RECORD OF DECISION

for

Marine Seismic Research

Funded by the National Science Foundation

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I. INTRODUCTION

Established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended), the National Science Foundation (NSF) is the federal government's only agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. In accordance with the Act, NSF's mission is to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." The primary roles of NSF are to support and fund the Nation's academic-based research in science and engineering, enhance the quality of education, and ensure that the U.S. maintains leadership in scientific discovery and the development of new technologies.

The Directorate for Geosciences (GEO), a Directorate within NSF, supports research in the atmospheric, Earth, and ocean sciences and is the principal source of federal funding for university-based fundamental research in the geosciences. GEO addresses the nation's need to know more about how our planet is structured, how it works as a system, and through its research support, improves our ability to understand, predict, and respond to environmental events and changes. GEO-supported research also advances our ability to locate new resources and understand and predict natural phenomena of economic and human significance, such as climate change, weather, earthquakes, tsunamis, and solar-atmosphere interactions.

Research for understanding the nature of the Earth's crust and dynamic processes often begins with seismic exploration. The opportunities for research using marine seismic data to understand the natural forces that shape and change our planet have never been greater than they are today. Major advances in data storage and microprocessor technology have allowed the development of a new generation of instruments for conducting marine seismic research and visualizing the results. These advances make it possible to probe deep beneath the oceans and observe Earth's interior and to carry out a whole new class of seismic research in the oceans, including discovering records of sea-level rise that are key to understanding global climate change, and mapping the deep structure and active geological processes along fault zones, which may give clues about fault behavior that lead to tsunami-generating earthquakes (Multichannel Seismic [MCS] Advisory Board 2006).

NSF has funded marine seismic research for over 50 years. Typically, four to seven NSF-funded marine seismic research cruises are conducted each year. These cruises are conducted across the world's oceans including the Gulf of Mexico, Caribbean Sea, Mid-Atlantic Ridge, North Atlantic, Norwegian Sea, Arctic Ocean, Bering Sea, Gulf of Alaska, Northeast Pacific, Eastern Tropical Pacific, and Southwest Pacific. More than one seismic research cruise at one time is rare. The final determination of specific cruise tracks includes multiple factors beginning with the research objectives of proposals recommended for award during panel reviews, the NSF research budget for a given fiscal year, vessel availability, and environmental considerations presented in this PEIS.

The purpose of the Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (hereafter called PEIS) is to address the environmental concerns for any NSF-funded marine seismic research, but the focus is for actions in the Divisions of Ocean Sciences and Earth Sciences within GEO. GEO is one of the primary research arms within NSF that provides funding for marine seismic research.

The U.S. Geological Survey (USGS) also conducts seismic research in support of its mission. In general, USGS marine seismic research is focused on federal offshore and trust territory land, but does occasionally include worldwide locations under special circumstances or collaborations. In light of USGS's similar activities, the NSF invited USGS to participate as a cooperating agency on the PEIS. Details regarding USGS activities can be found in detail in the PEIS and will not be described further in this document as the focus here is on the NSF actions and agency decision.

A. COOPERATING AGENCIES

NSF is the proponent for NSF-funded marine seismic research described in the PEIS and was the lead agency for the preparation of the PEIS. As defined in 40 CFR 1508.6, a cooperating agency may be any federal agency other than the lead agency that has jurisdiction by law or special expertise with respect to the environmental impacts expected to result from a proposal. An agency has "jurisdiction by law" if it has the authority to approve, veto, or finance all or part of the proposal (40 CFR 1508.15). An agency has "special expertise" if it has statutory responsibility, agency mission, or related program experience with regard to a proposal (40 CFR 1508.26). A lead agency must request the participation of cooperating agencies as early as possible in the NEPA process, use the environmental analyses and proposals prepared by cooperating agencies as much as possible, and meet with cooperating agencies at their request (40 CFR 1501.6[a]). A cooperating agency's responsibility includes participation in the NEPA process as early as possible, participation in the scoping process, and, on the lead agency's request, development of information to be included in the PEIS and providing staff support in its preparation (40 CFR 1501.6[b]).

The USGS agreed to be a cooperating agency for the Proposed Action in 2007. The nature and scope of the Proposed Action, which deals with marine seismic research, associated acoustic sources, and potential impact on marine resources, make it appropriate for the USGS to be a cooperating agency, even though the USGS conducts marine seismic research less frequently than NSF.

The National Oceanic and Atmospheric Administration (NOAA) agreed to be a cooperating agency for the preparation of the PEIS on NSF's Proposed Action. The nature and scope of the Proposed Action involving NSF's funding of seismic research, the use of associated acoustic sources, and potential impacts to marine resources under the jurisdiction of the National Marine Fisheries Service (NMFS), particularly marine mammals and sensitive marine species, including those listed or proposed for listing as threatened or endangered under the federal Endangered Species Act (ESA), led to NOAA's agreement to its participation as a cooperating agency. As a cooperating agency on the PEIS, NMFS is not proposing or authorizing any action through its participation in the programmatic NEPA analysis. NMFS has jurisdiction by law, as well as special expertise on living marine resources, including marine mammals and sea turtles. NMFS served as a technical expert to ensure that the PEIS contained acceptable analyses of impacts of underwater sound on marine mammals and a proper characterization of the general process for authorizing the incidental take of marine mammals under Sections 101(a)(5)(A) and (D) of the Marine Mammal Protection Act (MMPA). NMFS carried out its responsibilities as a cooperating agency in accordance with the procedures set forth by CEQ at 40 CFR 1501.6. Therefore, in addition to the regulations and requirements discussed elsewhere in this document, the PEIS was reviewed in accordance with NOAA Administrative Order Series 216-6, *Environmental Review Procedures for Implementing the National Environmental Policy Act* (May 20, 1999).

B. PURPOSE AND NEED

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. The Proposed Action is for academic and U.S. government scientists in the U.S., and possible international collaborators, to conduct marine seismic research from research vessels owned or operated directly by or on behalf of U.S. government agencies, including but not limited to UNOLS, contracted, and chartered vessels. The purpose of the Proposed Action is to fund the investigation of the geology and geophysics of the seafloor and subseafloor by collecting seismic reflection and refraction data that reveal the structure and stratigraphy of the crust and/or overlying sediment below the world's oceans. NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. Data collected from marine seismic surveys have allowed scientists to accomplish goals such as, but not limited to: validating the theory of plate tectonics; imaging ocean faults (key to studies of earthquake and landslide hazards); evaluating the potential for tsunami generation; and imaging magma chambers in volcanoes or mid-ocean ridges.

The funding and conducting of marine seismic research would continue to meet NSF's critical need to foster a better understanding of Earth's history, natural hazards, and climate history such as described in the PEIS. In addition to specific marine seismic research, geoscience exploration through ocean drilling has been an ongoing effort by NSF with international partners since the early 1970s. Seismic reflection surveying is a critical, required element for every site that gets drilled under the auspices of the Integrated Ocean Drilling Program (IODP), as well as under the program's predecessors: Ocean Drilling Program and Deep Sea Drilling Project. NSF prepared a separate EIS for IODP activities which is available at: http://www.nsf.gov/geo/oce/envcomp/.

C. Programmatic Approach

Currently, NEPA documentation is prepared for individual or a small group of research cruises. Between 2003 and 2009, NSF prepared 31 EAs assessing the impact of seismic surveys for research projects investigating the geology and geophysics of the seafloor. The main focus of the EAs was on sound propagation from the seismic sources and potential impacts to the environment, including marine species listed under the MMPA and ESA. The EAs have been used to provide the necessary information to initiate and conduct informal or formal consultation with the NOAA Office of Protected Resources (OPR) and the U.S. Fish and Wildlife Service (USFWS) under section 7(a)(2) of the ESA. For research cruises with the potential for adverse impacts to listed species, NOAA OPR and/or USFWS have issued a Biological Opinion and related Incidental Take Statements, which included terms and conditions to minimize impacts on threatened and endangered species. In parallel with this effort, when applicable, a separate application for an Incidental Harassment Authorization (IHA) under Section 101(a)(5)(D) of the MMPA was submitted for each cruise to another division within NOAA OPR, which subsequently issued the IHA.

NSF and the USGS decided that a Programmatic EIS/OEIS would minimize duplication of effort in environmental documentation and would address the potential for cumulative effects of marine seismic research acoustic sources upon marine resources. The PEIS addressed a variety of acoustic sources used for research activities conducted from various research vessels operated by U.S. academic institutions or government agencies. A variety of other geoscience research activities, such as, but not limited to, mapping, scientific dredging, drilling, and coring, might also be conducted on any seismic research cruise.

The programmatic NEPA approach provides a format for a comprehensive cumulative impacts analysis by taking a view of the planned marine seismic research activities as a whole. This is accomplished by assembling and analyzing the broadest range of direct, indirect, and cumulative impacts associated with all marine seismic research activities in addition to other past, present, and reasonably foreseeable projects in the region of influence. Furthermore, the collective analysis of representative project locations will provide a strong technical basis for a more global assessment of the potential cumulative impacts of NSF-funded and USGS marine seismic activities in the future. Subsequent project and cruise-specific NEPA documents or other appropriate environmental documents would, as appropriate, use or refer to this PEIS and address the potential impacts of specific cruise- and site-specific actions.

D. PROJECT DESCRIPTION

Under the Proposed Action, a variety of acoustic sources used for research activities funded by NSF would be operated from various research vessels operated by U.S. academic institutions or government agencies. The seismic acoustic sources would include various airgun configurations (particularly strings or arrays with as little as 2 to as many as 36 seismic airguns), as well as towed low-energy sources including swept frequency modulated (FM) chirp systems, sparker, and boomer type sub-bottom profilers (SBPs). Non-seismic acoustic sources would include multibeam echosounders (MBESs), SBPs, acoustic Doppler current profilers (ADCPs), fathometers, pingers, and acoustic releases. A variety of other geoscience research activities, such as, but not limited to, mapping, dredging, drilling, and coring, might also be conducted on any seismic research cruise funded by NSF.

D.1 NSF-funded Marine Seismic Research and Methods

Under the Proposed Action, marine seismic surveys funded by NSF may take place across the world's oceans, including the Atlantic, Pacific, Indian, Arctic, and Southern Oceans, and in the Mediterranean Sea, and may be located in the Exclusive Economic Zone (EEZ) or territorial waters of the U.S. or foreign countries. About 4-7 cruises are conducted each year with cruises lasting about 1-7 weeks, are generally more than 3 nautical miles (nm) (5.6 kilometers [km]) off the coast, and primarily utilize high-energy source systems such as strings or arrays of 6-36 airguns. The amount of time in which seismic operations are conducted during any specific research cruise may range from 20 to >800 hours (hr) and depends upon the objectives of the research and the requirements of the geophysical study. Seismic operations generally occur in deeper, open ocean waters but can range from <328 feet (ft) (100 meters [m]) to >26,247 ft (8,000 m). The research vessels have the capability of towing different airgun configurations, depending on the need of the research and the scientific objectives. A variety of other research can also be conducted on NSF-funded marine seismic research cruises, including, but not limited to, mapping, water sampling, and scientific dredging, drilling, and coring.

Under the Integrated Ocean Drilling Program (IODP), seismic reflection profiling is an essential technology required for characterization of scientific drilling objectives, as well as for characterization and mitigation of hazards due to environmental factors, and managing the potential safety and pollution risks (e.g., avoiding submarine hazards or the environmental dangers that result from drilling into gas zones or other potential pollution sources). The PEIS also addressed the acoustic sources proposed for use by the IODP's Scientific Ocean Drilling Vessel (SODV).

Seismic surveys use the principle of an active sound source (controlled sound source) and receiver system. The 'source' for marine seismic operations is most often a group (array) of airguns that are towed behind a research vessel moving approximately 4 nautical miles per hour (knots [kt]) (7 km per hour [km/hr]). Airguns produce low-frequency (10–50 hertz [Hz]) sound by releasing bubbles of compressed air every 5-60 seconds (sec). This sound propagates through the ocean floor, sometimes up to 19 miles (mi) (30 km) below it, and is reflected or refracted back by geological discontinuities or velocity gradients

(See PEIS, Figure 2-1). For seismic reflection studies, the 'receiver' is usually a long (0.6-3.7 mi [1-6 km]) string of hydrophones (streamer) towed behind the research vessel to record the reflected sound (echoes). Sophisticated computer algorithms process the multiple channels of seismic data (i.e., MCS) and construct a sub-surface map of the Earth's internal structure. Depth to the structures is calculated by measuring the amount of time it takes for the sound to make its round trip from the near sea surface (airguns) to the structures and back to the hydrophones. This total time can be converted to depth below the seafloor. For seismic refraction studies, ocean bottom seismometers/hydrophones (OBS/Hs) are often used to record the seismic signals. These bottom instruments remain stationary on the seafloor and generally provide better signal-to-noise ratios for seismic signals compared to older sonobuoy technology of hydrophones suspended from a buoy floating (and drifting) at the sea surface. Sonobuoys, however, are still sometimes used to address specialized research problems for which OBS/Hs are not practical. In the 1960s, airguns rapidly replaced the initial use of explosives as the sound source for marine seismic work and remain the most effective sound source presently available. As will be presented, variations in the typical airgun array and towed hydrophone streamer configuration exist and are used in circumstances that favor other methods.

