

Recent attention has focused on anthropogenic sound sources in use around the world for oil and gas exploration and seismic research. Though it is not known to what extent geophysical research has occurred in the Action Area, we do know how much has occurred in the Antarctic Convention area a few degrees south of the Action Area. Because large whales travel great distances and have long lifespans, it is reasonable to assume whales in the Action Area have encountered sounds from geophysical research, though we do not know to what extent individuals have been exposed.

Relationships between specific sound sources and/or anthropogenic sound, in general, and responses of marine mammals to those sounds are subject to extensive scientific research and public inquiry. Most observations have been limited to short-term behavioral responses, which include cessation of feeding, resting, or social interactions. Because responses to anthropogenic noise vary between species and individuals within species, it is difficult to determine long-term effects. However, there is concern that behavioral response could take the form of habitat abandonment, which could have implications at the population level.

We recognize that not enough is known about the effects of each specific threat, and, as such, we do not definitively know the level of impact each threat has on ESA-listed whales.

8 Effects of the Action

Under section 7(a)(2) of the ESA, Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any ESA-listed species or result in the destruction or adverse modification of critical habitat. The proposed use of the *Palmer* and issuance of the IHA by the Permits Division for “takes” of marine mammals during proposed project activities would expose ESA-listed whales to:

- the research vessel
- seismic surveys
- bathymetric profiling
- imaging surveys
- passive instruments
- dredging

In this section, we describe the:

1. potential physical, chemical, or biotic stressors associated with the proposed action,
2. probability of individual ESA-listed whales being exposed to these stressors, based on the best scientific and commercial evidence available, and

3. probable responses of those individuals (given probable exposures), based on the available evidence.

Any responses expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success) are assessed, to consider the risk posed to the viability of the ESA-listed population. The purpose of this assessment is to determine if it is reasonable to expect the proposed actions to affect ESA-listed populations to the extent that survival and recovery of the species in the wild could be appreciably reduced.

Issuance of the IHA would authorize non-lethal (Level B) harassment of ESA-listed whales. The ESA does not define harassment, nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the MMPA, as amended, defines harassment as "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B Harassment]" (16 U.S.C. 1362(18)(A)). The latter portion of this definition ("...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering [Level B Harassment]") is almost identical to the U.S. Fish and Wildlife Service's regulatory definition of harass.[14] Based on the ESA and Fish and Wildlife Service definitions, we define harassment as "an intentional or unintentional act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns essential to the animal's life history or its contribution to the population the animal represents."

Current NMFS acoustic guidelines establish thresholds for received pulse levels at which Level A or B Harassment is considered to occur, pursuant to the MMPA. Level A Harassment for cetaceans is defined as received pulse levels in excess of 180 dB re 1 μPa_{rms}. Level B Harassment for cetaceans is defined as received pulse levels equal to or greater than 160 dB re 1 μPa_{rms}. Our analysis considers that behavioral harassment or disturbance is not limited to the 160 dB acoustic threshold. Our analysis would consider an individual to have been harassed if the individual changes its behavioral state (e.g., from resting to traveling away from the acoustic source or from traveling to evading), regardless of the received pulse level to which it was exposed.

8.1 Stressors

During the course of this consultation, we identified the following potential stressors from the proposed activities:

- vessel discharge
- vessel strike
- entanglement in
  - towed hydrophone
  - dredge
- sounds from
  - vessel
  - airguns

[14] The U.S. Fish and Wildlife Service defines harass as "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 17.4).

  - sub-bottom profiler
  - acoustic Doppler current profiler
  - multibeam echosounder
  - dredging activities
- interaction with expendable bathythermographs
- disturbance of sediment

The acoustic Doppler current profiler operates at a frequency of 150 kHz, well outside the hearing range of ESA-listed whales. Therefore we conclude that acoustic Doppler would have no effect on ESA-listed species, and this stressor is not discussed further in this Opinion.

Disturbance of sediment from dredging activities is expected to have no effect on ESA-listed whales. Approximately 6,000 m^2 of sea floor would be disturbed by dredging. Dredging would not be conducted in vulnerable marine environments. Sediment would be disturbed during dredging, but it would be expected to disperse in the water column and re-settle on the seafloor. This activity would not impact whales directly or pose hazards to their food sources. Therefore, we conclude disturbance of sediment from dredging activities would have no effect on ESA-listed whales, and this stressor is not discussed further in this Opinion.

Below we discuss each stressor's potential to affect ESA-listed species.

8.1.1 Stressors not Likely to Adversely Affect ESA-listed Species

Based on a review of available information, we determined which of the possible stressors would be likely to occur but would be discountable or insignificant.

8.1.1.1 Vessel Discharge

Vessel discharge in the form of leakages of fuel, oil, or other substances is possible, though effects of any spills are expected to have insignificant effects on whales. The *Palmer* has reported eleven spills since 1990. Petroleum product spills are limited to five incidents involving hydraulic fluid in quantities less than 15 liters (L). The remaining six incidents involved various chemical spills in quantities less than 3.8 L, with the exception of one incident involving a slowly-leaking acid waste collection drum of 151 L. In the event of an accidental release, resources would be available to minimize migration of the material, facilitate cleanup, and remediate affected media. If vessel discharges should occur, the amounts of leakage would be small, would disperse into the Scotia Sea and South Atlantic Ocean, and would not impact whales directly or pose hazards to their food sources. Therefore, we conclude this stressor is discountable, and it is not discussed further in this Opinion.

8.1.1.2 Vessel Strike

The possibility of vessel strike is extremely unlikely. The *Palmer* would be traveling at relatively low speeds (less than 11.1 km/h [6 kts] during all surveys and an average of 18.7 km/hr [10.1 kts] during transit to and from Punta Arenas and between survey areas), reducing the probability of a ship-strike (Vanderlaan and Taggart 2007). Additionally, PSOs would be watching for whales during all surveys and transit, further reducing the possibility of ship strike. Therefore, we conclude this stressor is discountable, and it is not discussed further in this Opinion.

8.1.1.3 Entanglement

The possibility of entanglement in the towed hydrophone streamer(s) or mechanical wire for dredge deployment is extremely unlikely. Though it is possible that the towed hydrophone streamer(s) and mechanical wire could come in direct contact with ESA-listed whales, entanglement is highly unlikely due to the rigid design of the streamer(s) and stiffness of the mechanical wire. Also, a PSO would monitor during deployment and retrieval of gear, further minimizing risk of entanglement. Therefore, we conclude this stressor is discountable, and it is not discussed further in this Opinion.

8.1.1.4 Vessel and Dredging Noise

Vessel noise is expected to have insignificant effects on ESA-listed whales. The propulsion system of the *Palmer* is designed to be quieter than other vessels, to reduce acoustic interference with seismic activities. Though noise originating from vessel propulsion will propagate into the marine environment, the amount would be insignificant. The *Palmer's* passage past a whale would be brief and would not impact an individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking would be possible, though 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).

Noise from dredging activities is also expected to have insignificant effects on ESA-listed whales. NSF assumes, and we agree, that noise associated with the mechanical actions of the dredging activities would be below 120 dB. We expect ESA-listed whales would respond similarly to dredging noise as they would vessel noise, described above. Therefore, we conclude this stressor is insignificant, and it is not discussed further in this Opinion.

8.1.1.5 Expendable Bathythermographs

Interactions with expendable bathythermographs would be unlikely. Up to 60 2-kilogram expendable bathythermographs would be released into the water over the course of the surveys and would not be recovered. These devices would either sink to the seafloor or eventually wash ashore. The deposition of these devices on the seafloor would be extremely localized in the Action Area and would not be expected to impact ESA-listed whales or their habitat, as they are very small devices and would sink rapidly. Therefore, we conclude this stressor is discountable, and it is not discussed further in this Opinion.

8.1.1.6 Summary of Stressors Not Likely to Adversely Affect ESA-listed Species

In conclusion, based on review of available information, we determined the following stressors would be unlikely to occur, and thus are discountable:

- vessel strike
- entanglement in
    - towed hydrophone
    - mechanical wire for dredge deployment
- interactions with expendable bathythermographs

We determined the following stressors would have insignificant effects on ESA-listed whales:

- vessel discharge
- noise from
    - vessel
    - dredging activities
- disturbance of sediment

Lastly, we determined that sounds from the acoustic Doppler current profiler would not be perceived by whales and, therefore, not be classified as a stressor.

8.1.2 Stressors Likely to Adversely Affect ESA-listed Species

The following sections analyze the remaining stressors likely to adversely affect ESA-listed species. These stressors are sounds from:

- airguns
- sub-bottom profiler
- multibeam echosounder

8.2 Exposure

Our exposure analyses identify the co-occurrence of ESA-listed species with the action's effects in space and time as well as the nature of the co-occurrence. When possible, we identify the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects, as well as the populations(s) or subpopulation(s) those individuals represent.

For the exposure analysis conducted for this consultation, we focused primarily on the estimated number of individual whales likely to be exposed to received sound levels greater than 160 dB re 1 μPa_{rms}. This number represents the best estimate of adverse response of ESA-listed whales available to us. A review of available literature (see Section 8.3.1) supports this threshold as the point at which baleen whales tend to show avoidance response to received seismic sound. The NSF's assumption that individuals will move away if they experience sound levels high enough to cause significant stress or functional impairment is also reasonable (see Sections 8.3.1.1 and 8.3.1.4).

8.2.1 Airguns

As described in Section 3.1.2.1, the Lamont-Doherty Earth Observatory modeled exposure radii for the airguns proposed for use (see Table 2). The maximum distance from airguns where received levels might reach 160 dB re 1 μPa_{rms} is 670 m. To calculate the area around the *Palmer* that would be ensonified during seismic surveys, NSF multiplied the distance by two (670 m x 2 = 1.34 km), then multiplied by the proposed total length of the seismic tracklines (2,950 km), to provide an estimated maximum ensonified area of 3,953 km^2.

In the early stages of this consultation, we reviewed available marine mammal densities with NSF, the Permits Division, and the Marine Mammal Commission and agreed upon which densities constituted the best available scientific information for each ESA-listed species. The NSF multiplied these densities by the estimated maximum ensonified area to estimate the numbers of whales that would be exposed to sounds in excess of 160 dB re 1 μPa_{rms} during proposed project activities. The Permits Division adopted these estimates for use in its proposed incidental harassment authorization, and we have adopted them for our exposure analysis. Table 5 summarizes the densities, data sources, and estimated exposures.

We assume these estimates represent the maximum number of whales that would be exposed, because the ensonified area has been increased by 25 percent to allow for equipment testing, ramp-up, line changes, or repeat coverage.

Table 5. Estimated exposure of ESA-listed whales to sound levels greater than 160 dB re 1 μPa_{rms} during proposed seismic activities, Scotia Sea and South Atlantic Ocean.

Species	Density (# whales/km^2)[1]	Estimated Exposure (# of whales)[2]
Blue whale	0.000051	1
Fin whale	0.018204	72
Humpback whale	0.000661	3
Sei whale	0.006359	25
Southern right whale	0.007965	31
Sperm whale	0.002069	8

[1] *Densities from Department of the Navy (2012), except for southern right whale; density derived from sighting data reported in BAS (Undated).*

[2] *Calculated by multiplying each whale density by the estimated maximum ensonified area (3,953 km^2).*

From the information available, we cannot estimate the age or life stage, gender, or reproductive condition of the whales that might be exposed to survey activities. We assume whales could represent any age class and either sex.

8.2.2 Other Acoustic Sources

Two additional acoustic systems will operate during the proposed activities:

- single beam echo sounder
- multi-beam sonar

As shown in Section 3.1.3, both systems have the potential to expose ESA-listed species to sound above 160 dB re 1 μPa_{rms}. These systems operate at higher frequencies than airgun operations, meaning that their frequencies would attenuate more rapidly than frequencies from airguns. Whales would experience higher levels of airgun noise well before noise of equal amplitude from the above sources would reach them. Therefore, operational airguns would essentially mitigate exposure to sound from these sources because the animal would hear and respond to the airguns before the sounds from these sources reached them.

Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multibeam echosounders and sub-bottom profilers (single-beam echosounders) similar to the systems proposed to be used presented a very low risk of auditory damage or other injury to marine mammals. Because these systems emit energy in concentrated beams, a whale would have to pass the *Palmer* at very close range and match its speed in order to experience temporary threshold shift (TTS), a type of temporary hearing impairment (Kremser et al. 2005).[15] TTS could only occur at even closer ranges for single-beam echosounder signals, because their source level is lower. Therefore, though it is possible that whales could be exposed to sounds high enough to cause TTS during the proposed study, we would expect the number of individuals to be very small. We are unable to quantify the level of exposure, but assume it would be much lower than the number of whales that could be exposed to airguns.

