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15 July 2014

Donna S. Wieting
Office Director
Office of Protected Resources
NOAA Fisheries
1315 East-West Highway
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Jolie Harrison
Division Chief
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Office of Protected Resources
NOAA Fisheries
1315 East-West Highway
Silver Spring, MD 20910

Dear Ms. Weiting and Ms Harrison,

The U.S. National Science Foundation (NSF) plans to fund a scientific cruise in the Ross Sea from January through February 2015. The scientific activities would include 1) conducting a seismic survey, 2) conducting a bathymetric profile survey of the seafloor using transducer-based instruments such as a multibeam sonar and sub-bottom profiler, and 3) collecting core samples. The seismic survey would be conducted in waters between 100 and 1,000 m and would use a low-energy acoustic source consisting of a two generator-injector (GI) airgun array and a 100-m solid-state hydrophone streamer towed behind the vessel. Each airgun would be configured to a displacement volume of 105 in^3 (1,720 cm^3).

The research would be conducted by Louisiana State University; and the vessel would be operated by Antarctic Support Contract (ASC) which operates the United States Antarctic Program under contract to the NSF.

The ASC, NSF, and Louisiana State University request an Incidental Harassment Authorization allowing non-lethal takes of marine mammals incidental to the planned seismic survey.

On behalf of the ASC, the NSF, and Louisiana State University, attached is the Incidental Harassment Authorization application for the Ross Sea Cruise. The application is consistent with the requirements identified in 50 CFR 216. If the Office of Protected Resources approves this program, we would begin the mission in January 2015. Please contact Dr. Ted Doerr (ASC

Senior Environmental Scientist; ted.doerr.contractor@usap.gov; 720-568-2041) or Dr. Polly Penhale (NSF Environmental Officer; ppenhale@nsf.gov; 703-292-7149) if you have any questions. We look forward to working with you.

Regards,

BK Grant
Deputy Project Director
Antarctic Support Contract

cc:

Dr. Polly Penhale, Senior Environmental Advisor, NSF
Dr. Li Ling Hamady, Policy Specialist, NSF
Dr. Philip Bart, Principle Investigator (PI), Louisiana State University
Dr. Ted Doerr, ASC

Draft

Request by the National Science Foundation for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Geophysical Survey by the RVIB Nathaniel B. Palmer in the Ross Sea

NSF-Funded Research Project:
Timing and duration of LGM and post−LGM grounding events in the Whales Deep paleo ice streams, Eastern Ross Sea continental shelf

Period of Performance for the Proposed Action:
27-Day Cruise in 2015

Submitted to:
National Marine Fisheries Service
Office of Protected Resources
1315 East–West Hwy, Silver Spring, MD 20910-3282

Submitted by:

National Science Foundation
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15 July 2014

INTRODUCTION

In support of the United States Antarctic Program (USAP), the National Science Foundation (NSF) proposes to perform marine-based studies, including evaluation of the timing and duration of two grounding events (i.e., advances of grounded ice) to the outer and middle shelf of the Whales Deep Basin (WDB), a West Antarctic Ice Sheet paleo ice stream trough in eastern Ross Sea, as shown in Figure 1. The studies will involve a seismic survey, acquiring core samples from the seafloor, and performing radiocarbon dating of benthic foraminifera to meet a number of research goals. The area proposed for study is shown in Figure 2.

Pursuant to 50 C.F.R. § 216.104, items required to be addressed in a Submission of Requests for an Incidental Harassment Authorization (IHA) are set forth below. Table 1 provides a summary of these requirements and a cross-reference to supplemental information that is available in related environmental documents, including the Initial Environmental Evaluation (IEE)/Environmental Assessment (EA) to conduct marine-based studies of the Ross Sea and the Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (hereafter called PEIS) for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (http://www.nsf.gov/geo/oce/envcomp/index.jsp).

Descriptions of the marine mammal species that may be found in the proposed study area are derived primarily from information contained in the PEIS supplemented by scientific research surveys and observations. In addition, a significant portion of the analysis of the effects to marine mammals was based on the PEIS and information contained in the Environmental Analysis of a Marine Geophysical Survey by the R/V Marcus G. Langseth on the mid-Atlantic Ridge, April–May 2013, prepared by LGL Ltd., environmental research associates on behalf of Lamont-Doherty Earth Observatory and the National Science Foundation, Revised 4 April 2013 (LGL Report TA8220-1).

Figure 1. Ross Sea Study Area

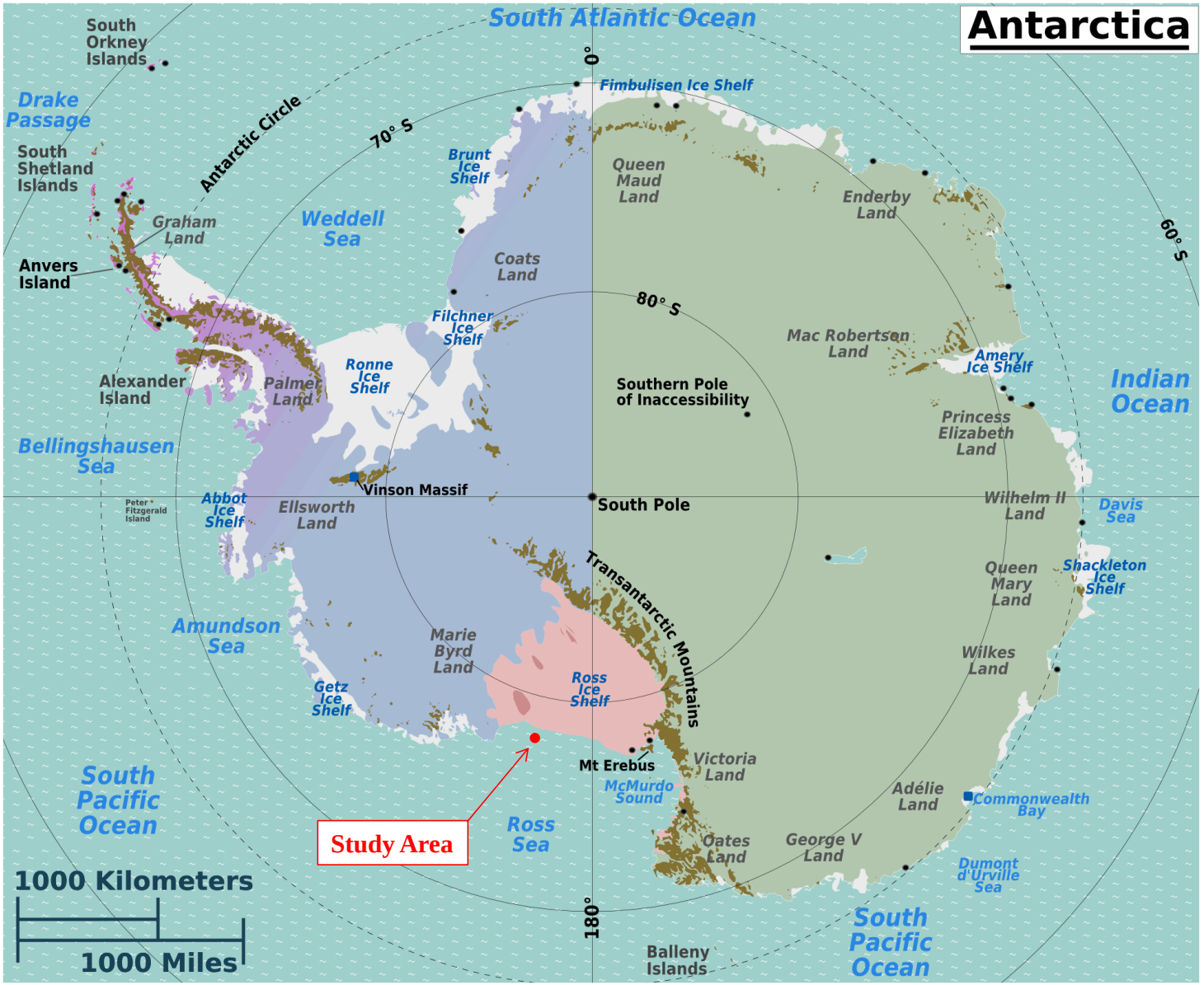

Figure 2. Ross Sea Proposed Cruise Track

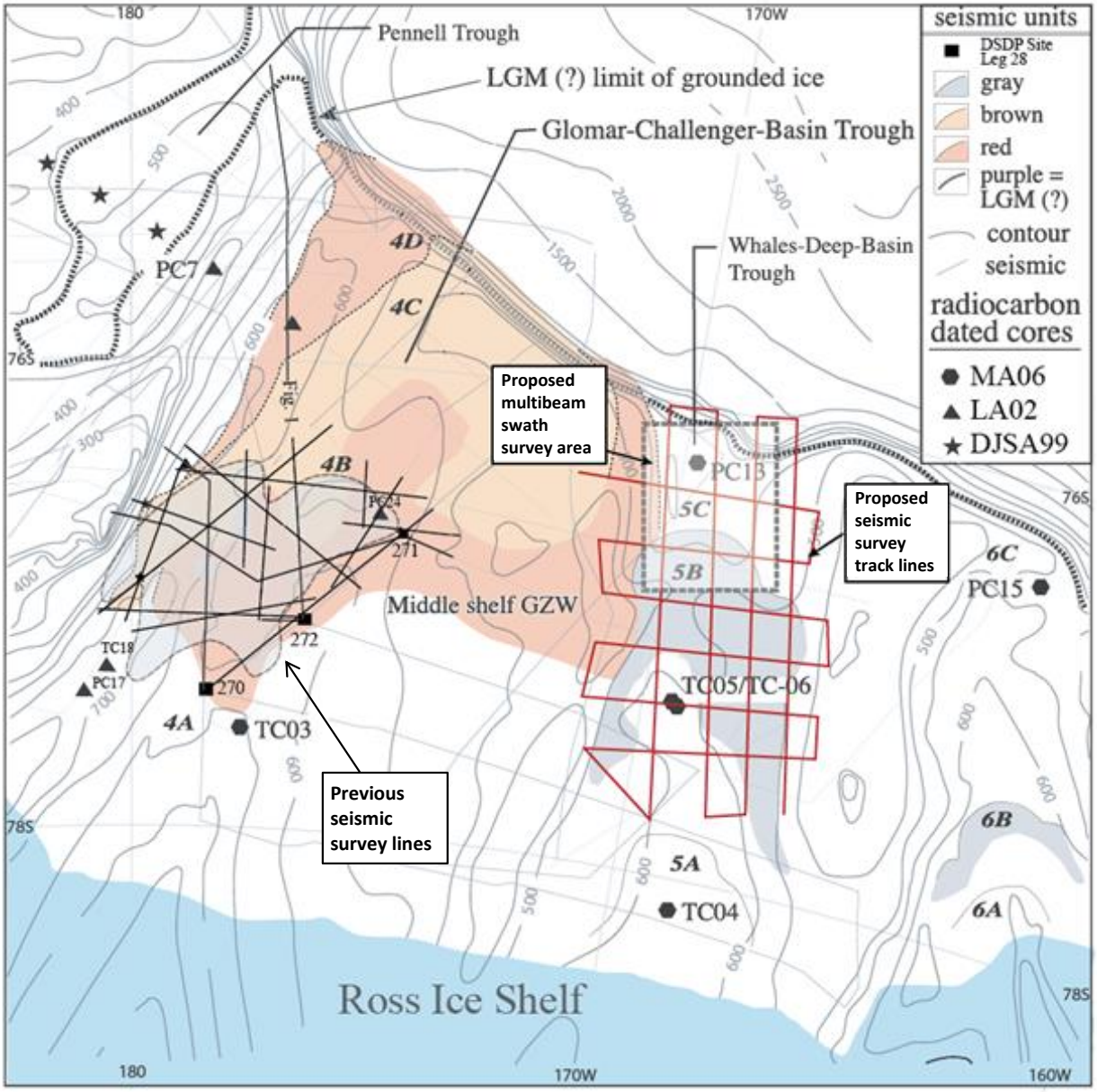

Table 1. IHA Application and IEE/EA/PEIS Information Crosswalk Table

IHA Application Section	NOAA Fisheries Requirement	Related IEE/EA and PEIS Documentation
1.0	A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals	Section 2.1 of the IEE/EA provides a description of the seismic survey activities (seismic survey with low-energy acoustic source, sediment, and water sampling).
2.0	The date(s) and duration of such activity and the specific geographical region where it will occur	Section 3.0 of the IEE/EA provides a description of the study areas and dates of proposed activities (45-day cruise in 2015).
3.0	The species and numbers of marine mammals likely to be found within the activity area	Tables 12 and 13 of the IEE/EA provide detailed estimates of the number of animals (Note: estimates based on historical sightings; comprehensive population density data for most marine mammal species in the Ross Sea region is not available).
4.0	A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities	Section 3.3.6 of the IEE/EA provides a description of the marine mammals in the study area, their migration and breeding patterns (Note: information is based on historical sightings; comprehensive migration and breeding pattern data for most marine mammal species in the Ross Sea is not available).
5.0	The type of incidental taking authorization that is being requested (i.e., takes by harassment only; takes by harassment, injury and/or death) and the method of incidental taking	Level B harassment.
6.0	By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in paragraph (a)(5) of this section, and the number of times such takings by each type of taking are likely to occur	Section 5.1.6 of the IEE/EA provides a description of the number of marine mammals expected to be encountered in the study area (detailed data characterizing the age, sex, and reproductive condition for marine mammals in the Ross Sea is not available).

Table 1. IHA Application and IEE/EA/PEIS Information Crosswalk Table

IHA Application Section	NOAA Fisheries Requirement	Related IEE/EA and PEIS Documentation
7.0	The anticipated impact of the activity upon the species or stock	Section 4.1 of the IEE/EA describes the impacts of the proposed survey activities on the species expected to be present in the Ross Sea; Sections 3.6, 3.7, and 3.8 of the PEIS describe the impacts of low-energy seismic surveys to marine mammals.
8.0	The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses	No impact; species or stocks of marine mammals found in the proposed study areas are not used for subsistence purposes.
9.0	The anticipated impact of the activity upon the habitat of the marine mammal populations and the likelihood of restoration of the affected habitat	No impacts to marine mammal habitats are expected.
10.0	The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved	No impacts to marine mammal habitats are expected.
11.0	The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance	Section 4.1 of the IEE/EA summarizes the mitigation measures that will be used during the proposed seismic survey, such as using the smallest airgun array needed to attain research objectives; Section 2.4.2 of the PEIS describes mitigation measures for low-energy acoustic sources; Section 3.2.5 identifies the use of low-energy sources as the preferred alternative.
12.0	Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses	Not applicable.

Table 1. IHA Application and IEE/EA/PEIS Information Crosswalk Table

IHA Application Section	NOAA Fisheries Requirement	Related IEE/EA and PEIS Documentation
13.0	The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding. Guidelines for developing a site-specific monitoring plan may be obtained by writing to the Director, Office of Protected Resources	Section 4.1 of the IEE/EA summarizes the monitoring and mitigation measures that will be used during the proposed seismic survey. Additionally, Section 2.4.2 of the PEIS describes generic mitigation measures for low-energy acoustic sources.
14.0	Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects	The proposed action will complement Ross Sea oceanographic and geological/geophysical studies, and ongoing development of ice sheet and other ocean models. It will facilitate learning at sea and ashore by students, help to fill important spatial gaps in a lightly sampled region of the world's oceans, provide additional data on marine mammals present in the study areas, and communicate its findings via reports, publications and public outreach.

1.0 DESCRIPTION OF ACTIVITIES

NOAA NMFS Requirement: A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

The proposed research activities are designed to meet a number of research goals and would include: 1) conducting a seismic survey along a 1,750-km track (Figure 2) using a two generator-injector (GI) airgun array (with a 'hot spare') as a low-energy seismic source and a hydrophone streamer, 2) conducting multibeam swath bathymetry (Figure 2), 3) acquiring bottom imaging, using underwater camera systems, and 4) collecting approximately 32 core samples from the seafloor using various methods and equipment.

Grounding events in the WDB are represented by seismically resolvable Grounding Zone Wedges (GZWs). During the proposed activities in the Ross Sea, researchers will acquire additional seismic data and multibeam bathymetry and imaging to precisely define the depositional and erosional limits of the outer and middle shelf GZWs. The proposed collection of benthic samples and resulting analyses will test the hypothesis and counter hypothesis regarding the West Antarctic Ice Sheet (WAIS) retreat as it relates to the WDB paleo ice stream through: 1) radiocarbon dating in situ benthic foraminifera isolated from diamict deposited on the GZW foreset; 2) ramped pyrolysis of acid insoluble organic (AIO) isolated from diatom ooze overlying GZW diamict; 3) calculating the duration of the two grounding events; and 4) extracting pore-water from the GZW diamict to determine salinity and $\delta^{18}O$ values to test a numerical model prediction regarding the WAIS retreat.

The proposed sediment coring activities include the following:

- Box coring at 3 locations;
- Gravity coring at 3 locations;
- Jumbo piston coring at 4 locations;
- Kasten coring at 11 locations; and
- Standard piston coring at 11 locations.

The locations of the coring activities will be determined by data collected during the seismic survey. From the sediment cores, the in situ foraminifera and ramped pyrolysis radiocarbon data will be used to conduct a detailed comparison of AIO versus foraminifera radiocarbon dates. The grounding-event duration data generated will provide a test of the two radiocarbon dating strategies.

Resolving which of the two interpretations of how near-surface sedimentology and stratigraphy of Glomar Challenger Basin GZW stratigraphy in eastern Ross Sea relates to post-Last Glacial Maximum (LGM) grounding-line migration is the goal of the proposed research; determining which of the strategies is more accurate and/or what offsets exist between the two dating strategies used to support these interpretations is important because constraining the timing of recent grounding events is essential to predict what factors might cause the current stability (i.e., a pause in grounding-line migration) to end with additional WAIS retreat.

Vessel Specifications

The USAP research vessel RVIB Nathaniel B. Palmer (NBP) would be used to conduct the proposed research activities. The NBP has a length of 93.9 meters (m), a beam of 18.3 m, and a design draft of 6.8 m. It is equipped with four Caterpillar Model 3608 diesel engines (each rated at 3,300 brake horsepower (BHP) @ 900 rpm) and a water jet azimuthing bow thruster. Electrical power is provided by four Caterpillar 3512, 1,050-kW diesel generators. The maximum speed of the NBP is 14.5 knots and the average speed is 10.1 knots. The cruising speed would be approximately 5 knots (vary between 4 and 6 knots) when the GI airguns are operating. The NPB operating range is 27,780 km (approximately 70 to 75 days).

The NBP also would serve as the platform from which vessel-based protected species observers (PSOs) will watch for marine mammals before and during airgun operations. The characteristics

of the vessel that make it suitable for visual monitoring are described in Sections 11 and 13. Other details of the NBP include the following:

Owner:	Edison Chouest Offshore, Inc.
Operator:	Edison Chouest Offshore, Inc.
Chartered:	NSF
Flag:	United States of America
Date Built:	1992
Gross Tonnage:	6,174 GT
GI Airgun Compressor:	Borsig-LMF Seismic Air Compressors, 1,200 cfm at 2000 psi
Accommodation Capacity:	22 crew and 37 scientists

2.0 DATE, DURATION, AND GEOGRAPHICAL REGION OF ACTIVITIES

NOAA NMFS Requirement: The date(s) and duration of such activity and the specific geographical region where it will occur.

The research would begin approximately on 24 January 2015 and span 27 days for the proposed research activities, ending approximately on 26 February 2015. The research team would join the USAP research vessel RVIB Nathaniel B. Palmer (NBP) at McMurdo Station, where the vessel would be completing other science and operational activities. At the end of this proposed research voyage in the Ross Sea, the NBP would resume other operational activities, and transit to and arrive at Hobart, Australia approximately on 20 March 2015.

The proposed marine action would occur in selected regions of the Ross Sea (located north of the Ross Ice Shelf) and focus on the WDB trough (encompassing the region between 76°S and 78°S, and between 165°W and 170°W) as shown on Figure 2. Figure 2 also illustrates the general bathymetry of the study area and the previously collected data with respect to seismic units and dated cores.