In addition to conventional airguns and similar systems (e.g., water guns and generator-injector [GI] guns), marine seismic researchers can utilize a variety of other seismic sources within a wide range of frequencies in order to carry out operations in a variety of environments. High frequency seismic systems provide the highest resolution, but are limited in amount of penetration below the sea floor. Low frequencies yield more penetration, but less resolution.

When selecting a system or systems to use in a prospective study, the research objectives and survey environment, or geologic setting, will dictate system choice. For example, a seismic survey might be designed to determine sediment lithologies, delineate stratigraphic boundaries, map submarine slide deposits, or find specific features (e.g., migrating gas, carbonate deposits). Often an investigator will operate multiple seismic-reflection systems simultaneously. One consideration in designing survey systems is the trade-off between range, or penetration, and resolution. In the marine, lacustrine, or estuarine environments, the best seismic source is determined primarily by the water depth, the type of sediments/rocks in the substrate, and the desired depth of penetration. Additionally, logistical parameters including cost, boat size, ship and crew availability, weather, and environmental factors (ambient noise, ship traffic, etc.) enter into the decision about which seismic source(s) will be used for a given marine seismic survey.

In addition to airguns or other active seismic acoustic sources, other 'non-seismic' acoustic sources, including MBESs, SBPs, ADCPs, fathometers, and pingers, are used during proposed NSF-funded marine seismic research activities. The following sections describe the various seismic acoustic sources (e.g., airguns, GI guns, water guns, sparkers, boomers, and chirp systems) and non-seismic acoustic sources (e.g., MBESs, SBPs, etc.) that may be used by NSF-funded researchers when conducting marine seismic research.

D.1.1 Seismic Acoustic Sources Used in Marine Seismic Research

Airguns and Airgun Arrays

The most common acoustic source for marine seismic research is airguns, the first of which was introduced in the 1960s. An airgun is essentially a stainless steel cylinder charged with high-pressure air (PEIS, Figure 2-2). The seismic signal is generated when that air is released nearly instantaneously into the surrounding water column. The compressed air is supplied by compressors on board the source vessel. Seismic pulses are typically emitted at intervals of 5-60 sec, and occasionally at shorter or longer intervals.

Airgun Operating Principles. An airgun is a pneumatic sound source that creates predominantly low-frequency acoustic impulses by generating bubbles of highly compressed air in water (PEIS, Figure 2-3). Compressed air is fed into the main chamber while the solenoid is closed (PEIS, Figure 2-3, Charge). Once the solenoid valve opens (i.e., the airgun is "fired"), the shuttle moves releasing the air into the surrounding water column (PEIS, Figure 2-3, Discharge). This rapid release of highly compressed air, typically at pressures of 2,000 pounds per square inch (psi), from the airgun chamber generates an oscillating air bubble in the water. The effect is similar to popping a balloon – when the high-pressure air inside the balloon is quickly expelled into the surrounding medium (air), a pressure pulse is created, and this is perceived by a listener as a loud sound. In the case of airguns, expansion and oscillation of the air bubble(s) in the water column generates a strongly peaked, high-amplitude acoustic impulse that is useful for seismic profiling.

The main features of the pressure signal generated by an airgun are the strong primary peak and the subsequent bubble pulses or 'bubble train'. For each airgun, the amplitude of the seismic signal is a function of the volume and pressure of the air inside the airgun and the airgun's depth under the water surface. For the marine seismic researcher, the train of bubble pulses is an undesirable feature of the airgun signal because it interferes with the detection of distinct sub-bottom reflections. Therefore, in order to both increase the pulse amplitude (to see deeper into the Earth) and dampen the bubble train quickly, marine seismic researchers generally combine multiple airguns together into arrays. Airgun arrays provide several advantages over single airguns for deep geophysical surveying:

- Airgun arrays, when designed appropriately, project maximum peak levels toward the seabed (i.e., in the vertical direction) and notably lower levels in some or all near-horizontal directions.

- By utilizing airguns of many different volumes that are spaced optimally, airgun arrays may be "tuned" to increase the amplitude of the primary peak and simultaneously decrease the relative amplitude of the subsequent bubble pulses.

Types of Airguns. Geophysicists use several different kinds of airguns for seismic surveying, depending on the application. Most commonly used is an airgun that utilizes the motion of an internal shuttle to release pressurized air from the gun chamber through several venting holes (ports) on the gun casing. Conventional airguns are available with a wide range of chamber volumes, from under 5 cubic inches (in^3) to over 2,000 in^3, and are used for many different applications from shallow-hazard surveys (requiring small airguns) to deep crustal studies (requiring large airguns). Due to the high pressures involved in their operation, traditional airguns are subject to wear from significant recoil forces (due to the motion of the shuttle), which hampers their reliability. Thus modern airguns, such as "recoilless" G-guns and sleeve-guns, have been developed with improved firing mechanisms to overcome some of the reliability issues associated with conventional airguns. However, the principle of operation remains the same and the acoustic overpressure waveforms produced by these modern airguns are very similar to those of traditional airguns.

A GI gun is a specialized kind of airgun that produces a different overpressure signature than conventional airguns. GI guns utilize two, independently fired air chambers (the "generator" and the "injector", respectively) to tune the air bubble oscillation and minimize the amplitude of the bubble pulse. Using one or more GI guns, the geophysicist can achieve very high peak-to-bubble amplitude ratios without an array. GI guns are often used for shallow, high-resolution seismic profiling.

For the purposes of this PEIS, the various types of airguns (e.g., traditional airgun, G-guns, and GI-guns) will all be referred to simply as 'airguns' unless it is important within the discussion to specifically state which type of seismic device is being addressed.

Water Guns

Water guns are another category of pneumatic sound source that is occasionally used for marine geophysical surveys as an alternative to airguns. Water guns generate frequencies on the order of 20-1,500 Hz depending on the size of the air chamber. The water gun is similar to the airgun, but unlike airguns, water guns are implosive rather than explosive and are more effective at collapsing the bubble pulse, thus generating a cleaner signal. The 15 in^3 water gun is an excellent source for shallow-water, high-resolution studies. The water gun is divided into two chambers: the upper firing chamber, which contains compressed air, and the lower chamber, which is filled with water. When the gun is fired, the compressed air forces the shuttle downward and this expels the water from the lower chamber. Because no air is released, there is no bubble pulse. The shot of water leaving the gun creates a void behind it and the collapse of water into this void creates an acoustic wave. High air pressure and small chamber size yield a higher frequency signal (high resolution and shallow penetration), whereas, low air pressure and large chamber size yield a low-frequency signal (low resolution and deep penetration). Water guns, like airguns, can be used individually or in arrays. The return signals are received by a towed hydrophone array.

Sparkers

Sparkers are electrical seismic sources that generate acoustic pulses by vaporizing seawater using high-voltage electrical currents. Sparkers employ banks of capacitors to generate voltages, which are then discharged across pairs of underwater electrodes that are separated by seawater. The spark generated by the electrodes creates steam bubbles in the water. The formation, oscillation, and collapse of these bubbles generate a strongly spiked acoustic pulse that can penetrate several hundred meters into the seafloor and that is useful for high-resolution seismic profiling. The sparker is one of the oldest marine seismic sources, and many different kinds of sparkers are currently in use.

Boomers

Boomers are electromechanical sound sources that generate short (≤ 1 millisecond [ms]), broadband acoustic pulses in the 300-3,000 Hz range useful for high-resolution, shallow-penetration sediment profiling. The acoustic impulse from a boomer is generated when two spring-loaded plates are electrically charged causing the plates to repel, thus generating an acoustic pulse. Spatial resolution of the boomer system ranges from 1.6 to 3.2 feet (ft) (0.5 to 1 meter [m]) and penetration of the seafloor ranges from 82 to 164 ft (25 to 50 m). This system is commonly mounted on a sled and towed off the stern or alongside the ship. The reflected signal is received by a towed hydrophone streamer.

Chirp Systems

Chirp systems are a type of SBP that achieves deep bottom penetration while maintaining high resolution. They emit a 'swept'-frequency signal, meaning that the transmitted signal is emitted over a period of time and over a set range of frequencies. This repeatable (transmitted) waveform can be varied in terms of pulse length, frequency bandwidth, and phase/amplitude. A matched filter, or correlation process, collapses the swept FM received signal into a pulse of short duration, maximizing the signal-to-noise-ratio. The reflected signal is received by the same tuned transducer array that generates the outgoing acoustic energy. Chirp systems enable high-resolution mapping of relatively shallow deposits, and in general, have less penetration than the impulse-type systems (air or water guns, sparkers, and boomers). Newer chirp systems are able to penetrate to comparable levels as the boomer, yet yield extraordinary detail or resolution of the substrate.

D.1.2 Non-Seismic Acoustic Sources Used in Marine Seismic Research

Non-seismic acoustic sources are those acoustic sources that are used in support of seismic acoustic sources (i.e., airguns, waterguns, etc. that are used to map the subsea floor) and primarily consist of bottom mapping echosounders, acoustic pingers used to detect or position equipment, current profilers, and acoustic releases.

Multibeam Echosounder (MBES) and Sub-bottom Profiler (SBP)

During marine seismic research activities, the ocean floor is usually mapped with an MBES and an SBP. Both systems are commonly operated simultaneously with the airguns. The MBES emits brief pings of medium- or high-frequency sound in a fan-shaped beam extending downward and to the sides of the ship, but not forward or aft. For operations in deep water (>3,281 ft [1,000 m]), the MBES usually operates at a frequency of 12-15 kilohertz (kHz), but for projects limited to shallow water (<328 ft [100 m]), a higher frequency MBES is often used.

The SBP is normally operated to provide information about the sedimentary features and the bottom topography that is simultaneously being mapped by the MBES. The energy from the SBP is directed downward by a 2.5-7 kHz transducer in the hull of the research vessel. The output varies with water depth from 50 watts in shallow water to 800 watts in deep water.

Pingers

Omnidirectional pingers would also be used during proposed marine seismic surveys to position or directionally locate the airgun arrays, hydrophone streamers, coring equipment, bottom cameras, or other supporting equipment. In addition, a 12-kHz pinger would normally be used only during those seismic survey cruises that have ancillary coring operations. The pinger is used to monitor the depth of the corer relative to the sea floor. It is a battery-powered acoustic beacon that is attached to the coring mechanism.

Acoustic Doppler Current Profiler (ADCP)

An ADCP can determine the speed and direction of water currents as a function of depth. This instrument can be placed on the seafloor, attached to a buoy, or mounted on a ship. The ADCP measures water currents with sound, using a principle of sound waves called the Doppler effect, and works by transmitting high frequency pings (normally 35-1,200 kHz) at a constant frequency into the water.

Acoustic Releases

OBS/Hs are self-contained data acquisition devices deployed from a survey ship and anchored to the sea floor (see below for more information on OBS/Hs). Once the OBS/H is ready to be retrieved, an acoustic release transponder interrogates the OBS/H with an omnidirectional 12-kHz signal with a source output of approximately 187 decibels referenced 1 microPascal at 1 m (dB re 1 μPa-m) and a ping duration of 8 ms. The burn wire release assembly is then activated, and the instrument is released from the anchor to float to the surface. Interrogation of an acoustic release is generally done while the ship is stationary or moving at very slow speeds.

D.2 Exemplary Analysis Areas

Due to the potential for NSF-funded marine seismic cruises to occur across the world's oceans, it was necessary to narrow the focus of the impact analysis presented in the PEIS to a number of representative or exemplary analysis areas. The exemplary analysis areas were selected in areas where it was considered likely that a future marine seismic research cruise would be proposed for NSF funding by a scientific investigator, while at the same time including analysis areas within a wide range of Longhurst Biomes. The pelagic biogeography by Longhurst was utilized as a guide to identify areas with similar ecological dynamics.