In addition, when airguns are not operational, PSOs would remain on duty. If ESA-listed whales were to closely approach the vessel, the *Palmer* would take evasive actions to avoid a ship strike. This evasive

[15] Please refer to Section 8.3.1.1 for further discussion about TTS.

action would also mitigate exposure of whales to high source levels from these acoustic systems. In Section 8.1.1.2 we determined that ship strike would be unlikely to occur. Consequently, high-level ensonification of whales from the above two sources would be unlikely to occur.

8.3 Response

As discussed in the Approach to the Assessment (Section 5), response analyses determine how ESA-listed resources are likely to respond after being exposed to an action's effects either on the environment or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals. Our response analyses consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

8.3.1 Airguns

Seismic airgun pulses displace water around the airgun and create a wave of pressure (i.e., sound), resulting in physical effects on the marine environment that can, in turn, affect marine organisms. Possible responses considered in this analysis are:

- threshold shifts
- auditory interference (masking)
- behavioral responses
- non-auditory physical or physiological effects

This analysis also considers information on the potential for stranding and potential effects of ESA-listed whale prey in the Action Area.

8.3.1.1 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. TTS is a temporary hearing change, and its severity is dependent upon the duration, frequency, sound pressure, and rise time of a sound (Finneran and Schlundt 2013). TTSs can last minutes to days. Full recovery is expected and this condition is not considered a physical injury. However, a study in mice indicated that although full hearing can be regained from TTS, cochlear nerve damage can occur, leading to delayed and permanent hearing loss (Kujawa and Liberman 2009). At higher received levels, or in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur. When PTS occurs, auditory sensitivity is unrecoverable (i.e., permanent hearing loss). Both TTS and PTS can result from a single pulse or from accumulated effects of multiple pulses. In the case of exposure to multiple pulses, each pulse need not be as loud as a single pulse to have the same accumulated effect. TTS and PTS occur only in the frequencies to which an animal is exposed.

Few data are available to define the hearing range, frequency sensitivities, or sound levels necessary to induce TTS or PTS in all ESA-listed species. Instead, the best available information (based upon studies of captive toothed whales, our understanding of terrestrial mammal hearing, and extensive modeling) supports the conclusion that energy levels of approximately 196 to 201 dB re 1 μPa_{rms} would be required to induce low-level TTS from a single pulse at a given frequency (Southall et al. 2007). To experience TTS during the proposed activities, a marine mammal would have to be within 20 m of the *Palmer's* airgun array to be exposed to sound levels of 190 dB re 1 μPa_{rms}. PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis (Southall et al. 2007). If exposed to several airgun pulses of approximately 190 dB re 1 µPa_{rms} during the proposed activities, an individual could experience PTS.

We do not expect TTS or PTS to occur to any ESA-listed whale as a result of airgun exposure for the following reasons:

- we assume individuals would move away from the airgun array as it approaches
- we assume that as sound intensity increases (i.e. as the *Palmer* approaches), individuals would experience conditions (stress, loss of prey, discomfort, etc.) that would prompt them to move away from the sound source
- ramp-ups would reduce the probability of TTS exposure at the start of seismic surveys
- shut-downs would be initiated if a whale comes within 100 m of the Palmer (i.e. before the whale experienced sound levels where TTS may occur)

8.3.1.2 Auditory Interference (Masking)

Auditory interference, or masking, occurs when an interfering noise is similar in frequency and loudness to (or louder than) the auditory signal received by an animal while it is processing echolocation signals or listening for acoustic information from other animals (Francis and Barber 2013). Masking can interfere with an animal's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Francis and Barber 2013).

There is frequency overlap between airgun noise and vocalizations of ESA-listed whales. The proposed seismic surveys could mask whale calls at lower frequencies. This could affect communication among individuals or affect their ability to receive information from their environment (Evans 1998).

Most energy in sperm whales clicks is concentrated between 2 to 4 kHz and 10 to 16 kHz. Though findings by Madsen et al. (2006) suggest frequencies of seismic pulses can overlap this range, the strongest dominant frequency range is 0.02 to 0.16 kHz for the *Palmer* airguns. Given the difference between sperm whale sounds and the dominant frequencies for seismic surveys, masking is not likely to occur in sperm whales.

Of greater concern is the possibility of masking in baleen whales from the overlap of dominant low frequencies of airgun pulses with low-frequency whale calls. However, the *Palmer's* airguns will emit a 0.1 sec pulse when fired every 5 to 10 sec. Due to the short time the pulse could be audible, we would not expect the pulses to "cover up" vocalizations of ESA-listed whales to a significant extent (Madsen et al. 2002).

In summary, we do not expect masking to occur in sperm whales. If masking does occur in baleen whales, we would not expect it to interfere with communication, given the short duration of seismic pulses.

8.3.1.3 Behavioral Responses

We expect the majority of whale responses to the proposed activities would occur in the form of behavioral response. Whales may exhibit a variety of behavioral changes in response to underwater sound and can be generally summarized as:

- modifying or stopping vocalizations
- changing from one behavioral state to another
- movement out of feeding or breeding areas

In cases where whale response is brief (i.e., changing from one behavior to another, relocating a short distance, or ceasing vocalization), effects are not likely to be significant at the population level, but could rise to the level of take of individual whales.

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). Though some studies are available which address responses of ESA-listed whales considered in this Opinion directly, additional studies to other related cetaceans (such as bowhead and gray whales and dolphins) are relevant in determining the responses expected by species in the Action Area. Therefore, studies from non-listed or species outside the Action Area are also considered here.

Several studies have described whale calling behavior in response to airgun sound:

- whales continued calling while seismic surveys were operating locally (Richardson et al. 1986, McDonald et al. 1995, Tyack et al. 2003, Smultea et al. 2004, Jochens et al. 2006)
- humpback whale males increasingly stopped vocal displays on breeding grounds as received seismic airgun levels increased (Cerchio et al. 2014)
- fin whales (presumably adult males) engaged in singing moved away from a seismic survey while airguns were operational and for at least a week after (Castellote et al. 2012)
- a blue whale discontinued calls in response to received airgun sound of 143 dB re 1 μPa for 1 hr before resuming (McDonald et al. 1995)
- blue whales may attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Di Iorio and Clark 2010)
- no response by sperm whales to received airgun sound levels up to 130 dB re 1 μPa_{rms}[16] (Madsen et al. 2002)
- bowhead whale calling rates decreased when exposed to seismic airguns at received levels of 116 to 129 dB re 1 μPa (possibly due to whale movement away from the airguns)
    - calling rates did not change at received levels of 99 to 108 dB re 1 μPa (Blackwell et al. 2013)
- bottlenose dolphins progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013)

Some exposed whales may cease calling in response to the *Palmer's* airguns; however, we expect the effect would be temporary.

Exposure to airgun sound may cause whales to change from one behavioral state to another. Most studies generally support a threshold of approximately 160 dB re 1 μPa_{rms} as the received sound level at which behavioral responses (other than vocalization changes) occur, though responses to lower-amplitude sounds are known (Richardson et al. 1995). Activity of individuals at the time of exposure seems to influence response, as indicated by several studies:

- feeding individuals responded less than mother/calf pairs and migrating individuals (Malme et al. 1984, Malme et al. 1985, Richardson et al. 1995)

[16] Originally reported as 146 dB re 1 $\mu Pa_{p\text{-}p}$.

- duration at the surface 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 showed strong avoidance reactions to received levels of 120 to 130 dB re 1 μPa$_{rms}$ at distances of 20 to 30 km
    - only changed dive and respiratory patterns while feeding
    - showed avoidance at received sound levels of 152–178 dB re 1 μPa$_{rms}$ (Richardson et al. 1986, Ljungblad et al. 1988, Richardson et al. 1995, Miller et al. 1999, Richardson et al. 1999)
    - bowhead whales showed temporary displacement from seismic sources (Richardson et al. 1986)
- despite exposure to repeated seismic surveys, bowhead whales continued to return to summer feeding areas (Richardson et al. 1986)
- gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re 1 μPa$_{rms}$ (Malme et al. 1984, Malme et al. 1986, 1987, Gailey et al. 2007)
- migrating gray whales began to show changes in swimming patterns at approximately 160 dB re 1 μPa$_{rms}$
    - showed slight behavioral changes at 140-160 dB re 1 μPa$_{rms}$ (Malme et al. 1984)

In the case of the bowhead and gray whales that return to feeding areas, it is not known whether the exposed whales are the same whales returning, nor is it known if whales that tolerate repeat exposures may still experience some kind of stress response or long-term effects, if they occur at all (Malme et al. 1984). Johnson et al. (2007) reported that gray whales exposed to seismic airguns off Sakhalin Island, Russia, did not experience any biologically-significant or population-level effects, based on research in the area from 2002 to 2005.

Humpback whales appear to be most tolerant to airgun activity during feeding. Whales along Alaska startled at 150 to 169 dB re 1 μPa$_{rms}$, but exhibited no clear evidence of avoidance at received levels up to 172 re 1 μPa$_{rms}$ (Malme et al. 1984, Malme et al. 1985). In general, humpback whales exhibit lower threshold responses when they are not 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 8 to 12 km from the seismic source
    - a startle response occurred as low as 112 dB re 1 μPa$_{rms}$
    - closest approaches were generally limited to 3 to 4 km
        - 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 to 164 dB re 1 μPa$_{rms}$ (McCauley et al. 1998, McCauley et al. 2000)

Observational data are sparse for baleen whale response to airguns on breeding and feeding grounds. Available data support a general avoidance response, though Weir (2008) did not observe any clear difference observed in encounter rate or point of closest approach during seismic versus non-seismic periods for humpback whales on Angolan breeding grounds. Differences in fin and sei whale sighting rates during seismic and non-seismic periods are not clear. Some data indicate similar sighting rates during seismic and non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone and Tasker 2006).

As discussed previously, sperm whale response to airguns includes 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 to seismic activity (Madsen et al. 2006, Stone and Tasker 2006, Weir 2008, Miller et al. 2009, Winsor and Mate 2013) Lack of response in this species may be due to its higher range of hearing sensitivity and the low-frequency (generally less than 0.188 kHz) pulses produced by seismic airguns (Richardson et al. 1995). However, several other studies have shown some level of disturbance in sperm whales:

- avoidance reactions in response to seismic ensonification in the Gulf of Mexico (Mate et al. 1994, Jochens and Biggs 2004)
- other anthropogenic sounds, such as pingers and sonars, were found to disrupt behavior and vocal patterns (Watkins and Schevill 1975, Watkins et al. 1985, Goold 1999)
- though generally unresponsive to airgun exposure in the Gulf of Mexico, possible delayed foraging and altered vocal behavior was noted (Miller et al. 2009)

As mentioned previously, an individual whale's behavioral response to airgun sounds is likely dependent on a variety of factors. We would not expect every whale to respond to sounds from the proposed activities in the same manner, if at all. For whales that do exhibit behavioral responses, we expect the following to represent the greatest level of behavioral response:

- exhibit an avoidance reaction during feeding, displacing individuals from the area temporarily
    - we expect secondary foraging areas would be available, allowing whales to continue feeding, though possibly not in their preferred area
- in the event that breeding would be occurring in the Action Area, we would expect temporary disruption of breeding
- deflection of a few kilometers from the route traveling or migrating whales would have otherwise traveled

We would not expect the proposed activities to substantially impact feeding or breeding opportunities, because any displacement would be temporary and localized. Further, there is no indication that the specific survey area from where animals would move is likely to be a preferred or higher quality habitat compared to areas where animals move into. We also would not expect traveling or migrating whales to alter their routes by more than a few kilometers and given the vastness of the area, this would not be a significant alteration of their migration.

8.3.1.4 Physical and 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. "Stress" is an adaptive response and does not normally place an animal at risk. "Distress" is a stress response resulting in a biological consequence to the individual. The mammalian stress response results from stimulation of the hypothalamic-pituitary-adrenal (HPA) axis by a stressor. This stimulation then causes a cascade of physiological responses, such as the release of stress hormones (Thomson and Geraci 1986, St. Aubin and Geraci 1988, St. Aubin et al. 1996, Gulland et al. 1999, Busch and Hayward 2009) such as:

- cortisol
- adrenaline (epinephrine)
- glucocorticosteroids
- numerous other stress hormones

This release of hormones can cause (Thomson and Geraci 1986, Kaufman and Kaufman 1994, St. Aubin and Dierauf 2001, Cattet et al. 2003, Greer et al. 2005, Elftman et al. 2007, Fonfara et al. 2007, Noda et al. 2007, Mancia et al. 2008, Busch and Hayward 2009, Dickens et al. 2010):

- short-term weight loss
- liberation of glucose into the blood stream
- impairment of the immune and nervous systems
- elevated heart rate
- changes in body temperature
- changes blood pressure
- alertness
- other responses

In highly stressful circumstances, or in species prone to strong “fight-or-flight” responses, more extreme consequences can result, including muscle damage and death (Curry and Edwards 1998, Cowan and Curry 2002, Herráez et al. 2007, Cowan and Curry 2008). Mammalian stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996, Gardiner and Hall 1997, Hunt et al. 2006, Keay et al. 2006, Romero et al. 2008).