The seismic survey would be conducted within an area of approximately 3,882 km^2. This estimate is based on the maximum number of kilometers for the seismic survey (1,750 km) multiplied by the area ensonified around the planned seismic lines (1.109 km x 2). The ensonified area is based on the predicted RMS radii (m) presented in modeling data (Attachment B) assuming 100% use of 2 x 105 in^3 GI airguns in water depths between 100 to 1,000 m) which was calculated to be 1,109 m (1.109 km).

If icebreaking is required during the course of the research activities in the Antarctica region, it is expected to occur on a limited basis. The research activities and associated contingencies are designed to avoid areas of heavy sea ice condition, and the Ross Sea region is typically clear during the January-February time period due to a large polynya that routinely forms in front of the Ross Ice Shelf.

Researchers will work to minimize time spent breaking ice. The proposed science operations are more difficult to conduct in icy conditions because the ice noise degrades the quality of the geophysical and Acoustic Doppler Current Profiler (ADCP) data. Also, time spent breaking ice

takes away from time supporting research. Logistically, if the vessel were in heavy ice conditions, researchers would not tow the air gun and streamer, as this would likely damage equipment and generate noise interference. It is possible that the seismic survey can be performed in low ice conditions if the RVIB NBP could generate an open path behind the vessel.

Because the RVIB NBP is not rated to routinely break multiyear ice, operations generally avoid transiting through older ice (i.e., 2 years or older, thicker than 1 m). If sea ice is encountered during the cruise, it is anticipated the RVIB NBP will proceed primarily through one year sea ice, and possibly some new, very thin ice, and would follow leads wherever possible. Satellite imagery from the Ross Sea region (http://www.iup.physik.uni-bremen.de:8084/ssmis/) documents that sea ice is at its minimum extent during the month of February.

Based on estimated transit to the proposed study area from McMurdo Station and expected ice conditions, it is estimated that the RVIB NBP may need to break along a distance of approximately 500 km or less. Based on the ship's speed of 5 knots under moderate ice conditions, 500 km represents approximately 54 hours of icebreaking operation. It is noted that typical transit through areas of primarily open water containing brash or pancake ice are not considered icebreaking for the purposes of this assessment.

Specific details of the activities to be performed are described below.

Seismic Survey

The proposed seismic survey would be performed in the Ross Sea along track lines totaling approximately 1,750 km and in water between 100 and 1,000 m deep (Figure 2). The trackline distance includes equipment testing, start-up, line changes, repeat coverage of areas as needed, and equipment recovery. The proposed seismic research activities would bisect approximately 25,500 square kilometers (km^2) in the Ross Sea region (see Figure 2). Seismic surveys would be conducted during the day (from nautical twilight-dawn to nautical twilight-dusk) and night, for up to 100 hours of continuous operation. Note that there would be 24-hour or near 24-hour daylight (civil twilight) in the study area between 24 January and 26 February (http://www.timeanddate.com/sun/antarctica/mcmurdo?month=2&year=2015).

The seismic survey would involve the use of a low-energy acoustic source consisting of a two GI airgun array and either one or two 100-m solid-state hydrophone streamers towed behind the vessel. A third gun would serve as a "hot spare" to be used as a backup in the event that one of the two firing guns malfunctions. Detailed specifications, including dominant frequency and source output, for the airguns can be found in Attachment B. The airguns would be deployed in an array at a depth of approximately 3 to 4 m below the surface, spaced approximately 3 m apart and between 15 and 40 m astern. Each airgun would be configured to a displacement volume of 1,720 cubic centimeters (cm^3)(105 cubic inches) for both the generator and injector, and are considered a low-energy acoustic source as defined in the PEIS. The guns would fire the compressed air volume in unison in a harmonic mode and at an approximate firing pressure of 2,000 pounds per square inch (psi). In harmonic mode, the injector volume is designed to destructively interfere with the reverberations of the generator (source component). Firing the guns in harmonic mode maximizes resolution in the data and minimizes any excess noise in the water column or data caused by the reverberations (or bubble pulses).

Weather conditions permitting, it is anticipated that the seismic surveying **would not exceed 1,750 km in length and 200 hours of operation for the entire cruise** as summarized in Table 2.

Table 2. Proposed Seismic Survey Activities in the Ross Sea

Survey Length (km)	Cumulative Duration [1] (hours)	Airgun Array Total Volume	Frequency Between Seismic Shots	Streamer Length
1,750	≤ 200	2 x 105 in^3 (2 x 1,720 cm^3)	5-10 seconds	100 m

Note: [1] Seismic operations are planned for no more than 100 continuous hours at a time.

During the seismic survey, the vessel would attempt to maintain a constant cruise speed of approximately 5 knots (9 km/hr). There would be between 360 and 720 shots per hour and the relative linear distance between shots would be between 15 and 30 m. The airguns would operate continuously for no more than 100 hours at a time based on operational constraints. The cumulative duration of airgun operation will not exceed 200 hrs which would include equipment testing, ramp-up, line changes, and repeat coverage.

Weather and sea conditions, including the presence of pack ice that could hinder operation of the airgun array and streamer, would be closely monitored as well as conditions that could limit visibility. If situations are encountered which pose a risk to the equipment, impede data collection, or require the vessel to stop forward progress, the seismic survey equipment would be shut down and retrieved until conditions improve. In general, the airguns and streamer could be retrieved in less than 30 minutes.

Multibeam Swath Bathymetric Survey

Complementing the seismic survey, detailed swath bathymetry measurements focused on a specific study area within the Ross Sea would be made using hull-mounted sonar systems during seismic survey operations. The proposed bathymetry research would bisect approximately 8,300 square kilometers (km^2) in the Ross Sea region (see Figure 2).

In addition, other transducer-based instruments onboard the vessel would be used continuously during the cruise for operational and navigational purposes. During operations, when the vessel is not towing seismic equipment, its average speed would be 10.1 knots (18.8 km/hr). Operating characteristics for the instruments to be used are described below.

Single Beam Echo Sounder (Knudsen 3260) – The hull-mounted CHIRP sonar would be operated continuously during all phases of the cruise. This instrument is operated at 12 kHz for bottom-tracking purposes or at 3.5 kHz in the sub-bottom profiling mode. The sonar emits energy in a 30° beam from the bottom of the ship.

Single Beam Echo Sounder (Bathy 2000) – The hull-mounted sonar characteristics of the Bathy 2000 are similar to the Knudsen 3260. Only one hull-mounted echo sounder can be operated at a

time and the specific model to be used is expected to be selected by the scientific researchers. The Bathy 2000 was the preferred instrument for many previous surveys on the RVIB NBP.

Multibeam Sonar (Simrad EM120) – The hull-mounted multi-beam sonar would be operated continuously during the cruise. This instrument operates at a frequency of 12 kHz and has an estimated maximum source energy level of 242 dB re 1µPa (rms) and emits a very narrow (< 2°) beam fore to aft and 150° in cross-track. The multi-beam system emits a series of nine consecutive 15 millisecond (ms) pulses.

Acoustic Doppler Current Profiler (ADCP) (Teledyne RDI VM-150) –The hull-mounted ADCP would be operated continuously throughout the cruise. The ADCP operates at a frequency of 150 kHz with an estimated acoustic output level at the source of 223.6 dB re 1µPa (rms). Sound energy from the ADCP is emitted as a 30° conically-shaped beam.

Acoustic Doppler Current Profiler (ADCP) (Ocean Surveyor OS-38) – The characteristics of this backup hull-mounted ADCP unit are similar to the Teledyne VM-150. It would be continuously operated.

Acoustic Locator (Pinger) – A pinger would be deployed with certain instruments (e.g., camera) and equipment (e.g., corers) so these devices can be located in the event they become detached from their lines. A pinger typically operates at a frequency of 12 kHz, generates a 5 ms pulse per second, and has an acoustical output of 162 dB re 1µPa (rms). A maximum total of 32 coring samples would be obtained using these devices and ranging from 1.5 to 3 hours per sample and require approximately 62 hours per sample. Therefore, it is estimated that the pinger would operate a total of 62 hours.

Passive Instruments – During coring activities in the Ross Sea, underwater imagery will be obtained through deployment of a benthos bottom camera and towed benthic camera system. In addition, approximately 50 expendable bathythermographs (XBTs) would also be released over the course of the cruise to obtain temperature data necessary to calculate sound velocity profiles used by the multibeam sonar.

Core Sampling

The primary sampling goals involve the acquisition of sediment cores for analysis. The coring locations will be determined using data generated by the seismic survey. It is anticipated that cores will be advanced at a total of 32 coring locations using several different types of equipment designed to meet research specific objectives. The proposed coring activities are summarized in Table 3.

The small-diameter coring devices would collect sediment from the seafloor at 32 sample locations. At each sampling location up to 176 cm^2 of seafloor would be disturbed by deployment of the coring devices, yielding a cumulative total of approximately 0.6 m^2 disturbance during the project.

Table 3. Proposed Coring Activities in the Ross Sea

Sampling Device	Core Diameter (cm)	Core Length (m)	No. of Cores
Box core (rectangular profile)	10	0.5	3
Gravity core	7.5	3	3
Jumbo piston core	12.7	12	4
Kasten core	15	6	11
Standard piston core	8.9	9	11

The Committee for Conservation of Antarctic Marine Living Resources (CCAMLR) has adopted conservation measures (22-06, 22-07, and 22-09) to protect vulnerable marine ecosystems (VME), which include seamounts, hydrothermal vents, cold water corals and sponge fields. The conservation measure 22-07 includes mitigation and reporting requirements if VME are encountered. The science team would follow these requirements if VMEs are encountered while sampling the sea bottom.

3.0 TYPE AND ABUNDANCE OF MARINE MAMMALS IN PROJECT AREA

NOAA NMFS Requirement: The species and numbers of marine mammals likely to be found within the activity area

3.1 Number of Animals

The Ross Sea and surrounding Southern Ocean is a feeding ground for a variety of marine mammals, including cetaceans (whales), both baleen (mysticetes) and toothed whales (odontocetes) and pinnipeds (seals). A cross-reference of species names used in this document to their common names appears in Attachment A.

The PEIS examines the potential impacts that may result from geophysical exploration and scientific research using seismic surveys that are funded by NSF or conducted by the USGS. Due to the potential for NSF-funded marine seismic cruises to occur across the world's oceans, it was necessary to narrow the focus of the impact analysis presented in the PEIS to a number of representative or exemplary analysis areas. Thirteen such areas were selected for analysis in the PEIS, including 5 areas subject to detailed analyses (Detailed Analysis Areas [DAAs]) and 8 subject to qualitative analysis (Qualitative Analysis Areas [QAAs]). One of the QAAs, designated Sub-Antarctic and defined as the region between 42°S and 60°S (NSF, 2011) is generally relevant to the proposed action described in this request for IHA as it includes the species that may migrate to the Antarctic (i.e., below 60°S).

Functionally, this document will use the impact assessment data presented in the PEIS for the Sub-Antarctic QAA as a basis for the evaluation. In general, the species present in the Sub-Antarctic QAA may be present or migrating through the Southern Ocean in the Ross Sea region during the proposed marine seismic research activities. However, historical sightings data and estimated densities from previous cruises and other research in the proposed study areas will be used to provide a more accurate representation of the species that may be encountered in the Ross Sea and surrounding Southern Ocean, and provide quantitative estimates of species population density. Because the species identified in the PEIS cover a wide area of the Southern

Ocean, population data and marine mammal sightings data and density data specific to the Ross Sea region were reviewed and compiled to characterize marine mammals expected to be present in the Ross Sea. The listing of the data sources, observational characteristics associated with sightings data, species observed within the data sets, correction factors, and population density estimates by data source for cetacean and pinniped species that would be present in the proposed study area are summarized in Attachment C.

Following the review of available data (see Attachment C) and consultation with NOAA, cetaceans and pinnipeds population density estimates considered suitable for the proposed study area and time period (January-February) were selected for the purposes of estimating acoustic harassment and are presented in Tables 4 and 5, respectively.

The population density estimates are based on sightings data but also take into account animals that may have been in the water but were not sighted and reported. For cetaceans, a correction factor of 5 was used, (i.e., assumes that only 20% of animals present were reported).

The densities used for purposes of estimating acoustic harassment takes do not take into account the patchy distributions of marine mammals in an ecosystem, at least on the moderate to fine scales over which they are known to occur. Instead, animals are considered evenly distributed throughout the assessed area and seasonal movement patterns are not taken into account.

Table 4. Cetacean Densities in the Ross Sea

Common Name	Area Surveyed (km)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported) Note 1	Estimated Linear Density (#/km)	Half Strip-Width (km) Note 2	Visual Transect Width (km) Note 3	Areal Density (#/ km^2) Note 4	Data Source	Year/Season/Area	Comments
Mysticetes											
Blue whale	8,905	24	58	290	0.0326	2.50	5.00	0.0065132	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Fin whale	8,905	238	273	1,365	0.1533	2.50	5.00	0.0306570	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Humpback whale	8,905	277	286	1,430	0.1606	2.50	5.00	0.0321169	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Minke whale	8,905	753	753	3,765	0.4228	2.50	5.00	0.0845595	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Sei whale								0.0046340	NMSDD Note 5	Winter, maximum range south of 70° S	
Odontocetes											
Arnoux's beaked whale								0.0134420	NMSDD Note 5	Winter, maximum range south of 70° S	
Hourglass dolphin	8,905	158	169	845	0.0949	2.50	5.00	0.0189782	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Killer whale	8,905	186	186	930	0.1044	2.50	5.00	0.0208872	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Layard's beaked whale	8,905	3	40	200	0.0225	2.50	5.00	0.0044919	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Long-finned pilot whale	8,905	226	356	1,780	0.1999	2.50	5.00	0.0399777	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Southern bottlenose whale	8,905	84	105	525	0.0590	2.50	5.00	0.0117912	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Sperm whale	8,905	88	88	440	0.0494	2.50	5.00	0.0098821	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	

Notes:

IWC SOWER = International Whaling Commission-Southern Ocean Whale and Ecosystem Research; NMSDD = Naval Marine Species Density Database;

[1] Sightings data accounts for all individuals observed in groups; corrected sightings assumes only 20% of animals present were observed and reported.

[2] Assumes 2.5 km half strip-width on each side of the vessel.

[3] Visual transect width = half strip-width x 2, representing the total width of observations.

[4] Density values (#/km^2) directly from NMSDD as indicated; density values derived from IWC references calculated by multiplying the linear density (#/km) times 1/visual transect width (km)

[5] Maximum density values for the Weddell and Amundsen Seas (between 40° W and 100° W); extrapolated for use in the Ross Sea (between 170° E and 150 °W)

Table 5. Pinniped Densities in the Ross Sea

Common Name	Area Surveyed (km^2)	Animals (#)	Animals (# including unidentified)	Correction Factor Note 1	Estimated # in the Water Note 2	Estimated Linear Density (#/km)	Half Strip-Width (km) Note 3	Visual Transect Width (km) Note 4	Areal Density (#/ km^2)	Data Source	Year/Season/Area	Comments
Antarctic Fur Seal												
Crabeater	300,000	NA	204,000	NA	NA	NA	NA	NA	0.68000	State of the Ross Sea Region (NZAI, 2001)	More common in the northern regions of the Ross Sea, concentrated in the pack ice over the Antarctic Slope Front.	No primary source cited for population estimate.
Leopard	300,000	NA	8,000	NA	NA	NA	NA	NA	0.02667	State of the Ross Sea Region (NZAI, 2001)	Individual leopard seals are often seen in summer...off the Adélie penguin rookeries of Ross Island.	No primary source cited for population estimate.
Ross	300,000	NA	5,000	NA	NA	NA	NA	NA	0.01667	State of the Ross Sea Region (NZAI, 2001)	A seal of pack ice and open waters and seems to prefer dense consolidated pack ice rather than the open pack frequented by crabeaters.	No primary source cited for population estimate.
Weddell	300,000	NA	32,000	NA	NA	NA	NA	NA	0.10667	State of the Ross Sea Region (NZAI, 2001)	The Weddell seal is the most commonly encountered seal in the Ross Sea.	Counts from Ainley, 1985]
Elephant	300,000	NA	40	NA	NA	NA	NA	NA	0.00013	Seals: Trophic modelling (Pinkerton, Bradford-Grieve n.d.)	Enters the Ross Sea only in the summer from breeding and feeding grounds further to the north. The southern elephant seal is consequently the least common seal in the Ross Sea.	Estimates from Brownell & Ainley 1976; Ainley 1985.

Notes:

NA = Not Applicable

[1] Not applicable for Ross Sea pinniped data. Correction factor for pinnipeds accounts for animals that may be in the water but were not sighted and reported.

[2] Number of animals x correction factor.

[3] Assumes 400 m half strip-width on each side of the vessel.

[4] Visual Transect Width = visual range x 2, representing the total width of observations.

3.2 Endangered Species

Marine organisms inhabiting the South Atlantic Ocean and adjacent Southern Ocean are included in the International Union for Conservation of Nature (IUCN) Red List, a comprehensive inventory of the global status of plant and animal species. The Red List uses established criteria to evaluate the extinction risk of thousands of species and subspecies. Table 6 identifies the status of species in the Southern Ocean including blue, fin, and sei whales which are identified as endangered.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments, whose purpose is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Roughly 5,000 species of animals and 29,000 species of plants are protected by CITES against over-exploitation through international trade. These species are listed in the three CITES Appendices, with data compiled and provided by the United Nations Environmental Program (UNEP) World Conservation Monitoring Centre. Table 6 indicates those species that are included in one of the CITES Appendices.

Table 6. IUCN Red List and CITES Species – Southern Ocean

Common Name(s)	Red List Category	CITES
Emperor penguin	NT ver 3.1 (2012)	
King penguin	LC ver 3.1 (2012)	
Antarctic fur seal, Subantarctic fur seal	LC ver 3.1 (2008)	App II
Antarctic minke whale	DD ver 3.1 (2008)	App I
Sei whale	EN A1d ver 3.1 (2008)	
Blue whale, sibbald's rorqual, sulphur-bottom whale	EN A1d ver 3.1 (2008)	App I
Common rorqual, fin whale, fin-backed whale, finback, finner, herring whale, razorback	EN A1d ver 3.1 (2008)	App I
Arnoux's beaked whale	DD ver 3.1 (2008)	App I
Cuvier’s beaked whale	LC ver 3.1 (2008)	
Pygmy right whale	DD ver 3.1 (2008)	
Southern right whale	LC ver 3.1 (2008)	App I
Long-finned pilot whale	DD ver 3.1 (2008)	
Leopard seal	LC ver 3.1 (2008)	
Flatheaded bottlenose whale, southern bottlenose whale	LC ver 3.1 (2008)	
Hourglass dolphin	LC ver 3.1 (2008)	App I
Weddell seal	LC ver 3.1 (2008)	
Southern right whale dolphin	DD ver 3.1 (2008)	App I
Crabeater seal	LC ver 3.1 (2008)	
Humpback whale	LC ver 3.1 (2008)	App I

Table 6. IUCN Red List and CITES Species – Southern Ocean

Common Name(s)	Red List Category	CITES
Gray's beaked whale, southern beaked whale	DD ver 3.1 (2008)	
Layard's beaked whale, strap-toothed whale	DD ver 3.1 (2008)	
Southern elephant seal	LC ver 3.1 (2008)	App II
Ross seal	LC ver 3.1 (2008)	
Killer whale, orca	DD ver 3.1 (2008)	App I
Spectacled porpoise	DD ver 3.1 (2008)	App II
Sperm whale	VU A1d ver 3.1 (2008)	
Adelie penguin	NT ver 3.1 (2012)	
Chinstrap penguin	LC ver 3.1 (2012)	
Gentoo penguin	NT ver 3.1 (2012)	

Note: IUCN Red List Categories: EX - Extinct, **EW** - Extinct in the Wild, **CR** - Critically Endangered, **EN** - Endangered, **VU** - Vulnerable, **LR/cd** - Lower Risk/conservation dependent, **NT** - Near Threatened (includes **LR/nt** - Lower Risk/near threatened), **DD** - Data Deficient, **LC** - **Least** Concern (includes LR/lc - Lower Risk, least concern); **CITES** = Convention on International Trade in Endangered Species of Wild Fauna and Flora (www.cites.org); **APP** – Appendix I or II

The National Marine Fisheries Service (NMFS) is responsible for listing marine species under the Endangered Species Act (ESA) and implementing conservation and recovery efforts under its Protected Resource Program. The ESA listings include species inhabiting the Southern Ocean around Antarctica. The seismic survey, as a proposed Federal action funded by NSF, has the potential to affect these species. Table 7 identifies the ESA-listed species that may be present during the proposed action, including in the study areas and transit to and from the study areas.