This concept describes how individual species are distributed in the ocean, and explains how these species aggregate to form characteristic ecosystems under regional conditions of temperature, nutrients, and sunlight exposure. Although Longhurst Biomes are extremely large, the biome concept provided a large-scale selection criterion. For the purposes of the PEIS, 13 exemplary (representative) analysis areas were proposed for analysis, as listed in Table 1: 5 areas were subject to detailed analysis [Detailed Analysis Areas (DAAs)] and 8 subject to qualitative analysis [Qualitative Analysis Areas (QAAs)].

Table 1. Detailed and Qualitative Analysis Areas

Site Name	*Survey Track Area*	*Latitude*	*Longitude*	*Longhurst Biome*	*Survey Season*
DAA					
Western Gulf of Alaska (W Gulf of Alaska)	Between Kodiak & Shumagin Islands	53°–55°N	151–159°W	Pacific Westerly Winds	Summer
Southern California (S California)	Santa Barbara Basin	35° N	120° W	Pacific Coastal	Late Spring/ Early Sum
Galapagos Ridge	W of Galapagos Islands	4°S	103.6°W	Pacific Trade Wind	Austral Sum
Caribbean Sea (Caribbean)	Offshore of Venezuela	12° N	65° W	Atlantic Coastal	Spring/Summer
Northwestern Atlantic (NW Atlantic)	Offshore of New Jersey	39.5° N	73.5° W	Atlantic Coastal	Summer
QAA					
British Columbia Coast (BC Coast)	Queen Charlotte Basin	52° N	129° W	Pacific Coastal	Fall
Mid-Atlantic Ridge	Deep water (>9,842 ft [3000m])	26° N	40° W	Atlantic Westerly Winds	Spring, Summer, or Fall
Mariana Islands (Marianas)	Marianas Islands	17° N	145° E	Pacific Trade Wind	Spring
Sub-Antarctic	E of New Zealand	42° S	145° W	Antarctic Westerly Winds	Austral Summer
Northern Atlantic/Iceland (N Atlantic/Iceland)	S of Iceland	59°–65° N	33°–25° W	Atlantic Polar	Summer
Southwestern Atlantic (SW Atlantic)	NE of Brazil	5° N	45° W	Atlantic Trade Winds	Anytime
Western India (W India)	W of India	20° N	65° E	Indian Ocean Coastal	Late Spring or Early Fall

Table 1. Detailed and Qualitative Analysis Areas

Site Name	*Survey Track Area*	*Latitude*	*Longitude*	*Longhurst Biome*	*Survey Season*
Western Australia (W Australia)	Offshore of NW Australia	18° S	120° E	Indian Ocean Coastal	Austral Spring or Fall

D.3 Acoustic Modeling

Under the Proposed Action, a variety of airgun configurations ranging from small arrays of 1-4 airguns to large arrays of 18-36 airguns, as well as other lower energy non-seismic acoustic sources including MBESs, SBPs, and pingers, would be operated. Because of the complexities and variability of sound propagation from these sources in different ocean environments, acoustic modeling is a key component in an effective scientific analysis of the extent of the potential acoustic impacts. As described previously, five exemplary areas were identified for detailed acoustic analysis, and a representative seismic survey scenario using airguns as the seismic acoustic source was modeled for each area.

For a quantitative assessment of the potential impact of an exemplary marine seismic survey on marine mammals, the predicted (modeled) seismic survey sound field was integrated with the expected distribution of marine mammals. A three-part process was followed in the PEIS:

1. Estimate the 3-dimensional (3-D) sound field while the airguns are operating at representative locations within the analysis area using an airgun array source model and a sound propagation model.
2. Estimate the 3-D locations and movements of simulated animals in space and time.
3. Integrate these two sets of model outputs to estimate the maximum and cumulative airgun sound that would be received by each simulated animal (in the form of Level A and B (as defined by the MMPA) exposures), and then assess the potential impact of the seismic survey sound source on a specific species or group.

The computer models used to develop these estimates were described in detail in Appendix B, *Acoustic Modeling Report*, of the PEIS. A further step in the analysis process was to assess, in a qualitative manner, how the impacts in eight additional scenarios would be expected to compare with those in the five scenarios analyzed in detail.

In the PEIS, the full process outlined above was applied for marine mammals. Marine mammals are a resource of particular concern with regard to seismic surveys. Also, marine mammals are the animals for which most progress has been made in identifying the specific sound exposure criteria that need to be defined in order to undertake a quantitative assessment of impact. Other resources were analyzed in a less detailed and more qualitative way, but taking into account specific impact criteria where available.

II. ENVIRONMENTAL COMPLIANCE

A. COMPLIANCE WITH NEPA

The PEIS was prepared by NSF in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [USC] §4321 et seq.); the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [CFR] §§1500-1508); NSF procedures for implementing NEPA and CEQ regulations (45 CFR 640); and

Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*. The NEPA process ensures that environmental impacts of proposed major federal actions are considered in the decision-making process. EO 12114 requires environmental consideration (i.e., preparation of an OEIS) for actions that may significantly affect the environment outside United States (U.S.) Territorial Waters. The Final PEIS satisfied the requirements of both NEPA and EO 12114.

A.1 Public Involvement

Official notification of NSF's Proposed Action began with the publication of the Notice of Intent (NOI) in the *Federal Register* on September 22, 2005. The NOI briefly summarized the Proposed Action; the scoping process; and the dates, times, and locations of the public scoping meetings.

A.1.1 Scoping Process

Scoping meetings were held in the following six communities that were expected to have public, agency, research institution, or industry interest in the Proposed Action: Silver Spring, Maryland; Woods Hole, Massachusetts; College Station, Texas; Anchorage, Alaska; San Diego, California; and Honolulu, Hawaii. An advertisement describing the Proposed Action was placed a week before the scoping meetings in local newspapers. A copy of this advertisement was included in Appendix A of the PEIS. The advertisements provided the times, dates, and locations of the scoping meetings. Public comment was solicited in the advertisements and during the scoping meetings.

The scoping meetings were designed in an "open house" format to facilitate dialogue with NSF and agency personnel and the public. Displays were presented to enhance public understanding of the NEPA process, the need for the Proposed Action, and the public's role in shaping the proposal.

NSF provided the public with several avenues for submitting comments during the scoping process and at the meetings. Scoping meeting attendees could submit written comments prepared prior to the meeting, complete a comment form provided by the NSF, or dictate their comments to an NSF representative for computer entry. An e-mail address for submitting comments was also provided at the meetings and in the advertisements. A total of 78 people attended the six scoping meetings. In total, four written comments were received during the official comment period between September 22 and October 28, 2005. Only one written comment sheet (praising the posters as very informative and personnel quite knowledgeable) was received from the six meetings; three more letters (via email) were received during the scoping comment period: (1) the Office of Hawaiian Affairs expressed their regrets at not attending the meeting but indicated they were looking forward to receiving the PEIS; (2) the USGS indicated they had no comments at that time; and (3) the Natural Resources Defense Council (NRDC) stated their concerns regarding the proposed marine seismic surveys and their potential to kill, injure, and harass marine mammals and other marine life over wide geographic areas, and that NSF should incorporate a rigorous, objective analysis into the earliest possible stages of the project's planning and NEPA compliance process. Comments received during the scoping period helped refine the NSF proposal and the preparation of Chapter 2 of the Draft PEIS.

A.1.2 Draft PEIS

The Draft PEIS was made available for public review beginning in October 2010, with the 45-day public comment period occurring from October 8, 2010 through November 22, 2010. An NOA for the Draft PEIS was announced in the *Federal Register*; local newspapers; and in letters and e-mails to federal agencies, state agencies, and other interested parties (see Appendix I of the Final PEIS). This notice indicated the duration of the public review and comment period, the address where comments could be sent, and the time and location of the public hearings. The Draft PEIS was also made available on NSF's Division of Ocean Sciences environmental compliance website at: http://www.nsf.gov/geo/oce/envcomp/. Once the public comment period commenced, NSF also:

- Mailed hard copies and electronic copies on CDs of the Draft PEIS to federal and state agencies, and other interested parties, including those who had requested a copy of the Draft PEIS through the scoping process.
- Conducted two public hearings each with an "open house" poster session staffed by NSF, USGS, and NMFS subject matter experts, a formal briefing by NSF, and the opportunity to provide oral and/or written comments. The presentation slides used by NSF at the public hearings can be found in Appendix I of the Final PEIS and on the NSF's environmental compliance website at http://www.nsf.gov/geo/oce/envcomp.
- Distributed a comment sheet to help facilitate public input and feedback.
- Provided a CD to any individual requesting a copy of the Draft PEIS at the public hearings.

The public hearings were held at the following dates, times, and locations:

- October 25, 2010; Scripps Institution of Oceanography, University California-San Diego, Vaughn Hall, Room 100, Discovery Way, La Jolla, CA.
- October 27, 2010; Marine Acoustics, Inc. (MAI), 4100 Fairfax Drive, Arlington, VA.

The Arlington, Virginia public hearing location was originally planned to be held at the NSF building at 4201 Wilson Blvd. Unfortunately, due to a fire in the NSF building on the afternoon of October 27, 2010, the public hearing location was moved nearby to the offices of MAI located at 4100 Fairfax Drive (a building two blocks from NSF). Signs were posted on the outside doors of the NSF building announcing the new hearing location, and a security guard stationed at the main NSF entrance outside the meeting room directed hearing attendees who were unaware of the NSF emergency to the new hearing venue.

A total of 31 individuals attended the 2 public hearings, and 2 individuals provided oral comments on the Draft PEIS that expressed support for the Proposed Action (Table 2); no written comments were submitted at the public hearings.

Table 2. Summary of Public Hearing Attendance and Written Comments on the Draft PEIS

Location (Date)	*# Attendees*	*# Comments* *Written*	*Oral*
PUBLIC HEARINGS (see Appendix I for transcripts)			
Scripps Institution of Oceanography, La Jolla, CA (October 25, 2010)	21	0	1
MAI, Arlington, VA (October 27, 2010)	10	0	1
Total	**31**	**0**	**2**
WRITTEN COMMENT LETTERS (see Appendix J)			
Federal Agencies		1	
State Agencies		1	
Interested Parties		5	
Total		**7**	

In addition to the 2 oral comments received at the public hearings in support of the Proposed Action, 7 written comment letters expressing support of or concerns with the Proposed Action were submitted via the NSF comment e-mail address (nepacomments@nsf.gov) or via postal mail. Complete transcripts of the public hearings are provided in Appendix I of the Final PEIS, and all submitted public comments, as well as responses to those comments, are provided in Appendix J. The following is a summary of the topics of concern identified by public commenters through comments received via email and postal mail.

- Support for the Proposed Action and implementation of the Preferred Alternative;
- Sufficient peer review of proprietary acoustic models used in the analysis, compliance with Information Quality Act (IQA) and Council for Regulatory Monitoring (CREM) guidelines, and overall usefulness and applicability of those models in the impact analysis;
- Appropriate range of action alternatives;
- Pre-cruise planning guidelines;
- Mitigation and monitoring measures, including use of Pr otected Species Visual Observers (PSVOs);
- Robustness of cumulative impacts analysis;
- Use of 'precautionary approach' in impact analysis;
- Definition of 'generic' mitigation zones; and
- Use of Passive Acoustic Monitoring (PAM).

To obtain further clarification on some of the public comments received from the Marine Mammal Commission (MMC) (See Appendix J), NSF, USGS and NMFS representatives contacted MMC representatives via telephone on January 25, 2011. The discussion helped inform the federal agencies in developing their response to the MMC's comments and making appropriate changes to the Final PEIS, where appropriate.

A.1.3 Final PEIS

Following the close of the public comment period, written and oral comments on the Draft PEIS were reviewed and responses to those comments prepared. The Final PEIS was prepared, incorporating responses to comments and any additional evaluation that was warranted. Copies of all comments received on the Draft PEIS and the corresponding responses are included in Appendix J of the Final PEIS. The Final PEIS was distributed and made publically available in the same manner as the Draft PEIS, but to an expanded list of recipients based on requests received during the Draft PEIS comment period.

Following the issuance of the Final PEIS in the Federal Register and the NSF website, one comment was received. The public comment, which is available as Appendix A to this document, wanted clarification as to why the Santa Monica Bay area which has geologic faults and is a region of economic importance was not included in the Southern California Detailed Analysis Area (DAA) in the Final PEIS.

