National Science Foundation
Division of Polar Programs
Arlington, Virginia

DRAFT ENVIRONMENTAL DOCUMENT CONCURRENCE

Activity:
Study of the Totten Glacier System and Marine Record of Cryosphere – Ocean Dynamics
[PGAN1401.IEE]

I have read the attached document and concur with the findings and recommendation. I concur that the proposed activity can commence.

Proposals Covered, Collaborative Research: Totten Glacier System and the Marine Record of Cryosphere – Ocean Dynamics: Leventer **1143836**; Domack **1143837**; Huber **1143834;** Orsi **1143833;** Blankenship/Gulick **1143843**

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Dr. Polly Penhale Date
Senior Advisor, Environment

National Science Foundation
Division of Polar Programs
Arlington, Virginia

DRAFT ENVIRONMENTAL DOCUMENT AND FINDING OF NO SIGNIFICANT AND NOT MORE THAN MINOR OR TRANSITORY ENVIRONMENTAL IMPACT

Study of the Totten Glacier System and Marine Record of Cryosphere – Ocean Dynamics
NSF Tracking Number **[PGAN1401.IEE]**

FINDING

The National Science Foundation (NSF) has prepared an Initial Environmental Evaluation (IEE)/Environmental Assessment (EA) to conduct marine-based studies of the Totten Glacier system. Three Alternatives were evaluated:

Alternative A: Perform Geophysical and Oceanographic Survey of the Totten Glacier System in the Sabrina Coast, East Antarctica beginning in February 2014 with an Incidental Harassment Authorization

Alternative B: Perform Geophysical and Oceanographic Survey of the Totten Glacier System in the Sabrina Coast, East Antarctica at an alternate time with an Incidental Harassment Authorization

Alternative C: No Action and no Incidental Harassment Authorization

Based on the analyses in the environmental document (IEE/EA), I believe that implementation of Alternative (A) is the preferred alternative and is not a major federal action that would have a significant effect on the human environment, within the meaning of the National Environmental Policy Act (NEPA) of 1969, whose standards are expressly incorporated in section 2403a of the Antarctic Conservation Act of 1978, as amended, as specified therein. The proposed action involves marine-based activities onboard the R/V Nathaniel B. Palmer occurring in February through March 2014 and includes the use of a low-energy acoustic source for seismic surveying over a 2,800 km track, operation of transducer-based instruments (e.g., ADCP, sonar), collection of sediment core, grab, and rock samples from the seafloor, and measurement of various water quality parameters. Likewise, the action is also not one that would have more than a minor or transitory effect on the Antarctic environment, within the meaning of the Antarctic Conservation Act of 1978, as amended, and the Protocol on Environmental Protection to the Antarctic Treaty (1991). Therefore, a comprehensive environmental evaluation would not be prepared.

The time frame for Alternative A was chosen because this is the time of year with the most favorable weather conditions. Icy conditions prevent deploying the research gear or could entirely block access to the research site. A second alternative (Alternative B) was considered. This alternative would defer project initiation to late April or May 2014. In general, potentially affected species would be less common in the area as they would have started migrations to northern latitudes. The detailed elements of the proposed action for Alternative B would be

identical to Alternative A. Environmental conditions (e.g., increased darkness, increased ice coverage, increased ice thickness) would make implementation of Alternative B extremely difficult. These conditions likely would result in some or many of the science activities not being accomplished. The resulting impacts from Alternative B likely would be similar to those described in this environmental document. Because of the potential risks of not meeting science objectives, further analysis of Alternative B beyond the details described herein is not warranted.

I recommend this activity proceed based on the implementation of Alternative A. This alternative provides for the use of field studies to collect data that would determine the dynamics of the Totten Glacier (TG) system and its role in climate change. The research activities are consistent with the NSF efforts to promote scientific investigations while protecting the Antarctic environment.

Recommending Official **Date**	**Recommending Official** **Date**
Scott Borg	Adrian Dahood
Antarctic Sciences Section Head	Environmental Policy Specialist

DRAFT INITIAL ENVIRONMENTAL EVALUATION

National Science Foundation
Division of Polar Programs
Arlington, Virginia

Study of the Totten Glacier System and Marine Record of Cryosphere – Ocean Dynamics [PGAN1401.IEE]

1.0 PURPOSE AND NEED

Overview

In support of the United States Antarctic Program (USAP), the National Science Foundation (NSF) proposes to perform marine-based studies in the Dumont D'Urville Sea, to include evaluation of geophysical and physical oceanographic features in two areas along the coast of East Antarctica (Figure 1). The two areas proposed for study include the Totten Glacier (TG) system (preferred study area), including the Moscow University Ice Shelf (MUIS) along the Sabrina Coast and, in a secondary study area, the Mertz Glacier (MG) and Cook Ice Shelf (CIS) along the George V and Oates Coast and the nearby Frost Glacier (Figures 2 and 3). If the preferred study area (TG system) cannot be accessed due to ice conditions, the secondary area would be studied to support the research goals by providing data that would contribute to the knowledge of the sedimentary record of sub-glacial meltwater outflow. The proposed research activities would include: 1) conducting a seismic survey along 2,800-km of tracklines using a two generator-injector airgun array as a low-energy seismic source and a hydrophone streamer, 2) conducting a bathymetric profile survey of the seafloor using transducer-based instruments such as a multibeam sonar and sub-bottom profiler, 3) conducting imaging surveys using an underwater camera assembly, 4) collecting sediment cores and dredge samples, and 5) collecting water samples and conductivity (salinity), temperature, depth (CTD) and current data through the use of short-term (approximately one month duration) and long-term(approximately one year duration moorings, CTD equipment casts, and the use of transducer-based Acoustic Doppler Current Profiler (ADCP) instruments.

Despite scrutiny of marine-based systems in the West Antarctic Ice Sheet (WAIS), little is known about the inherent dynamics of the TG system and its relationship to the larger East Antarctic Ice Sheet (EAIS). The TG system is of critical importance because it drains one-eighth of the EAIS and contains the volume equivalent of 6.9 m eustatic sea level rise, greater than the entire WAIS. Independent, space-based platforms indicate accelerating mass loss of the TG system.[1]

Recent aerogeophysical surveys of the Aurora Subglacial Basin (ASB), which contains the deepest ice in Antarctica and drains into the TG system, have provided the subglacial context for measured surface changes and show that TG has been the most significant drainage pathway for

[1] References to specific research articles and papers presented in the proposal for this research (NSF Proposal Number 1143836, June 20, 2011 revision) have been omitted in this IEE/EA.

at least two previous ice flow regimes. However, the offshore context is far less understood. While surrounding drainages to the west (Vanderford Glacier) and to the east (Mertz / Ninnis / Astrolabe Glaciers) have complementary oceanographic and marine geologic databases with which to assess cryospheric dynamics, the large unnamed bay to the east of Law Dome, where the floating tongue of the Totten Glacier delivers its significant iceberg load, is unsurveyed (Figure 2). Limited physical oceanographic data indicate the presence of Modified Circumpolar Deep Water (MCDW) within a thick bottom layer but these measurements are close to the continental shelf break, over 100 km northeast of TG's terminus.

The TG glacial system possesses a potentially unsteady dynamic. If it were to melt, sea-level would rise by more than five meters worldwide. Recent measurements show that the Totten Glacier is thinning at up to 1.9 m per year, a three-fold increase over the past 10 years. The direct cause of this alarming statistic is not yet known, but is believed to be ocean driven. The leading hypothesis is that relatively warm water derived from MCDW, is mixed and modified and flows southwards onto the continental shelf, enhancing the melting of the glacier. Recent assessments of ice sheet mass balance suggest that despite the long held paradigm of increasing snowfall with increasing temperature across the EAIS, and even some regional indications of increases in accumulation, there is a strong prevailing trend toward a decreasing mass. The most likely candidate for this mass loss is the rapid drawdown and thinning of TG and its contributories.

Figure 1. Totten Glacier System and Mertz Glacier Study Areas

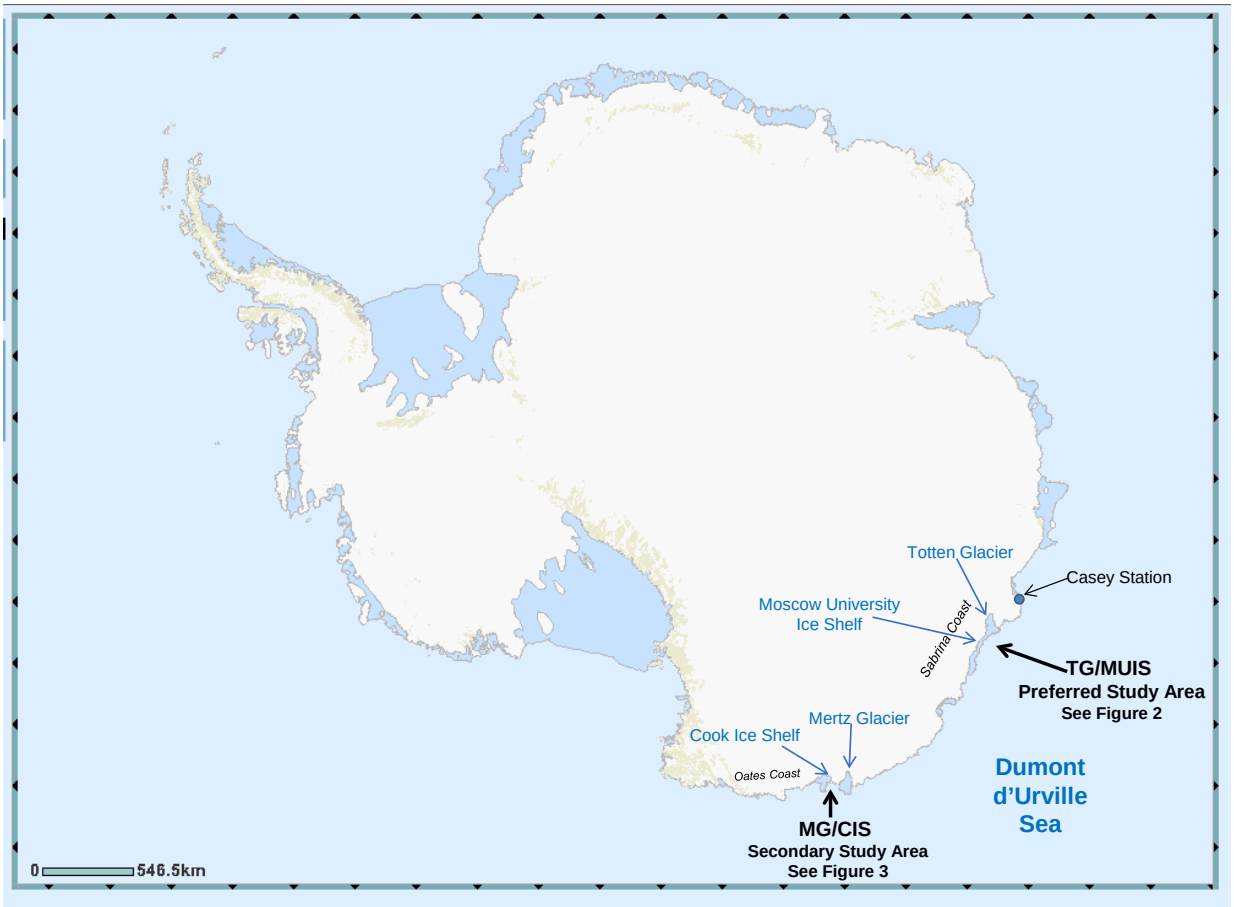


Figure 2. Totten Glacier System Study Area

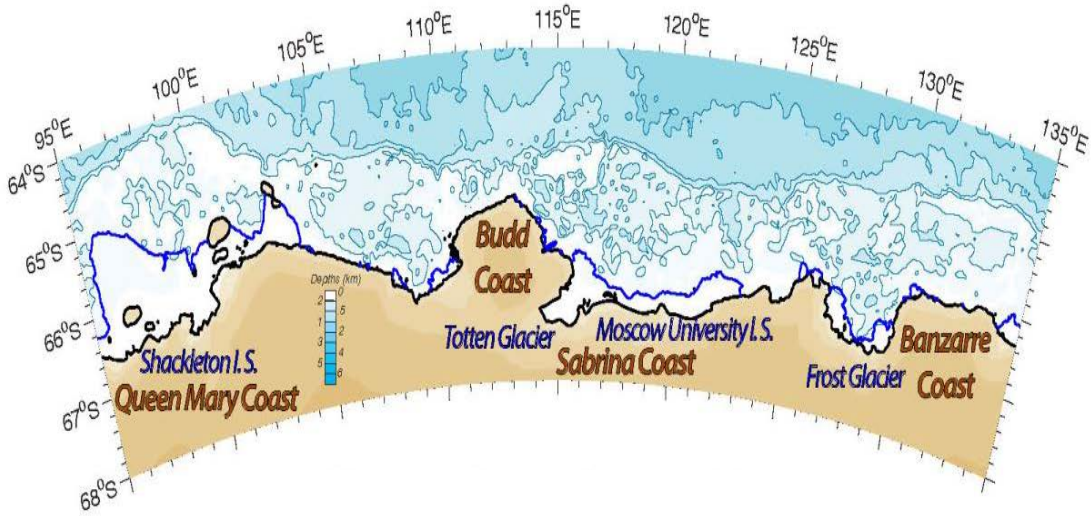
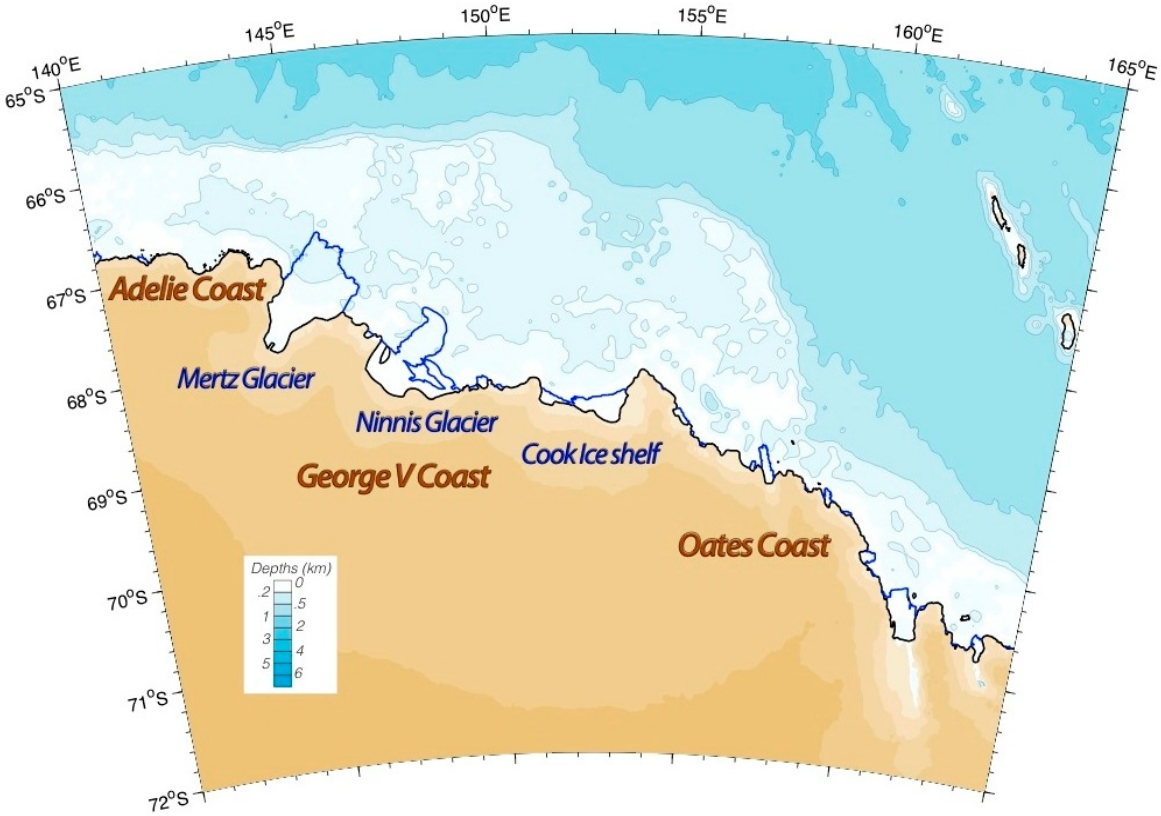