Table 7. Status of ESA-listed Species Found in the Southern Ocean

ESA-listed Species	Year Listed	Status	Critical Habitat	Recovery Plan
Cetaceans				
Blue whale	1970	E	n/a	final
Fin whale	1970	E	n/a	final
Humpback whale	1970	E	n/a	final
Sei whale	1970	E	n/a	final
Southern right whale	1970	E (F)	n/a	n/a
Sperm whale	1970	E	n/a	final
Pinnipeds				
None identified in the study area				
Sea Turtles				
None identified in the study area; expected to be present in the transit to and from the study area.				

Note: E = endangered; **F**= foreign species that occur entirely outside of U.S. territory; Critical habitat and recovery plans are not required for foreign species; critical habitat is also not required for species listed prior to the 1978 ESA amendments that added critical habitat provisions.
Source: NOAA, January 2014. NSF consulted the published FWS listing of foreign species and noted that no listed species occur in the Ross Sea Region http://ecos.fws.gov/tess_public/SpeciesReport.do?lead=10&listingType=L

3.3 Protected Area Status

The Ross Sea region is not currently designated a marine protected area.

4.0 DESCRIPTION OF MARINE MAMMALS IN PROJECT AREA

NOAA NMFS Requirement: A description of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals likely to be affected by such activities.

4.1 Cetaceans

Mysticetes

The following provides general information on mysticetes that may feed or migrate in the study area and may be present during the proposed action.

Blue Whale/Pygmy Blue Whale

The Antarctic blue whale occurs as a subspecies in the Antarctic (*Balaenoptera musculus intermedia*) mainly in relatively high latitudes south of the "Antarctic Convergence" and close to the ice edge. It is relatively rare in the Southern Ocean, with an abundance estimate of 1,700 animals (Academic Press, 2009). The population structure in the Southern Ocean is not well understood. Blue whales arrive in the Antarctic feeding grounds each austral summer and some probably migrate past 60° S during early austral summer (October-November). Visual and acoustic surveys conducted by the IWC in Antarctic waters recorded 710 blue whale calls in January and 2,559 calls in February 2002. During two separate surveys, 24 (Ensor et al., 2003) and 30 (Smith, Jr. et al., 2012) individuals were observed in the Ross Sea. Blue whales begin migrating north out of the Antarctic to winter breeding grounds earlier than fin and sei whales.

The pygmy blue whale (*Musculus brevicauda*) is also found in the Southern Hemisphere, typically north of the Antarctic Convergence, approximately 55°S.

Fin Whale

Fin whales (*Balaenoptera physalus*) are found throughout the world's oceans and likely migrate south beyond 60° S during the early to mid-austral summer, arriving on more southern feeding grounds after blue whales. The distribution of fin whales during the austral summer ranges from 40 to 60° S in the Southern Indian and South Atlantic oceans and 50° to 65° S in the South Pacific. Approximately 200 fin whales have been observed in the Ross Sea (Pinkerton, M.H. et al., n.d.; Ensor et al., 2003). The New Zealand stock summers from 170° E to 145° W. Fin whales migrate north before the end of austral summer toward breeding grounds in and around the Fiji Sea.

Humpback Whale

All Southern Hemisphere humpback whales (*Megaptera novaeangliae*) share feeding grounds in the Antarctic south near 60°S and between 120°E and 110°W during the austral summer (December-March). Two separate surveys recorded 150 (Pinkerton, M.H. et al., n.d.) and 277 (Ensor et al., 2003) animals. It is estimated that fewer than 5 percent (150 animals) of the Southern Ocean population (3,000 animals) are present in the Ross Sea for only two months per year (Pinkerton, M.H. et al., n.d.).

Minke Whales (Antarctic Minke, Dwarf Minke)

Two species of minke whales are found in the Southern Hemisphere: the Antarctic minke (*Balaenoptera bonaerensis*), and the dwarf minke (*Balaenoptera acutorostrata*). In the Southern Atlantic Ocean, the Antarctic minke whale is usually found between 20°- 65° S and has been reported as far south as 78° S in the Ross Sea during the austral summer.

The Antarctic minke whales begin their southern migration from breeding grounds in the north in November (austral spring) and arrive in Antarctic feeding grounds by early summer (January), where they are abundant from 60°S to the edge of the pack ice. The current population in the Ross Sea is estimated to range from slightly less than 800 (Ensor et al., 2003) to over 87,000 animals (Matsuoka et al., n.d.).

Dwarf minke whales have a circumpolar distribution in the Southern Hemisphere (reported as far south as 60-65° S), especially during the summer months, overlapping that of the Antarctic minke, but are more common in temperate and warmer waters of middle and lower latitudes.

Sei Whale

Sei whales (*Balaenoptera borealis*) arrive in the Southern Ocean during the austral summer. Their main summer feeding concentration occurs between 40° and 50° S.

Populations of sei whales, like other rorquals, may seasonally migrate toward the lower latitudes during the winter and higher latitudes during the summer. The population in the Ross Sea is estimated to be around 100 animals (Pinkerton et al., n.d.).

Odontocetes

The following provides general information on odontocetes that may feed or migrate in the study area and may be present during the proposed action. Certain species of odontocetes have a stratified distribution within the Southern Ocean relative to the polar front and edge of the pack ice.

Arnoux's Beaked Whale

Arnoux's beaked whales (*Berardius arnuxii*) inhabit vast areas of the Southern Hemisphere outside the tropics, as far south as the Ross Sea at approximately 78°S (Academic press, 2009). Habitat preferences are not well known but likely are similar to those of Baird's beaked whales, which prefer deep waters over the continental slopes. Arnoux's beaked whales feed primarily on deep-water bottom fish. They have been sighted in waters near New Zealand and Antarctica

during January-March. Populations of Arnoux's Beaked Whale in the Ross Sea have been estimated to be between 50 (Pinkerton, M.H. et al., n.d.) and 150 (Smith Jr. et al., 2012) animals.

Hourglass Dolphins

Hourglass dolphins (*Lagenorhynchus cruciger*) are found throughout the Southern Hemisphere, in both Antarctic and Subantarctic waters, from south of 45°S to pack ice. It feeds at high latitudes in summer, exploiting biologically productive areas.

Hourglass dolphins are often seen near islands and banks, especially in turbulent waters. One estimate of hourglass dolphins for the 2002-2003 austral summer was 158 individuals (Ensor et al., 2003).

Killer Whales

Orca or killer whales (*Orcinus orca*) are present in all oceans and are commonly found in coastal and temperate waters of high productivity. It is estimated that 25,000 killer whales are found in the Southern Ocean (Academic Press, 2009), although another source estimates a total of 80,000 animals south of the Antarctic Convergence (Jefferson, et al. 2008). Estimates of killer whales in the Ross Sea range from a low of 186 (Ensor et al., 2003) to as many as 3,500 (Pinkerton, M.H. et al., n.d.; Ainley, 2002) individuals.

Layard's Beaked Whale (Strap-toothed whale)

Layard's beaked whale (*Mesoplodon layardii*), also known as the strap-toothed whale due to its unusual tooth configuration, is distributed in cool temperate waters of the Southern Hemisphere between 30° S and the Antarctic Convergence. There have been reports of strandings of this species from New Zealand, Australia, southern Argentina, Tierra del Fuego, southern Chile, and the Falkland Islands. Three (3) Layard's beaked whales were observed in the Ross Sea during the 2002-2003 austral summer (Ensor et al., 2003).

Long-finned Pilot Whales

Millions of long-finned pilot whales (*Globicephala melas*) are found throughout the mid-latitude waters of the North Atlantic and Southern Hemisphere. They are pelagic, feeding on squid and some fish.

In the Southern Hemisphere, their range extends from 19° to 60° S but they have been regularly sighted in the Antarctic Convergence Zone (47°- 62° S) and in the Central and South Pacific as far south as 68° S. Their distribution is considered circumpolar, and they have been documented near the Antarctic sea ice.

In the Southern Hemisphere, there are an estimated 200,000 long-finned pilot whales in Antarctic waters (NOAA, 2014). During the 2002-2003 season, 226 individuals were observed in the Ross Sea (Ensor et al., 2003).

Southern Bottlenose Whale

The southern bottlenose whale (*Hyperoodon planifrons*) is a large, robust beaked whale distinguished by its large, bulbous forehead and short, dolphin-like beak (Academic Press, 2009). It can be 6 to 9 m long. The southern bottlenose whale has a circumpolar distribution in the Southern Ocean, from ice edges to 30° S. There is no information on population status, trends or known areas of concentration in the Southern Hemisphere, but it is estimated that 500,000 animals are found south of the Antarctic Convergence (Jefferson, et al. 2008). Estimates of southern bottlenose whales in the Ross Sea range between 84 (Ensor et al., 2003) and 500 (Pinkerton, M.H. et al., n.d.) animals.

Sperm Whales

Sperm whales (*Physeter macrocephalus*), consisting of solitary males and mixed sex/age classes, are likely to occur in the Southern Ocean during the austral summer. Young calves could also be present during summer. A single group of four sperm whales was sighted in February 2005 during an NSF-funded SIO academic seismic survey in the southwest Pacific Ocean. Female and immature sperm whales generally occur at tropical and temperate latitudes of 50° N to 50° S, while solitary adult males are found to 75° N and 75° S. Home ranges of individual females span distances of up to 620 mi (1,000 km); however, some females travel several thousand miles across large parts of an ocean basin. Sperm whales generally occur in waters more than 180 m deep; waters in the sub-Antarctic to the Antarctic coastal shelf are more than 1,000 m deep. Populations of sperm whales in the Ross Sea are estimated to range between 88 (Ensor et al., 2003) and 800 (Pinkerton, M.H. et al., n.d.) individuals.

Pygmy sperm whales (*Kogia breviceps*) may be present in the sub-Antarctic but are rarely sighted at sea due to avoidance of vessels, inconspicuous surfacing, and logging (lying still at the water surface) behaviors. Their distribution in more temperate regions of the Southern Ocean is mostly known from strandings. The pygmy sperm whale is a frequently stranded cetacean species in New Zealand (Brabyn, 1991).

4.2 Pinnipeds

There are six species of seals that live in the Southern Ocean and five of these are expected to be present in the sub-Antarctic study area. These six species belong to two families. The first family is called the Phocidae, or true seals, of which there are five Antarctic species: the crabeater, leopard, Weddell, elephant, and Ross seals. The second family is the Otariidae, or eared seals, which includes the Antarctic fur seal.

Crabeater Seals

Crabeater seals (*Lobodon carcinophaga*) are found throughout Antarctica but are almost never spotted on land because they breed and rest on pack ice. Crabeaters account for over half of the world's seal population. Worldwide population estimates have ranged widely but a reasonable range is 5 to 15 million (Academic Press, 2009). Crabeater seals have a circumpolar Antarctic distribution, spending the entire year in the pack ice zone. Occasionally, they can be found along the southern fringes of South America (Academic Press 2009). Crabeaters migrate over large distances in association with the annual advance and retreat of pack ice and it is typical to find

higher densities of crabeater seals over and at the edge of the continental shelf as well as the marginal ice zone. In the Ross Sea, crabeater seals are estimated to number between 4,800 (Bester, M.N. and Stewart, B.S., 2006) and 205,000 (Ainley, 2002) individuals.

Crabeater is actually a misnomer as 90% of this seal's diet is krill. Female crabeaters can reach 2.5 m and weigh 225 kg while males are smaller. Crabeater seals sometimes congregate in large groups.

Functional hearing range for crabeater seals is an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from less than 4 to 120 kHz (Department of Navy [DON], 2008).

Elephant Seals

Southern elephant seals (*Mirounga leonine*) are the largest of all pinnipeds. Their name comes from their size and from the males' inflatable nose, or "trunk." Males can weigh up to 3600 kg and grow to a length of fifteen feet (4.5 meters); females are much smaller, at about 900 kg and nine feet (2.8 m). Southern Elephant seals spend most of their time at sea feeding on squid and fish, but in September they come ashore to breed in three large groups in the Sub-Antarctic Islands. The southern elephant seal population is estimated at 640,000 while the population at South Georgia alone is estimated at 470,000 (Academic Press, 2009). Southern elephant seals utilize the Southern Ocean ranging from the Antarctic Convergence to the Antarctic pack ice. It is estimated that the number of elephant seals in the Ross Sea ranges between 40 (Pinkerton, Bradford-Grieve, n.d.; Ainley, 2009) and 100 (Smith, Jr. et al., 2012; Smith, Jr. et al., 2006) animals.

Elephant seals are fiercely territorial. The males use their inflatable nose during breeding, to stake out claims and intimidate other males by erupting into resonating bellows. Male elephant seals often scar each other violently during breeding season, and they also scar the females' necks during intercourse. Elephant seals are highly polygynous, with large dominant males presiding over large aggregations of females, known as harems consisting of up to 100 animals (Academic Press, 2009).

Males tend to feed in shallower water over the shelf while females forage in deep water. In the Antarctic, juvenile males remain in the pack ice to forage (Academic Press, 2009). Elephant seals prey on deepwater and bottom dwelling organisms, including fish, squid, crab, and octopus. They are extraordinary divers with some dive depths exceeding 1,500 m and 120 minutes (Academic Press, 2009).

The breeding population on South Georgia is reported to remain stable (McMahon et al. 2005). During the 2008/2009 AMLR surveys (in waters encircling Antarctica south of 60°S latitude) to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.0003 elephant seals/km within the survey area (NMFS, 2013).

Like other pinnipeds, functional hearing range for elephant seals is an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from less than 4 to 120 kHz (DON, 2008).

Leopard Seals

The leopard seal (*Hydrurga leptonyx*) name comes from its spotted coat. Leopard seals hunt and travel alone on the northern edge of the pack ice and move north to the Sub-Antarctic islands in the winter. Population estimates range between 220,000 and 440,000 (Jefferson et al., 2008; Academic Press, 2009). The strong jaws and highly developed teeth of leopard seals allow them to consume a variety of prey including krill, fish, cephalopods, penguins, seabirds, and seals (Kooyman 1981b). Female leopard seals measure about eleven and a half feet (nearly three meters) and weigh on average 540 kg. Males are smaller.

Leopard seals breed on the outer fringes of the pack ice where females give birth during October to mid-November, with mating occurring in December and early January (Academic Press, 2009). Lactation lasts about 4 weeks.

There have been no systematic, large-scale population census studies for this species but it is known that leopard seals are abundant, with the estimated population ranging from 220,000 to 440,000 seals (Academic Press, 2009). Population densities are greatest in areas of abundant cake ice and least in areas with larger floes; densities range from 0.003 to 0.051 seals/square km (Academic Press, 2009). During the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.0003 leopard seals/km within the survey area (Santora et al. 2009). The population of leopard seals in the Ross Sea is estimated to range from as few as 10 (Bengtson, J.L. et al., 2011) to as many as 8,000 (Ainley, 2002; Smith, Jr. et al., 2012; Smith, Jr. et al., 2006) individuals.

Acoustics play an important role in the mating system for the leopard seal and they become highly vocal prior to and during breeding. Leopard seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from less than 4 to 120 kHz (DON, 2008).

Ross Seals

Ross seals (*Ommatophoca rossii*) are considered the rarest of the Antarctic seals. They are the least documented because they are spotted infrequently. Ross seals have a short snout, big eyes, long flippers, and hooked teeth. They are widely distributed but are generally solitary (Costas and Crocker, 1996). Ross seals breed on the pack ice in the austral spring and early austral summer, and feed on squid, fish, and krill. From late summer through the austral winter they are in open water. On occasion, single seals are observed in the South Sandwich and South Orkney Islands (Academic Press, 2009). Their population has been estimated from 20,000-50,000 (Scheffer, 1958) to 220,000 (Erikson et al., 1971) per Academic Press (2009). They are the smallest of the five species of true seals in the Antarctic. The females grow to seven feet (slightly more than two meters) and weigh 185 kg. The males are slightly smaller. In the Ross Sea, estimates of Ross Seal populations vary from as few as 10 (Bengtson, J.L. et al., 2011) to slightly over 5,000 (Ainley, 2009) animals.

Weddell Seals

The Weddell seal (*Leptonychotes weddellii*) has a circumpolar distribution around Antarctica, preferring land-fast ice habitats that have access to open water. Seals haul out through cracks in the ice. Their range is further south than that of the rest of the Antarctic seals. Occasionally, they are seen at Subantarctic islands (Academic Press, 2009).

There have been no systematic, large-scale population census studies but it is known that the Weddell seal is abundant with the estimated number of seals ranging from 500,000 to 1 million (Academic Press, 2009). Estimates of Weddell seal populations in the Ross Sea vary from about 2,200 (Bengtson, J.L. et al., 2011) to 32,000 (Smith, Jr., et al., 2006; Pinkerton, M.H. et al., n.d.; Ainley, 2002) individuals.

Since they do not migrate north, Weddell seals live under the vast coating of sea ice during the coldest months, keeping breathing holes open with their teeth. They may suffer shortened lives due to damage sustained by their teeth and gums. Weddell seals can remain underwater for more than one hour, diving to 600 m. Weddell seals use sonar to hunt and navigate and feed on fish, krill, and squid. The females can grow longer than three meters and weigh nearly 450 kg.

The fur covers the entire body except a small portion of the underside of the fore and hind flippers; they are black with grayish silver streaks; they do not have an under-fur. The canine and incisor teeth are robust and project forward, used perhaps as an ice reamer, which allows the animal to maintain breathing holes and remain in the ice year-round (Kooyman 1981a).

Weddell seals breed and pup on the fast ice. Mating takes place in the water. Males establish underwater territories and exhibit a variation of harem defense polygamy (Kooyman 1981a; Academic Press, 2009). Females give birth on the fast ice in late September to early November. There is no predictable migration. Weddell seals' diet includes Antarctic cod and smaller fish. They forage in the upper water column but may dive to 600 m for up to 82 minutes, although shallow dives are more typical (Kooyman 1981a; Academic press, 2009). They may range out to 5 km from a breathing hole and return on a single dive. Type B or 'pack ice' ecotype killer whales are known to consume Weddell seals off the western Antarctic Peninsula (Pitman and Durban 2012).

Males patrol their territories using loud trills (up to 193 dB re 1 μPa) to advertise and defend their underwater territories (Academic press, 2009). Like other pinnipeds, Weddell seals utilize an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from less than 4 to 120 kHz (DON, 2008).

5.0 REQUESTED TYPE OF INCIDENTAL TAKE AUTHORIZATION

NOAA NMFS Requirement: The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

The NSF Division of Polar Programs (PLR) requests an IHA pursuant to Section 101(a)(5)(D) of the MMPA for incidental take by harassment during its planned seismic survey in the Ross Sea during a 27-day cruise in 2015.

Some of the research activities described in Section 2 may have the potential to "take" marine mammals by harassment. Takes by harassment may result when marine mammals near the activities are exposed to, and behaviorally disturbed by, pulsed sounds generated from acoustic sources, mainly airguns, during seismic surveying. The potential impacts may depend on the species of marine mammal, the behavior of the animal at the time of exposure to the acoustic release, the received sound level (see Section 7), and the environmental conditions in the proposed study areas. Marine mammals in the general vicinity of the seismic surveying source tracklines may display disturbance reactions to the airguns (Level B Harassment). No takes by serious injury (Level A) are anticipated, given the nature of the planned operations, the use of low-energy sources, and implementation of related mitigation measures (see Section 11). Similarly, no takes or injury by physical strike or entanglement are anticipated given the implementation of mitigating measures during the seismic survey.

In addition, "take authorization" has been requested for icebreaking operations in Addendum A.

6.0 NUMBER OF INCIDENTAL TAKES BY ACTIVITY

NOAA NMFS Requirement: **By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in paragraph (a)(5) of this section, and the number of times such takings by each type of taking are likely to occur**

Detailed data characterizing the age, sex, and reproductive condition for marine mammals in the Ross Sea and nearby Southern Ocean is extremely limited. Available information for these parameters was presented in Section 4.0. Due to the use of low-energy acoustic sources, all potential takes due to the proposed action would be anticipated to be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied (see Section 11) would further minimize the possibility of injurious takes. The following paragraphs describe methods to estimate the number of potential exposures to various received sound levels and presents estimates of the density of marine mammals and the number of individuals that could be affected during the proposed seismic survey. The estimates are based on the density of marine mammals expected to be present in the Ross Sea region using data from visual surveys conducted in the region and applied to strip transect methods.