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 226 dB re 1 $\mu Pa_{0\text{-}p}$ pressure) and single pure tones (up to 201 dB re 1 μPa) had increases in stress chemicals, including catecholamines, which can affect an individual’s immune response. 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, suggesting that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to their previous level within 24 hrs after the resumption of shipping traffic. Exposure to loud noise can also adversely affect reproductive and metabolic physiology (Kight and Swaddle 2011). 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).

Whales use hearing as a primary way to gather information about their environment and for communication; therefore, we assume that limiting these abilities would be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (National Research Council 2003, NMFS 2006).

As discussed in Section 8.3.1.1, we do not expect individuals to experience TTS or PTS; therefore, we also do not expect any ESA-listed individual to experience stress responses at high levels. We assume that stress responses could be associated with displacement, whether due to disruption of feeding, breeding, traveling, or migrating. If whales are not displaced and remain in a stressful environment (i.e. near sounds associated with the airguns and other acoustic sources), we expect the stressors would dissipate in a short period as the *Palmer* (and stressors) moves away. In any of the above scenarios, we would not expect significant or long-term harm to individuals from a stress response.

8.3.1.5 Strandings

There is some concern regarding marine mammal strandings and seismic surveys; however, no conclusive evidence has linked stranding events to seismic surveys.

Suggestions of a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well-founded (IAGC 2004, IWC 2006). In September 2002, two Cuvier's beaked whales stranded in the Gulf of California, Mexico. The *R/V Maurice Ewing* had been operating a 20-airgun, 139,126-cm^3 (8,490-in^3) airgun array 22 km offshore of the general area at the time that the 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 not 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).

Because there is no conclusive evidence linking seismic surveys and strandings, we do not expect ESA-listed whales to strand as a result of the proposed seismic survey.

8.3.1.6 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. Species-specific information about prey of ESA-listed whales is generally not available; however, we expect teleost, cephalopod, and krill prey of ESA-listed whales to react in manners similar to the fish and invertebrates described below.

Some support has been found for fish or invertebrate mortality resulting from airgun exposure, though this is limited to close-range exposure to high-amplitude sounds (La Bella et al. 1996, Santulli et al. 1999, McCauley et al. 2000, Hassel et al. 2003, McCauley et al. 2003, Popper et al. 2005, Thomsen 2013). In general, we would expect fish to be capable of moving away from the airgun array if it causes discomfort. However, if any lethal effects did occur, we would expect it only within a few meters of the airgun array.

More evidence exists for sub-lethal effects:

- several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re 1 μPa) at close distances, with some cases of injury (McCauley et al. 2003)
- at average received levels of 197 dB re 1 μPa_{rms}:
    - pike showed TTS (10 to 15 dB of hearing loss) with recovery within 1 day
    - whitefish did not experience TTS (Popper et al. 2005)
- exposure to airguns at close range was found to produce balance issues in fry (Dalen and Knutsen 1986)

However, 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).

The most common response by fishes is a startle response, where fish react momentarily by changing orientation, swimming speed, or their vertical distribution in the water column:

- caged *Pelates* spp. (terapon), pink snapper, and trevally (a member of the jack family) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns, though received sound levels were not reported
    - effects generally persisted for several minutes
    - subsequent exposures to the same individuals did not necessarily elicit a response (McCauley and Fewtrell 2013)
- startle responses were observed in rockfish at received airgun levels of approximately 190 dB re 1 μPa_{rms}[17]
    - alarm responses were observed at sound pressure levels greater than 167 dB re 1 μPa_{rms}[18]
    - fish tightened schools and shifted their distribution downward
    - previous position and behavior resumed 20 to 60 min after seismic firing ceased (Pearson et al. 1992)
- whiting exhibited downward shifts upon exposure to 168 dB re 1 μPa_{rms}[19] seismic sound
    - habituated to the sound after 1 hr and returned to previous depth (sound environments of 185 to 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 shift downward (La Bella et al. 1996)
- blue whiting and mesopelagic fishes redistributed themselves 20 to 50 m deeper in response to airguns
    - shifted away from the survey area (Slotte et al. 2004)
- in several fish species, responses were generally observed at received sound levels of 156 to 161 dB re 1 μPa_{rms}
    - smaller fish showed startle responses at lower sound levels than larger fish
    - responses tended to decrease over time, suggesting habituation
    - caged fish showed increases in swimming speeds and downward vertical shifts (McCauley et al. 2000)
- increased swimming activity and reduced foraging activity were observed in response to airgun exposure (Løkkeborg et al. 2012)
- cod and haddock likely vacate seismic survey areas in response to airgun activity
    - estimated catchability decreased starting at received sound levels of 150 to 170 dB re 1 μPa_{rms}[20] (Dalen and Knutsen 1986, Turnpenny and Nedwell 1994, Engås et al. 1996)
- startle responses were infrequently observed in salmonids at received levels of 126 to 170 dB re 1 μPa_{rms}[21] (Thomsen 2002)

Startle responses to airguns were not found in some studies:

- bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 153 to 181 dB re 1 μPa_{rms}[22] (Turnpenny and Nedwell 1994)
- European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al. 1994)

[17] Originally reported as 200 dB re 1 $\mu Pa_{0\text{-}p}$.
[18] Originally reported as 177 dB re 1 $\mu Pa_{0\text{-}p}$.
[19] Originally reported as 178 dB re 1 $\mu Pa_{0\text{-}p}$.
[20] Originally reported as 160 to 180 dB re 1 $\mu Pa_{0\text{-}p}$.
[21] Originally reported as 142 to 186 dB re 1 $\mu Pa_{p\text{-}p}$.
[22] Originally reported as 163 to 191 dB re 1 $\mu Pa_{0\text{-}p}$.

A mixture of responses was found in other studies:

- no differences in trawl catch data before and after seismic operations
    - echosurveys of fish occurrence did not reveal differences in pelagic biomass
    - fish kept in cages did show behavioral responses to approaching airguns (La Bella et al. 1996)
- pollock did not respond to received airgun sounds of 185 to 208 dB re 1 μPa_{rms}[23]
    - startle responses were exhibited and fish fled from the seismic source when visible (Wardle et al. 2001)

Some studies have documented squid responses to airguns:

- exhibited both startle (ejecting ink) and avoidance responses at received sound levels of 174 dB re 1 μPa_{rms}
- upward movement was noted
- did not discharge ink during ramp-up
- alarm responses occurred when received sound levels reached 156 to 161 dB re 1 μPa_{rms} (McCauley et al. 2000, McCauley and Fewtrell 2013)
- mortality of giant squid has been suggested in association with seismic surveys, based upon coincidence of carcasses with surveys in time and space, as well as pathological information from carcasses (Guerra et al. 2004)

Lobsters did not exhibit delayed mortality or loss of ability to right themselves after up to eight months post-exposure to airguns fired at 186 to 211 dB re 1 μPa_{rms}[24] pressure, though feeding did increase in exposed individuals (Payne et al. 2013).

The overall response of fishes and squids to airgun exposure 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 ESA-listed baleen whales) to experience effects from airgun sound. Though humpback whales consume fish regularly, we expect that any disruption to their prey would 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 would be feeding while in the Action Area during the proposed survey. Based upon the best available information, fishes and squids ensonified by approximately 160 dB re 1 μPa_{rms} could vacate the area, dive to greater depths, or be more alert for predators. Because fish would need to be within a few meters of the airguns to experience mortality, we would not expect reduced feeding opportunities for sperm whales. Any effects would be temporary and, if displaced, both sperm whales and their prey would be expected to return to the area once survey activities have passed.

In summary, though the prey of ESA-listed whales may respond temporarily to sound from airguns or possibly experience mortality in small numbers, we would not expect these effects to, in turn, affect ESA-listed whales by reduction in prey availability.

8.3.2 Other Acoustic Sources

In addition to airguns, we also expect ESA-listed whales to experience ensonification from:

[23] Originally reported as 195 to 218 dB re 1 $\mu Pa_{0\text{-}p}$.

[24] Originally reported as 202 or 227 dB re 1 $\mu Pa_{p\text{-}p}$.

- single beam echo sounder
- multi-beam sonar

Hearing is poorly understood in ESA-listed whales, but it is assumed that they are most sensitive to frequencies in which they vocalize. The above systems operate at higher frequencies than those used by most ESA-listed whales, with the exceptions being humpback and sperm whales.

In general, if the following species are exposed to frequencies from the above systems, we expect that they would be unlikely to hear the frequencies well (if at all) and would not expect them to respond:

- fin whale
- sei whale
- southern right whale

We expect that the single beam echo sounder and multi-beam sonar systems will produce harmonic components in frequencies above and below the center frequency, similar to other commercial sonars (Deng et al. 2014). However, we also would not expect harmonic frequencies in the systems proposed to be used to be audible to these species as the harmonics would be outside the hearing range of ESA-listed species.

The single beam echo sounder emits frequencies of 3.5 kHz or 12 kHz, depending on the mode of operation. The multi-beam sonar operates at a frequency of 12 kHz. As discussed in Section 6.3.2, humpback whales vocalize between the frequencies of 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz. Therefore, we would expect humpback whales to be able to detect sounds produced by the single beam echo sounder and possibly harmonics created by the operation of the multi-beam sonar, but not its center frequency of 12 kHz. As discussed in Section 6.6.2, sperm whales are assumed to be capable of hearing the same frequencies they produce (0.1 to 20 kHz). In addition, an audiogram of a juvenile sperm whale indicated a hearing range of 2.5 to 60 kHz. Therefore, we expect that sperm whales would be able to detect sounds produced by the single beam echo sounder and the multi-beam sonar systems. Though blue whales produce very low frequencies (0.016 to 0.060 kHz), Goldbogen et al. (2013) found blue whales responded to 3.5 to 4.0 kHz mid-frequency sonar at received levels below 90 dB re 1 μPa.

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 match the vessel's speed; therefore, we expect a very small possibility that ESA-listed whales would be exposed to single beam echo sounder or multi-beam sonar sounds. Burkhardt et al. (2013) estimated the risk of injury from multibeam sonar was less than three percent that of ship strike. However, if a whale were to be exposed, we would expect whale responses to be similar to those described below:

- Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kHz sonar (Maybaum 1993)
- sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding
    - did not respond while traveling (André and López Jurado 1997)
- sperm whales stopped vocalizing in response to 6 to 13 kHz pingers
    - did not respond to 12 kHz echo-sounders (Watkins and Schevill 1975)

- responses of blue whales exposed to 3.5 to 4.0 kHz mid-frequency sonar at received levels below 90 dB re 1 μPa included
    - cessation of foraging
    - increased swimming speed
    - directed travel away from the source (Goldbogen et al. 2013)

We would not expect masking of blue, sperm, or humpback whale communications to occur because multibeam sonar and single-beam have narrow beams in which sound is emitted and both operate in short pulses. If exposure was to occur, we would it expect it to be too brief to interfere with communications.

Investigations of a 2008 stranding event in Madagascar suggested a 12 kHz multibeam sonar, similar in operating characteristics to that proposed for use aboard the *Palmer*, played a significant role in the mass stranding of melon-headed whales (Southall et al. 2013). Though the authors note that pathological data suggesting direct physical effects are lacking, all other possibilities were either ruled out or believed to be of much lower likelihood as a cause of or contributor to the stranding (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 *Palmer* multibeam echosounder. Though the use of this type of sonar is common worldwide and effects of this magnitude have not been documented for ESA-listed species, it is possible that the combination of exposure to 12 kHz sonar with other factors, such as those below, could combine to produce a response that is greater than would otherwise be anticipated or has been documented (Ellison et al. 2012, Francis and Barber 2013):

- behavioral and reproductive state
- oceanographic and bathymetric conditions
- movement of the source
- previous experience of individuals with the stressor

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 (NMFS and Navy 2001). The systems proposed for use on the *Palmer* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the downward-directed multibeam sonar and single beam echosounder. The sound energy received by any individuals exposed to these systems during the proposed activities would be lower than that of naval sonars, and would be briefer. The area of possible influence is also smaller, consisting of a narrow zone close to and below the source vessel.

In summary, while we accept that it is possible for ESA-listed whales to be exposed to sounds from single beam echo sounder and multi-beam sonar, we would not expect injury to occur. If exposed, blue, sperm, and humpback whales may respond briefly (i.e., startling or increasing swimming speed), but we would not expect any such responses to have any long-term impacts or to impact the fitness of any individual whales. We would not expect fin, sei, or southern right whales to respond.

9 Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the Action Area considered by this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation, per section 7 of the ESA.

We searched for information on non-federal actions reasonably certain to occur in the Action Area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline. We expect natural sources of mortality, climate change, fishing, shipping, seismic surveys, scientific research, and ecotourism will continue into the future. We expect moratoria on commercial whaling to remain in place, which will aid in the recovery of ESA-listed whales. Creation of the Marine Protected Area around South Georgia may also benefit ESA-listed whales.