In response, given the globally ranging nature of the NSF-funded marine seismic surveys, it was necessary to narrow the focus of the analyses presented in the PEIS. The DAAs and the Qualitative Analysis Areas (QAAs) were selected as representative of potential future survey sites and a variety of bathymetric, acoustic, and biologically diverse environments. As such, a DAA in Southern California in the Santa Barbara Basin was selected as a site to highlight features in that region and specific sound propagation modeling that was also representative of that type of marine environment. The DAAs and QAAs in the PEIS are therefore simply exemplary or representative potential marine seismic surveys that NSF or USGS might propose in the future. There may be unique geologic features of interest in the Santa Monica Bay area. Marine seismic surveys funded by NSF are awarded via a merit review process. Proposals are submitted to the agency for funding consideration and are then reviewed by a panel of external experts or by ad hoc mail review. Scientific, technical and programmatic issues are taken into consideration when determining awards. Should a proposal to conduct a marine seismic survey in the Santa Monica Bay area be submitted to NSF it would be considered and evaluated through this standard NSF merit review process. Should an award be considered, procedures identified in the PEIS would be followed and any additional environmental analyses deemed necessary would be prepared and tiered to the PEIS.

A.2 Action Alternatives Considered

Two action alternatives and the No-Action Alternative were assessed on the Final PEIS. The two action alternatives were:

- Alternative A: Conduct Marine Seismic Research Using Cruise-specific Mitigation Measures
- Alternative B: Conduct Marine Seismic Research Using Cruise-specific Mitigation Measures with Generic Mitigation Measures for Low-energy Acoustic Sources (Preferred Alternative)

Marine seismic research cruises would use a variety of airgun (pneumatic sound source) array configurations, and often use other non-seismic acoustic sources as well, including multi-beam echo sounders (MBESs), sub-bottom profilers (SBPs), pingers, acoustic Doppler current profilers (ADCPs), and acoustic releases. Seismic sources would include high-energy source arrays of 18-36 airguns (up to a discharge volume of 6,600 cubic inches [in^3]) and low-energy source arrays of 1-4 airguns (up to a discharge volume of 425 in^3). Sources used in NSF-funded marine seismic research include those on the R/V *Langseth*, the primary U.S. vessel used to support high-energy source seismic research, as well as airguns and other low-energy seismic acoustic sources (e.g., chirp systems, sparkers, water guns, etc.) such as those on University-National Oceanographic Laboratory System (UNOLS) vessels operated directly by or on behalf of the U.S. Government, and other vessels as needed via contract or charter. All NSF-funded marine seismic cruises would be conducted according to applicable U.S. federal and state laws and regulations, and as applicable, foreign laws and regulations recognized by the U.S. Government.

Numerous species of marine mammals and sea turtles are expected to be encountered during marine seismic research activities. The following subsections describe mitigation measures that were identified as integral parts of NSF-funded marine seismic research activities under Alternatives A and B.

Alternatives A and B differed in how the proposed safety radii or mitigation zones (MZs) were determined. For operations with no request for MMPA incidental take authorization, the MZs were the same in Alternative A and Alternative B. Where take is expected and authorization would be requested, Alternative A would require a specific calculation of MZs and FMZs for every proposed cruise, whereas Alternative B introduced a generic set of MZ conditions that would be applied to low-energy seismic operations proposed in water depths >328 ft (100 m).

The use of small numbers of generator-injector (GI) guns and other acoustic sources (e.g., towed chirp systems, sparkers, boomers) for low-energy seismic survey work in waters >328 ft (100 m) in depth, most often conducted on UNOLS vessels or in support of ocean-drilling operations, have modeled MZs of <328 ft (100 m). Therefore, in Alternative B, for situations which incidental take of marine mammals is anticipated, NSF would conservatively apply the use of a 328-ft (100-m) MZ for all low-energy acoustic sources in water depths >328 ft (100 m). For operations of low energy seismic sources for which incidental take of marine mammals is not anticipated, a 200m FMZ will be will be observed, regardless of water depth.

For the purposes of the PEIS, a low-energy source was defined as an acoustic source whose received level is ≤180 decibels reference 1 microPascal (dB re 1μPa) at 328 ft (100 m). Based on this definition and previous modeling results of various acoustic sources previously assumed to be low-energy sources, the following categories of acoustic sources were defined as low-energy seismic sources:

- GI Guns:
  - Any single or any two GI guns.
  - Three or four GI guns, within the allowable range of tow depths and element separations explained in detail in Appendix F.
- Generic single-chamber airguns:
  - A tuned array of four airguns (volumes between 25 and 160 in^3 each) within the allowable range of tow depths and element separations explained in detail in Appendix F.
  - A single pair of clustered airguns with individual volumes of 250 in^3 or less.
  - Two small 2-clusters (four airguns) with maximum volumes of 45 in^3.
  - Any single airgun 425 in^3 or smaller, at any tow depth.
- Any towed sparker, boomer, water gun, or chirp system with a source level <205 dB re 1μPa-m.

Table 3 provides a summary of the MZs proposed under Alternative A and Alternative B.

Table 3. Comparison of Alternatives A and B

Stipulation	*Alternative A*	*Alternative B (Preferred Alternative)*
200-m FMZ for expected **no-take** situations	X	X
100-m MZ for defined low-energy sources for **potential take** situations in water depths >100m		X
Cruise-specific calculations of MZs for all sources defined as low energy	X	
Cruise-specific calculations of FMZs for all sources defined as low or high energy	X	X

A.3 Mitigation Measures

The following mitigation measures were described in the Final PEIS under Alternatives A or B and would be applied, as appropriate, to all proposed NSF-funded marine seismic research cruises. These mitigation measures are considered standard; however, future cruises may have unique situations where the monitoring and mitigation measures may need to be tailored to cruise- and site-specific situations. Mitigation and monitoring may be required for incidental take authorizations under the MMPA; these measures would be developed in coordination with NMFS or the USFWS on a case-by-case basis for specific cruises during the processing of the incidental take authorization. When possible, the NEPA documentation will reflect the mitigation and monitoring requirements issued in an IHA; NSF and the ship operator will however implement any requirements issued in the IHA, even if they deviate from those identified in the EA. For those cruises that may be conducted within the territorial waters and/or EEZ of another nation, additional or different mitigation measures may be required by that nation.

As described in the PEIS for Alternative B, for any seismic survey cruise that fits the low-energy source as defined above, there will be a standard MZ of 328 ft (100 m) for all marine mammals and turtles. For acoustic sources not defined as low-energy sources, cruise-specific MZs would need to be modeled to determine the effective MZs for marine mammals and turtles.

A.3.1 Mitigation During Planning Phases

Research proposals submitted to NSF undergo a competitive, merit review process which typically includes external expert review by a panel and/or *ad hoc* mail review. After scientific, technical, and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the Division Director whether the proposal should be declined or recommended for award. After Division approval has been obtained, the proposals recommended for funding are forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications and the processing and issuance of a grant or other agreement. NSF strives to make funding decisions within 6 months of proposal receipt. Awardees that require time on research vessels are typically scheduled a minimum of 1 year in advance of the desired cruise date.

Considerable planning is required to schedule a marine seismic research cruise. In scheduling a seismic survey, NSF and the entities that propose to conduct the cruise would consider potential environmental impacts including seasonal, biological, and weather factors; ship schedules; and equipment availability. This preliminary assessment of potential environmental impacts would be part of the NSF proposal review and cruise scheduling processes, with a full assessment completed prior to cruise departure.

A preliminary assessment would identify within a proposed seismic survey area the occurrence, level and type of use (e.g., breeding, feeding, migrating, etc.), and seasons of use by marine mammals, sea turtles, and other ESA-listed species; potential occurrence of commercial, local, and subsistence fishing activities; and other site-specific concerns. This preliminary information would be used to assess the feasibility of conducting an NSF-funded marine seismic study at a specific location; to determine specific times or locations within an area where potential impacts would be avoided or minimized; and to identify any additional mitigation and/or monitoring measures that would be implemented to avoid or minimize potential impacts.

For each proposed research cruise, NSF and the project applicants would consider whether the research objectives could be met with a smaller source and a survey design that minimizes seismic operations. If there is concern about exposure of sensitive biota, NSF and the project proponents would also consider whether a different survey time would reduce those effects. Through pre-cruise planning, areas and seasons where there are expected concentrations of marine mammals and sea turtles would be identified and avoided to the maximum extent practicable. Special consideration would be given to marine biota engaged in sensitive activities such as breeding, rearing of young, and feeding. If appropriate, NSF and the project proponents would also implement mitigation measures to address potential impacts to fishing activities.

A.3.2 Visual Monitoring for Marine Mammals and Turtles

Under Alternatives A and B, PSVOs would be based aboard the seismic source vessel, and would watch for marine mammals and turtles near the vessel during daytime airgun operations and start-ups of airguns at night. PSVOs would also watch for marine mammals and turtles near the seismic vessel for at least 30 minutes (min) prior to the start of airgun operations after an extended shutdown. When feasible, PSVOs would also make observations during daytime periods when the seismic systems are not operating for comparison of animal abundance and behavior during seismic and non-seismic periods. Based on PSVO observations, airguns would be powered down (see below) or, if necessary, shut down completely, when marine mammals are observed within or about to enter a designated MZ (see below). The MZ is a region in which a possibility exists of effects on animal hearing or other physical effects (Level A harassment).

PSVOs also monitor for species to the full mitigation zone (FMZ) which includes the area identified for potential behavioral harassment (Level B harassment).

After NMFS Office of Protected Resources review and concurrence of their qualifications, PSVOs would be appointed by the academic institution conducting the NSF-funded research cruise. At least one PSVO would monitor the MZ during daytime airgun operations and any nighttime startups. PSVOs would normally work in shifts of 4-hr duration or less and work no more than three shifts in a 24-hr period. The vessel crew would also be instructed to assist in detecting marine mammals and turtles. A report summarizing PSVO observations would be submitted to NMFS and/or USFWS after the cruise in compliance with terms of authorizations for marine mammal harassment or endangered species takes. The report would describe the seismic operations and include a complete description of the data collected about marine mammals, turtles, and any other threatened or endangered species observed.

All vessels conducting NSF-funded marine seismic research would be required to have suitable platforms for marine mammal and turtle observation. On the observation platform, the eye level of the PSVO would be sufficiently above sea level, and the observer would have a clear view around most of the vessel. During daytime operations, the PSVO would scan the area around the vessel systematically with reticule binoculars, "Big-eye" 25x power binoculars (on the R/V *Langseth* only), and with the naked eye. Night vision devices (NVDs) would be available for their use. Laser rangefinding binoculars would be available to assist in distance estimation.

A.3.3 Passive Acoustic Monitoring (PAM)

PAM involves towing hydrophones that detect frequencies produced by vocalizing marine mammals. Ideally, two or more hydrophones are used to allow some localization of the bearing (direction) of the animal from the vessel. A key component of PAM which allows more effective use is the computer signal processing to detect and localize marine mammal vocalizations. Several prototype systems are under development.

During some cruises, PAM would be used during seismic operations in conjunction with visual monitoring. PAM would normally be used for high-energy source surveys unless in the rare and unlikely circumstances that, (1) it is damaged and rendered inoperable during a survey and back-up systems fail; (2) it is deemed to be ineffective in detecting animals under the circumstances of the cruise; or (3) safety of operations prevent its use. When implemented, PAM would typically be used during both daytime and nighttime seismic operations as well as when the vessel is underway in the survey area with the airguns silent. During a seismic survey, PAM can be effective at detecting some animals before they are detected visually. Its value can be limited, however, by bottom configuration (water depth) and other environmental factors, and in some cases towing the PAM equipment is not practicable. Because of present limitations to determine range of acoustic contacts, the value of PAM is to detect acoustic cues that alert visual observers of the presence and general direction of marine mammals.

Inclusion of PAM does not reduce the need for visual observations, and it is expected that PAM operation would require additional personnel beyond those aboard as PSVOs, including at least one with previous PAM experience. NMFS would need to provide concurrence on the use of PAM personnel after review of their qualifications. When PAM is used, PAM procedures and results would be included in post-cruise reports submitted to NMFS and/or USFWS in accordance with MMPA and ESA regulatory requirements.

A.3.4 Proposed Safety Radii or MZ: Operations for Which Incidental Take of Marine Mammals is Anticipated

For operations under an IHA or LOA (Letter of Authorization) under Alternative A, detection of marine mammals within a specified distance around the airguns (the MZ) would be followed by an immediate power down or shutdown of the airguns. The mitigation radii under Alternative A would normally be the distances at which the effective received sound level would diminish below 190 or 180 dB re 1 μPa (rms).