It should be noted that critical habitat and recovery plans are not required for foreign species and critical habitat is not required for species listed prior to the 1978 ESA amendments that included those provisions. The marine mammals inhabiting the Ross Sea and Antarctic Region are considered foreign species by the U.S. Fish and Wildlife Service (FWS). NSF consulted the published FWS listing of foreign species and noted that no species under FWS jurisdiction are on the list. There are several cetacean species that fall under NOAA's jurisdiction which are currently listed under the ESA (see Table 7 above).

Potential Number of Marine Mammals Exposed

The number of different individuals that could be exposed to airgun sounds on one or more occasions was estimated by considering the areal density (# per km^3) and the total extent of ocean expected to be transited during the 200-hour seismic survey. This conservatively assumes all animals sighted within a calculated mitigation zone would be exposed to sound levels larger than or equal to 160 dB re 1 μPa (rms), resulting in Level B Harassment. The mitigation zone is based on acoustic modeling data for the airguns that would be used during the proposed action (Attachment B).

As summarized in Table 8, the modeling results for the proposed low-energy airguns indicate that the received sound levels are dependent on the water depth. Table 8 also presents the proposed mitigation zone (MZ) and full mitigation zone (FMZ) criteria based on modeling data and the PEIS. Since the entire portion of the proposed seismic survey would be conducted in waters between 100 and 1,000 m deep, only the FMZ criteria of 1,109 m is applicable in this case.

Table 8. Proposed Mitigation Zone (MZ) and Full Mitigation Zone (FMZ) for the Seismic Survey

Source and volume	Water depth	Predicted RMS radius (m) based on modeling and empirical measurements			Proposed MZ and FMZ based on modeling/empirical measurements and the PEIS	
		190 dB	180 dB	160 dB	MZ (190/180 dB)	FMZ (160 dB) [1]
2 x 105 in^3 GI guns	100-1000 m	36	111	1109	100/100	1109

Table 9 summarizes the estimated density of cetaceans and pinnipeds that would be exposed to underwater sounds during the 200-hr seismic survey, based upon the estimated density for each species multiplied by the3,882 km^2 area ensonified to 160 dB (rms) around the planned seismic tracklines (1.109 km x 2 x 1,750 km).

The estimated takes are a very small percentage of the population for each species and within the small number of takes definition in the MMPA. For mysticetes species, auditory impairment or other non-auditory physical effects (Level A exposures) would be unlikely, and limited to exposures within short distances from the acoustic sources, since this group of whales typically avoid seismic vessels (Richardson et al. 1995). Level B disturbances may occur, but are not expected to result in long-term or significant consequences to disturbed individuals or their populations. No exposures resulting in injury or mortality are expected.

Odontocetes species display variable reactions to seismic surveys, but can be generally tolerant and show some disruption of foraging; therefore, short-term Level B exposures may occur. Injuries may occur at a received level from a single seismic pulse; however, similar to mysticetes, potential injuries (Level A exposures) are not likely due to behavioral avoidance.

Table 9. Projected Number of Cetacean and Pinniped Takes in the Proposed Study Area

Common Name	Areal Density (No. /km^2)	Estimated Level B Harassment/Take (No. of animals) Note 1
Mysticetes		
Blue whale	0.0065132	25
Fin whale	0.0306570	119
Humpback whale	0.0321169	125
Minke whale	0.0845595	328
Sei whale	0.0046340	18
Odontocetes		
Arnoux's beaked whale	0.0134420	52
Hourglass dolphin	0.0189782	74
Killer whale	0.0208872	81
Layard's beaked whale	0.0044919	17
Long-finned pilot whale	0.0399777	155
Southern bottlenose whale	0.0117912	46
Sperm whale	0.0098821	38
Pinnipeds		
Crabeater seal	0.6800000	2,640
Elephant seal	0.0001300	1
Leopard seal	0.0266700	104
Ross seal	0.0166700	65
Weddell seal	0.1066700	414

Note: Calculated take is estimated density multiplied by the 3,882 km^2 area ensonified to 160 dB (rms) around the planned seismic lines (1,109 m x 2 x 1,750 km).

Several of the cetacean species that may be taken during the proposed action, including sei, fin, blue, humpback, and sperm whales are listed as Endangered under the ESA. The number of possible exposures may include repeated exposures of the same individuals; however, these would be minimal over the short duration of the survey (200 hours over the entire cruise duration) and it is unlikely that a particular animal would remain in the vicinity of the ship for the entire cruise. In addition, the monitoring and mitigating measures that would be used to protect marine mammals during the seismic survey include immediately shutting down the airguns if an animal (including species protected under the ESA and MMPA) is observed in, or entering, the MZ (that would result in a Level A exposure).

Based on the wide-range distribution of pinnipeds in the Southern Ocean with over 1 million crabeater seals alone, the estimated number of takes would affect significantly less than 20% of

the local population for each pinniped species and would be within the small number of takes defined by the MMPA. The effects of exposure are expected to be limited to behavioral disturbance and, in some cases, localized avoidance of the area near the active airguns.

Possible Effects of Multibeam Echosounder (MBES) and Sub-bottom Profiler (SBP) Signals

It is assumed that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES, SBP, and acoustic release transponders would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the MBES, SBP, and acoustic release transponders, given their characteristics (e.g., narrow downward-directed beam) and other considerations described in Sections 3.6.4.3, 3.7.4.3, and Appendix E of the PEIS. Such reactions are not considered to constitute "taking" (NMFS 2001).

Conclusions

The proposed seismic survey would involve towing an airgun array that introduces pulsed sounds into the ocean, along with simultaneous operation of an MBES and SBP and other transducer-based instruments. The survey would employ a 2-airgun array similar to the airgun arrays used for typical low-energy seismic surveys that were evaluated in the PEIS (NSF, 2011). The total airgun discharge volume would be ~210 in^3 (3,440 cm^3). Routine vessel operations, other than the proposed airgun operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

In Sections 3.6.7 and 3.7.7, the PEIS concluded that low-energy airgun operations with implementation of the proposed monitoring and mitigation measures may result in a small number of Level B behavioral effects in some mysticete and odontocete species; that Level A effects were highly unlikely; and that operations were unlikely to adversely affect ESA-listed species. In this IHA application, estimates of the numbers of marine mammals that could be exposed to low-energy airgun sounds during the proposed program have been presented, together with the requested "take authorization". In addition, "take authorization" has been requested for icebreaking operations in Addendum A. Because of the limited, site-specific quantitative population density data, sightings reported during previous research cruises and conservative correction factors were used to estimate the number of takes. It is possible the estimated number of pinniped takes overestimates the actual number of animals that would be exposed to and react to the seismic sounds because many pinnipeds may not be in the water or would leave the affected area when the disturbance is first recognized. The relatively short-term exposures that may occur would be unlikely to result in any long-term negative consequences for the individuals or their populations.

No "taking" of marine mammals is expected in association with echosounder or other transducer-based equipment operations given the considerations discussed in Section 3.6.4.3, 3.7.4.3, and Appendix E of the PEIS.

7.0 DESCRIPTION OF IMPACT ON MARINE MAMMALS

NOAA NMFS Requirement: The anticipated impact of the activity upon the species or stock of marine mammal.

Summary of Potential Effects of Airgun Sounds

A significant portion of the analysis for the potential effects of airgun sounds below was based on information contained in the Environmental Analysis of a Marine Geophysical Survey by the R/V Marcus G. Langseth on the mid-Atlantic Ridge, April–May 2013 prepared by LGL Ltd., (LGL, 2013).

The effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Southall et al. 2007). Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not an injury (Southall et al. 2007). Although the possibility cannot be entirely excluded, it is unlikely that the project would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter the survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various mysticetes and odontocetes, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of whales is quite variable.

Masking

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data on this.

The proposed airguns for the seismic survey have dominant frequency components of 2-188 Hz. This frequency range fully overlaps the lower part of the frequency range of odontocete calls and/or functional hearing (full range about 150 Hz to 180 kHz). Airguns also produce a small proportion of their sound at mid- and high frequencies, which overlap most, if not all, frequencies produced by odontocetes. While it is assumed that all mysticetes can detect acoustic impulses from airguns and vessel sounds (Richardson et al. 1995), SBPs, pingers, and most of the MBESs, would likely be detectable only by some mysticetes based on presumed mysticete hearing sensitivity. Odontocetes are presumably more sensitive to the mid- to high frequencies produced by the MBESs, SBPs, and pingers than to the dominant low frequencies produced by

the airguns and vessel. A more comprehensive review of the relevant background information for odontocetes appears in Sections 3.6.4.3, 3.7.4.3, and Appendix E of the PEIS.

Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. GI airguns used in this survey are specifically designed to reduce reverberations in the water column and thus could mitigate this risk, although no studies have been undertaken to examine this issue. Some mysticetes and odontocetes are known to continue calling in the presence of seismic pulses and their calls usually can be heard between the seismic pulses. The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), NRC (2005), and Southall et al. (2007), exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking", and would not have deleterious effects to the well-being of individual marine mammals or their populations.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al., 2004; Southall et al., 2007; Weilgart, 2010). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder, 2007; Weilgart, 2010). Given the many uncertainties in predicting the quantity and types of impacts of sound on marine mammals, and the lack of abundance estimates and population trend data for marine mammals in the Southern Hemisphere, the conservative approach used in this Application is to estimate how many marine mammals would be encountered during the 200-hour survey period and/or exposed to the acoustic outputs generated by the seismic source. This approach likely overestimates the numbers of marine mammals that would be affected in a biologically important manner. The sound criteria used to estimate how many marine mammals might be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other whale species, but for many there are no data on responses to marine seismic surveys.

A description of the disturbance reactions observed for different types of cetaceans is presented below.

Mysticetes - These whales generally tend to avoid airguns that are in operation, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from

large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, mysticetes exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees but within the natural boundaries of the migration corridors.

Responses of humpback whales to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects in the Brazilian wintering grounds. Off western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods at about 3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs. However, some individual humpback whales, especially males, approached within distances of 100–400 m.

In the Northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic as opposed to non-seismic periods. On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 µPa on an approximate rms basis. It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys, but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys.

There is no data on reactions of right whales to seismic surveys, but results from the closely related bowhead whale show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source. However, more recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. Reactions of migrating and feeding (but not wintering) gray whales to seismic surveys have been studied off St. Lawrence Island in the northern Bering Sea. It was estimated, based on small sample sizes, that 50% of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 µPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1 µPa (rms). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and western Pacific gray whales feeding off Sakhalin Island, Russia.

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses; sightings by observers on seismic vessels off the United Kingdom from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were either

shooting or silent, although there was localized avoidance. Singing fin whales in the Mediterranean moved away from an operating airgun array.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rates or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year, and bowhead whales have continued to travel to the eastern Beaufort Sea each summer. Bowhead whale numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Odontocetes- Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels. In most cases, the avoidance radii for delphinids appear to be small, on the order of one km or less, and some individuals show no apparent avoidance. The beluga, however, is a species that (at least at times) shows long-distance (tens of km) avoidance of seismic vessels. Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors.

Most studies of sperm whales exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance, and they continue to call, but foraging behavior can be altered upon exposure to airgun sound. There are almost no specific data on the behavioral reactions of beaked whales to seismic surveys. However, some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys. Most beaked whales tend to avoid approaching vessels of other types, and may also dive for an extended period when approached by a vessel. It is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel, although this has not been documented explicitly. Most odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. An equal to or greater than 170 dB disturbance criterion (rather than 160 dB) is considered appropriate for delphinids, which tend to be less responsive than other cetaceans.

Hearing Impairment and Other Physical Effects

Temporary (TTS) or permanent (PTS) hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds. However, there has been no

specific documentation of TTS, let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds with received levels equal to or greater than 180 dB and 190 dB re 1 μPa (rms), respectively (NMFS 2000). These criteria have been used in establishing the mitigation (i.e., shutdown) zones planned for the proposed seismic survey. However, they were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals.

Recommendations for science-based noise exposure criteria for marine mammals, frequency weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations have not, as of early 2013, been formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys. However, some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations.

As presented in the *Supplemental Draft Environmental Impact Statement for the Effects of Oil and Gas Activities in the Arctic Ocean* (NMFS, 2013), NMFS is in the process of revising and updating acoustic thresholds to incorporate newer science and utilize improved methods. NMFS is proposing to modify the criteria using more recent data suggesting that: 1) hearing impairment effects to phocids differ from otariids, because of their inner ear anatomy, and; 2) cetaceans are more likely to incur TTS and subsequent PTS within the frequency ranges of their best hearing sensitivity. NMFS is using a phased approach to conduct these updates. The thresholds currently being revised include: 1) the injury (Level A Harassment) thresholds to be applied to all sound sources and; 2) the behavioral (Level B Harassment) thresholds to be applied only to seismic activities and seismic-like sound sources (e.g., primarily mobile and impulsive sources). NMFS will provide a full description of the derivation of the revised acoustic thresholds once the internal review is complete and the revised acoustic thresholds are released for public comment through a separate process. Depending on the timing and implementation of revisions to the acoustic thresholds, changes to the distances from sound sources within which impacts are quantified would be revised for the proposed action.

NMFS' preliminarily plans include exploring the use of dose-response or risk function-like curves to characterize the relationship between received sound level and behavioral responses. Additionally, it has become increasingly evident that the context in which marine mammals are exposed to sound (e.g., the behavioral state of the animal, whether a sound source is approaching and how fast, etc.) can affect both how an animal initially responds to a sound and the ultimate impacts of the sound exposure on that individual. NMFS is also exploring additional methods of augmenting the use of a dose-response-like curve to address contextual factors beyond received level (such as distance from the sound or behavioral state of the animal), as well as the more chronic effects of sound sources operated over longer periods of time.

NMFS has conducted preliminary evaluation and suspects that the distances from the source within which animals would be potentially exposed to injurious levels would primarily fall within the distances to the current 180-dB SPL rms threshold for cetaceans. However, for phocids, the distances within which received levels may exceed the new thresholds could be

somewhat larger than the distances to the current 190-dB threshold. Depending on the timing and implementation of revisions to the acoustic thresholds, changes to the distances from sound sources within which impacts are quantified would be revised for the proposed action.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds. However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most mysticetes, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the deep water in the study area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Possible Effects of Multibeam Echosounders (MBES) and Sub-bottom Profilers (SBPs)

The PEIS found in Sections 3.6.4.3 and 3.7.4.3 that operation of MBES and SBPs is not likely to impact mysticetes or odontocetes because the intermittent and narrow, downward-directed nature of these acoustic sources would result in no more than one or two brief ping exposures of any individual animal, given the movement and speed of the vessel. Similarly, the intermittent nature of ADCPs and other pingers would, at most, result in short-term, localized behavioral changes.

Summary of Potential Effects from Coring Activities

During coring, the noise created by the mechanical action of the devices on the seafloor is expected to be perceived by nearby fish and other marine organisms and deter them from swimming towards the source. Coring activities would be highly localized and short-term in duration, and would not be expected to significantly interfere with marine mammal behavior. The PEIS identified potential direct effects to include temporary localized disturbance or displacement from associated sounds and/or physical movement/actions of the operations. Additionally, the potential indirect effects to mysticetes were identified to consist of very localized and transitory/short-term disturbance of bottom habitat and associated prey in shallow-water areas as a result of coring and sediment sampling.

8.0 DESCRIPTION OF IMPACT ON SUBSISTENCE USES

NOAA NMFS Requirement: The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

There are no indigenous or native people in the Sub-Antarctic, and subsequently there is no subsistence hunting of marine mammals near the survey areas. Therefore, the proposed action would not have an adverse impact on the availability of the species or stocks used as a food source.

9.0 DESCRIPTION OF IMPACT ON MARINE MAMMAL HABITAT

NOAA NMFS Requirement: The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The proposed seismic survey would not result in any permanent impact on habitats used by marine mammals or to the food sources they use, such as fish and invertebrates. The main impact issue associated with the proposed activity would be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in Section 7. Effects of airguns on fish and invertebrates are reviewed in Section 3.2.4.3, Section 3.3.4.3, and Appendix D of the PEIS.

10.0 DESCRIPTION OF IMPACT FROM LOSS OR MODIFICATION TO HABITAT

NOAA NMFS Requirement: The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The effects of the planned activity on marine mammal habitats and food resources are expected to be negligible, as described above. Some marine mammals present near the proposed action may be temporarily displaced as much as a few kilometers by the planned research activities.

During the proposed survey, marine mammals would be distributed according to their habitat preferences, in pelagic waters in depths 100 to 1,000 m (cetaceans) or on or near sea ice (pinnipeds). While some marine mammals may be encountered feeding in the proposed survey areas, the proposed activity would not be expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, because operations would be limited in duration.

11.0 MEASURES TO REDUCE IMPACTS TO MARINE MAMMALS

NOAA NMFS Requirement: **The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance**

Marine mammals are known to be present in the proposed study area. To minimize the likelihood that impacts would occur to the species and stocks, airgun operations would be conducted in accordance with the MMPA and the ESA, including obtaining permission for incidental harassment or incidental 'take' of marine mammals and other endangered species. The following provides more detailed information about the mitigation measures that would be an integral part of the planned activities, including the use of a mitigation zone (MZ) and procedures for ramp-up, power-down, and shut-down.

Mitigation measures for the low-energy seismic survey would include:

- Pre-planning of the cruise to identify the smallest airgun array that could be used and still meet the geophysical scientific objectives.
- Employing three Protected Species Observers (PSOs) consistent with NMFS requirements, including a marine mammal expert familiar with species in the Southern Ocean to serve as the lead PSO.
- Establishing the MZ and FMZ
- Minimum of one observer maintaining a visual watch for marine mammals during all airgun operations.
- Two observers maintaining a visual watch for marine mammals from 30 minutes before the start of ramp ups through the duration of the ramp ups (and when possible at other times) during the day. One observer would then be on station during daytime operations.
- Shutdowns when marine mammals are detected in or about to enter the designated MZ. Following a shutdown, airgun activity would not resume until the PSO has visually observed the marine mammal(s) exiting the mitigation zone and concluded that it is not likely to return or has not been seen within the mitigation zone for 15 minutes for species with shorter dive durations (small odontocetes) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes). Although power-down procedures are often standard operating practice for seismic surveys, they are not proposed to be used during this planned seismic survey because powering-down from two airguns to one airgun would make only a small difference in the mitigation zone(s) - but probably not enough to allow continued one-airgun operations if a marine mammal came within the mitigation zone for two airguns.

Based on modeling data, the outputs from a pair of 105/105 in^3 GI airguns such as those being used in the proposed action are considered a low-energy acoustic source in the PEIS for marine seismic research (NSF, 2011). A low-energy source was defined in the PEIS as an acoustic source whose received level at 100 m is less than 180 decibels re 1 microPascal (dB re 1µPa). The PEIS also established for these low-energy sources, a standard MZ of 100 m for all low-energy sources in water depths >100 m. This 100 m standard MZ would be used during the proposed activity.

The PEIS did not define a standard FMZ for low-energy acoustic sources, therefore modeling results (Attachment B) are proposed to be used during the proposed action for the region in which NMFS estimates behavioral disturbance (≥160 dB re 1 µPa [rms]) might occur (Level B Harassment). The FMZ is dependent on the array used and the water depth (see Table 8) and

would be used accordingly to identify and report an event that could be interpreted as behavioral disturbance of marine mammals.

To implement these measures, PSOs would monitor for the visual presence of cetaceans and pinnipeds prior to and during daylight seismic survey operations. Monitoring procedures and resources are described in detail in Section 13. During seismic operations, three PSOs would be based aboard the RVIB NBP. The PSOs would be approved by NMFS and the lead PSO would be experienced with species in the Southern Ocean. The other PSOs would receive additional specialized training from the PSO to ensure that they can identify Southern Ocean species. During the majority of seismic operations, one PSO would monitor for marine mammals around the seismic vessel.