10 Integration and Synthesis of Effects

The NSF proposes to allow the use of the U.S. Antarctic Program research vessel/icebreaker *Nathaniel B. Palmer* to conduct a seismic survey by the University of Texas at Austin and University of Memphis. Because this action could incidentally harass several marine mammal species, NMFS's Permits Division proposes to issue an IHA to NSF for the proposed activities.

The narrative that follows integrates and synthesizes the information contained in the Status of the Species (Section 6), the Environmental Baseline (Section 7) and the Effects of the Action (Section 8) sections of this Opinion to assess the risk that the proposed activities pose to ESA-listed whales.

The species that may be affected by the proposed action are:

- blue whale
- fin whale
- humpback whale
- sei whale
- southern right whale
- sperm whale

All of these species are ESA-listed as endangered throughout their ranges. As discussed in the Status of the Species section (Section 6), past commercial whaling is the primary reason for their reduced populations. Though large-scale, commercial harvests no longer occur for these species, some whales are killed for subsistence purposes and scientific research in portions of their ranges. Several other factors discussed in the Environmental Baseline (Section 7) may be affecting survival and recovery of ESA-listed whales in the Action Area:

- natural mortality
    - predation
    - disease
    - parasites
    - stranding
- climate change
    - prey distribution
    - habitat quality
- commercial fishing
- ship strike
- anthropogenic noise

- seismic surveys
- scientific research
- whale watching

Despite these pressures, available trend information indicates most populations of ESA-listed whales are stable or increasing. In Cumulative Effects (Section 9), we identified actions in the Environmental Baseline (Section 7) that we expect to continue into the foreseeable future.

We concluded in the Effects of the Action (Section 8) that ESA-listed whales would be harassed by the proposed seismic activities. We expect the following numbers of whales could be exposed to airgun sounds:

- 1 blue
- 72 fin
- 3 humpback
- 25 sei
- 31 southern right
- 8 sperm

We expect this exposure could elicit the following temporary behavioral responses:

- cessation of calling
- avoidance of the ensonified area
    - displacement from feeding or breeding areas
    - deflection from travel or migration routes

We expect low-level, brief stress responses would accompany these behaviors. We would not expect whales exposed to these sounds to experience a reduction in fitness.

Prey may also exhibit temporary displacement from the ensonified area. We would not expect this displacement to limit the prey available to whales.

We also considered effects of the operation of single beam echo sounder and multi-beam sonar systems. These systems are not expected to be audible to the following whale species:

- fin
- sei
- southern right

Therefore, the operation of single beam echo sounder and multi-beam sonar systems are not expected to have any direct effects on these species.

The following whale species could hear sounds produced by these systems:

- blue
- humpback
- sperm

We would expect individuals of these species exposed to sounds from single beam echo sounder and multi-beam sonar may exhibit brief behavioral responses, such as startling or increasing swimming speed. We would not expect whales exposed to these sounds to experience a reduction in fitness.

In summary, we would not expect exposure to any of the stressors related to the proposed project to reduce fitness in any individual whale. Therefore, we would not expect fitness consequences to ESA-listed whale populations or species.

11 Conclusion

After reviewing the current status of ESA-listed whale species, the environmental baseline for the Action Area, the anticipated effects of the proposed activities and the possible cumulative effects, it is NMFS's opinion that the proposed geophysical surveys in the South Atlantic Ocean and Scotia Sea and the Permits Division's issuance of an IHA for the proposed action are **not likely to jeopardize** the continued existence of the following species:

- blue whale
- fin whale
- humpback whale
- sei whale
- southern right whale
- sperm whale

12 Incidental Take Statement

Section 9 of the ESA and Federal regulations under section 4(d) of the ESA prohibit the "take" of endangered and threatened species, respectively, without 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". NMFS further defines "harm" as "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." Under the terms of sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the NSF and the Permits Division so that they become binding conditions for NSF 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), under section 7(o) of the ESA.

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 the Permits Division's proposed authorization of the incidental taking of fin, blue, sei, humpback, southern right, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA. The final authorization will be issued and its mitigation and monitoring measures are incorporated in this Incidental Take Statement as Terms and Conditions. With this authorization, the incidental take of ESA-listed whales is exempt from the take prohibition of section 9(a), under section 7(o) of the ESA, as long as such take is consistent with this statement.

12.1 Amount or Extent of Take

NMFS anticipates the proposed seismic survey in the South Atlantic Ocean and Scotia Sea is likely to result in the incidental take of ESA-listed species by harassment. As presented in Table 5 in Section 8.2.1 of this document, the proposed action is expected to take by harassment the following numbers of ESA-listed whales:

- 1 blue
- 72 fin
- 3 humpback
- 25 sei
- 31 southern right
- 8 sperm

Harassment of these individuals would occur by exposure to received seismic sound levels greater than 160 dB re 1 μPa_{rms}. These estimates are based on the best available information of whale densities in the area that would be ensonified at sound levels greater than 160 dB re 1 μPa_{rms}. This incidental take would result primarily from exposure to acoustic energy during seismic operations and would be in the form of harassment. Death or injury is not expected for any individual whales that are exposed to these sounds.

Harassment is not expected for ESA-listed whale species exposed to seismic studies at levels less than 160 dB re 1 μPa_{rms}. If overt adverse reactions (for example, startle responses, dive reactions, or rapid departures from the area) by ESA-listed whales are observed at less intense levels than 160 dB re 1 μPa_{rms} while airguns are operating, incidental take may be exceeded. If such reactions by ESA-listed species are observed while airguns are in operation, this may constitute take that is not covered in this Incidental Take Statement. The NSF and Permits Division must contact the ESA Interagency Cooperation Division to determine whether reinitiation of consultation is required because of such operations.

Any incidental take of ESA-listed whale species considered in this consultation is restricted to the permitted action as proposed. If the actual incidental take exceeds the predicted level or type, NSF and the Permits Division must reinitiate consultation. All anticipated takes would be "takes by harassment," as described previously, involving temporary changes in behavior.

12.2 Effect of the Take

In this Opinion, NMFS has determined that the level of incidental take is not likely to jeopardize the continued existence of any ESA-listed species. Critical habitat for ESA-listed species will not be impacted because no critical habitat has been designated for species considered in this Opinion.

12.3 Reasonable and Prudent Measures

NMFS believes the reasonable and prudent measure described below is necessary and appropriate to minimize the amount of incidental take of ESA-listed whales resulting from the proposed actions. This measure is non-discretionary and must be a binding condition of the NSF's proposed action and the Permits Division's authorization for the exemption in section 7(o)(2) to apply. If NSF or the Permits Division fails to ensure compliance with this reasonable and prudent measure, the protective coverage of section 7(o)(2) may lapse:

- The NSF and the Permits Division must implement and monitor the effectiveness of mitigation measures incorporated as part of the proposed authorization for the incidental taking of blue, fin, sei, humpback, southern right, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA, as specified below.

12.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, NSF and the Permits 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 section 7 regulations (50 CFR 402.14(i)). These terms and conditions are non-discretionary. If NSF or the Permits Division fails 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, NSF and the NMFS Permits and Conservation Division shall ensure the following:

- buffer and exclusion zones
    - prior to operation of the airgun array, a 160 dB re 1 μPa_{rms} buffer zone and 180 dB re 1 μPa_{rms} exclusion zone for cetaceans must be established
- PSOs and visual monitoring
    - three PSOs shall be based onboard the vessel
    - one NMFS-qualified, vessel-based PSO would visually 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 ramp-ups of airguns, day or night
        - PSOs shall
            - have shifts lasting no longer than 4 hrs at a time
            - have access to reticle binoculars (7 x 50 Fujinon) equipped with a built-in daylight compass and range reticles
            - make observations during daytime periods when seismic airguns are not operating for comparison of animal abundance and behavior, when feasible
            - conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water
            - record the following information when a marine mammal is sighted
                - 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
- this information shall also be recorded 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
- time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, and sun glare

- PSOs would visually observe the entire extent of the exclusion zone for at least 30 min prior to starting the airgun array (day or night)
  - if the PSO(s) see a marine mammal within the exclusion zone, the seismic survey would be delayed until the marine mammal(s) has left the area
    - if the PSO(s) sees a marine mammal that surfaces, then dives below the surface, the PSO(s) would wait 30 min
      - if the PSO sees no marine mammals during that time, they would assume that the animal has moved beyond the exclusion zone
- the *Palmer*'s crew shall also assist in detecting marine mammals, when practicable
- if, for any reason (i.e., rough seas, fog, darkness), the entire radius cannot be seen for the entire 30 min, or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be ramped-up
  - if one airgun is already running at a source level of at least 180 dB re 1 μPa_{rms}, the second airgun could be started without observing the entire exclusion zone for 30 min prior, provided no marine mammals are known to be near the exclusion zone (in accordance with the condition below)

- ramp-up procedures
  - "ramp-up"[25] procedures would be implemented when beginning seismic operations or any time the entire array has been shut-down[26] for more than 15 min
    - during ramp-up, PSOs shall monitor the exclusion zone, and if marine mammals are sighted, a shut-down shall be implemented as though the full array (both GI airguns) were operational
    - initiation of ramp-up procedures from shut-down would require that PSOs be able to view the full exclusion zone
- shut-down procedures
  - airgun(s) would be shut down if a marine mammal is detected within, approaches, or enters the exclusion zone
    - following a shut-down, airgun activity shall not resume until the PSO(s) either:
      - have visually observed the marine mammal exiting the exclusion zone and it is not likely to return; or
      - have not seen the marine mammal within the exclusion zone for 30 min
  - following a shut-down and subsequent animal departure, airgun operations could be resumed, following ramp-up procedures described above
- speed or course alteration

[25] For this survey, a "ramp-up" would consist of firing one GI airgun for five min before starting the second airgun.
[26] "Shut-down" means all operating airguns are turned off.

- if, based on its position and relative motion, a marine mammal appears likely to enter the exclusion zone, the *Palmer's* speed or course would be altered
    - further mitigation measures, such as a shut-down shall be taken if speed or course alteration is not safe or practicable or, if after alteration, the marine mammal still appears likely to enter the exclusion zone
- survey operations at night
    - survey operations would be scheduled during daylight hours, to the maximum extent practicable
    - survey operations may continue into night and low-light hours if the survey is initiated when the entire exclusion zone is visible and can be effectively monitored
    - no initiation of airgun operations is permitted at night or during low-light hours (such as in dense fog or heavy rain) when the entire exclusion zone cannot be effectively monitored by the PSO(s)
- reporting requirements
    - within 90 days of the completion of the cruise, the NSF and ASC are required to submit a draft report to the Permits Division containing and summarizing the following information:
        - 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
        - species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (e.g., number of shut-downs), observed throughout all monitoring activities
        - an estimate of the number (by species) of marine mammals that
            - are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa_{rms} (for seismic airgun operations), and/or 180 dB re 1 μPa_{rms}
                - including a discussion of any specific behaviors those individuals exhibited
            - may have been exposed (based on modeled values for the two GI airgun array) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa_{rms} (for seismic airgun operations), and/or 180 dB re 1 μPa_{rms}
                - including a discussion of the nature of the probable consequences of exposure on the individuals that have been exposed
        - a description of the implementation and effectiveness of
            - these Terms and Conditions
                - the report shall 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 ESA-listed marine mammals
            - the mitigation measures of the IHA
    - within 30 days after receiving comments from NMFS on the draft report, submit a final report to the Chief, Permits Division
        - if the Permits Division decides that the draft report needs no comments, the draft report shall be considered to be the final report

- reporting prohibited take
  - in the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA (i.e. injury [Level A harassment][27] or serious injury or mortality [e.g., ship-strike, gear interaction, and/or entanglement]), NSF and ASC shall immediately cease the specified activities and immediately report the incident to the Chief, Permits Division and include the following information:
    - time, date, and location (latitude/longitude) of the incident
    - the name and type of vessel involved
    - the vessel's speed during and leading up to the incident
    - description of the incident
    - status of all sound source use in the 24 hrs preceding the incident
    - water depth
    - environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility)
    - description of marine mammal observations in the 24 hrs preceding the incident
    - species identification or description of the animal(s) involved
    - fate of the animal(s)
    - photographs or video footage of the animal (if equipment is available)
  - activities shall not resume until NMFS is able to review the circumstances of the prohibited take
    - NMFS shall work with NSF and ASC to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance
    - NSF and ASC may not resume their activities until notified by NMFS via letter, email, or telephone
- reporting an injured or dead marine mammal with an unknown cause of death
  - in the event that NSF and ASC discovers an injured or dead marine mammal, and the lead PSO 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 described in the next paragraph), NSF, ASC, and the Permits Division shall immediately report the incident to the Chief, ESA Interagency Cooperation Division and include the same information listed above
  - activities may continue while NMFS reviews the circumstances of the incident
    - NMFS shall work with NSF and ASC to determine whether modifications in the activities are appropriate
- reporting an injured or dead marine mammal not related to the activities
  - in the event that NSF and ASC discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to authorized project activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), NSF, ASC, and the Permits Division shall report the incident to the Chief, ESA Interagency Cooperation Division within 24 hrs of the discovery
    - NSF and ASC shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS
    - activities may continue while NMFS reviews the circumstances of the incident

[27] For additional information about Level A harassment, please refer to Section 8 of this Opinion.