Figure 3. Mertz Glacier Study Area



If the measured MCDW has access to TG through one or more troughs, it is possible that ocean forcing could explain the recently observed mass loss, a process considered to be responsible for the rapid grounding line retreat of Pine Island Glacier in West Antarctica. The overall goal of the proposed research, therefore, is to help to understand both the dynamics and the controls on the TG system, and to resolve ambiguity in large ice mass dynamic behavior.

To achieve research goals and place the modern TG system into a longer-term perspective, the proposed action would (1) evaluate the recent behavior of the glacial system, (2) elucidate the longer term role of the TG as it responded to late Quaternary changes in climate and sea level, and (3) assess the present day physical oceanographic and particulate dynamic processes associated with the TG tongue and the deep basins that surround it. Secondary research targets along the Wilkes Land Margin, including the nearby Mertz Trough, as well as adjacent Frost, George V and Cook Glacier systems, would complement and support the science objectives of the research by providing west-east transit data that would contribute to the knowledge of the sedimentary record of sub-glacial meltwater outflow and the time of ice retreat from the Wilkes Land Margin.

The data resulting from the proposed research activities would allow researchers to interpret the marine geologic, geochemical and geophysical records of the longer term behavior and response of the TG system. The resulting data would complement fieldwork studying other Antarctic ice

shelves, oceanographic studies near the Antarctic Peninsula, 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 coastal Antarctica, and communicate its findings via publications and outreach. Long-term records of currents and oceanographic properties in this region are consistent with the objectives of the Southern Ocean Observing System for climate change. The work would enhance general understanding of air-sea-ice interactions, ocean circulation, ice shelf sensitivity to climate change, and the present and future roles of EAIS in sea level rise.

Additional benefits derived from the marine geochemical research include testing the utility of several paleoceanographic tracers in Antarctic margin sediments. These techniques have yet to be employed in East Antarctic continental margin sediments, but have the potential to significantly advance the paleoclimate community's ability to extract and interpret high-resolution Antarctic paleoclimate records from $CaCO_3$-poor marine sedimentary sequences and make comparisons with globally distributed records. Such studies in the TG region are particularly important due to its proximity to the Law Dome ice core, providing an important opportunity to link atmospheric and oceanic records from a climatically sensitive region.

Present State of Understanding

At present, substantial uncertainty remains on the question of overall mass balance of the Antarctic Ice Sheet. Whereas ice mass loss, principally through calving of the ice sheet at the termini of fast-moving glaciers, moves mass from the ice sheet to the ocean, snowfall on the ice sheet adds mass and helps to mitigate the Antarctic contribution to global sea level rise. The best estimates available for the overall net mass change have large uncertainty and there are significant differences between East Antarctica, West Antarctica and the Antarctic Peninsula (e.g. Hanna et al., 2013; Shepherd et al., 2012). The majority of current ice mass loss takes place in the Amundsen Sea sector of the WAIS and appears related to the glaciers, such as the Pine Island Glacier system, that are grounded below sea level and not subject to buttressing effects of ice shelves. These conditions may cause mass discharge to the ocean to rapidly accelerate, raising concerns about future contributions to sea level rise and thus drawing attention for research work. In contrast, dynamic fluctuations of the larger EAIS have received less attention due to its perceived stability. Although the majority of the EAIS is grounded on bedrock above sea level, key sectors of the EAIS are grounded well below sea level. Thus, the conventional wisdom regarding the stability of the EAIS may be inappropriate.

Assessments of the TG mass balance have been equivocal, due largely to the scarcity of snowfall data across its range, placing the glacier in modest states of growth, stasis, and retreat. The most recent surveys indicate that the TG is retreating, losing mass from its ~ 250 km long central trunk.

Since 1992, a 46,000 km^2 section of the TG trunk (78%) thinned at an average rate of 91 ± 12 mm yr^{-1}, a mass loss of 3.8 ± 0.6 gigatons per year (Gt yr^{-1}). In this 13,000 km^2 region, the median ice speed was 220 m/yr, which provides a total mass loss from the central trunk of 65 ± 15 Gt of ice between 1992 and 2003. Although the TG surface lowering signal is smaller in amplitude, its loss is comparable to that of the Pine Island Glacier (PIG) in West Antarctica (44 ± 4 Gt) during the same time period since PIG's thinning is more widespread. The bedrock

geometry beneath TG ensures that marginal thinning affects a grounding line retreat and, when combined with geometric data, the elevation data suggest a retreat rate of 0.6 ± 0.2 km yr^{-1}, or 4 km since it was last mapped in 1996. Pritchard et al. (2009, p. 972), based on ICESat laser altimetry data, "thinning of TG, the highest-flux East Antarctic outlet, is three times greater than previously reported. The similar behavior of its smaller, independent neighbors indicates a common, regional and perhaps ocean-driven cause."

Recently-acquired aerogeophysical data are unveiling a complex environment of ice-ocean interaction in the TG system. New ice draft data reveal that vast areas of TG's floating tongue require water above only -3ºC to initiate melting (-4ºC at the grounding line). Radar reflectivity measurements from the glacier base reveal patterns of melting in large areas, indicating that active thermal forcing in the ice shelf cavity is present over a broader extent than previously supposed, not simply at the grounding line. Initial airborne gravity processing reveals the likely presence of a seafloor-high on the eastern side of the cavity. Such an observation is consistent with an apparent western trend in the reflectivity-based melt signals, since incoming and outgoing water would tend to flow around such a feature. These data would be used to guide the placement of the moorings proposed for this project.

Additional details regarding research data gaps that would be addressed by the proposed action are included in Attachment A.

Broader Impacts of Proposed Research

This survey of TG and MUIS along the Sabrina Coast continental shelf addresses several critical questions. The TG system, which drains one-eighth of the EAIS, remains the single largest and least understood glacial system which possesses a potentially unsteady dynamic. The proposed action would help to understand both the dynamics and the controls of the TG system, and to resolve ambiguity in large ice mass dynamic behavior. This would be accomplished via the collection of glaciologic, geologic, and physical oceanographic data. In order to place the modern system, as well as more recent changes to the system, into a longer-term perspective, researchers would collect and interpret marine geologic, geochemical and geophysical records of the longer term behavior and response of this system.

The proposed research would complement fieldwork studying other Antarctic ice shelves, oceanographic studies near the Antarctic Peninsula, 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 sparsely sampled region of coastal Antarctica, and communicate its findings via publications and outreach. Obtaining long-term records of currents and oceanographic properties in this region are consistent with the objectives of the Southern Ocean Observing System for climate change. The work would enhance general understanding of air-sea-ice interactions, ocean circulation, ice shelf sensitivity to climate change, and the present and future roles of EAIS in sea level rise.

Polar marine science cruises have provided a platform for undergraduate and graduate education. Processing and interpreting kasten and jumbo piston cores would be the basis for undergraduate student theses and processing and interpreting the seismic data would serve as the basis for a graduate, post-doctoral and undergraduate work. The principal investigators (PIs) of the

proposed action have a well-documented record of involving students in all phases of shipboard operations, data collection and publication. A POLARTREC teacher would be invited to participate in the project. This program presents a strong collaboration among the Antarctic Programs of the United States and Australia. While several of the PIs have worked together in the past, in the field and on collaborative science, this shared effort brings the larger group of investigators together as a single team, with each group contributing resources, personnel, and intellectual exchange.

Programmatic Environmental Analysis

The NSF prepared a Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (hereafter called PEIS) for Marine Seismic Research funded by the National Science Foundation (NSF) or Conducted by the U.S. Geological Survey in compliance with the National Environmental Policy Act (NEPA); the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA; NSF procedures for implementing NEPA and CEQ regulations (45 CFR 640); and Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions. A Record of Decision (ROD) followed the publication of the Final PEIS in June 2012 and concluded the NEPA process.

The PEIS examined 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 Final PEIS to a number of representative or exemplary analysis areas. In this regard, 13 exemplary (representative) analysis areas were proposed for analysis within the Final PEIS, including 5 areas which were subject to detailed analysis [Detailed Analysis Areas (DAAs)] and 8 subject to qualitative analysis [Qualitative Analysis Areas (QAAs)]. One of the QAAs was designated the Sub-Antarctic (located east of New Zealand at 42° S, 145° W) and is particularly relevant to the proposed action described in this IEE with respect to biota that may be present in the Southern Ocean during the austral summer. However, the study area is not contained in this QAA and has some unique biomes to those described in the Sub-Antarctic QAA.

The PEIS set up a framework for streamlining the preparation of subsequent environmental documents where needed for individual cruises. Thus, while NSF-funded marine seismic research were reviewed in the PEIS, the analysis of site-specific impacts from future cruises such as the proposed action off the East Antarctic coast would be supplemented with additional analysis. Tiering this environmental document off of the PEIS increases its utility and meaning to the public, without duplicating previous paperwork and environmental analyses. Finally, the PEIS enabled the identification of an appropriate and prudent set of standard mitigation measures to be integrated into this and future NSF-funded cruises:

- Development of mitigating measures during the design and planning of research activities;
- Visual monitoring for marine mammals and turtles;

- Proposed safety radii or mitigation zone (MZ) (standard 328-ft (100-m) MZ for all research efforts with low-energy acoustic sources in water depths >100 m); and
- Mitigating measures to be implemented during operations, including: ramp-ups, shutdowns, and avoidance.

Functionally, this IEE/EA would use the environmental setting and impact assessment data presented in the PEIS for the Sub-Antarctic QAA as a basis for the evaluation and supplemented with available site-specific data for the subject regions of the Antarctic coast. A conservative assumption is made that the species present in the Sub-Antarctic QAA may seasonally migrate to higher latitude areas along the East Antarctic Coast and be present during the proposed marine seismic research activities. In addition, historical sightings data from previous cruises in the proposed study areas would be used to augment the Sub-Antarctic QAA data and provide semi-quantitative estimates of species population density.

In addition, a significant portion of the environmental analysis for the effects to marine mammals was based on the PEIS and recently tiered environmental documents, including 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).

2.0 PROPOSED ACTION

The proposed research activities to be conducted in the Dumont D'Urville Sea near the TG and MUIS along the Sabrina Coast, and in proximity to the MG and CIS regions along the George V and Oates Coasts have been designed to collect data to address research questions regarding these areas and resolve ambiguity in large ice mass dynamic behavior. Ice-free water conditions are preferred in order to collect high quality seismic data and not impede passage of the vessel between sampling locations.

Under Alternative A, the research would begin in February 2014 and span 45 days (including transit time to and from Hobart, Tasmania) using the USAP research vessel icebreaker (RVIB) Nathaniel B. Palmer (NBP). The approximate departure date would be 29 January 2014 and the approximate arrival date would be 16 March 2014. The time frame for Alternative A was chosen because this is the time of year with the most favorable weather conditions. Icy conditions prevent deploying the research gear or could entirely block access to the research site.

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 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 3300 brake horsepower (BHP) @ 900 rpm) and a water jet azimuthing bow thruster. Electrical power is provided by four Caterpillar 3512, 1050-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 guns 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. 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 Comprssor:	Borsig-LMF Seismic Air Compressors, 1,200 cfm at 2000 psi
Accommodation Capacity:	22 crew plus 37 scientists

Ice-free water conditions are preferred in order to collect high quality seismic data and not impede passage of the vessel between sampling locations. Under Alternative B, the project initiation would be deferred to late April or May 2014. In general, potentially affected species would be less common in the area as they would have started migrations to northern latitudes. The detailed elements of the proposed action for Alternative B would be identical to Alternative A. Delaying the initiation of the project compared to Alternative A would increase the risk of failing to meet scientific objectives and increase safety risks. Ice-free water conditions would be reduced, resulting in reduced data collection opportunities and potential damage to scientific equipment. In addition, more operations would need to be conducted in the dark due to fewer daylight hours. Because of the potential risks to not meet science objectives, further analysis of Alternative B beyond the details described herein are not warranted.

Specific details of the activities to be performed under Alternatives A or B are described below.