Seismic operations would be conducted during the day and night (there would 24-hour daylight or civil twilight during the cruise) and up to 100 continuous hours during the survey. The PSOs would be on duty in 4-hour shifts; however during off -hours, the resting PSO may be called for consultation should a second opinion be needed. Other crew would also be instructed to assist in detecting marine mammals and implementing mitigation requirements (if practical). Before the start of the seismic survey, the crew would be given additional instruction regarding how to do so. PSOs will have direct radio contact with the bridge and chief scientist during the seismic surveys. The vessel operator, science support personnel, and the science party must comply immediately with the observer's call to shut down any/all the airguns.

For at least 30 minutes prior to the seismic survey, two PSOs would scan the surface looking for animals within the MZ from the ship. If no animals are in or approaching the 100-m MZ, the airguns would be ramped up (gradually increasing the output sound level by first using one GI gun and then adding the second) to provide time for undetected animals to vacate the area. During ramp-up, the time between airgun shots would be five minutes. The observations would continue during the seismic survey and if a marine mammal is sighted within the FMZ, the crew would be notified of a possible shutdown if the animal approaches the inner MZ. Observations within the FMZ would also include searching for pinnipeds that may be present on the surface of the sea ice (i.e., hauled out) and that could potentially dive into the water as the vessel approaches. The ship may use evasive maneuvers (altering vessel course and speed) to avoid intercepting the path of an approaching marine mammal if the maneuver can be implemented safely and without damaging the deployed equipment

Seismic survey activities would only be initiated during periods of optimum visibility when marine mammal observers could see the MZ without compromise by adverse weather or diminishing ambient light levels. During periods of reduced visibility, seismic survey activities would cease if observers cannot delineate the MZ.

12.0 MEASURES TO REDUCE IMPACTS TO SUBSISTENCE USERS

NOAA NMFS Requirement: Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be

taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

The activity would not take place in the Arctic; therefore, the proposed activities would not have any impact on the availability of the species or stocks for subsistence users under this requirement.

13.0 MONITORING AND REPORTING

NOAA NMFS Requirement: The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

NSF proposes to sponsor marine mammal monitoring during the present project, in order to implement the proposed mitigation measures that require real-time monitoring, and to satisfy the anticipated monitoring requirements of the IHA.

NSF's proposed Monitoring Plan is described below. NSF understands that this Monitoring Plan is subject to review by NMFS and that refinements may be required. The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same region. NSF is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

PSO observations (described in Section 11) would take place during airgun operations as described in detail below.

The RVIB NBP is a suitable platform for marine mammal observations. When stationed on the bridge, the eye level would be about 16.5 m above sea level for an approximate view of 270 degrees around the vessel, and the observer would have a good view around the vessel. In addition, there is an aloft observation tower at approximately 24.4 m above sea level that is protected from the weather and affords observers a 360 degree view around the entire vessel. The PSO would scan the area around the vessel systematically with reticle binoculars and with the naked eye. The reticular binoculars are equipped with built-in daylight compass and range reticle and would be used to measure distances to animals directly.

Protected Species Observers (PSOs)

- NSF will utilize three NMFS-qualified vessel-based PSOs to visually watch for and monitor marine mammals near the vessel during daytime airgun operations (from nautical

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

- The RVIB NBP vessel crew will also assist in detecting marine mammals, when practicable.

- PSOs will have access to reticle binoculars (7 x 50 Fujinon or equivalent) equipped with a built-in daylight compass and range reticle

- PSO shifts will last no longer than 4 hours at a time.

- When feasible, PSO(s) will also make observations during daytime periods when the seismic airguns are not operating for comparison of animal abundance and behavior.

- PSO(s) will conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water.

Visual Monitoring at the Start of the Airgun Operations

- PSOs will visually observe the entire extent of the mitigation zones (180 dB re 1 μPa [rms] for cetaceans and 190 dB re 1 μPa [rms] for pinnipeds [reference Table 8]) for at least 30 minutes prior to starting the airgun array (day or night).

- If the PSO(s) sees a marine mammal within the mitigation zone, NSF and ASC must delay the seismic survey 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) shall wait 15 minutes for species with shorter dive durations (small odontocetes) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes). If the PSO(s) sees no marine mammals during that time, they should assume that the animal has moved beyond the mitigation zone.

- If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the mitigation 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), NSF and ASC may start the second airgun without observing the entire mitigation zone for 30 minutes prior, provided no marine mammals are known to be near the mitigation zone.

Ramp-up Procedures

- Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or any time after the entire array has been shut down for more than 15 minutes, which means starting with a single GI airgun and adding a second GI airgun after five minutes. During ramp-up, the two PSOs shall monitor the mitigation zone, and if marine mammals are sighted, a shut-down shall be implemented as though the full array (both GI airguns) were operational. Therefore, initiation of ramp-up procedures

from shut-down requires that the two PSOs be able to view the full mitigation zone as described above.

Shut-down Procedures

- Shut-down the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant mitigation zone (reference Table 8). A shut-down means all operating airguns are shut-down (i.e., turned off).

- Following a shut-down, the airgun activity shall not resume until the PSO has visually observed the marine mammal(s) exiting the mitigation zone and is not likely to return, or has not been seen within the mitigation zone for 15 minutes for species with shorter dive durations (small odontocetes) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, killer, and beaked whales).

- Following a shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described above.

Speed or Course Alteration

- Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant mitigation zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the mitigation zone, further mitigation measures, such as a shut-down, shall be taken.

Survey Operations at Night

- Marine seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant mitigation zones are visible and can be effectively monitored.

- No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant mitigation zone cannot be effectively monitored by the PSO(s) on duty.

- To the maximum extent practicable, seismic operations (i.e., shooting airguns) will be scheduled during daylight hours.

PSO Data and Documentation

PSOs would record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data would be used to estimate numbers of animals potentially taken by harassment (as defined in the MMPA). PSOs would also provide information needed to order a power down or shutdown of the airguns when a marine mammal is within or near the MZ.

When a sighting is made, the following information about the sighting would be recorded:

1. 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 behavioral pace.
2. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), sea state and wind force, visibility, and sun glare. This data will 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.

All observations and shut downs would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database.

These procedures would allow initial summaries of data to be prepared during and shortly after the field program, and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations would provide:

1. The basis for real-time mitigation (airgun shutdown).
2. Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS. During the proposed action, the number of takes would be monitored and used to stop seismic operations should the requested number of takes be reached.
3. Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted.
4. Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity.
5. Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

A report would be submitted to NMFS within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report would summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report would also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways.

14.0 RESEARCH COORDINATION

NOAA NMFS Requirement: Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

ASC and NSF will coordinate the planned marine mammal monitoring program associated with the seismic survey with other parties that may have interest in this area. ASC and NSF will coordinate with applicable U.S. agencies (e.g., NMFS), and will comply with their requirements. The proposed action would complement fieldwork studying other Antarctic ice shelves, oceanographic studies, and ongoing development of ice sheet and other ocean models. It would facilitate learning at sea and ashore by students, help to fill important spatial and temporal gaps in a lightly sampled region of the Ross Sea, provide additional data on marine mammals present in the Ross Sea study areas, and communicate its findings concerning the chronology and cause of eastern Ross Sea grounding-line translations during the last glacial cycle via reports, publications and public outreach.

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Draft Addendum to the Draft IHA Application for a Marine Geophysical Survey of the Ross Sea by the National Science Foundation in 2015

1.0 INTRODUCTION

This addendum supplements the Incidental Harassment Authorization Application (IHAA) for the proposed marine seismic survey of portions of the Ross Sea, Antarctica to be conducted by the National Science Foundation (NSF) in the austral summer of 2015 (NSF, 2014a). NSF conducted early coordination with the National Marine Fisheries Service (NMFS) and solicited their comments on the preliminary draft of the subject EA (NSF, 2014b). Supplemental information to the draft Initial Environmental Evaluation/Environmental Assessment (IEE/EA) (NSF, 2014b) was requested by NMFS to address potential marine mammal "takes" from icebreaking activity intrinsic to the project.

Icebreaking is considered by NMFS to be a continuous sound and NMFS (2005) indicates the existing threshold for Level B harassment by continuous sounds is a received sound level of 120 dB SPL. Potential takes of marine mammals may ensue from the icebreaking activity in which the USAP research vessel RVIB Nathaniel B. Palmer (NBP) is expected to engage, i.e. along the Ross Sea region (between 76°S and 78°S, and 165°W and 170°W). The draft IHAA and draft IEE/EA presents take estimates based exclusively on the seismic survey component of the project. If icebreaking does occur in the Antarctic region, we expect it to occur on a limited basis. The research activities and associated contingencies are designed to avoid areas of heavy sea ice condition, and the Ross Sea region is typically clear during the January-February time period. If the NBP breaks ice during transit operations within the Ross Sea, seismic operations will not be conducted concurrently. It is noted that typical transit through areas of primarily open water and containing brash ice or pancake ice will not be considered icebreaking for the purposes of this addendum.

Data characterizing the sound levels generated by icebreaking activities conducted by the NBP are not available. Therefore data for noise generated from an icebreaking vessel such as the USCG Cutter (USCGC) Healy will be used for purposes of this addendum.

This addendum presents calculations of exposures to marine mammals due to icebreaking when the NBP is transiting through ice. It is noted that the NBP is a smaller vessel and has less icebreaking capability than the Coast Guard's polar icebreakers, being only capable of breaking ice up to 1 m thick at speeds of 3 knots. Therefore, the sound levels that may be generated by the NBP are expected to be lower than the conservative levels estimated and measured for the USCGC Healy.

It is important to note that non-icebreaking vessels, as well as natural sounds such as those arising from sea ice motion and whale flukes hitting the ocean surface, also present similar sound impacts. Underwater noise from various vessels, including tug boats, oceanographic research vessels, and fisheries research vessels in open water, as well as icebreakers traversing sea ice, often exceed 120 dB, the existing threshold for Level B harassment set by NMFS (2005).

The sound level and other estimates provided in this addendum are for information purposes only and do not represent any conclusions with regard to harassment. Further studies are needed before a precedent can be established.

The objectives and plans of the proposed project remain unchanged from those described in the accompanying IHAA and IEE/EA. The following includes specifics of the estimation of trackline while the NBP breaks ice outside U.S. waters and the calculation of the resulting potential takes. The supplemental information has been organized in a manner consistent with the draft IHAA. The estimated takes provided in this addendum are in addition to the number of estimated takes due to seismic activities within U.S. waters that are presented in the IHAA and IEE/EA submitted to the NMFS on 15 July 2014.

2.0 DATES, DURATION, AND REGION OF ACTIVITY

The proposed geophysical survey will be conducted for ~27 days from approximately 24 January to 26

February 2015. Icebreaking will occur, as necessary, between the latitudes of ~76°S and 78°S, and 165°W and 170°W. The NBP would pick up the research team at McMurdo Station, where the vessel would be completing other science and operational activities, and transit to the study area. At the end of this proposed research voyage in the Ross Sea, the NBP would resume other operational activities, and transit to and arrive at Hobart, Australia approximately on 20 March 2015. The total distance the vessel will travel in the region to conduct the proposed research activities (i.e., seismic survey, swath bathymetry survey, and transit to coring locations and McMurdo Station) represents approximately 12,000 kilometers (km) of which only a small portion, 500 km, may involve icebreaking. This estimate of total distance is based on 27 days research and assumes an average speed of 10.1 knots (18.7 km/hr).

Researchers will work to minimize time spent breaking ice as science operations are more difficult to conduct in icy conditions since the ice noise degrades the quality of the geophysical and ADCP data and time spent breaking ice takes away from time supporting research. Logistically, if the vessel were in heavy ice conditions, researchers would not tow the airgun array and streamer, as this would likely damage equipment and generate noise interference. It is possible that the seismic survey can be performed in low ice conditions if the NBP vessel could generate an open path behind the vessel.

Because the NBP is not rated to routinely break multiyear ice, operations generally avoid transiting through older ice (i.e., 2 years or older, thicker than 1 m). If sea ice is encountered during the cruise, it is anticipated the NBP will proceed primarily through one year sea ice, and possibly some new, very thin ice, and would follow leads wherever possible. Satellite imagery from the Ross Sea region documents that sea ice is at its minimum extent during the month of February and is relatively clear in the proposed study area due to a large polynya that routinely forms in front of the Ross Ice Shelf.

Based on historical sea ice extent and the proposed cruise track it is estimated that the NBP may actively break ice up to a distance of 500 km. Based on a ship's average speed of 5 knots under moderate ice conditions, this distance represents approximately 54 hours of icebreaking operation. It is noted that typical transit through areas of primarily open water and containing brash ice or pancake ice will not be considered icebreaking for the purposes of this addendum.

The estimated ensonified area due to icebreaking operations and the resulting number of takes is described below.

3.0 TYPE AND ABUNDANCE OF MARINE MAMMALS IN PROJECT AREA

A description of the cetacean and pinniped species that were previously observed by marine mammal observers (MMOs) during research and surveys conducted in the region from 1968 through 2013, and estimated populations are described in Section 3.0 of the IHA (NSF, 2014a). These species may be expected to be present in the project area during icebreaking operations.

4.0 DESCRIPTION OF MARINE MAMMALS IN PROJECT AREA

Within the cruise track where the NBP may need to break ice, cetaceans and pinnipeds may be present. A description of the cetacean and pinniped species that were previously observed in the region from February 1991 through November 2004 are described in Section 3.0 of the IHA (NSF, 2014a).

At least one Protected Species Observer (PSO) will stand watch at all times while the NBP is operating airguns during the seismic survey; this procedure will also be followed when the vessel is conducting icebreaking during transit. We expect that PSOs will observe few cetaceans during icebreaking activities, and will be limited to those species in proximity to the ice margin habitat. Observations would utilize the Proposed Mitigation Zone (MZ) and Full Mitigation Zone (FMZ) criteria described in Section 6.0 of the IHA (NSF, 2014a).

Observations within the FMZ would also include searching for pinnipeds that may be present on the surface of the sea ice (i.e., hauled out) and that could potentially dive into the water as the vessel approaches, indicating disturbance from noise generated by icebreaking activities.

5.0 REQUESTED TYPE OF INCIDENTIAL TAKE AUTHORIZATION

As described in Section 5.0 of the IHA (NSF, 2014a), marine mammals in the general vicinity of the vessel tracklines may display disturbance reactions to the operating airguns (Level B Harassment). These reactions may also occur as a result of icebreaking operations. No serious injury or lethal takes (Level A) are anticipated, given the nature of the planned icebreaking operations and implementation of related mitigation measures.

As described in the draft IEE/EA, marine mammals in the general vicinity of the vessel tracklines may display disturbance reactions to the operating airguns (non-lethal harassment). These reactions may also occur as a result of icebreaking operations. Therefore, the authors request non-lethal 'take' of odontocetes and mysticetes protected under the Endangered Species Act that may be in the area where icebreaking activities may occur during the cruise.

NMFS (2005) indicates the existing threshold for Level B harassment for continuous sounds is a received sound level of 120 dB SPL. NMFS provided the results of noise modeling using a practical spreading model with a source level of 185 dB. The model results showed a sound level decay to 120 dB in about 21.54 km. Therefore, as the ship travels through the ice, a swath 43.08 km wide would be subject to sound levels ≥120 dB. This results in the potential exposure of 21,540 km^2 to sounds ≥120 dB from icebreaking. As previously mentioned in Section 1, the NBP is a smaller vessel and has less icebreaking capability than the Healy, being only capable of breaking ice up to 1 m thick at speeds of 3 knots. Therefore, the sound levels that may be generated by the NBP are expected to be lower than the conservative levels estimated and measured for the Healy.

6.0 NUMBER OF INCIDENTAL TAKES BY ACTIVITY

All anticipated takes caused by icebreaking activities would be "takes by harassment", as described in Section 5 of the original IHAA, involving temporary changes in behavior. The mitigation measures to be applied will minimize the possibility of injurious takes.

There are no stock assessments of marine mammals and very limited population information for the Ross Sea. The lack of population data is further acknowledged in the NMFS recovery plans for several endangered species (e.g. blue, fin, and sei whales). The lack of abundance estimates and population trend data for marine mammals in the southern hemisphere, including animals that are not threatened, hinders traditional quantitative analysis of potentially affected organisms.

Available sightings data from the 2002-2003 International Whaling Commission-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) Circumpolar Cruise, Area V (Ensor, et al. 2003) were used to estimate densities for four mysticetes and six odontocetes. Densities of sei whales and Arnoux's beaked whales were based on the areal densities (number of animals per km^2) reported in Naval Marine Species Density Database (NMSDD) (NAVFAC, 2012). Densities of pinnipeds were estimated using best available data (NZAI, 2001; Pinkerton & Bradford-Grieve, undated) by dividing the estimated population of pinnipeds (number of animals) by the area of the Ross Sea (300,000 km^2).

The number of marine mammals that may be present and potentially disturbed are presented below based on available data of mammal sightings in the area. "Take by harassment" is calculated by multiplying the expected presence of marine mammals within an area where the received sound levels due to icebreaking would be equal to or exceed 120 dB. It is anticipated that the linear distance of icebreaking operations would not exceed 500 km during the proposed actions. The estimated density of cetaceans and pinnipeds was provided in Tables 4 and 5 in the original application (NSF, 2014a) and is included in Table Add-1. Table Add-1 summarizes the estimated number of cetacean and pinniped takes anticipated during icebreaking operations. The estimated number of takes for pinnipeds accounts for both seals that may be in the water and those hauled-out on ice surfaces. While the number of cetaceans that may be encountered within the ice margin habitat would be expected to be less than open water, the estimates below utilize the estimated densities for the open water and therefore; represent conservative estimates.

Table Add-1. Projected Number of Cetacean Takes in the Proposed Study Areas from Icebreaking Operations

Common Name	Estimated Density of Animals (no/km^2)	Number of Estimated Takes and Requested Authorization [2]
Mysticetes[1]		
Blue whale (e)	0.0065132	140
Fin whale (e)	0.0306570	660
Humpback whale (e)	0.0321169	692
Minke whale	0.0845595	1,821
Sei whale (e)	0.0046340	100
Odontocetes[1]		
Arnoux's beaked whale	0.0134420	290
Hourglass dolphin	0.0189782	409
Killer whale	0.0208872	450
Layard's beaked whale	0.0044919	97
Long-finned pilot whale	0.0399777	861
Southern bottlenose whale	0.0117912	254
Sperm whale	0.0098821	213
Pinnipeds[1]		
Crabeater	0.6800000	14,647
Elephant	0.0001300	3
Leopard	0.0266700	574
Ross	0.0166700	359
Weddell	0.1066700	2,298
Antarctic Fur[3]	0.0000	-

Note:
(e) = Endangered species
[1] For cetaceans and pinnipeds, conservatively assumes all sightings could result in Level B harassment
[2] Calculated take is estimated density multiplied by the area ensonified to 120 dB (rms) around the possible icebreaking lines around the possible icebreaking lines (21.54 km x 2 x 500 km).
[3] A take was not requested for Antarctic fur seals because preferred habitat for these species is not within the project area.

It is conservatively assumed that individual marine mammals that are sighted are potentially exposed to received levels ≥120 dB re 1 μPa (rms) by icebreaking operations. Some of the animals estimated to be exposed to sound levels ≥120 dB re 1 μPa, might show avoidance reactions before actual exposure to this sound level. Thus, these calculations estimate the number of individuals potentially exposed to ≥120 dB rms that would occur if there were no avoidance of the area ensonified to that level.

In 2008, acousticians from Scripps Institute of Oceanography Marine Physical Laboratory and University of New Hampshire Center for Coastal and Ocean Mapping conducted measurements of sound pressure levels (SPL) of Healy icebreaking under various conditions (Roth and Schmidt 2010). The results indicated that the highest mean sound pressure level (SPL; 185 dB) was measured at survey speeds of 4 to 4.5 knots in conditions of 5/10 ice[1] and greater. Mean SPL under conditions where the ship was breaking heavy ice by backing and ramming was

[1] Ice cover expressed in tenths.

actually lower (180 dB). In addition, when backing and ramming, the vessel is essentially stationary, so the ensonified area is limited for a short period (on the order of minutes to tens of minutes) to the immediate vicinity of the boat until the ship breaks free and once again makes headway. Based on the operational plans and marine mammal densities described above, the estimates of marine mammals potentially exposed to sounds ≥120 dB during icebreaking are included in Table Add-1.