13 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to:

- minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat
- help implement recovery plans
- develop information

We recommend the following conservation recommendation, which would provide information for future consultations involving seismic surveys and the issuance of IHAs that may affect ESA-listed large whales:

- **Collaboration with researchers**. We recommend that the NSF collaborate with whale researchers that may have satellite tags on ESA-listed whales in the Scotia Sea and South Atlantic Ocean during the same time as the proposed action. Collaboration with these researchers would allow for increased understanding of ESA-listed whale movement in response to seismic surveys.

In order for the ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their habitats, NSF and the Permits Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 Reintiation Notice

This concludes formal consultation on the proposed geophysical survey to be funded by NSF and conducted by the University of Texas at Austin and University of Memphis on board the *Nathaniel B. Palmer* (operated by ASC) in the South Atlantic Ocean and Scotia Sea and the proposed issuance of an IHA for the proposed survey pursuant to section 101(a)(5)(D) of the MMPA. As provided in 50 CFR § 402.16, 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:

- the amount or extent of proposed take is exceeded
- 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
- the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat not considered in this Opinion
- a new species is ESA-listed or critical habitat designated that may be affected by the action

In instances where the amount or extent of authorized take is exceeded, NSF and the Permits Division must immediately request reinitiation of section 7 consultation.

15 Literature Cited

Aburto, A., D. J. Rountry, and J. L. Danzer. 1997. Behavioral response of blue whales to active signals. Technical Report 1746, RDT&E Division, Naval Command, Control and Ocean Surveilance Center, U.S. Department of the Navy, San Diego, California.

Allen, B. M., and R. P. Angliss. 2013. Alaska marine mammal stock assessments, 2012. NOAA Technical Memorandum NMFS-AFSC-245, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Seattle, Washington.

Amaral, K. A., and C. A. Carlson. 2005. Scientific basis for whale watching guidelines: a review of current research. Paper SC/57/WW1 presented to the International Whaling Commission Scientific Committee, Ulsan, Korea.

Anderson, R. C., T. A. Branch, A. Alagiyawadu, R. Baldwin, and F. Marsac. 2012. Seasonal distribution, movements and taxonomic status of blue whales (*Balaenoptera musculus*) in the northern Indian Ocean. Journal of Cetacean Research and Management **12**:203-218.

André, M., and L. F. López Jurado. 1997. Sperm whale (*Physeter macrocephalus*) behavioural response after the playback of artificial sounds. Page 92 Tenth Annual Conference of the European Cetacean Society, Lisbon, Portugal.

Angliss, R. P., and R. B. Outlaw. 2005. Alaska marine mammal stock assessments, 2005. NMFSAFSC-161, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Atkinson, A., V. Siegel, E. Pakhomov, and P. Rothery. 2004. Long-term decline in krill stock and increase in salps within the Southern Ocean. Nature **432**:100-103.

Au, W. W. L. 2000. Hearing in whales and dolphins: An overview. Pages 1-42 *in* W. W. L. Au, A. N. Popper, and R. R. Fay, editors. Hearing by Whales and Dolphins. Springer-Verlag, New York.

Au, W. W. L., A. A. Pack, M. O. Lammers, L. M. Herman, M. H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. Journal of the Acoustical Society of America **120**:1103-1110.

Baldwin, R., T. Collins, G. Minton, K. Findlay, P. Corkeron, A. Willson, and M.-F. Van Bressem. 2010. Arabian Sea humpback whales: canaries for the northern Indian Ocean? , International Whaling Commission Scientific Committee, Agadir, Morocco.

Bannister, J. 2001. Status of southern right whales (*Eubalaena australis*) off Australia. Journal of Cetacean Research and Management:103-110.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon, and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97- 11, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

Barlow, J. 2003. Preliminary estimates of the abundance of cetaceans along the U.S. West Coast: 1991-2001. Administrative Report LJ-03-03, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn II, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., P. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science **27**:793-818.

BAS. Undated. Large scale distribution in the Scotia Sea, JR82 scientific cruise, January and February 2003: cruise report. Q3 Dynamoe Programme, Biological Science Division, British Antarctic Survey.

Baulch, S., and C. Perry. 2014. Evaluating the impacts of marine debris on cetaceans. Marine Pollution Bulletin **80**:210-221.

Beamish, P., and E. Mitchell. 1971. Ultrasonic sounds recorded in the presence of a blue whale *Balaenoptera musculus*. Deep Sea Research and Oceanogaphic Abstracts **18**:803-809.

Berzin, A. A. 1972. The sperm whale. Pacific Scientific Research Institute of Fisheries and Oceanography, Moscow, Russia.

Best, P. B., A. Brandão, and D. S. Butterworth. 2001. Demographic parameters of southern right whales off South Africa. Journal of Cetacean Research and Management:161-169.

Best, P. B., P. A. S. Canham, and N. MacLeod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Report of the International Whaling Commission **Special Issue 6**:51-79.

Best, P. B., and G. J. B. Ross. 1986. Catches of right whales from shore-based establishments in southern Africa, 1792-1975. Report of the International Whaling Commission **Special Issue 10**:275-289.

Best, P. B., C. M. Schaeff, D. Reeb, and P. J. Palsbøll. 2003. Composition and possible function of social groupings of southern right whales in South African waters. Behaviour **140**:1469-1494.

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

Blunden, J., D. S. Arndt, and Eds. 2014. 2014: state of the climate in 2013. Bulletin of the American Meteorological Society **95**:S1-S257.

Boebel, O., H. Bornemann, E. Burkhardt, and C. Ruholl. 2006. Risk assessment of Atlas Hydrographic Hydrosweep DS-2 deep sea multi-beam and Parasound DS-2 sediment echosounders. Pages 69-70 Twentieth Annual Conference of the European Cetacean Society, Gdynia, Poland.

Boyd, I. L. 2002. Antarctic marine mammals. Pages 30-36 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, California.

Branch, T. A., E. M. N. Abubaker, S. Mkango, and D. S. Butterworth. 2007. Separating southern blue whale subspecies based on length frequencies of sexually mature females. Marine Mammal Science **23**:803–833.

Breitzke, M. 2013. Overview of seismic research activities in the Southern Ocean - quantifying the environmental impact. Antarctic Science:13.

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

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

Calambokidis, J., T. Chandler, L. Schlender, G. H. Steiger, and A. Douglas. 2003. Final report: research on humpback and blue whale off California, Oregon and Washington in 2002. Report prepared by Cascadia Research for Southwest Fisheries Science Center, Olympic Coast National Marine Sanctuary, Scripps Institute of Oceanography, and Office of Naval Research, Olympia, Washington.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific Final report for Contract AB133F-03-RP-00078 Report by Cascadia Reseach, Olympia, Washington submitted to Western Administrative Center, U.S. Department of Commerce, Seattle, Washington, Olympia, Washington.

Carder, D. A., and S. H. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale, *Physeter* spp. Journal of the Acoustical Society of America **88**:S4.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, B. Hanson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, D. Lynch, L. Carswell, R. L. Brownell Jr., D. K. Mattila, and M. C. Hill. 2013. U.S. Pacific marine mammal stock assessments: 2012. Technical Memorandum NOAA-TM-NMFS-SWFSC-504, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Castellote, M., C. W. Clark, and M. O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation **147**:115-122.

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

CCAMLR. 2014. Statistical Bulletin, Volume 26. Available at: www.ccamlr.org.

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

Chapman, C. J., and A. D. Hawkins. 1969. The importance of sound in fish behaviour in relation to capture by trawls. FAO Fisheries Reports **62**:717-729.

Christal, J., and H. Whitehead. 1997. Aggregations of mature male sperm whales on the Galápagos Islands breeding ground. Marine Mammal Science **13**:59-69.

Christal, J., H. Whitehead, and E. Lettevall. 1998. Sperm whale social units: variation and change. Canadian Journal of Zoology **76**:1431-1440.

Christiansen, F., M. Rasmussen, and D. Lusseau. 2013. Whale watching disrupts feeding activities of minke whales on a feeding ground. Marine Ecology Progress Series **478**:239-251.

Clapham, P. J. 1996. The social and reproductive biology of humpback whales: An ecological perspective. Mammal Review **26**:27-49.

Clark, C., W. T. Ellison, B. Southall, L. Hatch, S. M. Van Parijs, A. S. Frankel, D. Ponirakis, and G. C. Gagnon. 2009. Acoustic masking of baleen whale communications: potential impacts from anthropogenic sources. Page 56 Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.

Clark, C. W., and R. A. Charif. 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996 - September 1997. JNCC Report Number 281 prepared for Joint Nature Conservation Committee, Aberdeen, Scotland.

Clark, C. W., and W. T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: evidence from models and empirical measurements. Pages 564-582 *in* J. A. Thomas, C. F. Moss, and M. Vater, editors. Echolocation in Bats and Dolphins. University of Chicago Press.

Clarke, M. R. 1977. Beaks, nets and numbers. Symposia of the Zoological Society of London **38**:89-126.

Clarke, M. R. 1980. Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. Discovery Reports **37**:1-324.

Clarke, R. 2004. Pygmy fin whales. Marine Mammal Science **20**:329-334.

Cook, A. J., S. Poncet, A. P. R. Cooper, D. J. Herbert, and D. Christie. 2010. Glacier retreat on South Georgia and implications for the spread of rats. Antarctic Science **22**:255-263.

Cooke, J. G., V. J. Rowntree, and R. Payne. 2001. Estimates of demographic parameters for southern right whales (*Eubalaena australis*) observed off Península Valdés, Argentina. Journal of Cetacean Research and Management:125-132.

Corkeron, P., P. Ensor, and K. Matsuoka. 1999. Observations of blue whales feeding in Antarctic waters. Polar Biology **22**:213-215.

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

COSEWIC. 2002. COSEWIC assessment and update status report on the blue whale, *Balaenoptera musculus*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, Canada.

COSEWIC. 2005. COSEWIC assessment and update status report on the fin whale *Balaenoptera physalus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, Canada.

COSEWIC. 2011. COSEWIC assessment and status report on the humpback whale (*Megaptera novaeangliae*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, Canada.

Coughran, D. K., N. J. Gales, and H. C. Smith. 2013. A note on the spike in recorded mortality of humpback whales (*Megaptera novaeangliae*) in Western Australia. Journal of Cetacean Research and Management **13**:105-108.

Cowan, D. E., and B. E. Curry. 2008. Histopathology of the alarm reaction in small odontocetes. Journal of Comparative Pathology **139**:24-33.

Cowan, D. F., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical Pacific tuna fishery. Administrative Report LJ-02-24C, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

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

Croll, D. A., A. Acevedo-Gutiérrez, B. R. Tershy, and J. Urbán-Ramírez. 2001. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? Comparative Biochemistry and Physiology A Molecular and Integrative Physiology **129**:797-809.

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

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound: technical report for LFA EIS. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz.

Cummings, W. C. 1985. Right whales, *Eubalaena glacialis* (Muller, 1776) and *Eubalaena australis* (Desmoulins, 1822). Pages 275-304 *in* S. H. Ridgway and S. R. Harrison, editors. Handbook of marine mammals. Academic Press, New York, New York.

Cummings, W. C., and P. O. Thompson. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. Journal of the Acoustical Society of America **50**:1193-1198.

Cummings, W. C., and P. O. Thompson. 1977. Long 20-Hz sounds from blue whales in the northeast Pacific. Page 73 Second Biennial Conference on the Biology of Marine Mammals, San Diego, California.

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

Curry, B. E., and E. F. Edwards. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean: research planning. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-254, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

Dalen, J., and G. M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. Pages 93-102 *in* H. M. Merklinger, editor. Progress in Underwater Acoustics. Plenum, New York.

Dawbin, W. H. 1986. Right whales caught in waters around south eastern Australia and New Zealand during the nineteenth and early twentieth centuries. Report of the International Whaling Commission **Special Issue 10**:261-267.

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

Department of the Navy. 2012. Commander Task Force 20, 4th, and 6th Fleet Navy marine species density database: technical report. Naval Facilities Engineering Command Atlantic, Department of the Navy, Norfolk, Virginia.

Di Iorio, L., and C. W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters **6**:51-54.

Dickens, M. J., D. J. Delehanty, and L. M. Romero. 2010. Stress: An inevitable component of animal translocation. Biological Conservation **143**:1329-1341.

Dierssen, H. M., R. C. Smith, and M. Vernet. 2002. Glacial meltwater dynamics in coastal waters west of the Antarctic peninsula. Proceedings of the National Academy of Sciences of the United States of America **99**:1790-1795.