2.1 Seismic Survey

The proposed seismic survey would be performed in the Dumont d'Urville Sea along track lines totaling up to 2,800 km and in water primarily 100 to 1,000 m deep and possibly exceeding 1,000 m in limited areas. The total track lines include equipment testing, start-up, line changes, repeat coverage, and equipment recovery. Because of the variability of the bathymetry, a small percentage (<5 %) of the survey track lines may approach areas 100 m deep. Because NBP operating procedures generally avoid shallow waters less than 100 m deep for safety reasons, the seismic survey would specifically <u>exclude</u> operating in waters of this depth. Due to highly variable ice conditions it is not possible to designate track lines a priori.

The seismic surveys would be within an area of approximately 2,814 sq km. This estimate is based on the maximum number of kilometers for the seismic survey (2,800 km) times the Predicted RMS radii (m) based on modeling and empirical measurements (assuming 100% use of 2 x 105in^3 GI guns in 100-1000 m water depths) which was calculated to be 1,005 m (1.005 km).

The seismic survey would involve the use of 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. The airguns would be deployed at a depth of up to 3 m below the surface, spaced approximately 3 or 6 m apart and between 15 and 40 m astern. Each airgun would be initially configured to a displacement volume of 45 in^3 (737 cm^3) for both the generator and injector. The guns would fire the compressed air volume (with a maximum firing pressure of 2,000 psi) in unison in a harmonic mode. 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).

If needed to improve penetration of the strata, the two airguns may be reconfigured to a displacement volume of 105 in^3 (1,720 cm^3) each and would still be considered a low-energy acoustic source as defined in the PEIS. Therefore, there are three possible 2-gun array configurations: two 45/45 in^3 guns separated by 3 m, two 45/45 in^3 guns separated by 6 m, and two 105/105 in^3 guns separated by 3 m. The two 45/45guns separated by 3 m layout is preferred, the two 45/45gun configuration separated by 6 m would be used in the event the middle of the three 45/45 GI guns fails, and the two 105/105 guns separated by 3 m would be used only if additional penetration is needed. To summarize, two strings of GI guns would be available: 1) three 45/45 GI guns on a single string where one of these is used as a "hot spare" in the event of failure of one of the other 2 guns; these three GI guns are separated by 3 m; and 2) two 105/105 GI guns on a second string without a hot spare. Weather and sea ice conditions permitting, it is anticipated that the seismic surveying **would not exceed 300 hours of operation for the entire duration of the cruise** as summarized in Table 1.

Table 1. Proposed Seismic Survey Activities in the Dumont d'Urville Sea

Survey Length (km)	Duration (hours)	Airgun Array Total Volume	Frequency (Distance) BetweenSeismic Shots	Streamer Length
2,800	$\leq 300^1$	2 x 45 in^3 (2 x 737 cm^3) **or** 2 x 105 in^3 (2 x 1,720 cm^3)	5 seconds (12.5 m)	100 m

Note: [1] Seismic operations are planned for no more than 16 continuous hours at a time.

During the seismic survey, the vessel would attempt to maintain a constant cruise speed of approximately 9 km/hr (5 knots). The relatively short, 24-channel streamer would provide operational flexibility to allow the survey to proceed along the designated cruise track with minimal interruption due to variable sea ice conditions. The seismic survey has been designed to achieve high-resolution images of the glacial marine sequence stratigraphy with the ability to correlate to the ultra-high frequency chirp data and provide cross-sectional views to pair with the seafloor bathymetry. If necessary, the proposed cruise path may be altered to avoid heavy ice conditions such as icebergs or dense areas of pack ice that could potentially damage the airguns or streamer and minimize proximity to potential marine receptors.

Weather conditions that could affect the movement of sea ice and hinder the streamer would be closely monitored, as well as conditions that could limit visibility. If a situation is encountered

which could 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 streamer and sources could be retrieved in less than 30 minutes.

Based on modeling data, the output from a pair of 45 or 105 in^3 GI airguns is considered a low-energy acoustic source in the PEIS because the received level at 328 ft. (100 m) is less than 180 decibels re 1 microPascal (dB re 1µPa). Since the proposed seismic surveying would not be conducted in waters < 100 m deep, the 100 m mitigation zone (MZ) criteria would be used throughout the proposed action. A full mitigation zone (FMZ) delineates the radii from a low-energy acoustic source which may result in a behavioral disturbance (≥160 dB re 1 µPa [rms]) and yield Level B Harassment. As summarized in Table 2, the complete modeling results for the proposed low-energy airgun array configurations (Attachment B) indicate the received sound level of ≥160 dB re 1 µPa [rms] is dependent on the water depth. The FMZ would be used as the criteria to identify and report a possible behavioral disturbance event. Since a majority of the proposed seismic survey would be conducted in waters 100 – 1,000 m deep and not in water > 100 m deep, the FMZ criteria of 600 m and 1,005 m would be used for the 2 x 45 in^3 or 2 x 105 in^3 GI guns, respectively, even if the survey intermittently entered waters greater than 1,000 m deep.

Table 2. Proposed MZ and FMZ for the Seismic Survey

Source and volume	Water depth	Predicted RMS radii (m) based on modeling and empirical measurements			Proposed MZ and FMZ based on modeling/empirical measurements and PEIS	
		190 dB	180 dB	160 dB	MZ (190/180 dB)	FMZ [1]
2 x 45 in^3 GI guns	>1000 m	10	40	400	100/100	400
	100–1000 m	15	60	600	100/100	600
2 x 105 in^3 GI guns	>1000 m	20	69	670	100/100	670
	100-1000 m	30	104	1005	100/100	1005

Note:
[1] The FMZ for the proposed seismic survey would be based on the 100 - 1,000 m deep criteria; the survey would not extend to water >100 m deep.
[2] The predicted RMS radii and proposed MZ and FMZ in water >100 m deep are included for reference purposes only.

Monitoring and mitigation measures for the low-energy seismic survey would include:

- Pre-planning of each cruise to identify the smallest airgun array that could be used and still meet the geophysical scientific objectives.
- Establishing the MZ and FMZ
- Employing two Protected Species Visual Observers (PSVO), consistent with NMFS requirements, including a marine mammal expert familiar with species in the Southern Ocean to serve as the lead PSVO.
- Minimum of one observer maintaining a visual watch for marine mammals during all daytime airgun operations.

- Two observers maintaining a visual watch for marine mammals from 30 min before the start of ramp ups through the duration of the ramp ups (and when possible at other times) during the day and at night. (Note: because of the high latitude locations of the study areas, twilight/darkness conditions are expected to be limited to between 3 and 6 hours per day during the proposed action).
- Shut downs when marine mammals are detected in or about to enter the designated MZ. Following a shutdown period, airgun activity would not resume until the PSVO has visually observed the marine mammal(s) exiting the MZ and is not likely to return or has not been seen within the MZ 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 exclusion zone(s) - but probably not enough to allow continued one-airgun operations if a marine mammal came within the exclusion zone for two airguns.

To implement these measures, the PSVOs would monitor for the visual presence of cetaceans and pinnipeds prior to and during seismic survey operations. Resources used for these efforts would include two observation platforms (i.e., ship's bridge deck approximately 16.5 m above sea level with a 270 degree view) and equipment (e.g., reticular binoculars) sufficient to provide a clear view around the vessel. The binoculars used would be Fujinon FMTRC-SX 7x50 binoculars or equivalent. These binoculars a built-in daylight compass and range reticle, but are not big-eye binoculars. Night vision devices would not be required. In addition, there is an aloft observation tower ~24.4 m above sea level with a 360 degree view that is protected from the weather, and affords observers an even greater view. PSVOs 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.

During seismic operations, two PSVOs would be based aboard the NBP. The PSVOs would be approved by NMFS and the lead PSVO would be experienced with species in the Southern Ocean. The second PSVO would receive additional specialized training from the lead PSVO to ensure that they can identify Southern Ocean species. During the majority of seismic operations, one PVSO would monitor for marine mammals around the seismic vessel. Use of two simultaneous observers would increase the effectiveness of detecting animals around the source vessel and would be standard practice during the 30 minutes prior to ramp up and during ramp up.

Seismic operations would not extend more than 16 continuous hours during any portion of the survey. The PSVOs would be on duty in 4- hour shifts and each PSVO would not work more than two shifts per day; however during off hours, the resting PSVO 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.

For at least 30 minutes prior to the seismic survey, two observers 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 shut-down 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.

Typically, the shut-down procedure would involve reducing the acoustic output of airguns to minimize the sound level exposure risk. In these instances, regular airgun operations would resume when the PSVO has visually observed the marine mammal(s) exiting the MZ or the animal has not been seen within the MZ for 15 minutes (small odontocetes) or 30 minutes (mysticetes and large odontocetes). A complete shutdown of the airguns for any reason for more than 15 minutes would require visual monitoring and ramp-up procedures consistent with those used at the start of the survey.

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

2.2 Bathymetric Profiling, Magnetometry, and Imaging Surveys

Besides the seismic survey, other geophysical measurements would be made using swath bathymetry, backscatter sonar imagery, high-resolution sub-bottom profiling ("CHIRP"), imaging, and magnetometer instruments. In addition, other transducer-based instruments onboard the vessel would be used continuously during the cruise for operational and navigational purposes.
These sources, described below, are similar to the non-seismic acoustic sources described in the PEIS. The PEIS concluded that the intermittent and narrow downward-directed nature of the non-seismic acoustic sources would result in no more than one or two brief ping exposures of any individual mysticete, odontocete, or pinniped given the movement and speed of the vessel; such brief exposure to this sound is not expected to cause injury or PTS based on results of limited studies of some odontocete and pinniped species.

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 would be operated instead of the Knudesn 3260 only if needed (i.e., only one would be in continuous operation during the cruise). The characteristics of the Bathy 2000 are similar to the Knudsen 3260.

Multi-beam 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 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 30^0 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.

Acoustic Locator (Pinger) – An acoustic locator (pinger) may be deployed when using the Smith- McIntyre grab sampler and multi-corer (Mega-corer) to enable these devices to 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 30 samples would be obtain using these devices and require approximately one hour per sample. Therefore, the pinger would operate a total of 30 hours.

Passive Instruments - During the seismic survey in the Dumont d'Urville Sea, a precession magnetometer and Air-Sea gravity meter would be deployed. In addition, 24 expendable bathythermographs (XBTs) would also be released and not recovered) over the course of the cruise to obtain temperature data necessary to calculate sound velocity profiles used by the multi-beam sonar.

2.3 Core and Dredge Sampling

The primary sampling goals include the acquisition of marine sediment cores of various lengths up to 25 m. It is anticipated that up to 65 sediment cores and grab samples and 12 rock dredge samples would be collected as summarized in Table 3. Approximately 75 m^2 of seafloor would be disturbed by each of four deployments of the dredge at three different sites (resulting in a total of 900 m^2 of affected seafloor for the project). For each sample, a dredge with an opening size of 0.5 to 1.5 m would be towed along the seafloor for short distances (~50 m) to collect samples of bedrock and ice rafted debris along the rocky substrates. In addition, a camera and towed video system would be deployed at up to 25 sites. This device would lightly touch the seafloor to establish baseline and rise to an optimum elevation to obtain the desired images. All cores and dredges would be deployed using a steel cable/winch system.

An acoustic locator (pinger) may be deployed when using the Smith- McIntyre grab sampler and multi-corer (Mega-corer) to enable these devices to 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 30 samples would be obtained using these devices and require approximately one hour per sample. Therefore, the pinger would operate a total of 30 hours.

Table 3. Proposed Coring and Dredging Activities in the Dumont d'Urville Sea

Sampling Device	No. of Deployments
Smith−McIntryre grab sampler	10-15
Multi−corer (Mega-corer)	10-15
Kasten corer (regular or jumbo)	20-25
Jumbo piston corer	8-10
Box cage rock dredge	10-12

The selection of the bottom sampling locations and sampling method would be based on observations of the seafloor, subsurface reflectivity, sediment type, and accessibility due to ice and weather conditions. Bottom sampling in the MG area would be conducted at strategically selected locations including possible re-sampling at a previous core site. The dredge sample locations would also be limited to the inner shelf (southern) perimeter of three areas: the Mertz Trough and two regions along the Sabrina Coast. Final selection of dredge sites would include a review to ensure that the seamounts or corals in the area are avoided (AOA, 2011).

Additionally, 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 (Attachment F) 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.

2.4 Water Sampling and Current Measurements

High-resolution CTD measurements would be collected to characterize the summer regional water mass stratification and circulation, and the meridional exchange of waters between the oceanic and shelf regimes. These physical measurements would involve approximately 120 SeaBird CTD system casts including the use of a lowered ADCP (LADCP).

The LADCP would consist of two Teledyne RDI Workhorse Monitor ADCPs mounted on the CTD/Rosette frame with one oriented upward and the other downward. The LADCPs would operate at a frequency of 307.2 kHz, with an estimated output acoustic pressure along each of 4 beams of 216.3dB re 1 micro-Pascal @ 1 meter. The beams are angled at 20 degrees from the centerline of the ADCP head, with a beam angle of 4 degrees for the individual beams. Typical pulse duration is 5.7 milliseconds, with a typical repetition rate of 1.75 seconds. The upward and downward-looking ADCPs are operated in master-slave mode so that only one head pings at a

time. The LADCP would be operated approximately one hour at every CTD/rosette station (maximum of 100 stations) for a total of 100 hours of operation.

These instruments would be used to profile the full water column for temperature, salinity (conductivity), dissolved oxygen and currents at a series of transects in the study area. Discrete water samples would be collected for salinity and dissolved oxygen to monitor CTD/rosette performance, and for oxygen isotopes (δO_{18}) to assess meltwater content. Water samples would also be collected for development and interpretation of marine sediment proxies using Niskin bottles.

Observations of the thermal structure along other portions of the cruise track would be made using an underway CTD system and XBTs while the sea floor is swath-mapped. The number and spacing of stations would be adjusted according to ocean features discovered through multibeam swath mapping and the sea ice conditions. If portions of the study area are inaccessible to the NBP, a contingency sampling focused on the inflows of MCDW would be pursued in adjacent shelf troughs.

It is noted that the underway ADCP on the NBP can, under ideal conditions, obtain profiles of ocean currents to depths greater than 800 m. On continental shelves where depths may be less than the range of the ADCP, the underway profiles cannot resolve the deepest 15% of the water column due to side lobe reflections from the bottom which contaminate the water column Doppler returns. For a depth of 800 m, expected in the MCDW, currents in the lower 120 m could not be measured by the ship ADCP; therefore, the LADCP can provide accurate current profiles to within a few meters of the bottom and provide complete coverage of the velocity field at each CTD station.