Radii in the PEIS were calculated for both M-weighted as well as flat (unweighted) levels. These radii were determined by acoustical modeling that considered site-specific acoustic characteristics (water depth, in particular), the airgun configurations to be used at the DAAs, and the hearing characteristics of expected marine mammals in the DAAs. Modeling incorporated current data on airgun output and species hearing characteristics, and for certain cetaceans of special concern, more precautionary criteria (shut downs) would apply, such as described in "*Special Mitigation Measures*" below.

For future cruises, NSF would use an appropriate acoustical modeling method for determining the MZs, FMZs, and marine mammal take estimates, taking into consideration suitable and available software applications and technology, agency feasibility to implement, and regulatory guidance/requirements.

A.3.5 Proposed Safety Radii or MZ: Operations for Which Incidental Take of Marine Mammals is not Anticipated or Authorized

These operations will use low-energy seismic sound sources in which 180 dB re 1 μPa (rms) is not exceeded or within close proximity to the source and the extent of 160 dB re 1 μPa (rms) sound levels are within 200 m of the source. As described in the Final PEIS, shutdowns or power downs would be required whenever marine mammals or turtles are detected within a FMZ, defined as an extended MZ encompassing the full region in which NMFS estimates behavioral disturbance (≥160 dB re 1 μPa [rms]), also called 'Level B harassment', might occur. The FMZ must be clearly visible and PSVOs available to monitor it throughout any period of seismic source use.

While technically the FMZ may be an overestimation of the area potentially ensonified to 160 dB re 1 μPa (rms), it must be within a range that can be effectively monitored. Proposed use of sources would be on the order of hours or short-duration shooting over several days (not extensive track-lines). Examples of proposed actions would be the use of 1 to 2 GI-guns for bore-hole testing (e.g., VSP). The small number of airguns in these situations limits application of ramp-ups and power-downs. Immediate shut-down for a marine mammal or turtle approaching the FMZ would be the primary mitigation response.

With mitigation, no takes would be expected. When proposed research cannot avoid an area of particular sensitivity, the action would require additional considerations and potentially an incidental take authorization. In general, surveying with small sources as well as VSP carried out in the vicinity of drill sites (stationary vessel sources) that have habitat sensitivity or other issues that might require a specific incidental take authorization (e.g., IHA or LOA) would be determined in consultation with NMFS OPR.

Based on source energy levels and outputs, and the type of use, NSF does not believe that towed chirp systems rise to the same level of potential impact on the environment as do potentially other towed low energy seismic systems identified in the PEIS. Therefore after further consideration the NSF does not feel that towed chirp systems warrant the same level of monitoring and mitigation measures as the other low energy seismic systems presented in the PEIS. NSF will advise operators of towed chirp systems to monitor the surrounding operational area and power down the system should a marine mammal approach closer than 200m to the vessel. Operations could continue into the night if the activity was started during the day and the 200m FMZ was observed to be clear of marine species. As noted later, adaptive management techniques will be employed for these types of systems, and therefore adjustments to this could be made if necessary.

A.3.6 Mitigation during Operations

As described in the Final PEIS, operational measures to mitigate the impact of sound on marine mammals and turtles would include:

1. Vessel speed or course alteration;
2. Airgun array power down;
3. Airgun array shutdown;
4. Airgun array ramp-up; and
5. Special mitigation measures for circumstances of particular concern.

Speed or course alteration. If a marine mammal or turtle is detected outside the MZ but is likely to enter it based on relative movement of the vessel and the animal, then if safety and scientific objectives allow, the vessel speed and/or course would be adjusted to minimize the likelihood of the animal entering the MZ. It should be noted that major course and speed adjustments are often impractical when towing long seismic streamers and large source arrays; thus for surveys involving large sources, alternative mitigation measures would often be required.

Power down procedures. A power down involves reducing the number of airguns operating to a single airgun in order to minimize the size of the MZ. The continued operation of one airgun is intended to alert marine mammals and turtles to the presence of the seismic vessel nearby.

If a marine mammal or turtle is detected within, or is likely to enter the MZ of the array in use, and if vessel course/speed changes are impractical or would not be effective to prevent the animal from entering the MZ, then the array would be powered down to ensure the animal remains outside the smaller MZ of the single airgun. If the size of the MZ for the single airgun would not prevent the animal from entering it, then a shutdown would be required, as described below.

Following a power down, airgun activity would not resume until the marine mammal or turtle is outside the MZ for the full array. The animal would be considered to have cleared the MZ if it:

- is visually observed to have left the MZ;
- has not been seen within the MZ for 15 min in the case of small odontocetes, pinnipeds, and sea otters;
- has not been seen within the MZ for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales; or
- the vessel has moved outside the applicable MZ in which the animal in question was last seen.

Following a power down and subsequent animal departure as noted above, the airgun array would resume operations following ramp-up procedures described below.

Shutdown procedures. If a marine mammal or turtle is within or about to enter the MZ for a single airgun, or for a single airgun following a power down, all operational airguns would be shut down immediately. Airgun activity would not resume until the animal had cleared the MZ for the full array of airguns to be used, as described above.

Ramp-up procedures. A ramp-up procedure would be followed when an airgun array begins operating after a specified period without operations. The period would vary depending on the speed of the source vessel and the size of the airgun array being used. In most cases the specified period would be defined as the time taken for the source vessel to travel the radius of the MZ specified for the array to be used. The Final PEIS did not take into consideration that in certain instances this approach may not be practical or feasible; in these instances, the time period and justification would be provided in the appropriate NEPA documentation.

Ramp-up would begin with the smallest airgun in the array. Airguns would be added in a sequence such that the source level of the array would increase in steps not exceeding 6 dB per 5-min period. A 36-airgun array would take approximately 30 min to achieve full operation via ramp-up. During ramp-up, the PSVOs would monitor the MZ, and if marine mammals or turtles are sighted, decisions about course/speed changes, power down, and shutdown would be implemented as though the full array were operational.

Initiation of ramp-up procedures from shutdown requires that the full MZ must be visible by the PSVOs for 30 min, whether conducted in daytime or nighttime. This requirement would often preclude startups under nighttime or poor-visibility conditions except for small sources with restricted MZs. Ramp-up is allowed from a power down under reduced visibility conditions, but only if at least one airgun has operated continuously with a source level of at least 180 dB re 1 μPa-m (rms) throughout the survey interruption. It is assumed that the single airgun would alert marine mammals and turtles to the approaching seismic vessel, allowing them to move away if they choose. Ramp-up procedures would not be initiated if a marine mammal or turtle is observed within the MZ of the airgun array to be operated.

Special mitigation measures. Airgun arrays would be shut down (not just powered down) if any of the following four species is sighted from the vessel, even if outside the MZ, due to their rarity and sensitive status: N Pacific right whale, N Atlantic right whale, Northeast Atlantic bowhead whale, and W Pacific gray whale. In case of confirmed sightings of any of these species, airgun operations would not resume until 30 min after the last documented whale visual sighting and the PSVO is confident that the whale is no longer in the vicinity of the vessel. Other species could be designated for special measures when appropriate.

Special measures would also apply over continental slopes, especially regions with submarine canyons, where beaked whales are believed to concentrate. Extra mitigation would be implemented to minimize potential impacts on these species. Where possible, NSF-funded seismic surveys would minimize operations near submarine canyons. Extra vigilance, including use of extra PSVOs, would be maintained where such approaches are unavoidable. These special monitoring and mitigation requirements would be established in advance in consultation with NMFS for each cruise that would conduct seismic survey operations over slopes and canyon regions.

In addition to the mitigation efforts described above, NSF-funded marine seismic research operations would take special precautions to avoid impacting migrating, breeding, and nursing congregations of marine mammals; waters proximal to nesting sites and feeding areas of sea turtles; and waters important to juvenile or adult listed salmon and other protected species.

A.4 Environmental Impacts

The Final PEIS presented a detailed analysis of the potential environmental impacts associated with implementation of Alternative A, Alternative B, and the No-Action Alternative in the exemplary analysis areas (DAAs and QAAs). These potential impacts are described below. The findings of the Final PEIS indicate that potential impacts of implementation of either Alternative A or Alternative B (preferred alternative) would have minor and transitory effects on the marine environment.

A.4.1 No-Action Alternative

Under the No-Action Alternative, NSF would not fund marine seismic research using airguns and other acoustic sources (e.g., MBES, SBP, pingers, etc.). The seismic data from the proposed surveys have important implications for scientific research and, in some cases, human safety and well-being. The No-Action Alternative, through the failure to conduct geophysical seismic research, would result in a loss of important scientific data and knowledge relevant to a number of research fields (e.g., detection of gas hydrate deposits and offshore freshwater aquifers; understanding of geohazards such as earthquake faults, the potential for submarine slide development and tsunami generation; and/or information about marine habitats and offshore cultural features). For geohazard or resource issues, this lack of further data acquisition could have a potentially harmful effect on marine or human populations. While the No-Action Alternative is not considered a reasonable alternative because it does not meet the purpose and need for the Proposed Action, as required under CEQ regulations (40 CFR 1502.14[d]), the No-Action Alternative was carried forward for analysis in the PEIS. The No Action Alternative would have no impacts on any resource, because the proposed marine seismic surveys funded by NSF would not occur.

A.4.2 Action Alternatives

A summary of the potential impacts to the natural and human environment with implementation of either Alternative A or Alternative B (preferred alternative) is provided below. As described in the Final PEIS, implementation of Alternative A or B would result in the same potential impacts.

<u>Marine Invertebrates</u>

The existing body of published and unpublished scientific literature on the impacts of seismic survey sound on marine invertebrates is limited, and there are no known systematic studies of the effects of sonar sound on invertebrates. Recent work by André et al. (2011) purports to present the first morphological and ultrastructural evidence of massive acoustic trauma (i.e., permanent and substantial alterations of statocyst sensory hair cells) in four cephalopod species subjected to low-frequency sound. The cephalopods, primarily cuttlefish, were exposed to continuous 50–400 Hz sinusoidal wave sweeps (100% duty cycle and 1-sec sweep period) for two hours while captive in relatively small tanks (one 2,000 L [$2m^3$] and one 200 L [$0.2m^3$] tank). The received SPL was reported as 157±5 dB re 1µPa, with peak levels at 175 dB re 1µPa. As in the McCauley et al. (2003) paper on sensory hair cell damage in pink snapper as a result of exposure to seismic sound, the cephalopods were subjected to higher sound levels than they would be under natural conditions, and they were unable to swim away from the sound source.

It has not been specifically documented that invertebrates are capable of detecting the acoustic sources proposed for use in NSF-funded marine seismic research. Generally, adverse effects on a particular invertebrate species can be considered significant if they result in a reduction in the overall health and viability of a population or significantly impact fisheries targeting that population.

Under Alternatives A and B, some decapod crustaceans and cephalopods might detect the sound from the airguns and airgun arrays (Table 4). The MBESs, SBPs, and pingers might be similarly detectable by fewer invertebrate species. For those invertebrate species capable of detecting such sounds, there would theoretically be potential for adverse pathological and physiological effects at extremely close range, and for behavioral effects extending to somewhat greater ranges. These effects could temporarily change the catchability of some crustacean and mollusk fisheries in localized areas. The likelihood of each of these effects depends on the sound level received by the individual. The received sound level is generally related to proximity to the source but is influenced by other factors as well (e.g., water depth, sound velocity profile of the water, bottom conditions, airgun array size, etc.). The potential for pathological effects is expected to be limited to those individual invertebrates within several meters of an active source operating at high levels and producing sounds within the frequency range to which the animals are sensitive. On a population level, the potential effects are considered insignificant.

Table 4. Summary of Potential Impacts to Crustaceans, Mollusks (Cephalopods), and Related Fisheries with Implementation of Alternative A and B (Preferred Alternative)

Analysis Area	*Alternatives A and B**
DAA	
NW Atlantic W Gulf of Alaska Caribbean Sea S California Galapagos Ridge	• Potential short-term behavioral or possibly physiological effects on individuals. • Potential adverse but not significant impacts to individuals < several m from the active sound source. • No significant impacts at the population level.
QAA	
BC Coast Marianas Sub-Antarctic N Atlantic/Iceland SW Atlantic W India W Australia Mid-Atlantic Ridge	• Potential short-term behavioral or possibly physiological effects on individuals. • Potential adverse but not significant impacts to individuals < several m from the active sound source. • No significant impacts at the population level.