Dolphin, W. F. 1987. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology **65**:83-90.

Drouot, V. 2003. Ecology of sperm whale (*Physeter macrocephalus*) in the Mediterranean Sea. University of Wales, Bangor, Wales, United Kingdom.

du Pasquier, T. 1986. Catch history of French right whaling mainly in the South Atlantic. Report of the International Whaling Commission:269-274.

Dunlop, R., D. H. Cato, M. J. Noad, and D. M. Stokes. 2013. Source levels of social sounds in migrating humpback whales (*Megaptera novaeangliae*). Journal of the Acoustical Society of America **134**:706-714.

Edds-Walton, P. L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics **8**:47-60.

Edds, P. L. 1982. Vocalizations of the blue whale, *Balaenoptera musculus*, in the St. Lawrence River. Journal of Mammalogy **63**:345-347.

Edds, P. L. 1988. Characteristics of finback Balaenoptera physalus vocalizations in the St. Lawrence Estuary. Bioacoustics **1**:131-149.

Elftman, M. D., C. C. Norbury, R. H. Bonneau, and M. E. Truckenmiller. 2007. Corticosterone impairs dendritic cell maturation and function. Immunology **122**:279-290.

Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology **26**:21-28.

Engås, A., S. Løkkeborg, E. Ona, and A. V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Sciences **53**:2238-2249.

Engel, M. H., M. C. C. Marcondes, C. C. A. Martins, F. O. Luna, R. P. Lima, and A. Campos. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. International Whaling Commission.

Engelhaupt, D. T. 2004. Phylogeography, kinship and molecular ecology of sperm whales (*Physeter macrocephalus*). University of Durham, Durham, England, United Kingdom.

Erbe, C. 2002. Hearing abilities of baleen whales. Atlantic report CR 2002-065. Contract Number: W7707-01-0828. Defence R&D Canada.

Evans, P. G. H. 1998. Biology of cetaceans of the North-East Atlantic (in relation to seismic energy). Page Chapter 5 *in* M. L. Tasker and C. Weir, editors. Seismic and Marine Mammals Workshop. Atlantic Margin Joint Industry Group (AMJIG), London.

Fazio, A., M. Bertellotti, and C. Villanueva. 2012. Kelp gulls attack southern right whales: a conservation concern? Marine Biology **159**:1981-1990.

Felix, F. 2001. Observed changes of behavior in humphack whales during whalewatching encounters off Ecuador. Page 69 Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Findlay, K. P. 2001. A review of humpback whale catches by modern whaling operations in the southern hemisphere. Memoirs of the Queensland Museum **47**:411-420.

Finneran, J. J., and C. E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). Journal of the Acoustical Society of America **133**:1819-1826.

Fonfara, S., U. Siebert, A. Prange, and F. Colijn. 2007. The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). Journal of the Marine Biological Association of the United Kingdom **87**:305-311.

Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: antipredator strategies of baleen whales. Mammal Review **38**:50-86.

Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. Frontiers in Ecology and the Environment **11**:305-313.

Frazer, L. N., and E. Mercado III. 2000. A sonar model for humpback whale song. IEEE Journal of Oceanic Engineering **25**:160-182.

Gailey, G., B. Würsig, and T. L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment **134**:75-91.

Gambell, R. 1985. Sei whale, *Balaenoptera borealis* Lesson, 1828. Pages 155-170 *in* S. H. Ridway and S. R. Harrison, editors. Handbook of Marine Mammals. Academic Press, London.

Gardiner, K. J., and A. J. Hall. 1997. Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). Canadian Journal of Zoology **75**:1773-1780.

Goldbogen, J. A., B. L. Southall, S. L. DeRuiter, J. Calambokidis, A. S. Friedlaender, E. L. Hazen, E. A. Falcone, G. S. Schorr, A. Douglas, D. J. Moretti, C. Kyburg, M. F. McKenna, and P. L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society of London Series B Biological Sciences **280**:Article 20130657.

Goold, J. C. 1999. Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. Journal of the Marine Biological Association of the United Kingdom **79**:541-550.

Goold, J. C., and S. E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America **98**:1279-1291.

Gordon, J., A. Moscrop, C. Carlson, S. Ingram, R. Leaper, J. Matthews, and K. Young. 1998. Distribution, movements and residency of sperm whales off the Commonwealth of Dominica, eastern Caribbean: implications for the development and regulation of the local whalewatching industry. Report of the International Whaling Commission **48**:551-557.

Gray, J. E. 1865. Dr. H. Burmeister on a new whale. Proceedings of the Zoological Society of London **33**:190-195.

Greer, A. W., M. Stankiewicz, N. P. Jay, R. W. McAnulty, and A. R. Sykes. 2005. The effect of concurrent corticosteroid induced immuno-suppression and infection with the intestinal parasite *Trichostrongylus colubriformis* on food intake and utilization in both immunologically naive and competent sheep. Animal Science **80**:89-99.

GSGSSI. 2013. South Georgia and the South Sandwich Islands Marine Protected Area management plan. Government of South Georgia and the South Sandwich Islands.

Guerra, A., A. F. González, and F. Rocha. 2004. A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations. ICES Annual Science Conference, Vigo, Spain.

Gulland, F. M. D., M. Haulena, L. J. Lowenstine, C. Munro, P. A. Graham, J. Bauman, and J. Harvey. 1999. Adrenal function in wild and rehabilitated Pacific harbor seals (*Phoca vitulina richardii*) and in seals with phocine herpesvirus-associated adrenal necrosis. Marine Mammal Science **15**:810-827.

Guzman, H. M., C. G. Gomez, C. A. Guevara, and L. Kleivane. 2013. Potential vessel collisions with Southern Hemisphere humpback whales wintering off Pacific Panama. Marine Mammal Science **29**:629-642.

Hain, J. H. W., M. J. Ratnaswamy, R. D. Kenney, and H. E. Winn. 1992. The fin whale, *Balenoptera physalus*, in waters of the northeastern United States continental shelf. Report of the International Whaling Commission **42**:653-669.

Hamilton, P. K., G. S. Stone, and S. M. Martin. 1997. Note on a deep humpback whale (*Megaptera novaeangliae*) dive near Bermuda. Bulletin of Marine Science **61**:491-494.

Hassel, A., T. Knutsen, J. Dalen, S. Løkkeborg, K. Skaar, Ø. Østensen, E. K. Haugland, M. Fonn, Å. Høines, and O. A. Misund. 2003. Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study. Institute of Marine Research, Bergen, Norway.

Hendrix, A. N., J. Straley, C. M. Gabriele, and S. M. Gende. 2012. Bayesian estimation of humpback whale (*Megaptera novaeangliae*) population abundance and movement patterns in southeastern Alaska. Canadian Journal of Fisheries and Aquatic Sciences **69**:1783-1797.

Herman, L. M., A. A. Pack, S. S. Spitz, E. Y. K. Herman, K. Rose, S. Hakala, and M. H. Deakos. 2013. Humpback whale song: who sings? Behavioral Ecology and Sociobiology **67**:1653-1663.

Herráez, P., E. Sierra, M. Arbelo, J. R. Jaber, A. Espinosa de los Monteros, and A. Fernández. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. Journal of Wildlife Diseases **43**:770-774.

Hogarth, W. T. 2002. Declaration of William T. Hogarth in opposition to plaintiff's motion for temporary restraining order, 28 October. Civ. No. 02-05065-JL, U.S. District Court, Northern District of California, San Francisco Division.

Horwood, J. 1987. The Sei Whale: Population Biology, Ecology and Management. Croom Helm, London, England.

Houser, D. S., D. A. Helweg, and P. W. B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals **27**:82-91.

Hunt, K. E., R. M. Rolland, S. D. Kraus, and S. K. Wasser. 2006. Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). General and Comparative Endocrinology **148**:260-272.

IAATO. 2014. IAATO member vessel directory 2014-2015. Available online at: http://apps.iaato.org/iaato/vessel/listVessels.jsp?sortBy=categoryD.

IAGC. 2004. Further analysis of 2002 Abrolhos Bank, Brazil humpback whale stradings coincident with seismic surveys. International Association of Geophysical Contractors, Houston, Texas.

International Court of Justice. 2014. Whaling in the Antarctic (Australia v. Japan: New Zealand intervening). 2014 31 March General List No. 148.

IPCC. 2014. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IWC. 1979. Report of the scientific committee, Annex G: report of the sub-committee on protected stocks.

IWC. 1996. Report of the Scientific Committee. IWC, Dublin Castle, Ireland.

IWC. 2001. Report of the workshop on status and trends in Western North Atlantic right whales: A worldwide comparison. Journal of Cetacean Research and Management **Special Issue 2**:1-60.

IWC. 2006. Annex K: Report of the standing working group on environmental concerns. International Whaling Commission.

IWC. 2014a. Aboriginal subsistence whaling catches since 1985. International Whaling Commission.

IWC. 2014b. Catches under objection or under reservation since 1985. International Whaling Commission.

IWC. 2014c. Shipstrikes Summary Data Table.*in* I. W. Commission, editor., http://iwc.int/ship-strikes.

IWC. 2014d. Special permit catches since 1985. International Whaling Commission.

Jaquet, N., D. Gendron, and A. Coakes. 2003. Sperm whales in the Gulf of California: residency, movements, behavior, and the possible influence of variation in food supply. Marine Mammal Science **19**:545-562.

Jochens, A., D. Biggs, D. Engelhaupt, J. Gordon, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, J. Wormuth, and B. Würsig. 2006. Sperm whale seismic study in the Gulf of Mexico: summary report 2002-2004. OCS Study MMS 2006-034, Report prepared by Department of Oceanography, Texas A&M University for Gulf of Mexico OCS Region, Minerals Management Service, U.S. Department of the Interior, , New Orleans, Louisiana.

Jochens, A. E., and D. C. Biggs. 2004. Sperm whale seismic study in the Gulf of Mexico. Annual report: Year 2. Minerals Management Service.

Johnson, S. R., W. J. Richardson, S. B. Yazvenko, S. A. Blokhin, G. Gailey, M. R. Jenkerson, S. K. Meier, H. R. Melton, M. W. Newcomer, A. S. Perlov, S. A. Rutenko, B. Würsig, C. R. Martin, and D. E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment **134**:1-19.

Kasuya, T. 1991. Density dependent growth in North Pacific sperm whales. Marine Mammal Science **7**:230-257.

Katona, S. K., and J. A. Beard. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Report of the International Whaling Commission **12**:295-305.

Kaufman, G. A., and D. W. Kaufman. 1994. Changes in body mass related to capture in the prairie deer mouse (*Peromyscus maniculatus*). Journal of Mammalogy **75**:681-691.

Keay, J. M., J. Singh, M. C. Gaunt, and T. Kaur. 2006. Fecal glucocorticoids and their metabolites as indicators of stress in various mammalian species: A literature review. Journal of Zoo and Wildlife Medicine **37**:234-244.

Ketten, D. R. 1997. Structure and function in whale ears. Bioacoustics: the International Journal of Animal Sound and Its Recording **8**:103-135.

Ketten, D. R. 1998. Marine mammal auditory systems: a summary of audiometric and anatomical data and its implications for underwater acoustic impacts. Technical Memorandum NOAA-TM-NMFS-SWFSC-256, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: An integrative, mechanistic review. Ecology Letters.

Kjeld, M., Ö. Ólafsson, G. A. Víkingsson, and J. Sigurjónsson. 2006. Sex hormones and reproductive status of the North Atlantic fin whales (*Balaenoptera physalus*) during the feeding season. Aquatic Mammals **32**:75-84.

Kozlov, A. N. 1995. A review of the trophic role of mesopelagic fish of the family Myctophidae in the Southern Ocean ecosystem CCAMLR Science **2**:71-77.

Kremser, U., P. Klemm, and W.-D. Kötz. 2005. Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. Antarctic Science **17**:3-10.

Kujawa, S. G., and M. C. Liberman. 2009. Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. Journal of Neuroscience **29**:14077-14085.

La Bella, G., S. Cannata, C. Froglia, A. Modica, S. Ratti, and G. Rivas. 1996. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Society of Petroleum Engineers Health, Safety and Environment in Oil and Gas Exploration and Production Conference, New Orleans, Louisiana.

Lambertsen, R. H. 1986. Disease of the common fin whale (*Balaenoptera physalus*): Crassicaudiosis of the urinary system. Journal of Mammalogy **67**:353-366.

Lambertsen, R. H. 1992. Crassicaudosis: A parasitic disease threatening the health and population recovery of large baleen whales. Revue Scientifique et Technique Office International des Epizooties **11**:1131-1141.

Lambertsen, R. H., B. A. Kohn, J. P. Sundberg, and C. D. Buergelt. 1987. Genital papillomatosis in sperm whale bulls. Journal of Wildlife Diseases **23**:361-367.

Leaper, R., J. Cooke, P. Trathan, K. Reid, V. Rowntree, and R. Payne. 2006. Global climate drives southern right whale (*Eubalaena australis*) population dynamics. Biology Letters **2**:289-292.