2.5 Instrumentation Moorings

Four instrumented moorings would be deployed during the cruise. Two of the moorings would be deployed for approximately one month (short-term moorings) and two moorings would be deployed for approximately one year (long-term moorings) The two short-term moorings and one long-term mooring would include Acoustic Doppler Current Profilers (ADCP) paired with CTD recorders, and additional intermediate T (temperature) recorders. The characteristics of the ADCP units deployed on the moorings are similar to the Teledyne VM-150; the moored ADCPs operate at frequencies of 75 kHz (one unit) and 300 kHz (two units). The fourth mooring would be equipped with sediment traps, a CTD recorder and intermediate T recorders, and be deployed for approximately one year (long-term mooring). The two long-term moorings would be retrieved approximately one year later by a USAP vessel or collaborators from other countries.

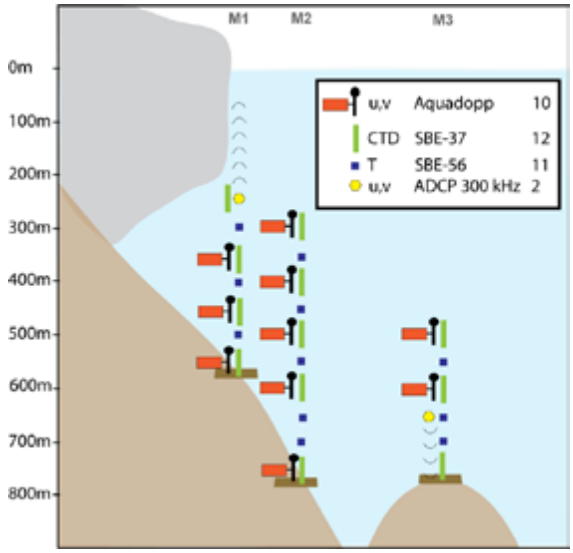
Subject to sea ice conditions, these moorings would preferably be placed in front of Totten Glacier (TG), but otherwise as close as possible inside adjacent cross-shelf troughs. If access to the inner shelf is not allowed by sea ice conditions we would attempt mooring deployments within the outer shelf close to the troughs mouth, where the TG is more directly connected to inflows from the oceanic domain offshore. The two long-term moorings would be deployed within 16 km of each other. The short-term moorings would be within a few kilometers of each

other and no farther than 32 km from the long-term moorings. All instruments would be kept at depths below 250 m to minimize damage or loss by icebergs (see Figure 4).

The mooring recovery process would be similar regardless of mooring type or when they would be retrieved. Locating the moorings and releasing the moorings from the steel railroad wheel anchors (which would not be recovered) are accomplished by transmitting sound over a period of several seconds. This is done with an acoustic deck command unit that sends a sequence of coded pulses to the receiving units, the acoustic releases, connected to the mooring anchors. The acoustic releases response to acknowledge the receipt of commands from the deck unit is by transmitting a short sequence of pulses back. Both of the acoustic units (onboard deck unit and moored releases) operate at frequencies between approximately 7 and 15 kHz. The beam pattern is approximately omnidirectional. The acoustic source level is < 192 dB rel 1micropascal at 1 m.

In addition to the U.S. moorings described above, three new moorings would be deployed on behalf of Australia's national science agency the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO)_ Physical Oceanography group in the Totten Glacier region by the project team. These moorings would be retrieved approximately one year later by collaborators from other countries. Also during this cruise, three CSIRO moorings that were deployed over a year ago in the western outlet of the Mertz-Ninnis Trough would be recovered. The recovery process and acoustic sources described above for the U.S. moorings would be used for recovery of the CSIRO moorings.

Figure 4. Generalized Illustration of Instrumentation Moorings



2.6 Icebreaking

If icebreaking does the cruise in the Antarctica region, it is expected to occur during transit operations to gain access to dredging or sampling locations and not during seismic survey

operations. The research activities and associated contingencies are designed to avoid areas of heavy sea ice condition.

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 air gun and streamer, as this would likely damage equipment and generate noisy data. It is possible that the seismic survey can be performed in low ice conditions if the RVIB *NBP* vessel could generate an open path behind the vessel.

Because the RVIB *NBP* is not rated to break multiyear ice routinely, 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 Totten region documents that sea ice is at its minimum extent during the month of February. The most recent ice image for the region, from November 21, 2013, shows that the sea ice is currently breaking up, with a significant coastal lead of open water.

Based on a maximum sea ice extent of 250 km and estimating that researchers will transit to the innermost shelf and back into open water twice – a round trip transit in each of potential work regions, it is estimated that the RVIB *NBP* will actively break ice up to a distance of 1,000 km. Based on a ship's speed of 5 knots under moderate ice conditions, this distance represents approximately 108 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 assessment.

3.0 AFFECTED ENVIRONMENT

The description of the affected environment in the PEIS, Chapter 3, focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) has focused mainly on those related to marine biological resources, as the proposed short-term activities have the potential to impact marine biological resources within the project area. These resources are identified in Section 3.0, whereas the potential impacts to these resources are discussed in Section 4.0. Initial review and analysis of the proposed project actions determined that the following resource areas did not require further analysis in this IEE/EA:

- *Transportation* — Only the NPB would be used during the marine seismic survey. Therefore, projected increases in vessel traffic attributable to implementation of the proposed activities would constitute only a negligible portion of the total existing vessel traffic in the analysis area;
- *Air Quality/Greenhouse Gases* — Project vessel emissions would result from the proposed activities, however these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the survey area;

- *Land Use* — All activities are proposed to occur in the marine environment. Therefore, no changes to current land uses or activities within the project area would result from the proposed actions;
- *Safety and Hazardous Materials and Management* — No hazardous materials would be generated or used during proposed activities. All project-related wastes would be disposed of in accordance with Federal and international requirements including the Protocol on Environmental Protection to the Antarctic Treaty;
- *Geological Resources (Topography, Geology and Soil)* — The proposed actions would result in only short-term displacement of soil and seafloor sediments through dredging and coring the seafloor. Proposed activities would not adversely affect geologic resources as only minor impacts would occur;
- *Water Resources* — No discharges to the marine environment are proposed within the project area that would adversely affect marine water quality. While research activities would include water sampling via CTDs, this would not be anticipated to have an impact on water resources;
- *Socioeconomic and Environmental Justice* — Due to the extremely remote location of the proposed activities, no environmental justice or socioeconomic impacts (including to commercial fishing or tourism activities) would be anticipated as result of the proposed activities;
- *Visual Resources* — No visual resources would be anticipated to be negatively impacted as a result of the location of the proposed activities; and
- *Cultural Resources* — there are no known cultural resources in the proposed project area. Therefore, no impacts to cultural resources would be anticipated.

The proposed action would occur in selected regions of the Dumont d'Urville Sea in East Antarctica and focus on the TG and MUIS located along the Sabrina Coast (>64°0′S, between 95°E and 135°0′E) and the MG and CIS systems near the George V and Oates Coast (>65°0′S, between 140°0′E and 165°E). The study site, comprised of the two areas, is entirely outside of the Sub-Antarctic QAA described in the PEIS. While many the marine mammal species travel between the Sub-Antarctic QAA and the study region, the QAA and study site consist of different biomes. The study site is characterized by heavy ice cover, with a seasonal breakup in the ice that structures biological patterns. The proposed studies would occur in both areas, or entirely in one or the other, depending on ice conditions and the biological environment is expected to be the same in both areas. Figure 4 illustrates the limited available detailed bathymetry of the two study areas due to ice conditions encountered during the previous surveys in the region.

3.1 Physical Conditions

3.1.1 Totten Glacier and Moscow University Ice Shelf Areas

The TG is approximately 60 km long and 30 km wide, while the MUIS is a narrow ice shelf, approximately 200 km long, located between TG and Paulding Bay. Water depths in the TG study area range from approximately 100 m to approximately 1,000 m (see Figure 5).

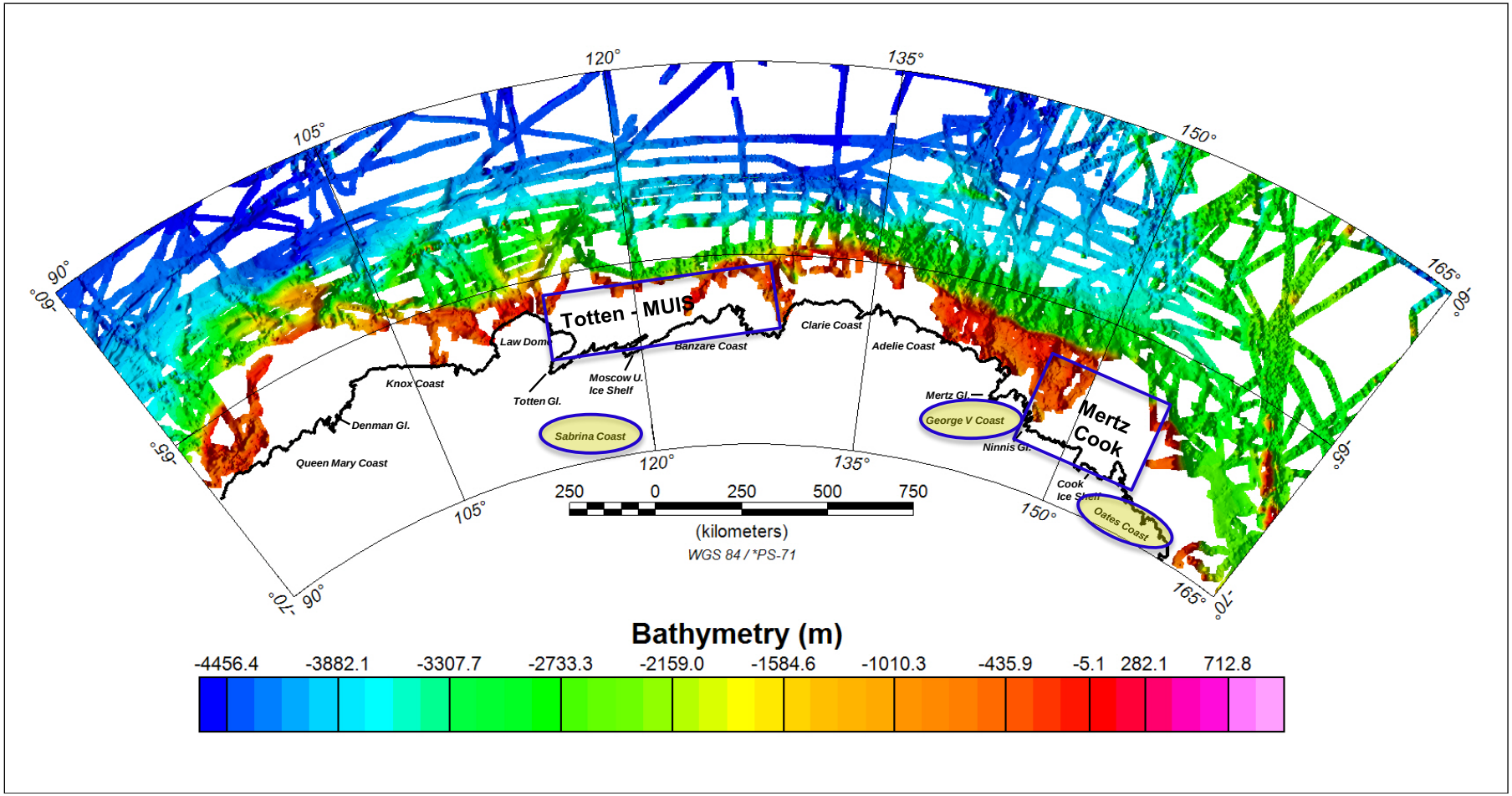
The TG is located on the eastern side of Law Dome and drains northeastward from the continental ice but turns northwestward at the coast where it terminates in a prominent tongue east of Cape Waldron. The TG discharges up to 70 Gt $yr^{-1}$of fresh glacial meltwater into the ocean. Its maximum thickness at the grounding line is approximately 2.5 km in the region where the glacier departs the continental ice sheet and begins to float and is nearly 200 m thick at the calving front, 150 km to the north. Recent measurements show that the Totten Glacier is thinning at up to 1.9 m per year. The direct cause is not yet known, but is believed to be ocean driven, derived from MCDW.

Once on the continental shelf, and with the appropriate bathymetric pathways to reach the glacier, the MCDW, which is denser than the surrounding shelf water masses, is able to sink to the grounding line of the glacier and cause increased melting and rapid glacier acceleration. This is also suspected to be the key cause of the increased melting of other ice shelves showing rapid thinning, such as the Pine Island Glacier in the Amundsen Sea region of West Antarctica.

The circulation and water temperature in the open ocean and under the Totten and Dalton ice shelves is illustrated in Figure 6. This depicts the depth averaged ocean currents for March 2006, colored for ocean temperature. Warm MCDW can be seen to flow onto the shelf break and towards the eastern side of the front of the ice shelf. The fresh meltwater then flows out of western side and continues westward around Law Dome. The melt rates for the Totten Glacier Ice Shelf were calculated using a model developed to examine thermodynamic interaction (Gwyther, *et al*, 2011). The model predicted melt rates of more than 50 m per year occurring at the deepest part of the ice shelf (Figure 7).