7.0 DESCRIPTION OF IMPACT ON MARINE MAMMALS

A description of the potential effects of airgun sounds and multibeam echosounders (MBES) and sub-bottom profilers (SBPs) are described in Section 7.0 of the IHA (NSF, 2014a). These effects to marine mammals as result of icebreaking operations are expected be expected to be similar.

8.0 DESCRIPTION OF IMPACT ON SUBSISTENCE USES

There are no indigenous or native people in the Antarctic, and subsequently there is no subsistence hunting of marine mammals near the survey areas. Therefore, the proposed action would not have an adverse impact on the availability of the species or stocks used as a food source.

9.0 DESCRIPTION OF IMPACT ON MARINE MAMMAL HABITAT

The NBP is designed for continuous passage at 3 knots through ice 1 m thick. During this project, the NBP will typically encounter first- or second-year ice while avoiding thicker ice floes, particularly large intact multi-year ice, whenever possible. In addition, the vessel will follow leads when possible while following the survey route. As the vessel passes through the ice, the ship causes the ice to part and travel alongside the hull. This ice typically returns to fill the wake as the ship passes. The effects are transitory, hours at most, and localized, constrained to a relatively narrow swath perhaps 10 m to each side of the vessel.

The NBP's maximum beam is 18.3 m. Applying the maximum estimated amount of icebreaking, i.e. 500 km, to the corridor opened by the ship, we anticipate that a maximum of ~9 km^2 of ice may be disturbed. This represents an insignificant amount of the total ice present in the Southern Ocean.

10.0 ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS

Icebreaking may damage seal breathing holes and will also reduce the haulout area in the immediate vicinity of the ship's track. Icebreaking along a maximum of 500 km of trackline will alter local ice conditions in the immediate vicinity of the vessel. This has the potential to temporarily lead to a reduction of suitable seal haul-out habitat. However the dynamic sea-ice environment requires that seals be able to adapt to changes in sea, ice, and snow conditions, and therefore, they create new breathing holes and lairs throughout winter and spring (Hammill and Smith 1989). In addition, seals often use open leads and cracks in the ice to surface and breathe (Smith and Stirling 1975). Disturbance to the ice will occur in a very small area relative to the Southern Ocean icepack and no significant impact on marine mammals is anticipated by icebreaking during the proposed project.

11.0 MEASURES TO REDUCE IMPACTS TO MARINE MAMMALS

A description of the mitigating measures that will be conducted to reduce potential impacts are described in Section 11.0 of the IHA (NSF, 2014a). The applicable measures will also be used during icebreaking operations.

12.0 MEASURES TO REDUCE IMPACTS TO SUBSISTENCE USERS

The activity would not take place in the Arctic, and there is no subsistence hunting near the proposed survey area; therefore, the proposed activities would not have any impact on the availability of the species or stocks for subsistence users

13.0 MONITORING AND REPORTING

A description of the monitoring and reporting procedures that will be performed during the cruise are described in Section 13.0 of the IHA (NSF, 2014a). The applicable measures will also be used during icebreaking operations.

14.0 RESEARCH COORDINATION

A description of the research co-ordination that will be performed as a result of the cruise are described in Section 14.0 of the IHA (NSF, 2014a). The applicable measures will also be used during icebreaking operations.

15.0 LITERATURE CITED

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Attachment A

Species Cross Reference

Species / Scientific Name	Common Name
Aptenodytes forsteri	Emperor penguin
Aptenodytes patagonicus	King penguin
Arctocephalus gazella	Antarctic fur seal, Kerguelen fur seal
Balaenoptera acutorostrata	Minke whale, dwarf minke whale
Balaenoptera bonaerensis	Antarctic minke whale
Balaenoptera borealis	Sei whale
Balaenoptera edeni	Bryde's whale, Omura's whale
Balaenoptera musculus	Blue whale, sibbald's rorqual, sulphur-bottom whale
Balaenoptera physalus	Fin whale, common rorqual, fin-backed whale, finback, finner, herring whale, razorback
Berardius arnuxii	Arnoux's beaked whale, Southern four-toothed whale
Caperea marginata	Pygmy right whale
Cephalorhynchus commersonii	Commerson's dolphin
Eubalaena australis	Southern right whale
Globicephala melas	Long-finned pilot whale
Grampus griseus	Risso's dolphin
Hydrurga leptonyx	Leopard seal
Hyperoodon planifrons	Southern bottlenose whale, flatheaded bottlenose whale
Hyperoodon spp	Bottlenose whales
Indopacetus pacificus	Longman's beaked whale
Kogia breviceps	Pygmy and dwarf sperm whales
Kogia sima	Dwarf sperm whale
Lagenodelphis hosei	Fraser's dolphin
Lagenorhynchus australis	Peale's Dolphin
Lagenorhynchus cruciger	Hourglass dolphin
Lagenorhynchus obscurus	Dusky dolphin
Lagenorhyncus cruciger	Hourglass dolphin
Leptonychotes weddellii	Weddell seal
Lissodelphis peronii	Southern Right whale dolphin
Lobodon carcinophagus	Crabeater seal
Megaptera novaeangliae	Humpback whale
Mesoplodon grayi	Gray's beaked whale, southern beaked whale
Mesoplodon layardii	Layard's beaked whale, strap-toothed whale
Mirounga leonina	Southern Elephant Seal
Neophocaena phocaenoides	Finless porpoise
Ommatophoca rossiigray	Ross seal
Orcinus orca	Killer whale, Orca

Species / Scientific Name	Common Name
Oreaella brevirostris	Irrawaddy (snubfin) dolphin
Peponocephala electra	Melon-headed whale
Phocoena dioptrica (Australophocaena dioptrica)	Spectacled porpoise
Physeter macrocephalus	Sperm whale
Pseudorca crassidens	False killer whale
Pygoscelis adeliae	Adelie penguin
Pygoscelis antarcticus	Chinstrap penguin
Pygoscelis papua	Gentoo penguin
Sotalia fluviatilis	Tucuxi dolphin
Sousa chinensis	Indo-Pacific humpbacked dolphin
Steno bredanensis	Rough-toothed dolphin
Tasmacetus shepherdi	Shepherd's beaked whale
Tursiops spp.	Bottlenose dolphins
Tursiops truncatus aduncus	Southern bottlenose dolphin
Ziphius cavirostris	Cuvier's beaked whale

Attachment B
Seismic Source Acoustic Modeling Data
prepared by Lamont-Doherty Earth Observatory

Elements for the "Airgun Description" section.

The R/V *Nathaniel B. Palmer* would tow a pair of 105-in^3 Sercel GI airguns and would acquire data at a cruising speed of ~ 5 knots. Seismic pulses would be emitted at intervals of 5 seconds or longer. Data would be recorded on a 100-m long, 24-channel streamer. Acquisition is planned along a series of predetermined lines in waters 100 to 1000 m in depth.

The two GI guns would be towed on a string at 3 m spacing from each other, at a tow depth of 3-4 m. The source would include a hot spare in case one of the elements breaks down. The source would be towed between 15 and 40 m astern.

As the survey line progresses, the towed hydrophone array (streamer) receives the reflected signals and transfers the data to the on-board acquisition system. Given the relatively short streamer length behind the vessel, the turning rate of the vessel while the gear is deployed is much higher than the limit of five degrees per minute for a seismic vessel towing a streamer of more typical length (>>l km). Thus, the maneuverability of the vessel is not limited much during operations.

The GI guns would be used in harmonic mode, that is, the volume of the injector chamber (I) of each GI gun is equal to that of its generator chamber (G): G=I=105 in^3 (1721 cm^3) for each GI gun. The generator chamber is the one responsible for introducing the sound pulse into the ocean. The injector chamber injects air into the previously-generated bubble to maintain its shape and thus prevent further oscillations, and does not introduce more acoustic energy into the water. The Nucleus modeling software used at Lamont-Doherty Earth Observatory of Columbia University (L-DEO) does not include GI guns as part of its airgun library, however signatures and mitigation models have been obtained for two 105-in^3 G guns that are close approximations. A tow depth of 4 m is assumed and would result in the largest radii.

The source output (downward) associated with this 210 in^3 total generator volume would be 234.1 dB re 1 μPa·m for 0-pk and 239.8 dB re 1 μPa·m for pk-pk. These numbers were determined using the aforementioned G-gun approximation to the GI gun and using signatures filtered with DFS V out-256 Hz 72 dB/octave. The dominant frequency range would be 20-150 Hz for a pair of GI guns towed at 4 m depth.

The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source, that is, 228.3 dB pk or 234.0 dB pk-pk. Actual levels experienced by any organism more than 1 m from either GI gun would be significantly lower.

A further consideration is that the rms (root mean square) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (0–pk) or peak to peak (pk–pk) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received level of 160 dB re 1 μPa rms in the far field would typically correspond to ~170 dB re 1 μPa pk, and to ~176–178 dB re 1 μPa pk-pk, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise

difference between rms and peak or peak- to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

Proposed Exclusion Zones

Received sound levels have been modeled by Lamont-Doherty Earth Observatory of Columbia University (L-DEO) for a number of airgun configurations, including two 105-in^3 G guns, in relation to distance and direction from the airguns (Fig. 2). The model does not allow for bottom interactions, and is most directly applicable to deep water. Because the model results are for G guns, which have more energy than GI guns of the same size, those distances overestimate (by ~10%) the distances for GI airguns; no adjustment is made to correct for this.

Empirical measurements concerning the 180- and 160-dB re 1 μPa (rms) distances ("radii" around the source) have been acquired for various airgun arrays during acoustic verification studies conducted by L-DEO in the northern Gulf of Mexico in 2003 (6-, 10-, 12-, and 20-airgun arrays, and 2 GI airguns; Tolstoy et al. 2004 [Referenced in PEIS Appendix H]) and 2007–2008 (18- and 36-airgun arrays; Tolstoy et al. 2009; PEIS Appendix H [Diebold et al. 2010]). For the 2 x 105-in^3 GI gun source, measurements were obtained only in shallow water. When compared to measurements acquired in deep water (>1000 m), mitigation radii provided by the L-DEO model are found to be conservative. The acoustic verification surveys also showed that distances to given received levels vary with water depth - these are larger in shallow water, while intermediate/slope environments show characteristics intermediate between those of shallow-water and those of deep-water environments - and documented the influence of a sloping seafloor.

The only empirical measurements obtained for intermediate water depths (100–1000 m) during either survey were for the 36-aigun array in 2007–2008 (PEIS Appendix H [Diebold et al. 2010]). Following results obtained at this site (PEIS Appendix H [Diebold et al., 2010]; their Fig. 16) and earlier practice, a correction factor of 1.5, irrespective of distance to the array, is used to derive intermediate-water radii from modeled deep-water radii. Estimates of the maximum distances from the GI guns where sound levels of 160, 180 and 190 dB re 1 μPa (rms) are predicted to be received in intermediate (100–1000 m) water are shown in Table 1: distances of 739 m, 74 m and 24 m, respectively, are obtained from L-DEO model results in deep water (Fig. 2), which after multiplication by the correction factor of 1.5 become 1109 m, 111 m, and 36 m in intermediate water depth environments.

The PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m exclusion zone (EZ) for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 105-in^3 GI airguns. A fixed full mitigation zone (FMZ), or 160 dB "Safety Zone" was not defined in the PEIS for the same suite of low-energy sources, therefore, L-DEO model results for the 105-in^3 G airguns are used here to determine the 160 dB radius.

The 180-dB re 1 μPa_{rms} distance is the safety criterion as specified by NMFS (2000) for cetaceans and 190-dB re 1 μPa_{rms} for pinnipeds. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in other seismic projects (e.g., Smultea et al. 2004; Holst et al. 2005a,b; Holst and Beland 2008; Holst and Smultea 2008; Hauser et al. 2008). If marine mammals or sea turtles are detected within or about to enter the appropriate EZ, the airguns would be shut down immediately.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. NSF would be prepared to revise its procedures for estimating numbers of mammals should NMFS implement new acoustic criteria guidelines. However, currently the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al (2013), and Wright (2014).

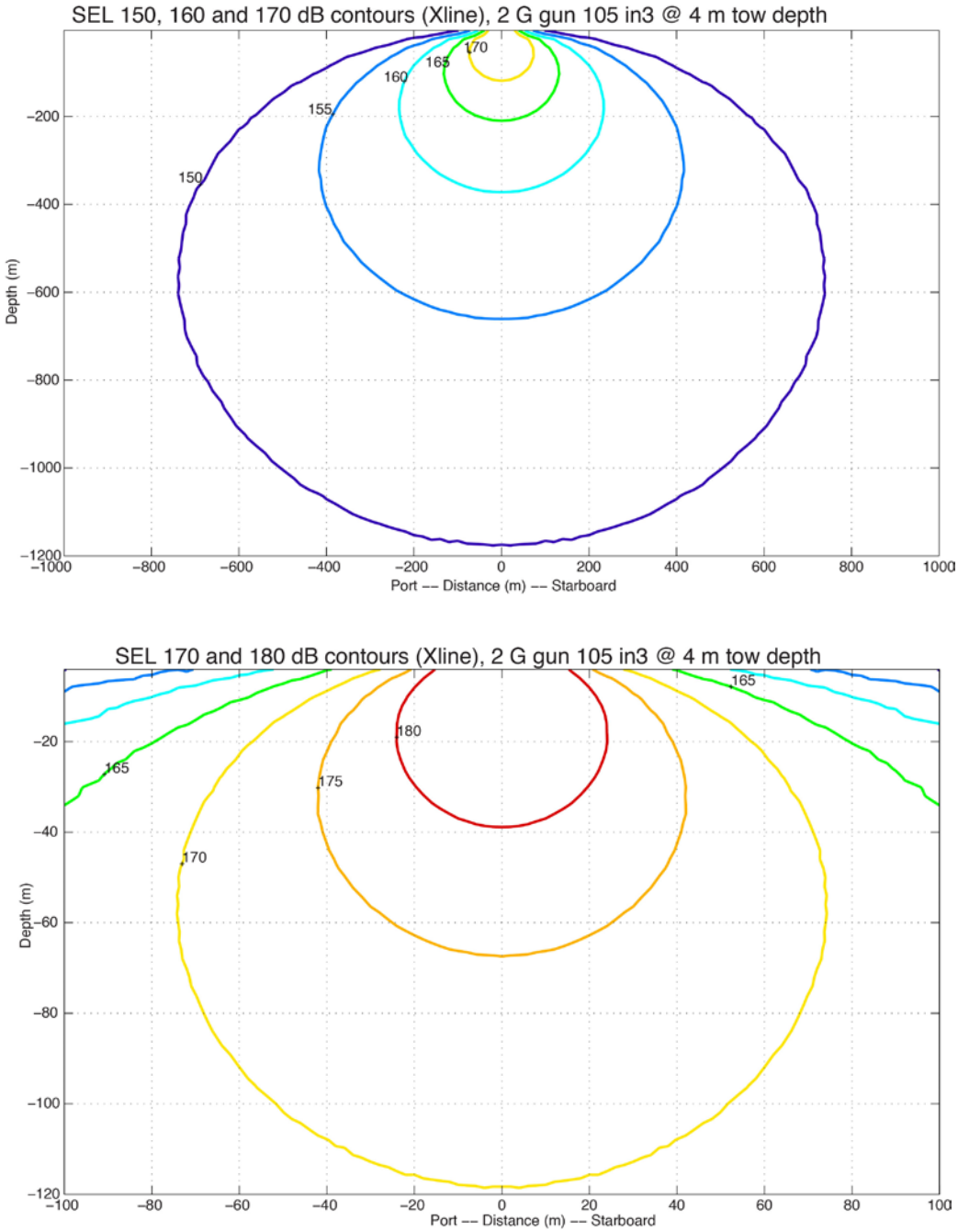

Figure 2. Deep-water model results showing received sound levels from two 105-in^3 G guns at 4 m tow depth, similar to the two 105-in^3 GI airguns that would be used during the *R/V Palmer* survey in the Ross Sea in January 2015. The distance to the 150 dB SEL contour (proxy for 160 dB RMS) is 739 m, the distance to the 170 dB SEL contour (proxy for 180 dB RMS) is 74 m, and the distance to the 180 dB SEL contour (proxy for 190 dB RMS) is 24 m. Model results provided by L-DEO.

Table 1. Predicted distances to which sound levels of 190, 180 and 160 dB re 1 µPa (rms) might be received from two 105-in^3 G guns, similar to the two 105-in^3 GI guns that would be used during the *R/V Palmer* survey in the Ross Sea in January 2015. Distances are based on model results provided by L-DEO (presented in Fig. 2). The Exclusion Zones (EZs) and Full Mitigation Zone (FMZs) proposed for this survey are provided below and are based on model results and standard EZs established in the PEIS for low energy sources.

Source and volume	Water depth	Predicted RMS radii (m) based on modelling			Proposed EZ and FMZ based on modelling and PEIS	
		190 dB	180 dB	160 dB	EZ (190/180 dB)	FMZ
2 x 105 in^3 GI guns 4 m tow depth	100-1000 m	36	111	1109	100/100	1109

Attachment C

Marine Mammal Sightings Data

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Ross Sea Marine Mammals Sightings Data Sources

Reference (Ross Sea Sightings Data Summary)	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area [i.e., 76°S to 78° S; 165°W to 170°W]	Observation Period	Numerical Counts (used to estimate density)	Methodology	Comments
Cetaceans							
Marine Ornithology (Ainley 2002)	Marine ornithology forum: the Ross Sea, Antarctica, where all ecosystem processes still remain for study, but maybe not for long (Ainley, D.G.)	South of and shallower than the 3000-m isobath; 69°S, 170°E to 76°S, 155°W. Included is a northward bend of the isobath, around Iselin Bank, to about 69°S, 175°W. The region is about 598 000 km2 and includes the continental slope (500–3000 m) and the continental shelf of the Ross Sea. Ichii et al. (1998) also included both the slope and the shelf to define the Ross Sea.	NA - Entire Ross Sea	1970s - early 1980s	√	Cited from cf. Stirling 1969, Gilbert & Erickson 1977, Ainley 1985 and Butterworth & Best 1982, Ainley 1985	
Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Smith, W.O. Jr., P.N. Sedwick, K.R. Arrigo, D.G. Ainley, and A.H. Orsi. 2012. The Ross Sea in a sea of change. Oceanography 25(3):90–103, http://dx.doi.org/10.5670/oceanog.2012.80.	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])	NA - Entire Ross Sea	NS	√	NS	
Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Whales: Trophic modelling of the Ross Sea (Pinkerton, M.H., J. Bradford-Grieve, P.M. Sagar)	"Ross Sea"	NA - Entire Ross Sea	1970 - 2004 (depending on species and data source)	√	Cited from previously-published sources	
Exploitation (Ainley 2009)	A history of the exploitation of the Ross Sea, Antarctica (David G. Ainley, 2009)**	The Ross Sea, about the size of southern Europe, is defined as the waters overlying the continental shelf and slope extending in a wavering line, including the northward projecting Pennell Bank, from Cape Adare,Victoria Land (71° 17'S, 170° 14'E), to Cape Colbeck, Marie Byrd Land (77° 07'S, 157° 54'W). Not included are waters around the Balleny Islands (66° 55'S, 163° 20' E).	NA - Entire Ross Sea	Population estimates from Ainley, 1985	√	Population estimates from Ainley, 1985	
CCAMLR 2007	CCAMLR WG-EMM-10/11 ROSS SEA BIOREGIONALIZATION - Part I: Validation of the 2007 CCAMLR Bioregionalization Workshop Results Towards Including the Ross Sea in a Representative Network of Marine Protected Areas in the Southern Ocean David G. Ainley, Grant Ballard, John Weller	The Ross Sea, about the size of southern Europe, is defined as the waters overlying the continental shelf and slope (3000m depth contour), including the northward projecting Pennell/Iselin Bank, from Cape Adare, Victoria Land (71° 17’S, 170° 14’E), to Cape Colbeck, Marie Byrd Land (77° 07’S, 157° 54’W) (from Ainley 2010).	NA - Entire Ross Sea	1969 - 2009	√	Cited from previously-published sources	
Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Trophic interactions within the Ross Sea continental shelf ecosystem (Walker O. Smith Jr, David G. Ainley and Riccardo Cattaneo-Vietti, 2006).	187,000 km2	NA - Ross Sea Continental Shelf	1969 - 1985	√	Cited from previously-published sources	
Minke Abundance (MATSUOKA, HAKAMADA, KIMURA, OKADA, undated)	Influence of sea ice concentration on Antarctic minke whale abundance estimation in the Ross Sea (KOJI MATSUOKA, TAKASHI HAKAMADA, KEISUKE KIMURA AND YOSIHIRO OKADA [no date])	Ross Sea south of 69° S	NA - Entire Ross Sea	2006 - 2009	√	IDCR/SOWER and JARPA II survey data	