Leatherwood, S., D. K. Caldwell, and H. E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: a guide to their identification. NOAA Technical Report NMFS CIRC-396, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Seattle, Washington.

Ljungblad, D. K., B. Würsig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic **41**:183-194.

Løkkeborg, S., E. Ona, A. Vold, A. Salthaug, and J. M. Jech. 2012. Sounds from seismic air guns: Gear- and species-specific effects on catch rates and fish distribution. Canadian Journal of Fisheries and Aquatic Sciences **69**:1278-1291.

Lurton, X., and S. DeRuiter. 2011. Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. International Hydrographic Review **November 2011**:7-17.

Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science **22**:802-818.

Lusseau, D., and L. Bejder. 2007. The long-term consequences of short-term responses to disturbance experiences from whalewatching impact assessment. International Journal of Comparative Psychology **201**:228-236.

Mackintosh, N. A. 1965. Blue and fin whales. Pages 174-182 The Stocks of Whales. Fishing News.

Madsen, P. T., M. Johnson, P. J. O. Miller, N. Aguilar Soto, J. Lynch, and P. Tyack. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America **120**:2366-2379.

Madsen, P. T., B. Møhl, B. K. Nielsen, and M. Wahlberg. 2002. Male sperm whale behaviour during exposures to distant seismic survey pulses. Aquatic Mammals **28**:231-240.

Magalhaes, S., R. Prieto, M. A. Silva, J. Goncalves, M. Afonso-Dias, and R. S. Santos. 2002. Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. Aquatic Mammals **28**:267-274.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior, Phase II: January 1984 migration. Report No. 5586, Report prepared by Bolt Beranek and Newman Inc., Cambridge, Massachusetts for Alaska OCS Office, Minerals Management Service, U.S. Department of Interior, Anchorage, Alaska.

Malme, C. I., P. R. Miles, P. Tyack, C. W. Clark, and J. E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. Report No. 5851, Report prepared by BBN Laboratories, Inc., Cambridge, Massachusetts for Alaska OCS Offfice, Minerals Management Service, U.S. Department of the Interior, Anchorage, Alaska.

Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling. Report No. 6265, Report prepared by BBN Laboratories, Inc. for Research Unit 675, Outer Continental Shelf Environmental Assessment Program, U.S. Department of the Interior.

Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1987. Observations of feeding gray whale responses to controlled industrial noise exposure. Pages 55-73 Ninth International Conference on Port and Ocean Engineering Under Arctic Conditions, Fairbanks, Alaska.

Mancia, A., G. W. Warr, and R. W. Chapman. 2008. A transcriptomic analysis of the stress induced by capture-release health assessment studies in wild dolphins (*Tursiops truncatus*). Molecular Ecology **17**:2581-2589.

Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural history of Oregon coast mammals. General Technical Report PNW-133, Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture and Bureau of Land Management, U.S. Department of the Interior, Portland, Oregon.

Mate, B. R., K. M. Stafford, and D. K. Ljungblad. 1994. A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. Journal of the Acoustical Society of America **96**:3268-3269.

Maybaum, H. L. 1993. Responses of humpback whales to sonar sounds. Journal of the Acoustical Society of America **94**:1848-1849.

McCauley, R. D., and J. Fewtrell. 2013. Experiments and observations of fish exposed to seismic survey pulses. Bioacoustics **17**:205-207.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid e-paper, Curtin University of Technology, Western Australia.

McCauley, R. D., J. Fewtrell, and A. N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America **113**:638-642.

McCauley, R. D., M.-N. Jenner, C. Jenner, and D. H. Cato. 1998. Observations of the movements of humpback whales about an operating seismic survey vessel near Exmouth, Western Australia. Journal of the Acoustical Society of America **103**:2909.

McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. Journal of the Acoustical Society of America **109**:1728-1735.

McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. Journal of the Acoustical Society of America **98**:712-721.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006a. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America **120**:711-718.

McDonald, M. A., J. A. Hildebrand, S. M. Wiggins, D. Thiele, D. Glasgow, and S. E. Moore. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America **118**:3941-3945.

McDonald, M. A., S. L. Mesnick, and J. A. Hildebrand. 2006b. Biogeographic characterisation of blue whale song worldwide: using song to identify populations. Journal of Cetacean Research and Management **8**:55-65.

Mellinger, D. K., K. M. Stafford, and C. G. Fox. 2004. Seasonal occurrence of sperm whale (*Physeter macrocephalus*) sounds in the Gulf of Alaska, 1999-2001. Marine Mammal Science **20**:48-62.

Miller, G. W., R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Ltd.

Miller, H., K. Gohl, G. Uenzelmann-Neben, C. Müller, and W. Jokat. 2004. Acoustic parameters and hydroacoustic equipment: natural noise, industrial exploration and basic science. Polarforschung **72**:109-114.

Miller, P. J. O., M. P. Johnson, P. T. Madsen, N. Biassoni, M. Quero, and P. L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep Sea Research Part I: Oceanographic Research Papers **56**:1168-1181.

Mitchell, E., and D. G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Report of the International Whaling Commission **Special Issue 1**:117-120.

Møhl, B., M. Wahlberg, P. T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. Journal of the Acoustical Society of America **114**:1143-1154.

National Research Council. 2003. Ocean noise and marine mammals. The National Academies Press, Washington, D.C.

NMFS. 1991. Final recovery plan for the humpback whale (*Megaptera novaeangliae*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 1998. Recovery plan for the blue whale (*Balaenoptera musculus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.

NMFS. 2006. Endangered Species Act section 7 consultation biological opinion on the United States Navy's 2006 Rim-of-the-Pacific Joint Training Exercises. Office of Protected Resources, National Marine Fisheries ServiceNational Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2007. 5-year review: summary and evaluation of southern right whale (*Eubalaena australis*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2009. 5-year review: summary and evaluation of sperm whale (*Physeter macrocephalus*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2010a. Final recovery plan for the fin whale (*Balaenoptera physalus*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2010b. Final recovery plan for the sperm whale (*Physeter macrocephalus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2011a. 5-year review: summary and evaluation of fin whale (*Balaenoptera physalus*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2011b. Final recovery plan for the sei whale (*Balaenoptera borealis*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2012a. 5-year review: summary and evaluation of sei whale (*Balaenoptera borealis*). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commmerce, Silver Spring, Maryland.

NMFS. 2012b. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2011. NOAA Technical Memorandum NMFS-NE-221, Northeast Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Woods Hole, Massachusetts.

NMFS. 2013a. 10 revised reports: U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2012. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

NMFS. 2013b. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2012. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

NMFS. 2014a. Endangered Species Act section 7 consultation biological opinion for a seismic survey by the Lamont-Doherty Earth Observatory along New Jersey and issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2014b. Endangered Species Act section 7 consultation biological opinion for geophysical and other research activities off East Antarctica and the issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

NMFS. 2014c. NOAA APPS: scientific research permits issued for blue, fin, humpback, Southern right, sei, and sperm whales, Atlantic and Southern Oceans. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

NMFS, and Navy. 2001. Joint interim report Bahamas marine mammal stranding event 15-16 March 2000. National Marine Fisheries Service, National Oceanic and Amospheric Administration, U.S. Department of Commerce and Installations and Environment, Department of the Navy.

Noda, K., H. Akiyoshi, M. Aoki, T. Shimada, and F. Ohashi. 2007. Relationship between transportation stress and polymorphonuclear cell functions of bottlenose dolphins, *Tursiops truncatus*. Journal of Veterinary Medical Science **69**:379-383.

NSF. 2014. Draft initial environmental evaluation: study of the role of the Central Scotia Sea and North Scotia Ridge in the onset and development of the Antarctic Circumpolar Current. PGAN1401.IEE, Division of Polar Programs, National Science Foundation, Arlington, Virginia.

NSF, and USGS. 2011. Final programmatic environmental impact statement/overseas environmental impact statement for marine seismic research funded by the National Science Foundation or conducted by the U.S. Geological Survey. National Science Foundation and U.S. Geological Survey, Arlington, Virginia.

Palsbøll, P. J., J. Allen, M. Bérubé, P. J. Clapham, T. P. Feddersen, R. R. Hudson, H. Jørgensen, S. Katona, A. H. Larsen, F. Larsen, J. Lien, D. K. Mattila, J. Sigurjónsson, R. Sears, T. Smith, R. Sponer, P. Stevick, and N. Øien. 1997. Genetic tagging of humpback whales. Nature **388**:767-769.

Panigada, S., M. Zanardelli, S. Canese, and M. Jahoda. 1999. Deep diving performances of Mediterranean fin whales. Page 144 Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, Hawaii.

Papastavrou, V., S. C. Smith, and H. Whitehead. 1989. Diving behaviour of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands. Canadian Journal of Zoology **67**:839-846.

Parente, C. L., J. P. Araujo, and M. E. Araujo. 2007. Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. Biota Neotropica **7**.

Parks, S. E. 2003. Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. Marine Mammal Science **19**:563-580.

Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research.

Patenaude, N. J. 2003. Sightings of southern right whales around 'mainland' New Zealand. Science For Conservation.

Patterson, B., and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. Pages 125-145 *in* W. N. Tavolga, editor. Marine Bio-acoustics. Pergamon Press, Oxford.

Payne, J. F., C. D. Andrews, L. L. Fancey, J. Guiney, A. Cook, and J. R. Christian. 2013. Are seismic surveys an important risk factor for fish and shellfish? Bioacoustics **17**:262-265.

Payne, J. F., J. Coady, and D. White. 2009. Potential effects of seismic airgun discharges on monkfish eggs (*Lophius americanus*) and larvae. Environmental Student Research Funds Report 170, St. John's, Newfoundland, Canada.

Payne, K., and R. Payne. 1985. Large scale changes over 19 years in songs of humpback whales in Bermuda. Zeitschrift fur Tierpsychologie **68**:89-114.

Payne, R., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Annals of the New York Academy of Sciences **188**:110-141.

Pearson, W. H., J. R. Skalski, and C. I. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences **49**:1343-1356.

Perrin, W. F., J. G. Mead, and R. L. Brownell Jr. 2009. Review of the evidence used in the description of currently recognized cetacean subspecies. Technical Memorandum NOAA-TM-NMFS-SWFSC-450, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review **61**:1-74.

Pickett, G. D., D. R. Eaton, R. M. H. Seaby, and G. P. Arnold. 1994. Results of bass tagging in Poole Bay during 1992. Laboratory Leaflet Number 74, Directorate of Fisheries Research, Ministry for Agriculture Fisheries and Food.

Pike, D. G., G. A. Víkingsson, T. Gunnlaugsson, and N. Øien. 2009. A note on the distribution and abundance of blue whales (*Balaenoptera musculus*) in the Central and Northeast North Atlantic. NAMMCO Scientific Publications **7**:19-29.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. Macgillicray, M. E. Austin, and D. A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America **117**:3958-3971.

Punt, A. E. 2010. Further analyses related to the estimation of the rate of increase for an unknown stock using a Bayesian meta-analysis. International Whaling Commission Scientific Committee, Agadir, Morocco.

Rankin, S., and J. Barlow. 2007. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. Bioacoustics - The International Journal of Animal Sound and Its Recording **16**:137-145.

Reeves, R. R., B. D. Smith, E. A. Crespo, and G. Notarbartolo di Sciara. 2003. Dolphins, whales, and porpoises: 2002-2010 conservation action plan for the world's cetaceans. International Union for Conservation of Nature and Natural Resources, Survival Service Commission Cetacean Specialist Group.

Reeves, R. R., and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. Canadian Field-Naturalist **111**:293-307.

Reid, K., and J. Croxall. 2001. Environmental response of upper trophic-level predators reveals a system change in an Antarctic marine ecosystem. Proceedings of the Royal Society London Series B **268**:377–384.

Reilly, S. B., J. L. Bannister, P. B. Best, M. Brown, R. L. Brownell Jr., D. S. Butterworth, P. J. Clapham, J. Cooke, G. P. Donovan, J. Urbán, and A. N. Zerbini. 2013. Balaenoptera physalus. IUCN Red List of Threatened Species.

Rice, D. W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Report of the International Whaling Commission **Special Issue 1**:92-97.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. Pages 29–44 *in* K. S. Norris and R. R. Reeves, editors. Workshop on Problems Related to Humpback Whales (*Megaptera novaeangliae*) in Hawaii. Marine Mammal Commission.

Rice, D. W. 1989. Sperm whale *Physeter macrocephalus* Linnaeus, 1758. Pages 177-233 *in* S. H. Ridway and S. R. Harrison, editors. Handbook of marine mammals. Academic Press, New York, New York.

Rice, D. W. 1998. Marine mammals of the world: systematics and distribution. The Society for Marine Mammology, Lawrence, Kansas.

Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995. Marine mammals and noise. Academic Press, Inc., San Diego, California.