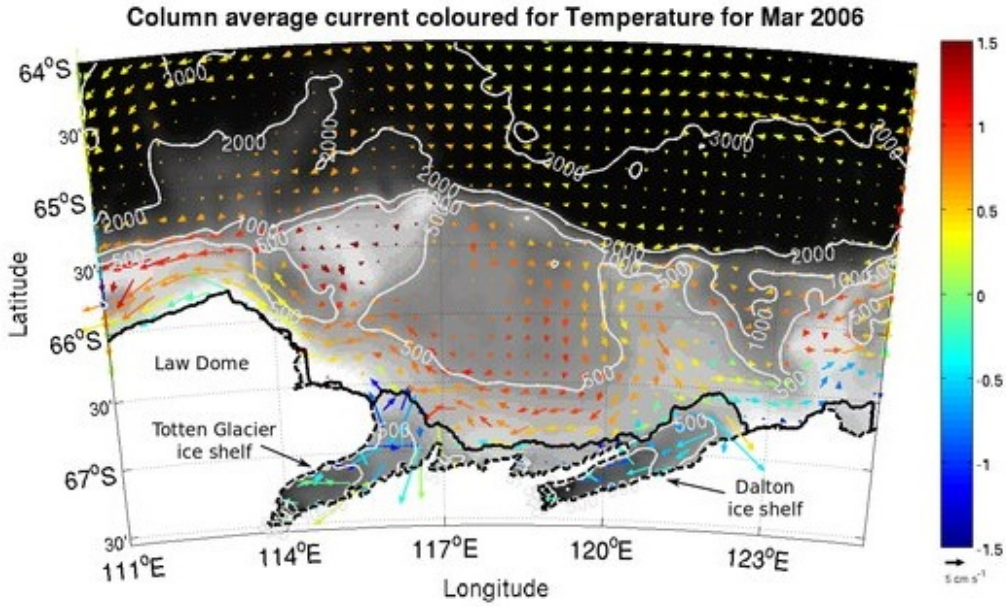
The proposed action would take place during February-March 2014 when open water conditions are generally expected to be present in the study areas. These open water conditions are required for the success of the study. The sea ice conditions in the region, based on analysis from satellites, ships, continental stations, and synoptic modeling, can vary significantly from year to year. Wind, currents and tides would influence sea ice coverage.

Figure 5. Totten and Mertz Glacier Study Area Bathymetry



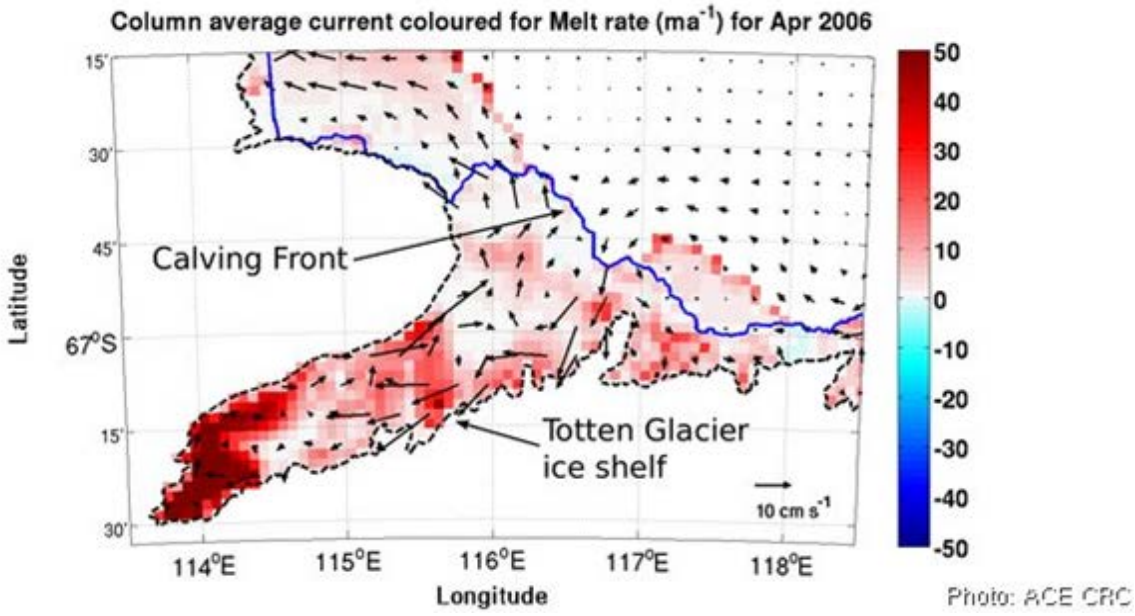
Source: LDEO Marine Geoscience Data System. Part of the Mertz area coverage is from two AAD cruises: au1121 from Jan. 2011 and au0803 from 2007/2008

Figure 6. Totten Glacier Region Circulation and Water Temperature



Source: Gwyther, *et al.*2011

Figure 7. Totten Glacier Region Melt Rate



Source: Gwyther, *et al.*2011

3.1.2 Mertz Glacier and Cook Ice Shelf Areas

The MG is about 72 km long and approximately 32 km wide, and is characterized by a large tongue that extends to the sea. The CIS is an ice shelf about 90 km wide, located between Cape Freshfield and Cape Hudson. Water depths in this region range up to 2 km deep (Figure 5); however, the seismic survey would be conducted in waters 100 – 1,000 m deep.

Within the MG region, dense saltwater forms at the surface, sinks, and is influenced by the Mertz polynya (an area of open-water or low sea ice concentration), which drives deep over-turning ocean circulation. The migration of sea ice in the region is strongly influenced by the polynya which routinely forms along the western margin of the MG tongue. This polynya is created by persistent katabatic winds which transport sea ice westward away from the coast.

The area around the MG is biologically active. The ice-free waters of the polynya allow light to reach the ocean surface and stimulate primary production. The high biological productivity attracts whales, penguins and seals to feed on plankton in one of the few areas not covered by ice in the Antarctic winter.

3.2 Acoustic Environment

The PEIS describes ambient noise conditions common throughout the world's oceans. The study area is distinguished by its heavy ice cover. Ice breakers are needed to access the area. In a study of noise levels generated by research icebreakers (Roth & Schmidt, 2010), mean sound pressure levels for vessels operating between 2-6 knots in moderate ice cover were found to result in a mean sound pressure level of 185 dB re 1 µPa-m (rms), while vessels operating at 6-8 knots in decreased ice cover resulted in mean source levels of 180 to 175 dB re 1 µPa-m (rms).

3.3 Biota

The Dumont d'Urville Sea is biologically active with krill populations, whales returning to feed from breeding areas in the north, penguins foraging in the sea to feed newly hatched offspring in nearby rookeries, as well as seal colonies, fish, and flying seabirds. The seafloor in the Dumont d'Urville Sea is also known to contain diverse benthic communities. ESA listed species are identified in section 3.3.7 and listed in Table 18.

As described in Section 2, this IEE/EA would use the environmental setting and impact assessment data presented in the PEIS for the Sub-Antarctic QAA as a basis for the evaluation of the proposed action. A conservative assumption is made that the species present in the Sub-Antarctic QAA may seasonally migrate to higher latitude areas along the East Antarctic coast and be present during the proposed marine seismic research activities. In addition, historical sightings data from previous cruises in the proposed study areas would be used to augment the Sub-Antarctic QAA data and provide incidental take estimates. The following presents descriptions of the biological communities that may be present in the study areas.

3.3.1 Marine Invertebrates

Various species of decapods and 35 squid, 10 octopus, and 4 cuttlefish species are listed in the PEIS as occurring in the sub-Antarctic area (Table 4). The cephalopods (squid and octopi) comprise an important part of the diet of a number of predator species, including penguins and other sea birds, seals and whales. It is noted that some of the species listed in the PEIS are not expected to occur in the proposed study area.

Table 4. Potential Occurrence of Decapod Crustaceans and Cephalopod Mollusks Identified in the PEIS Sub-Antarctic Area

Group	Potential Occurrence
Decapods	
Lobsters	B F E a
Crabs	B F E a
Shrimps	B F c
Cephalopods	
Octopuses	B F c
Squids	B F E M a
Cuttlefishes	B F c
Nautiluses	-

Notes: B = breeds within the area; **E** = economically important fishery within the area; **F** = feeds within the area; M = migrates through the area but unlikely to breed there. **a** = Abundant: the species group is expected to be encountered during a single visit to the area and the number of individuals encountered during an average visit may be as many as hundreds or more; **c** = common: the species group is expected to be encountered once or more during 2-3 visits to the area and the number of individuals encountered during an average visit is unlikely to be more than a few 10s; **-** = species group does not occur there. Table reproduced from the PEIS
Source: NSF 2011

3.3.2 Fish

Higher group fish species that potentially occur within the sub-Antarctic area are listed in Table 5. It is noted that some of the species' occurrence in the proposed study areas are not expected. There are no ESA-, IUCN-, or CITES-listed fish species identified for this analysis area. In addition, approximately 100 species of benthic fish unique to Antarctica are present and belong to the family Nototheniidae (co icefish). As a group, they are highly diversified in structure, habit and distribution.

Table 5. Potential Occurrence of Higher Fish Groups Identified in the PEIS Sub-Antarctic Area

Higher Fish Group	Potential Occurrence (Jan-Feb)
Hagfishes & Lampreys	-
Sharks, Skates, Rays, & Chimeras	B F M
Sturgeons	-
Herring-likes	-
Salmon, Smelts, etc.	-
Cod-likes	B E F M
Pipefishes & Seahorses	-
Scorpionfishes	B F M
Perch-likes	B E F M
Tuna & Billfishes	B F M
Flatfishes	B E F M

Table 5. Potential Occurrence of Higher Fish Groups Identified in the PEIS Sub-Antarctic Area

Higher Fish Group	Potential Occurrence (Jan-Feb)
Coelacanths	-

Notes: B = breeds within the area; **E** = economically important fishery within the area; **F** = feeds within the area; **M** = migrates through the area. Table reproduced from the PEIS.
Source: NSF 2011.

The sub-Antarctic oceans are productive with long day lengths in the austral summers. As a result, they have long been the target of international fisheries for fish, whales, and invertebrates. Due to the remote and harsh nature of the southern oceans, these are all high-seas industrial fisheries. Based on CCAMLR reports, fisheries in the East Antarctic region reported catches from three families: Channichthyidae (Icefish), Macrouridae (Rattails), and Nototheniidae.

3.3.3 Sea Turtles

Five species of sea turtles have been observed in the sub-Antarctic (Table 6) and are considered uncommon to common. No sea turtle nesting occurs in the region. The species' occurrences in the proposed study areas are not expected, though it is possible that leatherback turtles could be encountered in transit between Hobart and the study area.

Table 6. Potential Occurrence of Sea Turtles Identified in the PEIS Sub-Antarctic Area

Species	Potential Occurrence (winter)
Green Turtle	cM
Hawksbill	cM
Loggerhead	u? M
Olive ridley	cMF
Kemp's ridley	-
Leatherback	u? MF
Flatback	-

Notes: F = known to feed within the area, **M** = known to migrate through the area; **c** = common: the species is expected to be encountered once or more during 2-3 visits to the area and the number of individuals encountered during an average visit is unlikely to be more than a few 10s, **u** = uncommon: the species is expected to be encountered at most a few times a year assuming many visits to the area; **-** = species does not occur; **?** = uncertain. Table reproduced from the PEIS.
Source: NSF 2011.

3.3.4 Seabirds

Seabirds are considered species that nest on land but spend all or a considerable portion of their lives in marine environments and surface- or plunge-dive below the water surface in search of prey. Six seabird families may potentially occur within the sub-Antarctic area and are listed in Table 7.

Table 7. Potential Occurrence of Seabirds Identified in the PEIS Sub-Antarctic Area

Group	Potential Occurrence (Jan-Feb)
Albatrosses	FM a
Petrels/Shearwaters	FM a
Diving-petrels	F a
Gannets/Boobies	FM u
Gulls	M r
Terns/Noddies	FM c

Notes: F = known to feed within the area; **M** = known to migrate or disperse through the area; **a**= abundant: the species is expected to be encountered during a single visit to the area and the number of individuals encountered during an average visit may be as many as hundreds or more, **c** = common: the species is expected to be encountered once or more during 2-3 visits to the area and the number of individuals encountered during an average visit is unlikely to be more than a few10s, **u** = uncommon: the species is expected to be encountered at most a few times a year assuming many visits to the area, **r** = rare: the species is not expected to be encountered more than once in several years. Table reproduced from the PEIS.
Source: NSF 2011.

3.3.5 Penguins

Penguins may be found in open water throughout the region as they forage from numerous established colonies on nearby land masses. Based on data compiled by the Scientific Committee on Antarctic Research, Ad Hoc Group on Marine Acoustic Technology and the Environment, an adelie penguin colony containing more than 1,000 pairs of animals is located along the edge of the Moscow University Ice Shelf in the preferred study area (SCAR, 2002). In the secondary study area, a colony of < 1,000 pairs of Emperor penguins is present on the Ninnis Glacier and several Adelie penguin colonies of more than 10,000 pairs are present in proximity to the MG (SCAR, 2002). Although the proposed action would be conducted more than 100 km from the nearest land mass, the research activities are within a penguin's maximum foraging range of 550 km from one of these colonies. The proposed surveys would take place within the breeding period for the Adelie penguin (October-March).

3.3.6 Marine Mammals

The Dumont d'Urville Sea is a feeding ground for a variety of marine mammals, including pinnipeds (seals) and cetaceans (whales) including baleen (mysticetes) and toothed whales (odontocetes). Attachment C provides additional details on whale populations and habitat. Six species of seals found in the Southern Ocean which may be present in the study areas include the crabeater, leopard, Weddell, Ross, elephant, and Antarctic fur seals. Seal species breed on either the pack ice or sub-Antarctic Islands.

Based on the PEIS, Table 8 identifies the whale species that may occur in the sub-Antarctic area and therefore may be present in the proposed study areas. However, it is noted that several of

these species may not be encountered below 60°S. A cross-reference of species names to common names appears in Attachment D. Many of these whale species such as fin or sperm whales are capable of diving to great depths (>1,000 m) and remaining underwater for more than 30 minutes. Some species, particularly Minke and Killer whales, are expected to be present at higher concentrations along the ice edge (SCAR, 2002). In general, most species except for the Killer whale migrate north in the middle of the austral winter and return to Antarctica in the early austral summer.