Note: *Impacts under Alternatives A and B assume that provisions would be made to plan the seismic surveys to avoid EFH and commercially important fisheries to the maximum extent practicable.

In summary, based on the limited available information about the effects of airgun and sonar sounds on invertebrates, there would be no significant impacts to marine invertebrate populations, fisheries, and associated Essential Fish Habitat (EFH) with implementation of Alternative A or B.

<u>Marine Fish</u>

Short-term behavioral effects potentially resulting in short-term, localized displacement or disturbance of individual fish are the most likely effects expected under Alternative A or B as a result of exposure to airgun and airgun array sounds. 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.

The potential for impacts upon exposure of fish to the MBES and SBP is considerably less for two reasons. First, few fish species are capable of detecting or hearing the high-frequency sounds produced by these two acoustic sources. Secondly, the narrower along-track beam of these two acoustic sources would affect a considerably smaller area than the broader areas affected by the airguns and arrays; as a result, a given fish location near the transiting source would be ensonified for only one brief ping at most. The potential for impacts upon exposure of fish to the pingers is not likely given the much higher frequency of this instrument relative to fish hearing capabilities.

For any ESA-listed species of fish whose hearing is within the frequency range of the airguns, there may be short-term impacts to a small number of individuals that are very close to an airgun (a few meters), but these effects are not likely to adversely affect these populations. Furthermore, impacts to ESA-listed fish species or EFH are not anticipated to occur as implementation of Alternatives A or B include provisions to plan the seismic surveys to avoid, to the maximum extent practicable, federally designated critical habitat for threatened or endangered fish populations. With these mitigation measures in place, no significant impacts on threatened or endangered fish populations or to EFH are anticipated in any of the exemplary DAAs or QAAs due to any of the proposed sound sources (Table 5).

Table 5. Summary of Potential Impacts to Fish Species of Special Concern, EFH, and Related Fisheries with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Species, EFH, or Fisheries*	*Alternative A or B**
DAA		
NW Atlantic	• ESA-listed species: shortnose sturgeon, Atlantic salmon • EFH for numerous species • Important fisheries	• May affect but would not adversely affect ESA-listed species. • Primarily short-term behavioral or possibly physiological impacts to small numbers of individuals of most higher groups. • No significant impacts to fisheries. • No adverse effects on EFH. • No significant impacts at the population level.
W Gulf of Alaska	• Important fisheries • EFH for numerous species including salmon and groundfish	
Caribbean Sea Galapagos Ridge	• Important fisheries	
S California	• ESA-listed species: green sturgeon, Chinook & coho salmon, steelhead, bull trout • EFH for numerous species • Important fisheries	
QAA		
BC Coast	• ESA-listed species: green sturgeon; bull trout; steelhead; sockeye salmon; Chinook, chum, and coho salmon • Important fisheries	• May affect but would not adversely affect ESA-listed species. • Primarily short-term behavioral or possibly physiological impacts to small numbers of individuals of most higher groups. • No significant impacts to fisheries. • No adverse effects to EFH. • No significant impacts at the population level.
Mid-Atlantic Ridge Marianas Sub-Antarctic N Atlantic/Iceland	• Important fisheries	
SW Atlantic	• EFH for numerous species • Important fisheries	
W India W Australia	• Important fisheries	

Note: *Potential impacts under both alternatives assume that provisions would be made to plan the seismic surveys to avoid, to the maximum extent practicable, critical habitat for federally listed species

Sea Turtles

Little is known about the acoustic capabilities of sea turtles, either in terms of hearing ability or sound production. With such limited data, it is currently not possible to determine how far away a particular airgun array may be audible to a sea turtle. Thus, it is not possible to identify specific sound criteria for sea turtles above which temporary threshold shift (TTS), permanent threshold shift (PTS), or injury could occur based on empirical data. However, as a conservative measure, NMFS has identified two levels of sound exposure criteria for sea turtles during seismic research surveys in areas where sea turtles were anticipated to be numerous. The most recent (through 2009) of these two criteria correspond to a conservative safety radius of 180 dB re 1 μPa above which TTS or PTS is considered possible and should thus be avoided. The second is a conservative radius of 166 dB re 1 μPa above which behavioral "harassment" changes may occur. These criteria were identified to precautionarily limit the potential risk of physical injury and to address behavioral disturbance, respectively, since the associated limits were unknown.

Under Alternatives A and B, with the proposed monitoring and mitigation measures in place, no significant impacts are likely to sea turtle populations due to airgun operations in any of the analysis areas where they may occur (Table 6). The number of individual sea turtles expected to be closely approached during the exemplary surveys would be small in relation to regional population sizes. With the proposed monitoring, ramp-up, power- and shut-down provisions, effects on those individuals are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. Operation of the MBES, SBP, or pingers is not expected to affect sea turtles, because the associated frequency ranges are above the known hearing range of sea turtles. Furthermore, the intermittent and/or narrow downward-directed nature of these sounds and the fact that they are emitted from a transiting seismic vessel would result in no more than one or two brief pulse exposures to relatively slow-moving sea turtles. In summary, implementation of Alternative A or Alternative B may affect, but is not likely to adversely affect, ESA-listed sea turtle species occurring in analysis areas. No significant impacts are expected to occur at the population level for any sea turtle species.

Table 6. Summary of Potential Impacts to Sea Turtles with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Species**	*Alternative A or B***
DAA		
NW Atlantic, Caribbean	Green, hawksbill, Kemp's ridley, leatherback, loggerhead	• Short-term disturbance and localized displacement of small numbers of feeding/migrating leatherbacks and possibly loggerheads likely by small array in shallow to deep waters, other species highly unlikely. Affected number smaller than large-array areas with similar water depths. • Potential for TTS unknown, considered possible close to airguns but unlikely to occur as turtles expected to avoid such exposure and vessel would quickly pass. • Potential for PTS, injury, lethal effects from airguns unknown but considered unlikely as turtles expected to avoid such exposure and vessel would quickly pass. • No significant impacts expected at the population level. • May affect, likely to adversely affect leatherbacks and loggerheads. • May affect, not likely to adversely affect green, hawksbill, and Kemp's ridley.
S California, Galapagos	Green, hawksbill, leatherback, loggerhead, olive ridley	• Short-term disturbance and localized displacement of small numbers of breeding or feeding green and hawksbill likely and smaller numbers of breeding, feeding or migrating loggerhead, olive ridley, Kemp's ridley, and leatherback possible by large array in shallow to deep waters. • TTS and PTS unlikely, no significant impacts to populations (see NW Atlantic). • May affect, likely to adversely affect all six ESA-listed sea turtles.

Table 6. Summary of Potential Impacts to Sea Turtles with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Species**	*Alternative A or B***
W Gulf of Alaska	Green, leatherback, loggerhead, olive ridley	• Effects highly unlikely as all species considered rare in the project area. • No significant impacts to populations (see NW Atlantic). • May affect, not likely to adversely affect green, loggerhead, olive ridley and leatherback.
QAA		
BC Coast	Green, leatherback, loggerhead, olive ridley	• Short-term disturbance and localized displacement of small numbers of migrating green and leatherback possible by large array in shallow and intermediate-depth waters, other species highly unlikely/rare. • TTS and PTS highly unlikely, no significant impacts to populations (see NW Atlantic). • May affect, likely to adversely affect green and leatherback. • May affect, not likely to adversely affect loggerhead and olive ridley
Mid-Atlantic Ridge	Green, hawksbill, Kemp's ridley, leatherback, loggerhead, olive ridley	• Effects highly unlikely as all species considered rare within the project area. • No significant impacts to populations (see NW Atlantic). • May affect, not likely to adversely affect all six ESA-listed species
Marianas	Green, hawksbill, leatherback, loggerhead, olive ridley	• Short-term disturbance and localized displacement of small numbers of migrating or feeding individuals possible by large array in shallow to deep waters (all five species likely uncommon) • TTS and PTS highly unlikely, no significant impacts to populations (see NW Atlantic) • May affect, not likely to adversely affect green, hawksbill, loggerhead, olive ridley and leatherback.
Sub-Antarctic	Green, hawksbill, loggerhead, olive ridley, leatherback	• Short-term disturbance and localized displacement of very small numbers of migrating green, hawksbill and olive ridley likely and smaller numbers of migrating or feeding loggerhead and leatherback possible by small array in only deep waters. Affected number expected to be smaller than most other analysis areas with larger arrays and/or in shallow or intermediate-depth waters. • TTS and PTS unlikely, no significant impacts to populations (see NW Atlantic). • May affect, not likely to adversely affect green, hawksbill, loggerhead, olive ridley and leatherback.
SW Atlantic	Green, hawksbill, loggerhead, olive ridley, leatherback	• Short-term disturbance and localized displacement of small number of breeding or feeding green likely and smaller numbers of hawksbill, loggerhead, olive ridley and leatherback possible by large array in shallow to deep waters. • TTS and PTS unlikely, no significant impacts to populations (see NW Atlantic). • May affect, not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback.
W India	Green, hawksbill, loggerhead, olive ridley, leatherback	• Short-term disturbance and localized displacement of small number of breeding or migrating green and olive ridley likely and smaller numbers of hawksbill, loggerhead, and leatherback possible by large array in intermediate to deep waters. Affected number expected to be smaller than large array operating in shallow water. • TTS and PTS unlikely, no significant impacts to populations (see NW Atlantic). • May affect, not likely to adversely affect green, hawksbill, loggerhead, olive ridley and leatherback.
N Atlantic/ Iceland	Leatherback, loggerhead	• Effects highly unlikely as both species considered rare • No significant impacts to populations (see NW Atlantic) • May affect, not likely to adversely affect loggerhead and leatherback
W Australia	Green, hawksbill, leatherback, loggerhead, olive ridley, flatback	• Short-term disturbance and localized displacement of small numbers of breeding, feeding or migrating green, hawksbill and olive ridley likely and smaller numbers of feeding or migrating loggerhead and leatherback, and breeding or feeding non-listed flatback possible by small array in shallow to

Table 6. Summary of Potential Impacts to Sea Turtles with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Species**	*Alternative A or B***
		deep waters. Affected number expected to be smaller than areas with larger array at same water depths. • TTS and PTS unlikely, no significant impacts to populations (see NW Atlantic). • May affect, not likely to adversely affect all six ESA-listed species.

Notes: *All sea turtle species listed except for the flatback have ESA status. ** No acoustic impacts to sea turtles from MBES, SBP, or pingers (above turtle hearing capability) in all the analysis areas. Low risk of potential entanglement in towed/deployed seismic gear (e.g., lines, buoys, etc.); proposed mitigation and monitoring reduces this risk.

Seabirds

It is not possible to use quantitative sound-energy criteria to assess impacts of airguns or sonar on seabirds as there are no measured or predicted underwater audiograms for any seabird species, published or otherwise, or quantitative noise criteria used to characterize effects of airgun noise on seabirds, such as auditory thresholds corresponding to TTS or PTS levels caused by underwater noise. Considering the potential for other forms of acoustic injury, it is assumed that animals very close to the acoustic source (e.g., within a few meters) would theoretically be at risk. However, available data suggest that seabirds are not expected to occur this close to the acoustic source at depth. Other potential impacts from disturbance, collisions, and entanglement were evaluated according to documented ecological aspects of seabirds, description of the proposed action and alternatives, and documented interactions with analogous components of the proposed action (e.g., lighted vessel at night).

Implementation of Alternative A or B will have no significant impact on seabirds and no adverse effect on ESA-listed species or populations (Table 7). However, site-specific mitigation and monitoring measures should be considered if nesting or breeding colonies of ESA-listed seabirds or other sensitive aggregations or habitat-use areas for seabirds are found to be located near actual proposed seismic survey lines.

Table 7. Summary of Potential Impacts to Seabirds with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*ESA-listed Species* or Family*	*Alternative A or B*
DAA		
NW Atlantic	Loons, grebes, petrels/shearwaters, pelicans, gannets/boobies, cormorants, gulls, terns/noddies (**roseate tern**), alcids, seaducks	• Low numbers of birds potentially displaced by physical presence of vessel. • Potential for TTS, PTS, injury, lethal effects < several m from airguns unknown but not expected.** • Petrels/shearwaters and alcids possibly attracted to vessel lights at risk for collision. • For alcids that dive to escape disturbance, potential collision with vessel or gear. • No effect to ESA-listed species. • No significant impacts expected at the population level for all seabird species.
Caribbean	Grebes, petrels/shearwaters, tropicbirds, pelicans, gannets/boobies, gulls, terns/noddies (**roseate tern**), seaducks	• Same as above. • No significant impacts expected at the population level.
S California	Loons, grebes, albatrosses, petrels/shearwaters, tropicbirds, pelicans (**brown pelican**), gannets/ boobies, cormorants, gulls, terns/noddies, alcids	• Same as above. • No significant impacts expected at the population level.