Richardson, W. J., G. W. Miller, and C. R. Greene Jr. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America **106**:2281.

Richardson, W. J., B. Würsig, and C. R. Greene Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America **79**:1117-1128.

Richter, C. F., S. M. Dawson, and E. Slooten. 2003. Sperm whale watching off Kaikoura, New Zealand: effects of current activities on surfacing and vocalisation patterns. Science For Conservation **219**.

Rivers, J. A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Marine Mammal Science **13**:186-195.

Robertson, F. C., W. R. Koski, T. A. Thomas, W. J. Richardson, B. Würsig, and A. W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endangered Species Research **21**:143-160.

Rolland, R. M., S. E. Parks, K. E. Hunt, M. Castellote, P. J. Corkeron, D. P. Nowacek, S. K. Wasser, and S. D. Kraus. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society of London Series B Biological Sciences **279**:2363-2368.

Romano, T. A., M. J. Keogh, C. Kelly, P. Feng, L. Berk, C. R. Schlundt, D. A. Carder, and J. J. Finneran. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences **61**:1124-1134.

Romero, L. M., C. J. Meister, N. E. Cyr, G. J. Kenagy, and J. C. Wingfield. 2008. Seasonal glucocorticoid responses to capture in wild free-living mammals. American Journal of Physiology-Regulatory Integrative and Comparative Physiology **294**:R614-R622.

Samaran, F., C. Guinet, O. Adam, J.-F. Motsch, and Y. Cansi. 2010. Source level estimation of two blue whale subspecies in southwestern Indian Ocean. Journal of the Acoustical Society of America **127**:3800-3808.

Santulli, A., A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio. 1999. Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by offshore experimental seismic prospecting. Marine Pollution Bulletin **38**:1105-1114.

Saracco, J. F., C. M. Gabriele, and J. L. Neilson. 2013. Population dynamics and demography of humpback whales in Glacier Bay and Icy Strait, Alaska. Northwestern Naturalist **94**:187-197.

Schaffar, A., B. Madon, C. Garrigue, and R. Constantine. 2009. Avoidance of whale watching boats by humpback whales in their main breeding ground in New Caledonia. International Whaling Commission Scientific Committee, Madeira, Portugal.

Scheidat, M., C. Castro, J. Gonzalez, and R. Williams. 2004. Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. Journal of Cetacean Research and Management **6**:63-68.

Scientific Committee on Antarctic Research. 2004. SCAR report on marine acoustic technology and the antarctic environment. International Hydrographic Organization Hydrographic Committee on Antarctica, Kythnos, Greece.

Sigurjónsson, J., and T. Gunnlaugsson. 1990. Recent trends in abundance of blue (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*) off West and Southwest Iceland, with a note on occurrence of other cetacean species. Report of the International Whaling Commission **40**:537-551.

Silber, G. K. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology **64**:2075-2080.

Sironi, M., V. Rowntree, C. T. Snowdon, L. Valenzuela, and C. Marón. 2009. Kelp gulls (*Larus dominicanus*) feeding on southern right whales (*Eubalaena australis*) at Península Valdés, Argentina: updated estimates and conservation implications. International Whaling Commission Scientific Committee, Madeira, Portugal.

Širović, A., J. A. Hildebrand, and S. M. Wiggins. 2007. Blue and fin whale call source levels and propagation range in the Southern Ocean. Journal of the Acoustical Society of America **122**:1208-1215.

Širović, A., L. N. Williams, S. M. Kerosky, S. M. Wiggins, and J. A. Hildebrand. 2013. Temporal separation of two fin whale call types across the eastern North Pacific. Marine Biology **160**:47-57.

Slotte, A., K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research **67**:143-150.

Smith, A. W., and A. B. Latham. 1978. Prevalence of vesicular exanthema of swine antibodies among feral animals associated with the southern California coastal zones. American Journal of Veterinary Research **39**:291–296.

Smith, T. D., J. Allen, P. J. Clapham, P. S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, P. J. Palsbøll, J. Sigurjónsson, P. T. Stevick, and N. Øien. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science **15**:11689.

Smith, T. D., and D. G. Pike. 2009. The enigmatic whale: the North Atlantic humpback. NAMMCO Scientific Publications **7**:161-178.

Smith, T. D., and R. R. Reeves. 2010. Historical catches of humpback whales, *Megaptera novaeangliae*, in the North Atlantic Ocean: estimates of landings and removals. Marine Fisheries Review **72**:1-43.

Smultea, M. A., M. Holst, W. R. Koski, and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April-June 2004. LGL Rep. TA2822-26, Report prepared for Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York and Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland King City, Ontario.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals **33**:411-521.

Southall, B. L., T. Rowles, F. Gulland, R. W. Baird, and P. D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melonheaded whales (*Peponocephala electra*) in Antsohihy, Madagascar. Independent Scientific Review Panel.

St. Aubin, D. J., and L. A. Dierauf. 2001. Stress and marine mammals. Pages 253-269 *in* L. A. Dierauf and F. M. D. Gulland, editors. CRC Handbook of Marine Mammal Medicine. CRC Press, Boca Raton, Florida.

St. Aubin, D. J., and J. R. Geraci. 1988. Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whales, *Delphinapterus leucas*. Physiological Zoology **61**:170-175.

St. Aubin, D. J., S. H. Ridgway, R. S. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *Tursiops truncatus,* and influence of sex, age, and season. Marine Mammal Science **12**:1-13.

Stevick, P. T., J. Allen, P. J. Clapham, N. Friday, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, J. Sigurjónsson, T. D. Smith, N. Øien, and P. S. Hammond. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series **258**:263-273.

Stone, C. J., and M. L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research and Management **8**:255-263.

Strong, C. S. 1990. Ventilation patterns and behavior of balaenopterid whales in the Gulf of California, Mexico. San Francisco State University.

Thompson, P. O., W. C. Cummings, and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. Journal of the Acoustical Society of America **80**:735-740.

Thompson, P. O., L. T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. Journal of the Acoustical Society of America **92**:3051-3057.

Thompson, P. O., L. T. Findley, O. Vidal, and W. C. Cummings. 1996. Underwater sounds of blue whales, *Balaenoptera musculus*, in the Gulf of California, Mexico. Marine Mammal Science **12**:288-293.

Thompson, P. O., and W. A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology **45**:1-19.

Thomsen, B. 2002. An experiement on how seismic shooting affects caged fish. University of Aberdeen.

Thomsen, B. 2013. An experiment on how seismic shooting affects caged fish. Bioacoustics **17**:219-221.

Thomson, C. A., and J. R. Geraci. 1986. Cortisol, aldosterone, and leukocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. Canadian Journal of Fisheries and Aquatic Sciences **43**:1010-1016.

Thomson, D. H., and W. J. Richardson. 1995. Marine mammal sounds. Pages 159-204 *in* W. J. Richardson, C. R. G. Jr., C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego.

Tolstoy, M., J. B. Diebold, S. C. Webb, D. R. Bohnenstiehl, E. Chapp, R. C. Holmes, and M. Rawson. 2004. Broadband calibration of *R/V Ewing* seismic sources. Geophysical Research Letters **31**:4.

Turnpenny, A. W. H., and J. R. Nedwell. 1994. Consultancy report: the effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. FCR 089/94, Fawley Aquatic Research Laboratories, Ltd.

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. Report prepared under MMS Contract 1435-01-02-CA-85186 by Department of Oceanography, Texas A&M University for Gulf of Mexico OCS Region, Minerals Management Service, U.S. Department of the Interior, New Orleans, Louisiana.

Tyack, P., and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. Behaviour **83**:132-154.

Uhart, M. M., V. Rowntree, M. Sironi, A. Chirife, N. Mohamed, L. M. Pozzi, L. Musmeci, M. Franco, D. McAloose, G. Doucette, V. Sastre, and T. Rowles. 2009. Continuing southern right whale mortality events at Península Valdés, Argentina. International Whaling Commission Scientific Committee, Madeira, Portugal.

USFWS, and NMFS. 1998. Endangered species consultation handbook. U.S. Fish and Wildlife Service, U.S. Department of the Interior and National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

USFWS, and NMFS. 2014. Endangered Species Act section 7 consultation programmatic biological opinion on the U.S. Environmental Protection Agency's issuance and implementation of the final regulations section 316(b) of the Clean Water Act. Endangered Species Program, U.S. Fish and Wildlife Service, U.S. Department of the Interior and Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.

Valenzuela, L. O., M. Sironi, V. J. Rowntree, and J. Seger. 2009. Isotopic and genetic evidence for culturally inherited site fidelity to feeding grounds in southern right whales (*Eubalaena australis*). Molecular Ecology **18**:782-791.

Van der Hoop, J. M., M. J. Moore, S. G. Barco, T. V. Cole, P. Y. Daoust, A. G. Henry, D. F. McAlpine, W. A. McLellan, T. Wimmer, and A. R. Solow. 2013a. Assessment of management to mitigate anthropogenic effects on large whales. Conservation Biology **27**:121-133.

van der Hoop, J. M., M. J. Moore, S. G. Barco, T. V. N. Cole, P.-Y. Daoust, A. G. Henry, D. F. McAlpine, W. A. McLellan, T. Wimmer, and A. R. Solow. 2013b. Assessment of management to mitigate anthropogenic effects on large whales. Conservation Biology **27**:121-133.

Vanderlaan, A. S., and C. T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science **23**:144-156.

Vu, E. T., D. Risch, C. W. Clark, S. Gaylord, L. T. Hatch, M. A. Thompson, D. N. Wiley, and S. M. Van Parijs. 2012. Humpback whale song occurs extensively on feeding grounds in the western North Atlantic Ocean. Aquatic Biology **14**:175-183.

Wardle, C. S., T. J. Carter, G. G. Urquhart, A. D. F. Johnstone, A. M. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research **21**:1005-1027.

Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2010. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2010. NOAA Technical Memorandum NMFS-NE-219, Northeast Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce, Woods Hole, Massachusetts.

Watkins, W. A. 1981. Activities and underwater sounds of fin whales. Scientific Reports of the Whales Research Institute **33**:83-117.

Watkins, W. A. 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science **2**:251-262.

Watkins, W. A., M. A. Daher, K. M. Fristrup, T. J. Howald, and G. Notarbartolo di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Marine Mammal Science **9**:55-67.

Watkins, W. A., K. E. Moore, and P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology **49**:1-15.

Watkins, W. A., and W. E. Schevill. 1975. Sperm whales (*Physeter catodon*) react to pingers. Deep Sea Research and Oceanogaphic Abstracts **22**:123-129 +121pl.

Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). Journal of the Acoustical Society of America **82**:1901-1912.

Watwood, S. L., P. J. O. Miller, M. Johnson, P. T. Madsen, and P. L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). Journal of Animal Ecology **75**:814-825.

Weilgart, L. S., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. Canadian Journal of Zoology **71**:744-752.

Weir, C. R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. Aquatic Mammals **34**:71-83.

Weir, C. R., A. Frantzis, P. Alexiadou, and J. C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). Journal of the Marine Biological Association of the United Kingdom **87**:39-46.

Weirathmueller, M. J., W. S. D. Wilcock, and D. C. Soule. 2013. Source levels of fin whale 20Hz pulses measured in the Northeast Pacific Ocean. Journal of the Acoustical Society of America **133**:741-749.

Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series **242**:295-304.

Whitehead, H. 2003. Sperm Whales: Social Evolution in the Ocean. University of Chicago Press, Chicago, Ilinois.

Whitehouse, M. J., M. P. Meredith, P. Rothery, A. Atkinson, P. Ward, and R. E. Korb. 2008. Rapid warming of the ocean around South Georgia, Southern Ocean, during the 20th century: forcings, characteristics and implications for lower trophic levels. Deep-Sea Research I **55**:1218-1228.

Winn, H. E., P. J. Perkins, and T. C. Poulter. 1970. Sounds of the humpback whale. Pages 39-52 Seventh Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute, Menlo Park, California.

Winn, H. E., and N. E. Reichley. 1985. Humpback whale, *Megaptera novaeangliae* (Borowski, 1781). Pages 241-274 *in* S. H. Ridgway and S. R. Harrison, editors. Handbook of Marine Mammals. Academic Press, London, England.

Winsor, M. H., and B. R. Mate. 2013. Seismic survey activity and the proximity of satellite-tagged sperm whales *Physeter macrocephalus* in the Gulf of Mexico. Bioacoustics **17**:191-193.

Woude, S. v. d. 2013. Assessing effects of an acoustic marine geophysical survey on the behaviour of bottlenose dolphins *Tursiops truncatus*. Bioacoustics **17**:188-190.

Yochem, P. K., and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). Pages 193-240 *in* S. H. Ridgway and R. Harrison, editors. Handbook of marine mammals. Academic Press, London.

Yoder, J. A. 2002. Declaration of James A. Yoder in opposition to plaintiff's motion for temporary restraining order, 28 October. Civ. No. 02-05065-JL, U.S. District Court, Northern District of California, San Francisco Division.