Table 8. Potential Cetacean Species Identified in the PEIS Sub-Antarctic Area

Species	Potential Occurrence (summer)
Mysticetes	
Southern right whale	F u
Pygmy right whale	F u-c
Humpback whale	M r
Minke whale	F c
Dwarf minke whale subsp.	F r?
Antarctic minke whale	M r
Bryde's whale	F c
Sei whale	F c
Fin whale	M u
Blue whale	M u
Pygmy blue whale subsp.	F u
Odontocetes	
Sperm whale	BF c
Pygmy and dwarf sperm whales	F c [2]
Beaked whales	F u [1]
Shepherd's beaked whale	F u
Cuvier's beaked whale	F c
Longman's beaked whale	-
Beaked whales	B? F r-u-c [7]
Bottlenose whales	F c
Killer whale	F c
False killer whale	F c
Pygmy killer whale	F c
Melon-headed whale	-
Long-finned Pilot whales	F c [2]
Irrawaddy (snubfin) dolphin	-
Risso's dolphin	F u
Common dolphins	F r [1]
Fraser's dolphin	-
Indo-Pacific humpbacked dolphin	-
Tucuxi	-

Table 8. Potential Cetacean Species Identified in the PEIS Sub-Antarctic Area

Species	Potential Occurrence (summer)
Bottlenose dolphins	B? F c [1]
Dolphins (5 Stenella spp.)	F c [3]
Dolphins (6 Lagenorhynchus spp.)	F u [1]
Rough-toothed dolphin	-
Right whale dolphins	F na
Finless porpoise	-
Porpoises	B? F r [1]

Notes: [ ] = number of species found. **B** = known to breed or calve within the area/season; **F** = known to feed within the area/season; **M** = known to migrate through the area/season; **?** = unknown / possible; **a** = abundant: the species is expected to be encountered during a single visit to the area and the number of individuals encountered during an average visit may be as many as hundreds or more; **c** = common: the species is expected to be encountered once or more during 2-3 visits to the area, and the number of individuals encountered during an average visit is unlikely to be more than a few 10s; **u** = uncommon: the species is expected to be encountered at most a few times a year during the season assuming many visits to the area; **r** = rare: the species is not expected to be encountered more than once in several years during the relevant season; **na** = reliable data not available or uncertain or species status was not assessed; **-** = species does not occur. Table reproduced from the PEIS.
Sources: NSF 2011.

As a secondary check to the species identified in Table 8, various national Antarctic research programs along the coast of East Antarctic have conducted scientific cruises that included data on marine mammal sightings. The reported cetacean sightings are summarized in Tables 9 through 11, were made primarily between 30°E and 170°E and north to 60°S, and compare favorably with the occurrence data presented in Table 8. Because these data represent observations made over multiple cruises by different parities, some data may overlap; a complete listing of the sightings by date is provided in Attachment E.

Table 9. Cetaceans Observed in the Southern Ocean in Proximity to the Proposed Study Areas (July 1995 - November 2004)

Common Name	No. of Animals
Minke whale	393
Blue whale	26
Fin whale	70
Southern four-toothed whale	6
Dolphin (unidentified)	12
Southern right whale	8
Long-finned pilot whale	19
Southern bottlenose whale	13
Dusky dolphin	2
Hourglass dolphin	27
Southern right whale dolphin	4
Humpback whale	308

Table 9. Cetaceans Observed in the Southern Ocean in Proximity to the Proposed Study Areas (July 1995 - November 2004)

Common Name	No. of Animals
Baleen whale (unidentified)	4
Killer whale	101
Sperm whale	92

Source: GBIF, OBIS, SCAR-MarBIN and through the AADC web site

Table 10. Cetaceans Observed in the Southern Ocean in Proximity to the Proposed Study Areas (February 1991 – March 1997)

Common Name	No. of Animals
Minke whale	73
Sei whale	2
Southern right whale	2
Long-finned pilot whale	7
Southern bottlenose whale	1
Hourglass dolphin	2
Humpback whale	8
Baleen whale (unidentified)	1
Killer whale	14
Sperm whale	3

Source: ANARE-From SCAR-MarBIN

Table 11. Cetaceans Observed in the Southern Ocean in Proximity to the Proposed Study Areas (BROKE-West 52-day study period, January – March 2006)

Common Name	No. of Animals	Pro-Rated Number (include unidentified)	Corrected Sightings (assume only 20% reported) Note 1
Minke whale	114	136	680
Sei whale	3	4	20
Blue whale	2	2	10
Fin whale	195	232	1,160
Dolphin (unidentified)	13	--	--
Long-finned pilot whale	20	24	120
Hourglass dolphin	20	27	135
Humpback whale	200	238	1,190
Whale (unidentified)	116	--	--
Spectacled porpoise Note 2	26	26	130
Killer whale	52	62	310

Table 11. Cetaceans Observed in the Southern Ocean in Proximity to the Proposed Study Areas (BROKE-West 52-day study period, January – March 2006)

Common Name	No. of Animals	Pro-Rated Number (include unidentified)	Corrected Sightings (assume only 20% reported) Note 1
Sperm whale	27	32	160

Notes:

[1] Sightings data accounts for all individuals observed in groups, and was adjusted to account for unidentified species observations; the corrected sightings assumes 20% of all animals present will be observed and reported

[2] Sightings based on NOAA recommendation.

Source: AAD BROKE-West Survey

Observations from the AAD BROKE-West Survey (Table 11) represent sightings from a discrete time period and are the best data available for the region that can be used to estimate the number of animals that may be encountered during the proposed cruise in the Dumont d'Urville Sea. Because the areal extent is an important component of animal density calculations (no./km^2), the areal extent of the AAD BROKE-West survey was estimated accordingly, based on available data and using operating parameters form the R/V Laurence M. Gould as reference, as shown in Table 12. Estimates of cetacean densities in the study area are presented in Table 13.

Table 12. Estimated Aerial Extent of the AAD BROKE Survey (52-day period, January – March 2006)

Parameter	Value	Unit	Assumptions
Cruise speed	3	knots	Estimated speed of Nathaniel B. Palmer through broken pack ice Note 1
	5.56	km/hr	1 knot = 1.852 km/hr
Period of AAD BROKE-West Sightings	52	days	duration (Jan - March 2006)
	416	hours	8 hrs observations/day
Distance traveled during AAD BROKE-West survey (length)	2,311.3	km	speed (km/hr x time in hr)
Assumed visible distance around vessel (width)	5	km	Diameter around vessel
Estimated Area of AAD BROKE-West Sightings	11,556	km^2	area (length x width)

Note:

[1] The NPB speed in pack ice is effectively 3 knots and can operate in ice up to 3 feet thick.

Table 13. Estimated Cetacean Densities in the Proposed Study Areas

Common Name	Corrected Sightings AAD BROKE- West Survey 52-Day Period (11,556 km^2) [1]	Estimated Density (no/km^2) [2]
Mysticetes		
Blue whale	10	0.0008654
Fin whale	1160	0.1003808
Humpback whale	1185	0.1029768
Minke whale	680	0.0588439
Sei whale	20	0.0017307
Odontocetes		
Dolphin, Cruciger (hourglass)	135	0.0112496
Spectacled porpoise[3]	130	0.0142783
Killer whale	310	0.0268259
Long-finned pilot whale	120	0.0103842
Sperm whale	160	0.0138456

Notes:
[1] Sightings data accounts for all individuals observed in groups, and was adjusted to account for unidentified species observations; the corrected sightings assumes 20% of all animals present will be observed and reported (see Table 11);
[2] The sighting data was converted to an areal density by dividing the number of animals observed by the estimated area observed during the survey, a 11,556 km^2 study area for the AAD BROKE-West survey (see Table 12)
[3] Reported sighting based on NOAA-NMFS recommendation.

For pinnipeds, observations made during a scientific cruise over a 13-day period in East Antarctica are summarized in Table 14. These observations were made below 60°S and between 110°E to 165°E and include sightings of individual animals in the water as well as individuals that were hauled out (i.e., resting on the surface of the sea ice). These observations may represent the total number of pinnipeds that may be observed during the proposed seismic survey, both in the water and on the surface of the sea ice. A complete listing of the pinniped sightings is included in Attachment E. Similar to that performed for the cetacean sightings data, the areal extent of the AAD cruise was calculated to facilitate pinniped density estimates, as shown in Table 15. Estimates of pinniped densities in the study area are presented in Table 16.

Table 14. Pinnipeds Observed in the Southern Ocean in Proximity to the Proposed Study Areas (December 1999)

Species	Reported Sightings [Note 1]	Corrected Sightings (No. of Animals in the Water) [Note 2]	Corrected Sightings (No. of Animals On sea ice and in the Water) [Note 2]
Crabeater	2220	888	3108
Leopard	17	7	24
Ross	42	17	59
Weddell	0	0	0
Elephant	0	0	0
Antarctic Fur	0	0	0

Notes:
[1] Sightings 12/3-12/16/99 below 60°S between 110°E to 165°E.
[2] All sightings were animals hauled-out of the water and on the sea ice;
assumes 40% of sighted pinnipeds are in the water, conservatively based on an estimate by Southwell et al (2012) that 20 to 40% of crabeater seals may be in the water in a particular area while the rest are hauled out.
Source: Australian Antarctic Data Centre, May 2013;
https://data.aad.gov.au/aadc/biodiversity/

Table 15. Estimated Aerial Extent of the AAD Survey (13-day period, December 1999)

Parameter	Value	Unit	Assumptions
Cruise speed	3	knots	Estimated speed of Nathaniel B. Palmer through broken pack ice [Note 1]
	5.6	km/hr	1 knot = 1.852 km/hr
Period of AAD Sightings	13	days	duration (December 3 - 16 1999)
	104	hours	8 hrs observations/day
Distance traveled during AAD Survey	577.8	km	speed (km/hr x time in hr)
Assumed visible distance around vessel (width)	5	km	Diameter around vessel
Estimated Area of AAD Sightings	462	km^2	area (length x width)

Note:
[1] The NBP speed in pack ice is effectively 3 knots and can operate in ice up to 3 feet thick.

Table 16. Estimated Pinniped Densities in the Proposed Study Areas

Species	Reported Sightings [1]	Number of Pinnipeds on sea ice and in the Water [2]	Estimated Density (sea ice and water) (no/km^2) [2,3]
Crabeater[4]	-	-	0.868000
Leopard	17	24	0.051948
Ross	42	59	0.127201
Weddell[5]	-	-	0.0756

Table 16. Estimated Pinniped Densities in the Proposed Study Areas

Species	Reported Sightings [1]	Number of Pinnipeds on sea ice and in the Water [2]	Estimated Density (sea ice and water) (no/km^2) [2,3]
Elephant[6]	0	0	0
Antarctic Fur[6]	0	0	0

Notes:

[1] Sightings 12/3-12/16/99 below 60^0 S latitude between 110 to 165^0 E longitude. All sightings were animals hauled-out of the water and on the sea ice (see Table 14).

[2] Assumes 40% of sighted pinnipeds are in the water.

[3] This sighting data was converted to an areal density by dividing the number of animals observed by the estimated area observed during the survey, a 462 km^2 study area for the AAD survey (see Table 15).

[4] Reported density of 0.62 animals / km 2 from Southwell et al 2008 and includes both definite and probable crabeater seal observations and was used to estimate the density of animals both on sea ice and in water..

[5] Estimated density of 0.054 animals/km^2 for animals in the water was derived from NOAA input (2013, H. Goldstein, personal communication), and was used to estimate the density of animals both on sea ice and in water.

[6] No densities for elephant seals and Antarctic fur seals were calculated because preferred habitat for these species is not within the project area.

3.3.7 Endangered Species

Marine organisms inhabiting the 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. No fish or benthic invertebrates in the Southern Ocean are considered endangered in the IUCN Red List. Table 17 identifies the status of penguin and marine mammal species in the Southern Ocean. Three marine mammal species are identified as endangered by IUCN are blue, fin, and sei whales.

Table 17. 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, Kerguelen 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

Table 17. IUCN Red List and CITES Species – Southern Ocean

Common Name(s)	Red List Category	CITES
Arnoux's beaked whale	DD ver 3.1 (2008)	App I
Pygmy right whale	DD ver 3.1 (2008)	
Commerson's dolphin	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
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)	
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)	

Notes: 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.

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. They are listed in the three CITES Appendices, with data compiled and provided by the UNEP World Conservation Monitoring Centre. Table 17 also indicates those species that are included in one of the CITES Appendices.

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 the 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 18 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 18. Status of ESA-listed Species Found in the Southern Ocean

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; Leather back turtle potentially present in the transit to and from the study area.				

NOTES: 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. NSF consulted the published FWS listing of foreign species and noted that no Antarctic species are on the list.
http://ecos.fws.gov/tess_public/SpeciesReport.do?lead=10&listingType=L
Source: NOAA Fisheries, April 2013
The request for 'take' under the Endangered Species Act is located in Table 22

3.4 Protected Area Status

Two areas in the Dumont d'Urville Sea are under consideration as designated Marine Protected Areas (MPAs) and, if adopted, would be managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The areas contain distinctive deep-water flora and fauna and support important ecosystem roles, such as feeding areas for marine mammals, penguins and other seabirds. These proposed MPAs are being developed by Australia, France, and the European Union for the purpose of protecting the resources and biodiversity of the East Antarctic region. The two planned MPAs encompass both of the research areas for the proposed action including the Wilkes Subregion MPA (from 110°E to 137°E) and the Oates Region MPA (from 137°E to 150°E). It is anticipated that the MPAs may be designated as early as October 2014.

In addition, CCALMR has defined two Vulnerable Marine Ecosystems (VMEs) in the Dumont d'Urville Sea in which bottom fishing is prohibited. Both of these locations are within the MG/CIS study area. These VMEs encompass the seafloor in a radius approximately 18.5 km from 65°47.97'S 142°59.43'E and 65°39.61'S 140°27.90'E.

4.0 ENVIRONMENTAL ANALYSIS

This section of the IEE/EA identifies the potential environmental effects resulting from the proposed activities in Alternatives A. Potential environmental effects resulting from Alternative B would likely be similar to Alternative A since fewer animals would be in the area. The direct effects of the proposed actions include interactions with the environment such as physical changes or entities imposed on or released to the environment. The proposed actions involve the use of an acoustic source for seismic surveying, operation of transducer-based instruments (e.g., ADCP, sonar), and collection of sediment and rock samples from the seafloor. These activities would result in the release of acoustical energy to the underwater environment, physical disturbance of the seafloor, and the irretrievable deployment of certain devices and equipment.

The PEIS defined the preferred alternative as the use of low-energy acoustic sources with generic mitigation measures and sets up a framework for the preparation of subsequent environmental documents. Thus, the analysis of site-specific impacts from the proposed action and relevant mitigating measures is presented in this IEE/EA and is described below.

4.1 Acoustic Outputs

During the seismic and bathymetric surveys, multiple acoustic sources would be operating simultaneously and emitting sound energy to the marine environment. Acoustical energy released by the airguns would attenuate with distance from the source. Transducer-based instruments release pulsed and highly directional acoustic energy that is significantly less intense outside the focus of the beams. Although sounds emitted underwater from multiple sources are additive, the logarithm scale which characterizes sound energy causes the most intense sound source to be dominant while less intense sources contribute little to the overall sound energy received by a receptor.