Table 7. Summary of Potential Impacts to Seabirds with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*ESA-listed Species* or Family*	*Alternative A or B*
	(**marbled murrelet**), seaducks	
W Gulf of Alaska	Loons, grebes, albatrosses (**short-tailed albatross**), petrels/shearwaters, cormorants, gulls, terns/noddies, alcids (**marbled murrelet**), seaducks (**Steller eider**)	• Same as above. • No significant impacts expected at the population level.
Galapagos	Albatrosses, petrels/shearwaters, gannets/boobies, terns/noddies	• Same as above. • No significant impacts expected at the population level
QAA		
BC Coast	Loons, grebes, albatrosses (**short-tailed albatross**), petrels/shearwaters, cormorants, gulls, terns/noddies, alcids (**marbled murrelet**), seaducks	• Same as above. • No significant impacts expected at the population level
Mid-Atlantic Ridge	Loons, petrels/shearwaters, cormorants, gulls, terns/noddies, alcids	• Same as above. • No significant impacts expected at the population level
Marianas	Albatrosses (**short-tailed albatross**), petrels/shearwaters, tropicbirds, gannets/boobies, gulls, terns/noddies, alcids, seaducks	• Same as above. • No significant impacts expected at the population level.
Sub-Antarctic	Petrels/shearwaters, diving-petrels, gannets/boobies, gulls, terns/noddies	• Same as above. • No significant impacts expected at the population level.
N Atlantic/ Iceland	Loons, grebes, petrels/shearwaters, pelicans, gannets/boobies, cormorants, gulls, terns/noddies, alcids, seaducks	• Same as above. • No significant impacts expected at the population level.
SW Atlantic	Petrels/shearwaters, pelicans, gannets/boobies, gulls, terns/noddies, alcids, seaducks	• Same as above. • No significant impacts expected at the population level.
W India	Petrels/shearwaters, cormorants, gulls, terns/noddies, seaducks	• Same as above. • No significant impacts expected at the population level.
W Australia	Tropicbirds, gannets/boobies, Terns/noddies (**roseate tern**)	• Same as above. • No significant impacts expected at the population level.

Notes: *ESA-listed species in **bold** font.
**As determined from the lack of any published data of such effects, together with observational data by PSVOs with LGL Ltd. during numerous seismic surveys throughout the world, suggesting that seabirds do not remain in the water near the airgun array where they would be at risk of injury.

Marine Mammals: Cetaceans: Mysticetes

The potential impacts on mysticetes with implementation of Alternative A or Alternative B (Preferred Alternative) are summarized in Table 8. With implementation of the proposed monitoring and mitigation measures, unavoidable impacts to mysticetes under Alternative A or B are expected to be limited to short-term behavioral disturbance and short-term localized avoidance of the area near the active airguns. This is expected to have no significant short- and long-term impacts on individual mysticetes, their habitats, and regional populations within the exemplary analysis areas.

Based on empirical studies, mysticetes are expected to avoid exposure to seismic sounds levels ≥180 dB re 1 μPa (rms) and these avoidance behaviors typically begin at lower received sound levels. Furthermore, modeling indicates that no Level A exposures of mysticetes would occur under Alternative A or B based on the more realistic cumulative energy exposure criterion. However, because the modeled potential Level A (rms) exposures would be of concern and involve ESA-listed species, further site-specific consultation with NMFS would occur. If and when a specific NSF-funded survey is proposed for a specific area in the future, in accordance with ESA and MMPA, site-specific consultations with NMFS and USFWS would occur if necessary, as well as the preparation of any other appropriate tiered supporting environmental documentation (e.g., EA). Overall, the primary anticipated impacts to mysticetes with implementation of Alternative A or B are:

- Small numbers of mysticetes are modeled or would beexpected to experience Level B behavioral disturbance in all of the DAAs and potentially all eight of the QAAs. However, this is not expected to result in any long term or significant consequences to disturbed individuals or their populations. The S California DAA is the only site where mysticetes are not likely to be disturbed by the proposed seismic survey activities. This is due primarily to the near-zero estimated mysticete densities at the season (late spring/early summer) of the exemplary survey, the proposed small airgun array, and the acoustic characteristics of the S California DAA.

Table 8. Summary of Potential Impacts to Mysticetes with Implementation of Alternative A or B (Preferred Alternative) in the DAAs

DAA	*Whale Species*[(a)]	*Alternative A or B*[(a)]
NW Atlantic	**N Atlantic right, Humpback,** Minke, **Sei, Fin**	Limited to insignificant number of short-term Level B behavioral effects in shallow water. Likely to adversely affect ESA-listed species or their populations and consultation with NMFS required.
Caribbean	**Humpback, Fin**	Limited to insignificant number of short-term Level B behavioral effects in shallow water. Likely to adversely affect ESA-listed humpback and fin whales and consultation with NMFS required.
	Minke, **Sei, Blue**	Effects highly unlikely given expected 0 density. Not likely to adversely affect ESA-listed species.
	Bryde's	Limited to small number of short-term Level B behavioral exposures.
S California	**N Pacific right,** Bryde's, **Sei, Fin, Blue,** E Pacific gray, **Humpback**	Effects highly unlikely given expected 0 densities.
	Minke	Limited to insignificant number of short-term Level B behavioral exposures.
W Gulf of Alaska	**N Pacific right**	Limited to small number of short-term Level B behavioral exposures and likely to adversely affect right whales; consultation with NMFS required.
	E Pacific gray, Minke	Small number of Level B behavioral changes likely; Level A effects possible but highly unlikely--whales expected to avoid such exposure. No modeled Level A (SEL) cumulative energy exposure.
	Humpback, Fin	Limited to short-term Level B behavioral exposures. Likely to adversely affect ESA-listed humpback and fin whales and consultation with NMFS required. Level A effects possible but highly unlikely--whales expected to avoid such exposure. No Level A (SEL) cumulative energy exposure predicted. No effects expected at population level. However, given species' ESA status, common occurrence, and modeled small number of Level A (rms) exposures, further site-specific consultation with NMFS and tiered EA/OEA to be prepared when a seismic survey is definitively proposed in the future.
	Sei, Blue	Effects highly unlikely given expected 0 density.
Galapagos Ridge	**Humpback,** Minke	Effects highly unlikely given expected 0 density.
	Bryde's	Small number of Level B behavioral changes likely primarily in deep water; insignificant number of Level A (rms) exposures. No modeled Level A (SEL) cumulative energy exposure. Level A exposures highly unlikely as whales expected to avoid such exposure.
	Sei, Fin	Effects highly unlikely given expected 0 density.
	Blue	Limited to small number of short-term Level B behavioral exposures and likely to adversely affect blue whales; consultation with NMFS required.

[(a)]No effects expected at population level for any species. Insignificant number = >0.0 / <1.0 individual exposed representing <1% of estimated regional population size. Small number =>0.0 / ≤3.1% of estimated regional population size exposed. **bold** = ESA-listed species.

- Modeling predicts that, under Alternative A and Alternative B (Preferred Alternative), a small number of Level A exposures could occur in the W Gulf of Alaska DAA based on the current 180 dB re 1 μPa (rms) NMFS criterion, despite proposed mitigation and monitoring. However, no or insignificant (<0.019 whales) Level A exposures are expected to occur based on the more realistic cumulative energy exposure criterion. Cumulative energy (SEL) is now considered a more appropriate metric for assessing potential exposure of mysticetes to pulsed underwater sounds. Furthermore, Level A effects are highly unlikely to occur during a seismic survey, as mysticetes are expected to avoid exposure to seismic sound levels that could actually result in Level A exposures.

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 of any individual mysticete 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 species. The streamer and core-mounted pingers are also highly unlikely to affect mysticetes given their intermittent nature, short-term and transitory use from a moving vessel, relatively low source levels, brief signal durations, and in the case of ancillary core sampling their relatively infrequent use.

Marine Mammals – Cetaceans: Odontocetes

The potential impacts on odontocetes with implementation of Alternative A or Alternative B (Preferred Alternative) are summarized in Tables 9 and 10. Overall, the primary anticipated impacts to odontocetes with implementation of Alternative A or Alternative B (Preferred Alternative) are:

- Small numbers of odontocetes are modeled or would be expected to experience Level B exposures at all five DAAs and potentially all eight QAAs. These numbers represent <1.0% of regional populations of most species. The exception is *Stenella* spp. in the NW Atlantic and Caribbean DAAs where up to approximately 2.7% of the regional population could experience Level B behavioral disturbance.
- In general, modeling results indicate that large airgun arrays operating in shallow water where odontocetes are common to abundant would cause the highest numbers of short-term Level B exposures.
- No short- or long-term significant impacts are expected on odontocete populations or their habitats, including ESA-listed sperm whales, as a result of implementation of Alternative A or B.
- Modeling suggests that no cumulative energy exposures of odontocetes to ≥198 dB re 1 $\mu Pa^2 \cdot sec$ (SEL), the Level A criterion used in this analysis, would occur in any of the analysis areas.
- Small numbers of individuals representing approximately <0.1% of regional populations of some odontocetes are predicted to be exposed to the NMFS Level A criterion of ≥180 dB re 1 μPa (rms). Predicted Level A exposures would be similar for the two alternatives except for a few individuals of common to abundant delphinid species at the NW Atlantic and W Gulf of Alaska DAAs.
- No TTS and no potential injury (e.g., PTS) are expected to occur during the exemplary seismic surveys. Many odontocetes are expected to avoid exposure to seismic sound levels that could potentially cause these effects. The model used for analyses does not account for this expected behavioral avoidance and thus is precautionary. These avoidance behaviors typically begin at lower received sound levels. Moreover, modeling indicates that no Level A exposures of odontocetes would occur under Alternative A and Alternative B based on the more realistic cumulative energy (SEL) exposure criterion (Tables 9 and 10).

Table 9. Summary of Potential Impacts to Odontocetes with Implementation of Alternative A or B (Preferred Alternative) in the DAAs

DAA	Species	Alternative A or B
NW Atlantic	**Sperm whale**	Small number [a] of short-term Level B exposures. Negligible[b] NMFS Level A (rms) exposures primarily in shallow water. No modeled Level A (SEL) cumulative energy exposures. No Level A exposures expected in actual seismic survey due to proposed mitigation and monitoring measures and behavioral avoidance, but analysis model does not account for avoidance. Further site-specific consultation with NMFS would be required for actual seismic survey due to ESA status.
	Beaked whales	Small number[a] short-term Level B exposures in shallow water.
	Common, bottlenose, and Stenellid dolphins	Small number[a] short-term Level B exposures primarily in shallow water. Small number[a] Level A (rms) exposures of common & bottlenose dolphins in shallow water. No modeled Level A (SEL) cumulative energy exposures. No Level A exposures expected in actual seismic survey due to proposed mitigation measures and behavioral avoidance but analysis model does not account for avoidance.
	Other mid-frequency(MF) odontocetes	Small number[a] short-term Level B exposures. No modeled Level A exposures.
	High-frequency (HF) porpoises	Effects highly unlikely given expected zero densities. No modeled Level A or B exposures.
Caribbean	**Sperm whale**	Small number[a] short-term Level B exposures. No modeled Level A exposures.
	Beaked whales	Effects highly unlikely given expected zero densities. No modeled Level A or B exposures.
	Common , bottlenose, and Stenellid dolphins	Small number[a] short-term Level B exposures primarily in shallow water. Small number Level A (rms) exposures of primarily Atlantic spotted dolphins in shallow water. No modeled Level A (SEL) cumulative energy exposures. No Level A exposures expected in actual seismic survey due to proposed mitigation measures and behavioral avoidance, but analysis model does not account for avoidance.
	Other MF odontocetes	Small number[a] short-term Level B exposures of mostly pilot whales primarily in shallow water. No Level A exposure modeled or expected due to proposed mitigation measures and behavioral avoidance.
S California	Beaked whales	See above.
	Common dolphins	Small number[a] short-term Level B exposures in shallow water. No Level A exposures modeled or expected due to proposed mitigation measures and behavioral avoidance.
	Other MF odontocetes	Small number[a] short-term Level B exposures and modeled Level A (rms) exposures of only Pacific white-sided dolphins in shallow water. No modeled Level A (SEL) cumulative energy exposures. No Level A exposures expected in actual seismic survey due to proposed mitigation measures and behavioral avoidance, but analysis model does not account avoidance.
	HF porpoises	Small number[a] short-term Level B exposures of only Dall's porpoises in shallow water. No Level A exposures modeled or expected due to proposed mitigation measures and behavioral avoidance.