Ross Sea Marine Mammals Sightings Data Sources

Reference (Ross Sea Sightings Data Summary)	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area [i.e., 76°S to 78° S; 165°W to 170°W]	Observation Period	Numerical Counts (used to estimate density)	Methodology	Comments
Interactions (Naganobu, Nishiwaki, Yasuma, Matsukura, Takao, Taki, Hayashi, Watanabe, Yabuki, Yoda, Noiri, Kuga, Yoshikawa, Kokubun, Murase, Matsuoka, Ito, undated)	Interactions between oceanography, krill and baleen whales in the Ross Sea and Adjacent Waters: An overview of Kaiyo Maru-JARPA joint survey in 2004/05 (Naganobu, Nishiwaki, Yasuma, Matsukura, Takao, Taki, Hayashi, Watanabe, Yabuki, Yoda, Noiri, Kuga, Yoshikawa, Kokubun, Murase, Matsuoka, Ito [undated])	Survey area consisted of the western part of IWC Area VI (Area VIW, 170°W-145°W) and the entire Area V (130°E-170°W) in the area between south of 60°S and the ice edge line (total survey distance of 18,712.0 n.m.).	NA - Entire Ross Sea	2004 - 2005	√	Observations from sighting vessel	
CWR (2013)	Center for Whale Research (CWR) http://www.whaleresearch.com/#!member-about-orca/c1qa8; includes all Antarctic/Southern Hem. (Type A, B, C, D) orcas.	Antarctic	NA - Entire Antarctic	NS		NS	
Minke Whales (Branch & Butterworth, 2001)	Southern Hemisphere Minke Whales: Standardised Abundance Estimates from the 1978/79 to 1997/98 IDCR-SOWER Surveys Branch, T.A. and Butterworth, D.S. J. Cetacean Res. Manage. 3(2):143–174, 2001.	IWC Area V: 60°S to 76°S latitude, 130°E to 160°W longitude.	Adjacent to the northern edge of the study area	various	√	DESS database package (IWC Database-Estimation System Software v 3.0)	Compiles data from IWC/IDCR and SOWER 1978/79–1983/84, 1985/86–1990/91 and 1991/92–1997/98 cruises
Occurrence of killer whales (Lauriano et al. 2011)	Occurrence of killer whales (Orcinus orca) and other cetaceans in Terra Nova Bay, Ross Sea, Antarctica (Lauriano, G., Fortuna, C.M., and Vacchi, M. 2011)	Terra Nova Bay, western Ross Sea		5 January - 2 February 2004		Helicopter sightings	Area bordered to the south by the floating Drygalski Ice Tongue, to the north by Cape Washington and the Campbell Glacier Tongue in the middle. Article contains numbers of sightings, but not specific numbers of animals observed in each sighting.
Humpback Abundance (Branch, T.A. n.d.)	Humpback abundance south of 60°S from three completed sets of IDCR/SOWER circumpolar surveys (Branch, T.A. n.d.)	Southern Ocean south of 60°S		1978/79-1983/84, 1985/86-1990/91, 1991/92-2003/04		Cited from previously-published sources	Data compiled from various IDCR/SOWER surveys
IWC SOWER Report, 2002-2003	2002-2003 International Whaling Commission-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) Circumpolar Cruise, Area V (Ensor, et al. 2003). SC-55-IA1	Eastern portion of IWC Area V: 60°S to 70°S latitude, 170°E to 170°W longitude.	Approximately 1,000 km NE of study area	December 2002 - March 2003	√	Alternating closing mode (NSC) and passing mode with independent observers (IO).	Number of sightings in the research area presented in Table 2a of the document. "Unidentified" large whales, small whales, and whales could not be allocated to any species.
Navy Marine Species Density Database (NMSDD)	Commander Task Force 20, 4th, and 6th Fleet Navy Marine Species Density Database Technical Report. Naval Facilities Engineering Command. 2012.	various		various	√	Unknown	Maps with densities for various species for the Southern Ocean, only between 100°W and 80°E. Species occurs south of 60°S in these longitudes
Pinnipeds							

Ross Sea Marine Mammals Sightings Data Sources

Reference (Ross Sea Sightings Data Summary)	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area [i.e., 76°S to 78° S; 165°W to 170°W]	Observation Period	Numerical Counts (used to estimate density)	Methodology	Comments
Seals: Trophic modelling (Pinkerton, Bradford-Grieve, undated)	Seals: Trophic modelling of the Ross Sea (M.H. Pinkerton, J. Bradford-Grieve)	Seal abundance is estimated from the data of Ainley (1985) for an area bounded by the continental slope which more or less corresponds with our model area although there are more recent estimates for more limited areas (e.g. Cameron & Siniff 2004)	NA - Area of Ross Sea bounded by the continental slope	1985, 2004	√	Cited from previously-published sources	
Distribution, density and abundance (Bengtson, J.L. et al. 2011)	Distribution, density, and abundance of pack-ice seals in the Amundsen and Ross Seas, Antarctica (Bengtson, J.L. et al. 2011)	53,217 km2 in Ross and Amundsen Seas	**See comments**	26 Dec. 1999 - 24 March 2000	√	Ship and helicopter transects	Map showing transects on p. 1262 of article
Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Smith, W.O. Jr., P.N. Sedwick, K.R. Arrigo, D.G. Ainley, and A.H. Orsi. 2012. The Ross Sea in a sea of change. Oceanography 25(3):90–103, http://dx.doi.org/10.5670/oceanog.2012.80.	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])	NA - Ross Sea Continental Shelf bounded by the 700m isobath	NS	√	NS	
Exploitation (Ainley 2009)	A history of the exploitation of the Ross Sea, Antarctica (David G. Ainley, 2009)**	The Ross Sea, about the size of southern Europe, is defined as the waters overlying the continental shelf and slope extending in a wavering line, including the northward projecting Pennell Bank, from Cape Adare,Victoria Land (71° 17'S, 170° 14'E), to Cape Colbeck, Marie Byrd Land (77° 07'S, 157° 54'W). Not included are waters around the Balleny Islands (66° 55'S, 163° 20' E).	NA - Entire Ross Sea	Population estimates from Ainley, 1985	√	Population estimates from Ainley, 1985	
CCAMLR 2007	CCAMLR WG-EMM-10/11 ROSS SEA BIOREGIONALIZATION - Part I: Validation of the 2007 CCAMLR Bioregionalization Workshop Results Towards Including the Ross Sea in a Representative Network of Marine Protected Areas in the Southern Ocean David G. Ainley, Grant Ballard, John Weller	The Ross Sea, about the size of southern Europe, is defined as the waters overlying the continental shelf and slope (3000m depth contour), including the northward projecting Pennell/Iselin Bank, from Cape Adare, Victoria Land (71° 17’S, 170° 14’E), to Cape Colbeck, Marie Byrd Land (77° 07’S, 157° 54’W) (from Ainley 2010).	NA - Entire Ross Sea	1969 - 2009	√	Cited from previously-published sources	
Ross Sea Region (2001)	State of the Ross Sea Region - Marine Environment Ross Sea Region. A State of the Environment Report for the Ross Sea Region of Antarctica., Waterhouse, Emma J. (Hrsg.): New Zealand Antarctic Insitute, 2001	1,000 km wide and extending to 78° S	NA - Entire Ross Sea		√	Cited from previously-published sources	
Distribution of Weddell Seal (1968)	Distribution and Abundance of the Weddell Seal in the Western Ross Sea, Antarctica (Ian Stirling, 1968)	western Ross Sea between Cape Adare and McMurdo Sound	300+ N.M. east of study area	1967-1968	√	Observed from icebreakers and helicopters	

Ross Sea Marine Mammals Sightings Data Sources

Reference (Ross Sea Sightings Data Summary)	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area [i.e., 76°S to 78° S; 165°W to 170°W]	Observation Period	Numerical Counts (used to estimate density)	Methodology	Comments
APIS Report (2000)	The International Antarctic Pack Ice Seals (APIS) Program Multi-disciplinary Research into the Ecology and Behavior of Antarctic Pack Ice Seals Summary Update by The Expert Group on Seals (EGS) Scientific Committee on Antarctic Research (SCAR) Marthan N. Bester, D.Sc., Chief Officer Brent S. Stewart, Ph.D., J.D., Secretary 20 October 2006	18,576 km of pack ice habitat	Could not be determined	45 science days between 20 December and 10 February, 2000	√	Observed from air (helicopter)	
Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Trophic interactions within the Ross Sea continental shelf ecosystem (Walker O. Smith Jr, David G. Ainley and Riccardo Cattaneo-Vietti, 2006).	187,000 km^2	NA - Ross Sea continental shelf	1969 - 1985	√	Cited from previously-published sources	

NA = Not Applicable
NS = Not Specified

Ross Sea Marine Mammals Sightings Data Sources

Reference	Marine Ornithology (Ainley, 2002)	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Occurrence of killer whales (Lauriano et al. 2011)	Humpback Abundance (Branch, T.A. n.d.)	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Exploitation (Ainley 2009)	CCAMLR 2007	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Minke Abundance (Matsuoka, Hakamada, et al, undated)	Interactions (Naganobu, Nishiwaki, et al, undated)	CWR (2013)	Seals: Trophic modelling (Pinkerton, Bradford-Grieve, undated.)	Distribution, density and abundance (Bengtson, J.L. et al. 2011)	Ross Sea Region (2001)	Distribution of Weddell Seal (1968)	APIS Report (2000)	Minke Whales (Branch & Butterworth, 2001)	IWC SOWER Report 2002-2003	Navy Marine Species Density Database (NMSDD) [Note 1]
Observation period	1970s-Early 1980s	(not specified)	5 January - 2 February 2004	1978/79-1983/84, 1985/86-1990/91, 1991/92-2003/04	1970 - 2004 (depending on species and data source)	Population estimates from Ainley, 1985	1969 - 2009	1969 - 1985	2006 - 2009	2004 - 2005	(not specified)	Seal abundance is estimated from the data of Ainley (1985)	26 Dec. 1999 - 24 March 2000	(not specified)	1967-1968	45 science days between 20 December and 10 February, 2000	Various cruises between 1978 -1998	December 2002 - March 2003	various
Numerical counts reported	√	√			√	√	√	√	√	√	√	√	√				√	√	
Cetaceans																			
Mysticetes																			
Blue whale		X																X	X
Fin whale					X													X	X
Humpback whale				X	X													X	X
Minke whale	X	X	X		X	X	X	X	X	X							X	X	X
Sei whale					X														X
Southern right whale																			
Unidentified large baleen whale																		X	
Unidentified large whale																		X	
Unidentified small whale																		X	
Unidentified whale																		X	
Odontocetes																			
Arnoux's beaked whale		X	X		X														X
Grays beaked whale																			Note 2
Hourglass dolphin																		X	
Killer whale	X	X	X		X	X	X	X			X							X	X
Layard's beaked whale																		X	X
Long-finned pilot whale																		X	X
Peale's dolphin																			
Shepards beaked whale																			Note 2
Southern right whale dolphin																			Note 2
Southern bottlenose whale					X													X	X
Spectacled porpoise																			
Sperm whale					X													X	X
Unidentified large whale																		X	
Unidentified small whale																		X	
Unidentified whale																		X	
Pinnipeds																			
Antarctic Fur Seal																			
Crabeater	X	X				X	X	X				X	X	X		X			
Leopard	X	X				X	X	X					X	X		X			
Ross		X				X	X	X				X	X	X		X			
Weddell	X	X				X	X	X				X	X	X	X	X			
Elephant		X				X		X				X							

Notes:

[1] NMSDD presents density data and maps, by season, for species in the Southern Ocean between 100°W and 80°E. Density values from the Weddell and Amundsen Seas (between 40° W and 100° W) will be extrapolated for the Ross Sea (between 170° E and 150°W).

[2] NMSDD density data is available for this species for the Southern Ocean between 100° W and 80° E; however, this species has not been observed in the Ross Sea region in the other references and therefore the NMSDD data will not be used.

Cetaceans Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported)	Estimated Linear Density (#/km)	Half Strip-width (km) Note 6	Visual Transect Width (km) Note 7	Areal Density (#/ km^2) Note 8	Data Source	Year/Season/Area/Comments
Mysticetes											
Blue whale	466,100	NA	30	30	NA Note 2	NA	NA	NA	0.0000644	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
		8,905	24	58	290	0.0326	2.50	5.00	0.0065132	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0000510	NMSDD Note 9	Annual, maximum range south of 70° S
Fin whale	300,000	NA	200	200	NA Note 2	NA	NA	NA	0.0006667	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Estimates that fin whales only enter the Ross Sea 2 months out of the year; prefer ice edge habitats, particularly along the continental shelf.
		8,905	238	273	1,365	0.1533	2.50	5.00	0.0306570	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0011030	NMSDD Note 9	Winter, maximum range south of 70° S
Humpback whale	300,000	NA	150	150	NA Note 2	NA	NA	NA	0.0005000	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Estimated that less that 5% of Southern Ocean population spends any time in the Ross Sea; assumes that humpbacks are present in the Ross Sea for only 2 months per year.
		8,905	277	286	1,430	0.1606	2.50	5.00	0.0321169	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0000780	NMSDD Note 9	Winter, maximum range south of 70° S
	598,000	NA	14,300	14,300	NA Note 3	NA	NA	NA	0.0239130	Marine Ornithology (Ainley 2002)	Population estimates from surveys conducted during the 1970s and early 1980s.
	300,000	NA	4,766	4,766	NA Note 3	NA	NA	NA	0.0158867	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Assumes that minke whales are present in the Ross Sea for 3 months per year (Dec.-Feb.). Tend to be concentrated in the north and west Ross Sea. Article estimates areal density at **0.02-0.05/km2** in "Ross Sea model area [not defined in article]".
	466,100	NA	21,000	21,000	NA Note 3	NA	NA	NA	0.0450547	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	300,000	NA	14,280	14,280	NA Note 2	NA	NA	NA	0.0476000	Exploitation (Ainley 2009)	Summary of population estimates of marine mammals in the Ross Sea made on the basis of several cruises during the late 1970s-early 1980s (Ainley 1985).
	300,000	NA	21,000	21,000	NA Note 2	NA	NA	NA	0.0700000	CCAMLR 2007	The Ross Sea, about the size of southern Europe, is defined as the waters overlying the continental shelf and slope (3000m depth contour), including the northward projecting Pennell/Iselin Bank, from Cape Adare, Victoria Land (71° 17'S, 170° 14'E), to Cape Colbeck, Marie Byrd Land (77° 07'S, 157° 54'W) (from Ainley 2010). Population estimate from (T. Branch in Ainley 2010; Ainley 1985).
	187,000	NA	14,000	14,000	NA Note 2	NA	NA	NA	0.0748663	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	
	300,000	NA	19,400	19,400	NA Note 4	NA	NA	NA	0.0646667	Minke Abundance (Matsuoka, Hakamada, et al, undated)	Area of study was Ross Sea south of 69° S. Counts made during 2006/2007 season (high concentration of sea ice).
	300,000	NA	87,643	87,643	NA Note 4	NA	NA	NA	0.2921433	Minke Abundance (Matsuoka, Hakamada, et al, undated)	Area of study was Ross Sea south of 69° S. Counts made during 2008/2009 season (lower concentration of sea ice).

Cetaceans Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported)	Estimated Linear Density (#/km)	Half Strip-width (km) Note 6	Visual Transect Width (km) Note 7	Areal Density (#/ km^2) Note 8	Data Source	Year/Season/Area/Comments
Minke whale	NA	18,712	3,045	3,045	NA Note 5	0.1627	2.50	5.00	0.0325460	Interactions (Naganobu, Nishiwaki, et al, undated)	Survey area consisted of the western part of IWC Area VI (Area VIW, 170° W-145° W) and the entire Area V (130° E-170° W) in the area between south of 60° S and the ice edge line.
	714,818								0.8605604	Minke Whales (Branch & Butterworth, 2001) closing mode data	1980-1981. IWC Area V, EN strata
	339,162								1.4752464		1980-1981. IWC Area V, ES strata
	117,319								2.3687732		1980-1981. IWC Area V, WS strata
	339,162								1.2719536		1980-1981. IWC Area V, ES strata
	477,982								0.4993036		1980-1981. IWC Area V, WN strata
	960,184								0.6668828	Minke Whales (Branch & Butterworth, 2001) closing mode data	1985-1986. IWC Area V, EN strata
	359,931								0.5655798		1985-1986. IWC Area V, WS strata
	569,742								0.9982638		1985-1986. IWC Area V, EM strata
	571,242								0.5576816		1985-1986. IWC Area V, WM strata
	369,900								2.1538048		1985-1986. IWC Area V, ES strata
	477,549								0.3650342		1985-1986. IWC Area V, WN strata
	568,083								1.5775796	Minke Whales (Branch & Butterworth, 2001) closing mode data	1991-1992. IWC Area V, EN strata
	201,380								0.3787702		1991-1992. IWC Area V, WS strata
	281,722								0.4340576		1991-1992. IWC Area V, ES strata
	472,979								0.0501364		1991-1992. IWC Area V, WN strata
	960,184								0.6133124	Minke Whales (Branch & Butterworth, 2001) IO mode data	1985-1986. IWC Area V, EN strata
	359,931								1.2413910		1985-1986. IWC Area V, WS strata
	569,742								0.9093232		1985-1986. IWC Area V, EM strata
	571,242								0.7963446		1985-1986. IWC Area V, WM strata
	369,900								3.2386054		1985-1986. IWC Area V, ES strata
	477,549								1.2166662		1985-1986. IWC Area V, WN strata
	568,083								1.0714080	Minke Whales (Branch & Butterworth, 2001) IO mode data	1991-1992. IWC Area V, EN strata
	201,380								1.4460574		1991-1992. IWC Area V, WS strata
	281,722								0.4618730		1991-1992. IWC Area V, ES strata
	472,979								0.1328958		1991-1992. IWC Area V, WN strata
		8,905	753	753	3,765	0.4228	2.50	5.00	0.0845595	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.1301790	NMSDD Note 9	Winter, maximum range south of 70° S
Sei whale	300,000	NA	100	100	NA Note 3	NA	NA	NA	0.0003333	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Assume that only a very small minority of the Southern Ocean population of sei whales spends any time in the Ross Sea due to their preference for open-ocean temperate waters. Estimate is for presence of sei whales in Ross Sea for 2 months out of the year, which may still be an overestimate.
									0.0046340	NMSDD Note 9	Winter, maximum range south of 70° S
Odontocetes											
Arnoux's beaked whale	300,000	NA	50	50	NA Note 3	NA	NA	NA	0.0001667	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Assuming the total population of Arnoux's beaked whales is 10,000 and that these are widely distributed through the Southern Ocean (0.5% in Ross Sea), suggests a Ross Sea population of 50 animals. It is not known if this is reasonable. We assume that these whales are present in the Ross Sea for 3 months of the year.