The acoustic outputs from the airguns and the transducer-based instruments emit sufficient energy to be detected by many marine organisms including marine mammals a considerable distance from the source. If exposed to high sound levels, potential adverse effects to marine organisms may include behavioral disturbance, masking of natural sounds, injury and under extreme conditions to marine mammals, temporary or permanent hearing impairment.

A description of potential impacts to each type of biological community that may result from acoustic outputs during seismic studies is presented below.

4.1.1 Marine Invertebrates

There are currently no quantitative data indicating the effects of the proposed action would adversely affect a population of marine invertebrates. Extrapolation from several studies suggests that a small number of some species or developmental stages of individual invertebrates could theoretically sustain injurious effects if they are within several meters of an operating source; however, the number of invertebrates potentially disturbed in this way would not be expected to exceed the number disturbed under natural conditions.

4.1.2 Fish

Fish in proximity to the proposed activities may potentially be affected by acoustical outputs. Generally, physiological damage or mortality in fish would only be realized if an organism was extremely close to one of the acoustic sources.

Based on the available information, fish populations expected in the survey area would be limited to small numbers of Nototheniiformes. The potential impacts of scientific research using seismic surveys on marine fish populations in Antarctica are not predicted to be significant (NSF, 2011). Potential impacts as a result of exposure to airgun acoustic releases primarily include short-term behavioral or possibly physiological impacts to small numbers of individuals. The small number of individual fish that could potentially experience injurious or mortal impacts when within a few meters of a high-energy acoustic source is considered insignificant on a population scale.

Short-term behavioral effects such as localized displacement or disturbance of individual fish are the most likely effects expected. It is unlikely that fish individuals would remain sufficiently near an acoustic source to be exposed to a harmful noise level. Avoidance reactions are to be considered reversible and the organisms are expected to return to the area after the vessel departs. Overall, effects on fish are expected to be minor and transitory.

4.1.3 Sea Turtles

Because sea turtles are not expected to be present in the study area, no impacts to any of their populations are expected. However, they may be observed during the transit to and from Hobart, Australia.

4.1.4 Seabirds

There are no scientific data indicating or suggesting that seabirds are adversely affected by seismic airguns or other sound sources used during typical seismic surveys. Moreover, thousands of hours of observational data by observers during numerous seismic surveys throughout the world suggest that seabirds do not remain in the water near airgun acoustic sources where they would be at potential risk of injury. Therefore, acoustic impacts of airguns on seabirds would be limited to temporary displacement of individuals (avoidance response), and no significant impacts are expected at the population level for all seabird species.

4.1.5 Penguins

There is very little information available to suggest that the underwater sounds at the intensity level expected during the proposed seismic and bathymetric surveys would have an adverse impact on penguins. It is likely that the vessel could encounter penguins during the seismic survey since this area lies within the 550-km foraging range that penguins travel from established colonies (SCAR, 2002). If encountered, it is likely that penguins would be diving and foraging for food. Similar to impacts to seabirds, there would be no significant impacts to individual penguins or their populations expected from the proposed seismic surveys (NSF, 2011). Impacts to penguins, if any, would be limited to avoidance responses and would not likely result in exposure to harmful sound levels. Overall, the impact to penguins from acoustic outputs is considered to be minor and transitory.

4.1.6 Marine Mammals

Current NMSF Guidelines

If exposed to high sound levels, potential adverse effects to marine mammal species may include behavioral disturbance, masking of natural sounds, physiological stress and, under extreme conditions, temporary or permanent hearing impairment resulting in injury or mortality. Under the U.S. Marine Mammal Protection Act (MMPA), a "take" is defined as any action to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. The term "harassment" was further defined in the 1994 amendments to the MMPA as any act of pursuit, torment, or annoyance, at two distinct levels:

- Level A Harassment – potential to injure a marine mammal or marine mammal stock in the wild.

- Level B Harassment – potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavior patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Based on current NMFS guidelines, the threshold for received pulse levels that may result in injury or hearing impairment to marine mammals (i.e., Level A Harassment) is defined as ≥ 180 dB re 1 μPa (rms) for cetaceans and ≥ 190 dB re 1 μPa (rms) for pinnipeds. The threshold sound level that is expected to cause marine mammals to display avoidance reactions (behavioral disturbance, i.e., Level B harassment) is defined by NMFS as ≥ 160 dB re 1 μPa (rms). The NMFS guidelines were incorporated into the mitigating measures in the PEIS to prevent marine organism exposure to sound levels that may potentially result in physiological damage or hearing impairment (i.e., Level A harassment).

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.

Pending NMFS Guideline Revisions

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 currently 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, which suggest that: 1) hearing impairment effects to phocids differ from otariids, because of their inner ear anatomy, and; 2) that 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 NMFS' 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.)

Effects of the Proposed Action

No adverse effects to the marine mammals such as physiological damage or hearing impairment are expected to occur during the proposed action due to the implementation of monitoring and mitigation measures consistent with NMFS guidelines and the PEIS. During seismic and bathymetric surveying, effects on marine mammals are expected to be limited to short-term behavioral disturbance reactions exhibited by animals avoiding or being temporary displaced by acoustical sources such as the airgun array and narrowly focused transducer beams on the moving vessel (Level B Harassment). The acoustic outputs from the airguns and transducer-based equipment are not expected to mask underwater sounds used by marine mammals due to the short duration of the acoustic pulses even though some frequencies used may overlap with those used by certain cetaceans (SCAR, 2002).

The PEIS analysis determined that with implementation of the proposed monitoring and mitigation measures, impacts to cetaceans are expected to be limited to behavioral disturbance and localized avoidance in the area near the active airguns. This is expected to have negligible short- and long-term impacts on individual odontocetes, their habitats, and regional populations.

The PEIS also concluded that operation of transducer-based equipment is not likely to impact cetaceans. The intermittent and narrow downward-directed nature of these types of 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; such brief exposure to this sound is not expected to cause injury or PTS based on results of limited studies. The PEIS also concluded that any streamer and core-mounted pingers are also highly unlikely to affect cetaceans given their intermittent nature, their short-term and transitory use from a moving vessel, their relatively low source levels, their brief ping durations, and in the case of ancillary core sampling their relatively infrequent use.

A report on the effects of marine acoustics in the Southern Ocean by the SCAR concluded that airgun seismic surveys and transducer-based equipment are not considered a threat to marine mammal populations (SCAR, 2006). The SCAR report also documented that while acoustic outputs from transducer-based sources may create temporary behavioral changes and displace a small number of animals, their use is not considered a risk. Therefore, the effects of the proposed activities to marine mammals that may be encountered in the study area are expected to be minor and transitory. Overall, the disturbances that may result from the study activities are considered reversible and the animals are expected to return to the area after the vessel departs.

Coring and dredging 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, dredging, and sediment sampling.

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).

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.

Further details pertaining to potential effects from acoustic sources on different classes of marine mammals including pinnipeds and cetaceans are described below.

Pinnipeds

The six species of seals that may be present in the study area during the proposed action are expected to be mostly found near pack ice or coastal areas and not prevalent in open sea areas where the seismic survey would be conducted. Based on sightings data over a 13-day period (see Table 14), Table 19 provides an estimate of the frequency and number of pinnipeds that may be encountered during the 300-hr seismic survey.

With implementation of the proposed monitoring and mitigation measures (refer to Section 4.1), impacts of proposed seismic surveys to pinnipeds are expected to be limited to behavioral disturbance and, in some cases, localized avoidance of the area near the active airguns.

Table 19. Projected Number of Pinniped Encounters in the Study Area

Species	Estimated Density (sea ice and water) (no/km^2) [1]	Expected Sightings during the 300-hr Seismic Survey [2]	Expected Sightings during the 108-hr Icebreaking Operations [3]	Total Expected Sightings
Crabeater	0.868000	4,885	18,697	23,582
Leopard	0.051486	290	1,109	1,399
Ross	0.127201	716	2,740	3,456
Weddell	0.0756	425	1,628	2,054
Elephant[4]	0	0	0	0
Antarctic Fur[4]	0	0	0	0

Notes:
[1] See Table 16.
[2] Estimated sightings for seismic survey is estimated density (sea ice and water) multiplied by the area ensonified to 160 dB (rms) around the planned seismic lines (1005 m x 2 x 2800 km).
[3] Estimated sightings for icebreaking activities is estimated density (sea ice and water) multiplied by the area ensonified to 120 dB (rms) around the potential icebreaking tracklines (21.54 km x 1000)
[4] No sightings are expected for elephant seals and Antarctic fur seals because preferred habitat for these species is not within the project area.

These effects of the proposed action are expected to have negligible short- or long-term effects on individuals, habitats, and regional populations of pinnipeds. Because of prominent avoidance reactions, pinnipeds are not expected to be exposed to potentially harmful sound levels above 190 dB re 1 μPa (rms) during the seismic survey. If an individual pinniped experiences temporary hearing impairment, full recovery of hearing is anticipated once the organism is no longer exposed. No serious injury or mortality of pinnipeds is expected.

There are currently no data on the potential disturbance effects of echosounders or sub-bottom profilers on pinnipeds. Based on observed pinniped responses to underwater sounds and the narrowly focused nature of transducer produced acoustic releases, effects, if any, to pinnipeds are expected to be short-term or momentary startle responses of no lasting consequence to the organisms.

Mysticetes

Because mysticetes feed at high latitudes in summer, several species are expected to be in the area during the seismic survey, including blue, sei, minke, and humpback whales. As summarized for the sub-Antarctic region in the PEIS and separately corroborated by actual sightings data, some mysticetes are expected to be in the study area during the proposed action. Based on sightings data over a 52-day period (see Table 11), Table 20 provides an estimate of the frequency and number of mysticetes that may be encountered during the 300-hr seismic survey. The sightings data (Table 11) incorporates a correction factor of 5 that assumes that only 20% of the animals present were reported due to the presence of sea ice and other conditions that hindered their observation. As previously indicated in Tables 8 through 10, other mysticetes may be present in the study area as conservatively reflected by the data in the "unidentified whale" category. As indicated in the NMFS recovery plans for several endangered (blue, fin, sei whales), the lack of abundance estimates and population trend data for marine mammals in the southern hemisphere including animals which are not threatened hinders a traditional quantitative analysis of potentially affected organisms.

Table 20. Projected Number of Mysticetes Encounters in the Study Area

Common Name	Estimated Density (no/km^2) [1]	Expected Sightings during the 300-hr Seismic Survey [2]	Expected Sightings during the 108-hr Icebreaking Operations [3]	Total Expected Sightings
Blue whale	0.0008654	5	19	24
Fin whale	0.1003808	565	2,162	2,727
Humpback whale	0.1025441	580	2,218	2,798
Minke whale	0.0588439	331	1,267	1,599
Sei whale	0.0017307	10	37	47

Notes:
[1] See Table 13
[2] Estimated sightings for seismic survey is estimated density multiplied by the area ensonified to 160 dB (rms) around the planned seismic lines (1005 m x 2 x 2800 km).
[3] Estimated sightings for icebreaking activities is estimated density multiplied by the area ensonified to 120 dB (rms) around the potential icebreaking tracklines (21.54 km x 1000 km).

Auditory impairment or other non-auditory physical effects would be limited to exposures within short distances from the acoustic sources and unlikely, since mysticetes typically avoid seismic vessels (Richardson et al. 1995). Level B disturbances are not expected to result in long-term or significant consequences to disturbed individuals or their populations. Level A effects (injury, mortality) are highly unlikely.

Operation of MBESs, SBPs, and pingers is not likely to impact mysticetes. The intermittent and narrow downward-directed nature of the MBES and SBP acoustic sources would result in no more than one or two brief ping exposures to an individual mysticete given the movement and speed of the vessel and organism; such brief exposure to this sound is not expected to cause

injury or PTS based on results of limited studies of some odontocete species (PEIS Appendix E, NSF 2011).

Odontocetes

Odontocetes are highly mobile and often move seasonally, traveling to high latitudes for summer feeding. Based on sightings data presented in Table 11, Table 21 provides an estimate of the frequency and number of odontocetes that may be encountered during the 300-hr seismic survey. The sightings data (Table 11) incorporates a correction factor of 5 that assumes that only 20 percent of the animals present were reported due to the presence of sea ice and other conditions that hindered their observation. As indicated in Tables 6 through 8, other odontocetes may be present in the study area as conservatively reflected by the data in the "unidentified whale" and "unidentified dolphin" categories.

Table 21. Projected Number and Frequency of Odontocetes Encounters in the Study Area

Common Name	Estimated Density (no/km^2) [1]	Expected Sightings during the 300-hr Seismic Survey [2]	Expected Sightings during the 108-hr Icebreaking Operations [3]	Total Expected Sightings
Dolphin, Cruciger (hourglass)	0.0112496	63	242	306
Spectacled porpoise	0.0142783	80	308	388
Killer whale	0.0268259	151	578	729
Pilot whale	0.0103842	58	224	282
Sperm whale	0.0138456	78	298	376

[1] See Table 13
[2] Estimated sightings for seismic survey is estimated density multiplied by the area ensonified to 160 dB (rms) around the planned seismic lines (1005 m x 2 x 2800 km).
[3] Estimated sightings for icebreaking activities is estimated density multiplied by the area ensonified to 120 dB (rms) around the potential icebreaking tracklines (21.54 km x 1000).

The proposed airguns for the seismic survey have dominant frequency components of 2-188 Hz. This frequency range somewhat 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, although at progressively lower levels with increasing frequency. These frequencies overlap most, if not all, frequencies produced by odontocetes. 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.

Odontocetes 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. Similar to mysticetes, potential injuries (Level A exposures) are not likely due to behavioral avoidance.

Request for Take under the Endangered Species Act

The authors request non-lethal 'take' of odontocetes and mysticetes protected under the Endangered Species Act that may be in the area where proposed activities may occur during the the cruise. The estimated 'take' is listed in Table 22 and is based on the data provided in Tables 20 and 21.

Table 22. Take Request for Species Protected Under the Endangered Species Act Encounters in the Study Area

Common Name	Expected Sightings during the 300-hr Seismic Survey [2]	Expected Sightings during the 108-hr Icebreaking Operations [3]	Potential Take Expected in the Study Area
Blue whale	5	19	24
Fin whale	565	2,162	2,72,
Humpback whale	580	2,218	2,798
Sei whale	10	37	47
Southern right whale [1]	0	0	0
Sperm whale	78	298	376

Note:
[1]No take is requested for Southern right whales as this species is not anticipated to be present in the area where seismic and ice breaking activities would occur.