Cetaceans Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported)	Estimated Linear Density (#/km)	Half Strip-width (km) Note 6	Visual Transect Width (km) Note 7	Areal Density (#/ km^2) Note 8	Data Source	Year/Season/Area/Comments
	466,100	NA	150	150	NA Note 3	NA	NA	NA	0.0003218	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
									0.0134420	NMSDD Note 9	Winter, maximum range south of 70° S
Hourglass dolphin		8,905	158	169	845	0.0949	2.50	5.00	0.0189782	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
Killer whale	300,000	NA	3,500	3,500	NA Note 2	NA	NA	NA	0.0116667	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	**Population figure given does not distinguish between Type B & Type C**. Type C orca occur over the continental shelf and within the pack ice edge in the Ross Sea (Ainley 1985). Their occurrence in the Ross Sea was associated with the vicinity of the ice edge in the western Ross Sea near Ross Island (Ainley 1985; Andrews et al. 2008). We assume that Ross Sea orca ore mainly Type C and remain in the study are for the summer only (3 months of the year).
	466,100	NA	3,350	3,350	NA Note 3	NA	NA	NA	0.0071873	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	598,000	NA	3,500	3,500	NA Note 2	NA	NA	NA	0.0058528	Marine Ornithology (Ainley 2002)	Population figure does not differentiate between orca types.
	300,000	NA	3,440	3,440	NA Note 2	NA	NA	NA	0.0114667	Exploitation (Ainley 2009)	Population figure does not differentiate between orca types.
	300,000	NA	3,000	3,000	NA Note 2	NA	NA	NA	0.0100000	CCAMLR 2007	Most of the killer whales are the “Ross Sea” resident fish-eating type [Type C]; there are perhaps just a few dozen type-Bs, the apex predator in this system, although type-As (minke whale predator) could occur along the slope. **R**atio of Type-C to Type-B over ths shelf is about 50:1.
	300,000	NA	25,000	25,000	NA Note 2	NA	NA	NA	0.0833333	CWR (2013)	Estimates range as high as 27,000 individuals (in Antarctic). Does not differentiate between orca types.
	187,000	NA	7,500	7,500	NA Note 2	NA	NA	NA	0.0401070	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Does not distinguish orca type.
		8,905	186	186	930	0.1044	2.50	5.00	0.0208872	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0154510	NMSDD Note 9	Winter, maximum range south of 70° S
Layard's beaked whale		8,905	3	40	200	0.0225	2.50	5.00	0.0044919	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0014430	NMSDD Note 9	Winter, maximum range south of 70° S
Long-finned pilot whale		8,905	226	356	1,780	0.1999	2.50	5.00	0.0399777	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0078590	NMSDD Note 9	Winter, maximum range south of 70° S
Southern bottlenose whale	300,000	NA	500	500	NA Note 2	NA	NA	NA	0.0016667	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Estimate revised downward from Branch & Butterworth 2001a and Kasamatsu & Joyce 1995. Assume that southern bottlenose whales are present in the Ross Sea for 3 months of the year.
		8,905	84	105	525	0.0590	2.50	5.00	0.0117912	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0135650	NMSDD Note 9	Winter, maximum range south of 70° S
Sperm whale	300,000	NA	800	800	NA Note 2	NA	NA	NA	0.0026667	Whales: Trophic Modeling (Pinkerton, Bradford-Grieve, Sagar, undated)	Any occurrence of sperm whales in the Ross Sea is likely to be along the shelf edge. Ross Sea population estimate is subject to considerable uncertainty.

Cetaceans Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported)	Estimated Linear Density (#/km)	Half Strip-width (km) Note 6	Visual Transect Width (km) Note 7	Areal Density (#/ km^2) Note 8	Data Source	Year/Season/Area/Comments
Sperm whale		8,905	88	88	440	0.0494	2.50	5.00	0.0098821	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V
									0.0015600	NMSDD Note 9	Winter, maximum range south of 70° S

Notes:

NA = Not Available

1. Where the area surveyed was not indicated in the reference document, a value of 300,000 km^2 was used, estimate of Ross Sea area from Google Earth.
2. Assume reported number of animals has been corrected in the reference.
3. Assume reported number of animals has been corrected based on the methodology described in the cited source.
4. Sighting data from JARPA II; assume the reported number of animals has been corrected.
5. Population number as provided in cited source based on research of the authors; however, methodology not explained in article, so number provided is likely a corrected figure.
6. Distances not reported in reference; assumes 2.5 km half strip-width on each side of the vessel.
7. Visual transect width = half strip-width x 2, representing the total width of observations.
8. Estimated areal density [# animals/area surveyed (km2)] is provided either based on reported numbers in the reference or calculated based on the estimated linear density (#/km) x 1/visual transect width (km).
9. Maximum density values for the Weddell and Amundsen Seas (between 40° W and 100° W); extrapolated for use in the Ross Sea (between 170° E and 150 °W)

Cetacean Densities in the Ross Sea

Common Name	Area Surveyed (km^2)	Area Surveyed (km, linear survey)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported) [Note 1]	Estimated Linear Density (#/km)	Half Strip-Width (km) [Note 2]	Visual Transect Width (km) [Note 3]	Areal Density (#/ km^2)	Data Source	Year/Season/Area	Comments
Mysticetes												
Blue whale		8,905	24	58	290	0.0326	2.50	5.00	0.0065132	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Fin whale		8,905	238	273	1,365	0.1533	2.50	5.00	0.0306570	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Humpback whale		8,905	277	286	1,430	0.1606	2.50	5.00	0.0321169	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Minke whale		8,905	753	753	3,765	0.4228	2.50	5.00	0.0845595	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Sei whale									0.0046340	NMSDD [Note 4]	Winter, maximum range south of 70° S	
Odontocetes												
Arnoux's beaked whale									0.0134420	NMSDD [Note 4]	Winter, maximum range south of 70° S	
Hourglass dolphin		8,905	158	169	845	0.0949	2.50	5.00	0.0189782	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Killer whale		8,905	186	186	930	0.1044	2.50	5.00	0.0208872	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Layard's beaked whale		8,905	3	40	200	0.0225	2.50	5.00	0.0044919	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Long-finned pilot whale		8,905	226	356	1,780	0.1999	2.50	5.00	0.0399777	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Southern bottlenose whale		8,905	84	105	525	0.0590	2.50	5.00	0.0117912	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	
Sperm whale		8,905	88	88	440	0.0494	2.50	5.00	0.0098821	IWC SOWER Report 2002-2003 (Table 2a)	2002-03 austral summer. Eastern portion of IWC Area V	

Notes:

[1] Sightings data accounts for all individuals observed in groups; corrected sightings assumes only 20% of animals present were observed and reported.

[2] Assumes 2.5 km half strip-width on each side of the vessel.

[3] Visual transect width = half strip-width x 2, representing the total width of observations.

[4] Maximum density values for the Weddell and Amundsen Seas (between 40° W and 100° W); extrapolated for use in the Ross Sea (between 170° E and 150 °W)

Pinnipeds Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Correction Factor	Estimated # in the Water	Estimated Linear Density (#/km)	Half Strip-width (km) Note 2	Visual Transect Width (km) Note 3	Estimated Areal Density (#/ km^2) Note 4	Data Source	Year/Season/Area/Comments
Crabeater	598,000	NA	205,000	NA	NA	NA	NA	NA	0.34281	Marine Ornithology (Ainley 2002)	Population estimates from 1970s and early 1980s (cf. Stirling 1969; Gilbery & Erickson, 1977; Ainley 1985)
	300,000	NA	204,000	NA	NA	NA	NA	NA	0.68000	Seals: Trophic modelling (Pinkerton, Bradford-Grieve, undated)	Reside in the study area for about 3 months of the year over the summer.
	466,100	NA	204,000	NA	NA	NA	NA	NA	0.43767	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	300,000	NA	203,700	NA	NA	NA	NA	NA	0.67900	Exploitation (Ainley 2009)	Population estimates based on several cruises during the late 1970s to early 1980s.
	300,000	NA	204,000	NA	NA	NA	NA	NA	0.68000	CCAMLR 2007	Surveys made during 1976-1979 (Ainley 1985).
	187,000	NA	200,000	NA	NA	NA	NA	NA	1.06952	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Species breeds and probably occur in the Ross Sea region, if not the Ross Sea itself, continuously throughout the year. The remaining seals [other than the Weddell] are denizens of the pack ice, especially along the shelf break and the ice margins of the Ross Sea polynya (Ainley 1985; Ainley et al. 2003b).
	NA	18,576	4,817	NA	NA	0.25931	NA	NA	0.75 near shelf and slope	APIS Report (2000)	Area surveyed is linear distance (18,756 km). **From report:** Density was highest in the vicinity of the shelf and slope (0.75 crabeater seals per square kilometer) and it decreased exponentially as we proceeded north over deeper water (0.22 and 0.24 seals per square kilometer in the mid-pack and northern ice edge, respectively). Surveyed 18,576 km
									0.22 in mid-pack; 0.24 at northern ice edge	APIS Report (2000)	
	53,217	27,365	8,825	NA	98	0.32249	NA	NA	0.16583	Distribution, density and abundance (Bengtson, J.L. et al. 2011)	26 Dec. 1999 - 24 March 2000
	300,000	NA	204,000	NA	NA	NA	NA	NA	0.68000	Ross Sea Region (2001)	Although regularly seen in McMurdo Sound, they are more common in the northern regions of the Ross Sea, concentrated in the pack ice over the Antarctic Slope Front. [No primary source cited for population estimate.]
Leopard	187,000	NA	8,000	NA	NA	NA	NA	NA	0.04278	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Species breeds and probably occur in the Ross Sea region, if not the Ross Sea itself, continuously throughout the year.
	466,100	NA	8,000	NA	NA	NA	NA	NA	0.01716	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	598,000	NA	8,000	NA	NA	NA	NA	NA	0.01338	Marine Ornithology (Ainley 2002)	Population estimates from 1970s and early 1980s (cf. Stirling 1969; Gilbery & Erickson, 1977; Ainley 1985)
	300,000	NA	7,990	NA	NA	NA	NA	NA	0.02663	Exploitation (Ainley 2009)	Population estimates based on several cruises during the late 1970s to early 1980s.
	300,000	NA	8,000	NA	NA	NA	NA	NA	0.02667	CCAMLR 2007	Surveys made during 1976-1979 (Ainley 1985).
		18,576	33	NA	NA	0.00178	0.40	0.80	0.0022206	APIS Report (2000)	Surveyed 18,576 km of pack ice from air (helicopter)
	53,217	27,365	10	NA	10	0.00037	NA	NA	0.0001879	Distribution, density and abundance (Bengtson, J.L. et al. 2011)	26 Dec. 1999 - 24 March 2000

Pinnipeds Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Correction Factor	Estimated # in the Water	Estimated Linear Density (#/km)	Half Strip-width (km) Note 2	Visual Transect Width (km) Note 3	Estimated Areal Density (#/ km^2) Note 4	Data Source	Year/Season/Area/Comments
	300,000	NA	8,000	NA	NA	NA	NA	NA	0.02667	Ross Sea Region (2001)	Individual leopard seals are often seen in summer...off the Adélie penguin rookeries of Ross Island. [No primary source cited.]
Ross	300,000	NA	5,000	NA	NA	NA	NA	NA	0.01667	Seals: Trophic modelling (Pinkerton, Bradford-Grieve, undated)	Ross seals have a circumpolar distribution and are usually found in dense consolidated pack ice, but can also be found on smooth ice floes in more open areas. Ainley (1985) concluded that Ross seals are irregularly distributed with high concentrations in localised areas, and that the Ross Sea is apparently not an area where this species concentrates. [Population estimate from (Ainley 1985).]
	466,100	NA	500	NA	NA	NA	NA	NA	0.00107	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	300,000	NA	5,050	NA	NA	NA	NA	NA	0.01683	Exploitation (Ainley 2009)	Population estimates based on several cruises during the late 1970s to early 1980s.
	300,000	NA	5,000	NA	NA	NA	NA	NA	0.01667	CCAMLR 2007	Surveys made during 1976-1979 (Ainley 1985).
	187,000	NA	5,000	NA	NA	NA	NA	NA	0.02674	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Species breeds and probably occur in the Ross Sea region, if not the Ross Sea itself, continuously throughout the year. The remaining seals [other than the Weddell] are denizens of the pack ice, especially along the shelf break and the ice margins of the Ross Sea polynya (Ainley 1985; Ainley et al. 2003b).
	53,217	27,365	10	NA	10	0.0003654	NA	NA	0.00019	Distribution, density and abundance (Bengtson, J.L. et al. 2011)	26 Dec. 1999 - 24 March 2000
	NA	18,576	79	NA	NA	0.00425	0.40	0.80	0.0053160	APIS Report (2000)	Surveyed 18,576 km of pack ice from air (helicopter)
	300,000	NA	5,000	NA	NA	NA	NA	NA	0.01667	Ross Sea Region	A seal of pack ice and open waters and seems to prefer dense consolidated pack ice rather than the open pack frequented by crabeaters. [No primary source cited.]
	598,000	NA	32,000	NA	NA	NA	NA	NA	0.05351	Marine Ornithology (Ainley 2002)	Population estimates from 1970s and early 1980s (cf. Stirling 1969; Gilbery & Erickson, 1977; Ainley 1985)
	300,000	NA	32,000	NA	NA	NA	NA	NA	0.10667	Seals: Trophic modelling (Pinkerton, Bradford-Grieve, undated)	May range as high as 50,000 individuals; reports estimates from Ainley (1985) as **0.054 individuals per km2**, implying 32,000 individuals in Ross Sea area.
	466,100	NA	30,000	NA	NA	NA	NA	NA	0.06436	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Possibly as high as 50,000 individuals. Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	300,000	NA	31,990	NA	NA	NA	NA	NA	0.10663	Exploitation (Ainley 2009)	Population estimates based on several cruises during the late 1970s to early 1980s.

Pinnipeds Observed and Estimated Densities in the Ross Sea

Common Name	Area Surveyed (km^2) Note 1	Area Surveyed (km, linear survey)	Animals (#)	Correction Factor	Estimated # in the Water	Estimated Linear Density (#/km)	Half Strip-width (km) Note 2	Visual Transect Width (km) Note 3	Estimated Areal Density (#/ km^2) Note 4	Data Source	Year/Season/Area/Comments
Weddell	300,000	NA	30,000	NA	NA	NA	NA	NA	0.10000	CCAMLR 2007	The Weddell is the only seal species that can be considered a permanent resident of the Ross Sea. It occupies the fast ice areas for pupping and breeding activities. These seals move out into waters overlying the Ross Sea shelf after the breeding season, as do the juveniles produced. [Surveys made during 1976-1979 (Ainley 1985).]
	187,000	NA	32,000	NA	NA	NA	NA	NA	0.17112	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	**Estimates may be as high as 50,000.** Species breeds and probably occur in the Ross Sea region, if not the Ross Sea itself, continuously throughout the year. The Weddell seal occurs in areas of fast ice, such as McMurdo Sound, which supports the highest concentrations of this species in the world.
		18,576	2,852	NA	NA	0.15353	0.40	0.80	0.1919143	APIS Report (2000)	Surveyed 18,576 km of pack ice from air (helicopter)
	300,000	NA	32,000	NA	NA	NA	NA	NA	0.10667	Ross Sea Region (2001)	The Weddell seal is the most commonly encountered seal in the Ross Sea. [Counts from Ainley, 1985]
	53,217	27,365	2,270	NA	NA	0.0830	NA	NA	0.04266	Distribution, density and abundance (Bengtson, J.L. et al. 2011)	26 Dec. 1999 - 24 March 2000
	14,804	NA	19,097	NA	NA	0.43	NA	NA	1.28999	Distribution of Weddell Seal (1968)	Western Ross Sea between Cape Adare and McMurdo Sound: 77 Weddell seals observed over 178 nm in 1967; 45 observed over 106 nm
	11,064	NA	14,969	NA	NA	0.43	NA	NA	1.35295		
Elephant	300,000	NA	40	NA	NA	NA	NA	NA	0.00013	Seals: Trophic modelling (Pinkerton, Bradford-Grieve n.d.)	Enters the Ross Sea only in the summer from breeding and feeding grounds further to the north. The southern elephant seal is consequently the least common seal in the Ross Sea. Estimates from (Brownell & Ainley 1976; Ainley 1985).
	300,000	NA	40	NA	NA	NA	NA	NA	0.00013	Exploitation (Ainley 2009)	Population estimates based on several cruises during the late 1970s to early 1980s.
	466,100	NA	100	NA	NA	NA	NA	NA	0.00021	Sea of Change (Smith Jr., Sedwick, Arrigo, Ainley, Orsi 2012)	Area equated with size of "Ross Sea Continental Shelf." (Population estimates from Ballard et al. [2011])
	187,000	NA	100	NA	NA	NA	NA	NA	0.00053	Trophic Interactions (Smith Jr, Ainley, Cattaneo-Vietti 2006)	Text states "less than 100" of this species.

Notes:

NA = Not Available

1. Where the area surveyed was not indicated in the reference document, a value of 300,000 km^2 was used, estimate of Ross Sea area from Google Earth.
2. Distances not reported in reference; estimated assuming 400 m half strip-width on each side of the vessel.
3. Visual transect width = half strip-width x 2, representing the total width of observations.
4. Estimated areal density [# animals/area surveyed (km2)] is provided either based on reported numbers in the reference or calculated based on the estimated linear density (#/km) x 1/visual transect width (km).

Pinniped Densities in the Ross Sea

Common Name	Area Surveyed (km)	Animals (#)	Animals (# including unidentified)	Correction Factor [Note 1]	Estimated # in the Water [Note 2]	Estimated Linear Density (#/km)	Half Strip-Width (km) [Note 3]	Visual Transect Width (km) [Note 4]	Areal Density (#/ km^2)	Data Source	Year/Season/Area	Comments
Crabeater	300,000	NA	204,000	NA	NA	NA	NA	NA	0.6800000	Ross Sea Region (2001)	More common in the northern regions o	No primary source cited for population estimate.
Leopard	300,000	NA	8,000	NA	NA	NA	NA	NA	0.0266700	Ross Sea Region (2001)	Individual leopard seals are often seen ir	No primary source cited for population estimate.
Ross	300,000	NA	5,000	NA	NA	NA	NA	NA	0.0166700	Ross Sea Region (2001)	A seal of pack ice and open waters and s	No primary source cited for population estimate.
Weddell	300,000	NA	32,000	NA	NA	NA	NA	NA	0.1066700	Ross Sea Region (2001)	The Weddell seal is the most commonly	Counts from Ainley, 1985]
Elephant	300,000	NA	40	NA	NA	NA	NA	NA	0.0001300	Seals: Trophic modelling (Pinkerton, Bradford-Grieve n.d.)	Enters the Ross Sea only in the summer	Estimates from Brownell & Ainley 1976; Ainley 1985.

Notes:

[1] Correction factor for pinnipeds recommended by NOAA; accounts for animals that may be in the water but were not sighted and reported.

[2] Number of animals x correction factor.

[3] Assumes 400 m half strip-width on each side of the vessel.

[4] Visual Transect Width = visual range x 2, representing the total width of observations.

Projected Number of Cetacean and Pinniped Takes in the Proposed Study Area

Common Name	Areal Density (#/ km^2)	Estimated Level B Harassment Takes (#) [Note 1]
Mysticetes		
Blue whale	0.0065132	23
Fin whale	0.0306570	108
Humpback whale	0.0321169	113
Minke whale	0.0845595	297
Sei whale	0.0046340	16
Odontocetes		
Arnoux's beaked whale	0.0134420	47
Hourglass dolphin	0.0189782	67
Killer whale	0.0208872	73
Layard's beaked whale	0.0044919	16
Long-finned pilot whale	0.0399777	141
Southern bottlenose whale	0.0117912	41
Sperm whale	0.0098821	35
Pinnipeds		
Crabeater	0.6800000	2,392
Elephant	0.0001300	1
Leopard	0.0266700	94
Ross	0.0166700	59
Weddell	0.1066700	375

Notes:

[1] Calculated take for all animals estimated by using areal density multiplied by the (3,518 km2) area ensonified to 160 dB (rms) around the planned seismic lines. (1,005 m x 2 x 1750 km)

Projected Number of Cetacean and Pinniped Takes during Potential Icebreaking Activities

Common Name	Areal Density (#/ km^2)	Estimated Level B Harassment Takes (#) [Note 1]
Mysticetes		
Blue whale	0.0065132	140
Fin whale	0.0306570	660
Humpback whale	0.0321169	692
Minke whale	0.0845595	1,821
Sei whale	0.0046340	100
Odontocetes		
Arnoux's beaked whale	0.0134420	290
Hourglass dolphin	0.0189782	409
Killer whale	0.0208872	450
Layard's beaked whale	0.0044919	97
Long-finned pilot whale	0.0399777	861
Southern bottlenose whale	0.0117912	254
Sperm whale	0.0098821	213
Pinnipeds		
Crabeater	0.6800000	14,647
Elephant	0.0001300	3
Leopard	0.0266700	574
Ross	0.0166700	359
Weddell	0.1066700	2,298

Notes:

[1] Calculated take for all animals estimated by using areal density multiplied by the 21,540 km^2 area ensonified to 120 dB (rms) around the estimated icebreaking tracklines. (21.54 km x 2 x 500 km)