4.2 Physical Disturbances

Impacts resulting from coring activities would occur due to the inherent physical disturbance of the seafloor during sediment or rock sampling activities. In addition, there is a possibility that benthic organisms may be displaced or killed, if present. It is anticipated that the corers used to collect sediment in the Dumont d'Urville Sea region may extract up to 0.2 m^3 of material from the seafloor at each sampling location (10-cm diameter cores to 25 m depth).

At each of three locations, a dredge would be used to collect rock material on the seafloor and would disturb an area approximately 0.5 to 1.5 m wide along a 50 m long track (75 m^2). Four dredge samples would be collected from each site resulting in approximately 300 m^2 of disturbance along the 200 m of dredge line at each site. Therefore a total area 900 m^2 along 600 m of dredge line would be disturbed during the project.

During the proposed coring or rock dredging activities, it is anticipated that the resulting voids in the seafloor would quickly fill with sediment as the disturbed areas collapse and native material is redistributed by bottom currents. At coring sites, the disturbance would be minimal due to the relatively small penetrating profile of the corer and any affected benthic habitats would quickly re-establish due to infaunal mixing. Dredge sites would be carefully selected to avoid sensitive environments such as seamounts or corals (see also section 5.6). Impacts resulting from sediment sampling activities are expected to be minor and transitory.

When the sediment samples are retrieved from the seafloor, material may fall from the sampling device causing a temporary turbidity plume in the water column. Impacts resulting from the dispersal of sediment in the water column and deposition on the seafloor would be localized and would not significantly alter water quality or adversely impact benthic organisms.

4.3 Planned Releases

During proposed surveying activities, expendable XBT sensors may be released to the sea each day and would not be retrieved. The 2-kg XBT probes measure water temperature as each unit sinks while transmitting data through a wireline to the ship. Approximately 24 XBT probes are expected to be released and not recovered during the cruise. The deposition of these devices on the seafloor would be extremely localized events that would yield less than minor impacts.

Following their deployment, the steel railroad wheels to be used as anchors for the moorings and would not be retrieved, and would be released to the underlying sediments. Impacts resulting from the placement of the anchors may include smothering of underlying benthic organisms but the impacts would be localized and would not significantly alter benthic communities.

The number of expendable devices and mooring anchors released would be documented and reported per the requirements of the *USAP Master Permit*.

4.4 Accidental Releases

Potential releases to the environment may include accidental spills or leaks of fuel or other hazardous materials (oil, glycol) and the unexpected loss of equipment. Since accidental releases are not planned, their frequency, magnitude, composition, and resulting environmental effects cannot be projected in advance.

Accidental spills of fuel, oil, or other substances from vessel operations are possible but very unlikely based on previous experience. Over 10 years of operation the NBP has only experienced five spills, all of which have involved hydraulic fluid, as documented in the *USAP Master Permit* Annual Report for the years when these events occurred. Each spill incident represented the release of a small quantity of liquid (≤ 12 liters). Should an accidental release occur during the proposed surveys, specific resources would be available to minimize the migration of the material, facilitate cleanup, and remediate affected media. Should a spill or loss of equipment occur, the event would be documented and reported consistent with the requirements of 45 CFR §671 and the *USAP Master Permit.*

4.5 Endangered Species

No adverse impacts to endangered species are expected to occur during the proposed action. Endangered or threatened marine mammal species would not be exposed to harmful sound levels during the seismic survey that would result in injury or hearing impairment (Level A Harassment). Additionally, mitigating measures would be taken during seismic survey activities to immediately shut down the airguns if an endangered species is sighted and approaches the

MZ. In the event an endangered species enters the FMZ, it may experience short-term behavioral disturbance (Level B Harassment).

4.6 Protected Areas

No adverse impacts to populations of benthic organisms in the two proposed MPAs located in the Dumont d'Urville Sea are expected. The cores would disturb marine sediments in a 10-cm diameter area at each sampling location and any disturbed benthic habitats would be re-established through infaunal mixing.

Dredging activities would result in disturbed area up to 300 m^2 (1.5 m wide x 50 m long for each of four dredge samples) at each of three dredge locations. Because the total dredge sampling is small (approximately 900 m^2) and is intended to focus on benthic areas characterized by rocky conditions and, no adverse impacts to sensitive benthic habitats are expected. However, mitigation and reporting requirements contained in CCAMLR conservation measures 22-06b and 22-07 (Attachment F) would be followed if VMEs are encountered.

Mitigations include that if three or more VME indicator units are recovered at any one of the three sites, then no additional dredging would be conducted at that site within 1 nm radius of the dredges conducted, and the grantee would contact NSF. In addition, NSF would urge the grantee to contact the Southwest Science Center of the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) to provide the CCAMLR representative with information as stipulated in 22-06b.

4.7 Cumulative Impacts

Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. For example, the combined acoustic outputs from the seismic surveying activities along with the simultaneous use of transducer-based equipment (multi-beam sonar, sub-bottom profiler, ADCP) could be more significant than any of these sources operating individually.

Background underwater acoustic sources in Antarctic waters include the movement and grinding of ice floes, grounding of icebergs, wind, waves, precipitation, and earthquakes (SCAR, 2004). The proposed studies represent short-term events and would not incrementally increase background noise levels in the Dumont d'Urville Sea.

Potential biological receptors (including marine mammals, invertebrates, and fish) are expected to detect sounds emitted from the ship during the proposed survey activities and exhibit avoidance reactions before being exposed to sounds from multiple sources. The infrequent performance of seismic surveys in the area reduces the risk that individual animals may be cumulatively exposed to potentially disruptive or harmful sound levels. Cumulative impacts to seabirds including penguins would be negligible.

As described in the PEIS (NSF, 2011), impacts to marine mammals from low-energy seismic source surveys are expected to be limited to localized and short-term behavioral changes and no

impacts are anticipated at the regional population level. Thus, the proposed seismic survey would not cause chronic disruption of normal behavioral patterns or yield long-term displacement of marine mammals from preferred feeding or breeding areas. Furthermore, human-related activities in the Southern Ocean are comparatively limited when considered in the context of the global scale, and the few, relatively short, localized research cruises by the USAP or other nations (see Attachment G) would not have more than a negligible cumulative effect on marine mammals at the individual or population level. Planned monitoring and mitigation measures, which include visual monitoring and the use of mitigation zones, would serve to reduce the level of impact and the likelihood of cumulative effects.

It is possible that a long-migrating animal or population exposed during the proposed cruise could be exposed to anthropogenic sounds during migration to another location or region; seasonal migration patterns of some cetaceans and pinnipeds involve long distances. However, such exposures would be considered a series of short-term behavioral changes. There is no evidence that such short-term effects, whether considered alone or in succession, result in long-term adverse impacts to individuals or populations assuming important habitats or activities are not disturbed. Additionally, migrating marine mammals have been exposed to many anthropogenic underwater sound activities for decades in all ocean basins. Some of these populations continue to grow despite certain anthropogenic marine activities that have been shown to result in behavioral disturbances to some individuals. In summary, cumulative impacts to mysticetes, odontocetes, and pinnipeds are expected to be negligible and insignificant.

Coring activities in the Dumont d'Urville Sea would occur at approximately 65 discrete locations in the two study areas. Cumulatively, the effects of these sample collection activities on the seafloor would be highly localized, small scale, and therefore would not significantly alter the seafloor. The collection of rocky materials on hard substrates would be limited to 50-m long tracks using a dredge with a 0.5 to 1.5 m wide opening. These types of dredge samples typically recover glacial cobbles and stones with some epifaunal encrustations but would not otherwise severely disturb the bottom habitats. The cumulative effects of these sampling efforts are expected to be less than minor.

No cumulative impacts are expected to result from regular deployment of expendable instruments (XBTs) during the proposed activities. These devices would be released at various locations and would either sink to the seafloor or eventually wash ashore resulting in less than minor impact.

The study site is remote and difficult to access; therefore relatively few activities are conducted in it. Within the larger region of the marine environment off East Antarctic commercial fishing, tourism, and National Antarctic Program research cruises occur. Commercial fishing and tourism both occur at very low levels, if these types of vessels are encountered it is unlikely that the proposed research would impact them. National Antarctic Program research cruises also occur in low numbers. Efforts will be made to identify such cruises and coordinate with them to reduce potential impacts. The NSF has already reached out to Australian National Antarctic Program (lead by the Australian Antarctic Division), the program most likely to be operating in the area.

4.8 Impact Assessment Summary

The potential environmental impacts associated with the proposed action in Alternative A to perform geophysical and physical oceanographic studies in two areas along the coast of East Antarctica have been identified and evaluated in this IEE/EA. Table 23 summarizes the potential environmental impacts and their significance. The potential environmental impacts associated with the proposed action under Alternative B would be similar to those identified with Alternative A.

The findings of this assessment indicate that the outputs associated with the proposed research activities would have minor and transitory effects on the marine environment in the Dumont d'Urville Sea. The underwater release of acoustic energy from the two-airgun array and transducer-based equipment, and icebreaking activities has the potential to cause transient behavioral changes in sensitive marine receptors. While the acoustic sources are not expected to cause physiological damage to the biota, some organisms may experience short-term behavioral changes such as avoidance reactions. Short-term behavioral disturbances defined by NMFS as Level B Harassment of marine mammals are expected. These responses are likely to disappear either once the vessel leaves the area or the affected organism migrates outside the study area. Additionally, the short-term duration of the seismic survey and its relatively limited extent within the context of the Dumont d'Urville Sea portion of the Southern Ocean would minimize the risk of causing significant adverse effects to a population of marine organisms inhabiting the region. Considering these factors, it is not expected that marine organisms would be exposed to noise of sufficient intensity and duration to cause injury or permanent behavioral changes.

The No Action Alternative (Alternative C) would preclude the collection of the proposed seismic and bathymetric survey data and hinder the geophysical and physical oceanographic investigation of the Dumont d'Urville Sea. Data related to dynamics of the Totten Glacier system and its relationship to the larger East Antarctic Ice Sheet (EAIS), and the flux of Southern-sourced deep water to the rest of the world's oceans would not be collected and would not be available to the science community. Loss of these data would be significant.

Table 23. Summary of Potential Impacts from Geophysical and Oceanographic Studies in the Dumont d'Urville Sea

Activity	Output	Environmental Impacts[1]					
		Affected Environment	Duration	Extent	Intensity	Probability	Environmental Rating
Conduct Seismic Survey	Acoustic Releases (2-airgun array)	Cetaceans, Penguins, Pinnipeds, Fish	Short-term (≤ 300 hours)	5,628 km^2	Low (reversible)	Likely	2
		Benthos				Unlikely	0
Conduct Bathymetric Surveys	Acoustic Releases (single-beam echo sounder, multi-beam sonar, ADCP)	Cetaceans, Penguins, Pinnipeds, Fish	Short-term (≤ 31 days)	2 areas (TG/MUIS and MG/CIS) + transit	Low (reversible)	Possible	1
		Benthos				Unlikely	0
Conduct Visual Survey Using Towcam	Acoustic Releases (altimeter, pinger)	Cetaceans, Penguins, Pinnipeds, Fish	Short-term (< 31 days)	2 areas (TG/MUIS and MG/CIS)	Low (reversible)	Unlikely	0
		Benthos				Unlikely	0
Collect Sediment Cores	Acoustic Releases (pinger)	Cetaceans, Penguins, Pinnipeds, Fish	Short-term	Localized ≤ 65 locations	Low (reversible)	Unlikely	0
		Benthos				Unlikely	0
	Physical Disturbances	Seafloor (soft sediments)	Short-term	Localized ≤ 65 locations	Low (reversible)	Certain	1
		Benthos			Low	Unlikely	1
Collect Rock Dredge Samples	Physical Disturbances	Seafloor (hard substrates)	Short-term	Localized ≤ 12 locations (900 m^2 total)	Moderate	Certain	2
		Benthos				Likely	1
Collect Water Samples and C/T/D, Current Measurements	Acoustic Releases (pinger)	Cetaceans, Penguins, Pinnipeds, Fish	Short-term	Localized ≤ 120 locations	Low (reversible)	Unlikely	0
		Benthos				Unlikely	0
	Physical Disturbances	Water Column	Short-term	Localized ≤ 120 locations	Low (reversible)	Certain	0
Deploy XBTs	Material Releases	Dumont d'Urville Sea	Long-term	~24	Low	Unlikely	0
Conduct Icebreaking	Acoustic Releases	Cetaceans, Pinnipeds	Short-term (≤ 108 hours)	21,540 km^2	Low (reversible)	Likely	2

Operate the NBP in Study Areas	Operational Outputs (acoustic, air emissions, wastewater, mechanical)	Dumont d'Urville Sea	Short-term (≤ 31 days)	Localized	Low	Unlikely	0
	Accidental Releases/Spills	Dumont d'Urville Sea/Ice Floes	Long-term	Localized	Low-Moderate	Highly Unlikely	0

Table 23 Notes:
TG/MUIS = Totten Glacier and Moscow University Ice Shelf
MG/CIS = Mertz Glacier and Cook Ice Shelf
[1] The potential environmental impacts associated with the proposed action under Alternative B would be similar to those identified with Alternative A.
[2] Total length of survey; up to 300 hours of operation; individual receptors are not likely to be exposed over the entire survey.

Environmental Rating:
+ = environmental improvement
0 = no substantial effect or highly unlikely
1 = minor, short-term effect
2 = minor effect that continues for a limited period of time after the activity is completed
3 = minor, localized long-term effect
4 = environmental effects may be substantial or long-term

5.0 COORDINATION WITH OTHER AGENCIES

This document will be used as supporting documentation for an IHA application submitted by NSF to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals during this proposed seismic survey. Potential impacts to endangered species and critical habitat have also been assessed in the document; therefore, it will be used to support the ESA Section 7 consultation process with NMFS and USFWS.

NSF will coordinate the planned marine mammal monitoring program associated with the seismic survey with any parties that express interest in this survey activity. USGS have coordinated, and will continue to coordinate, with other applicable Federal agencies as required, and will comply with their requirements.

NSF is also consulting and coordinating proposed activities with the Australian Antarctic Division through CCAMLR about designated VMEs and other research that has been or will be conducted in East Antarctica.

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