Table 9. Summary of Potential Impacts to Odontocetes with Implementation of Alternative A or B (Preferred Alternative) in the DAAs

DAA	*Species*	*Alternative A or B*
W Gulf of Alaska	**Sperm whale**	Small number[a] short-term Level B exposures. No Level A exposures modeled or expected due to proposed mitigation measures and behavioral avoidance.
	Beaked whales	See sperm whale above.
	Other MF odontocetes	Small number[a] Level B behavioral effects of killer whales and Pacific white-sided dolphins primarily in shallow water. No Level A exposures modeled or expected due to planned mitigation measures and behavioral avoidance.
	HF porpoises	Small number[a] short-term Level B exposures and small number modeled Level A (rms) exposures of primarily Dall's porpoises in shallow water. No modeled Level A (SEL) cumulative energy exposures. No Level A exposures expected in actual seismic survey due to proposed mitigation measures and behavioral avoidance, but analysis model does not account for avoidance.
Galapagos	**Sperm whale**	See sperm whale above.
	Beaked whales	See sperm whale above
	Common, bottlenose, and Stenellid dolphins	Small number[a] short-term Level B exposures. Small number modeled Level A (rms) exposures of only Stenellid dolphins in shallow water. No modeled Level A (SEL) cumulative energy exposures. No Level A exposures expected in actual seismic survey due to proposed mitigation measures and behavioral avoidance, but analysis model does not account for avoidance.
	Other MF odontocetes	See sperm whale above.

Notes: [a] Small number = ≤2.1% of estimated regional population size exposed.
[b] Negligible number: for non-listed species = 0.5- <1.0 individual exposed representing <1.0% of estimated regional population size; for ESA-listed species = 0.05-<0.5 individual exposed representing <0.01% of estimated regional population size.

Table 10. Summary of Potential Impacts to Odontocetes with Implementation of Alternative A or B (Preferred Alternative) in the QAAs

QAA	*Species*	*Alternative A or B*
BC Coast	**Sperm whale,** beaked whales, other MF odontocetes, HF porpoises	Small number[b] short-term Level B exposures likely. No Level A exposures expected in actual seismic survey due to planned mitigation measures and behavioral avoidance
Mid-Atlantic Ridge	**Sperm whale,** beaked whales, other MF odontocetes	See above.
Marianas	**Sperm whale**, beaked whales, other MF odontocetes	See above.
Sub-Antarctic	**Sperm whale**, beaked whales, other MF odontocetes, HF porpoises	See above.
N Atlantic/Iceland	**Sperm whale**, beaked whales, other MF odontocetes, HF porpoises	See above.
SW Atlantic	**Sperm whale**, beaked whales, other MF odontocetes, HF porpoises	See above.
W India	**Sperm whale**, beaked whales, other MF odontocetes	See above.
W Australia	**Sperm whale**, beaked whales, other MF odontocetes	See above.

Notes: **bold** = ESA-listed species
[a] For the purpose of analysis, for non-listed species, only predicted exposures ≥0.5 animal are considered an actual exposure. For ESA-listed species, only predicted exposures ≥0.05 animal are considered an actual exposure.
[b] Small number = ≤2-3% of estimated regional population size.

Operation of MBESs, SBPs, and pingers is not likely to impact odontocetes. 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 of any individual odontocete 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 species. The streamer and core-mounted pingers are also highly unlikely to affect odontocetes 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.

In summary, implementation of Alternative A or B, with the proposed monitoring and mitigation measures, is likely to result in minor short-term and localized behavioral disturbance of small numbers of individual odontocetes. These temporary effects are not anticipated to result in any significant long-term or population-level impacts on odontocete populations. The numbers of individual odontocetes modeled or estimated to be exposed to the current NMFS Level B criterion of ≥160 dB re 1 µPa (rms) during the exemplary surveys would be small in relation to regional population sizes. No PTS or other potential injury of odontocetes is anticipated during an actual seismic survey under Alternative A or B with proposed mitigation and monitoring measures. If and when a specific NSF-funded survey is proposed for a specific area in the future, in accordance with ESA and MMPA, site-specific consultations with NMFS and USFWS would occur if necessary, as well as the preparation of any other appropriate tiered supporting environmental documentation (e.g., EA).

Marine Mammals – Pinnipeds

The potential impacts on pinnipeds with implementation of Alternative A or Alternative B (Preferred Alternative) are summarized in Table 11. Pinnipeds are absent or rare in the areas where some seismic surveys would occur. Overall, the primary anticipated impacts to pinnipeds with implementation of Alternative A or B are:

- Small numbers of individual pinnipeds are predicted to be exposed to ≥160 dB re 1 µPa rms at three of the five DAAs; these numbers represent <1.0% of regional populations. However, many of these exposed pinnipeds would not show any overt disturbance. These exposures are not expected to result in any long-term or significant consequences to the affected individuals or their populations.
- In general, modeling results indicate that large airgun arrays operating in shallow water where pinnipeds are common to abundant would cause the highest numbers of short-term Level B exposures.
- Small numbers of individuals representing <0.01% of regional populations of some pinnipeds are predicted to be exposed to the NMFS Level A criterion of ≥190 dB re 1 µPa (rms) or SEL ≥186 dB re 1 $\mu Pa^2 \cdot s$ in certain exemplary project areas under the simplifying assumptions of the modeling.
- PTS and other injurious effects are not expected to occur during the actual seismic surveys. Most pinnipeds are expected to avoid exposure to seismic sound levels that could potentially cause these effects. The model used for analysis overestimates Level A exposures, because it does not account for this expected behavioral avoidance and also does not allow for the higher TTS and PTS thresholds of some pinnipeds.

Table 11. Summary of Potential Impacts to Pinnipeds with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Species or Group[(a)]*	*Alternative A or B[(a)]*
DAA		
NW Atlantic	Non-ESA listed pinnipeds	Effects highly unlikely given expected zero densities.
Caribbean	No pinniped species	-
S California	**Steller sea lion, Guadalupe fur seal**	Effects highly unlikely given expected zero densities. No effect on ESA-listed species or their populations.
	Non-ESA listed pinnipeds	No significant impacts; limited to small number[(b)] of short-term Level B behavioral exposures. No modeled Level A exposures.
W Gulf of Alaska	**Steller sea lion**	May affect, likely to adversely affect ESA-listed species; consultation with NMFS required. Limited to small number[(b)] of short-term Level B behavioral exposures; <1 modeled Level A exposure but highly unlikely to occur in actual seismic survey as pinnipeds expected to avoid such exposure.
	Non-ESA listed pinnipeds	Limited to small number[(3)] of short-term Level B behavioral exposures; small number of modeled Level A exposures are highly unlikely to occur in actual seismic survey as pinnipeds expected to avoid such exposure.
Galapagos Ridge	No pinniped species	-
QAA		
BC Coast	**Steller sea lion**	See W Gulf of Alaska DAA.
	Non-ESA listed pinnipeds	See above
Mid-Atlantic Ridge	No pinniped species	-
Marianas	No pinniped species	-
Sub-Antarctic	Non-ESA listed pinnipeds	Level B behavioral effects possible but unlikely; Level A effects highly unlikely as species are rare and expected to avoid such exposure.
N Atlantic/Iceland	Non-ESA listed pinnipeds	See BC Coast QAA.
SW Atlantic	No pinniped species	-
W India	No pinniped species	-
W Australia	Australian sea lion	See Sub-Antarctic QAA.

[(a)]No significant effects expected at population level for any species. **Bold** = ESA-listed species.
[(b)] Small number (<1%) of estimated regional population size exposed.

Although the MBESs, SBPs, and pingers can presumably be heard by pinnipeds, their operation is not likely to affect pinnipeds. The intermittent and narrow downward-directed nature of the MBESs and SPBs would result in no more than one or two brief ping exposures of any individual pinniped given the movement and speed of the vessel and animal; such brief exposure to this sound is not expected to cause injury or PTS based on results of limited studies of some pinniped species (reviewed in Appendix E). The streamer-mounted pingers and pingers used during coring are also highly unlikely to affect pinnipeds 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.

In summary, implementation of Alternative A or B is likely to result in minor short-term and localized behavioral disturbance of small numbers of individual pinnipeds. These temporary effects are not anticipated to result in any long-term or population-level effects on pinniped populations. The numbers of individual pinnipeds estimated to be exposed to the current NMFS Level B criterion of ≥160 dB re 1 μPa (rms) during the exemplary surveys would be small in relation to regional population sizes. No PTS or other potential injury of pinnipeds is anticipated during an actual seismic survey under Alternative A or B with proposed mitigation and monitoring measures. No significant short- or long-term impacts are expected on pinniped populations or their habitats, including ESA-listed species, as a result of implementation of Alternative A or Alternative B (Preferred Alternative). If and when a specific NSF-funded survey is proposed for a specific area in the future, in accordance with ESA and MMPA, site-specific consultations with NMFS and USFWS would occur if necessary, as well as the preparation of any other appropriate tiered supporting environmental documentation (e.g., EA).

Other Marine Mammals (Sea Otter and W Indian Manatee)

Implementation of Alternatives A or B could result in minor short-term and localized behavioral disturbance of individual sea otters and W Indian manatees (Table 12). The number of individuals of these species estimated to be closely approached during the proposed seismic surveys is expected to be very small to none and limited to the three DAAs and one QAA where they occur. No PTS or other potential injury of these species is anticipated during an actual seismic survey under Alternative A with proposed mitigation and monitoring measures. No significant short- or long-term impacts are expected on ESA-listed species populations or their habitats as a result of implementation of Alternative A or B.

Table 12. Summary of Potential Impacts to Sea Otter and W Indian Manatee with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Species*	*Alternative A or B*
DAA		
Caribbean	West Indian manatee	Potential short-term disturbance and localized displacement of individuals possible, but species unlikely to occur in areas where seismic surveys would occur. Potential for TTS unknown, considered possible close to airguns but highly unlikely to occur. No significant impacts or adverse effects expected on individuals or regional populations.
S California	Sea otter	Potential short-term disturbance and localized displacement of individuals possible, but species unlikely to occur in areas where seismic surveys would occur. Potential for TTS unknown, considered possible close to airguns but highly unlikely to occur. No significant impacts or adverse effects expected on individuals or regional populations.
W Gulf of Alaska	Sea otter	Potential short-term disturbance and localized displacement of individuals possible, but species unlikely to occur in areas where seismic surveys would occur. Potential for TTS unknown, considered possible close to airguns but highly unlikely to occur. No significant impacts or adverse effects expected on individuals or regional populations.
QAA		
BC Coast	Sea otter	Potential short-term disturbance and localized displacement of individuals possible, but species unlikely to occur in areas where seismic surveys would occur. Potential for TTS unknown, considered possible close to airguns but highly unlikely to occur. No significant impacts or adverse effects expected on individuals or regional populations.

Sounds from some of the MBESs and SBPs are within the frequency ranges detectable to W Indian manatees and presumed detectable to sea otters. Short-term behavioral disturbance of these species may occur during proposed seismic activities. However, no Level A exposures are expected. W Indian manatees typically inhabit quite shallow coastal areas characterized by seabeds where seismic surveys are not proposed to occur. Furthermore, the intermittent and downward-directed nature of the echosounder signals emitted from the transiting seismic vessel would result in no more than one or two brief ping exposures to an animal that happened to occur under the vessel.

Socioeconomics

Based on available information, there would be no significant impacts to socioeconomics with implementation of Alternative A or B (Preferred Alternative) within the exemplary analysis areas (Table 13). The analysis is limited to the DAAs and QAAs found within the U.S. EEZ.

Table 13. Summary of Potential Impacts to Socioeconomics with Implementation of Alternative A or B (Preferred Alternative)

Analysis Area	*Alternative A or B*
NW Atlantic	• Temporary, localized reduced fish catch to some species – not significant to commercial fisheries. • No significant impacts to commercial shipping, research and exploration activities, subsistence hunting and fishing, and recreational fishing and boating.
S California	• Temporary, localized reduced fish catch to some species – not significant to commercial fisheries. • No significant impacts to commercial shipping, research and exploration activities, subsistence hunting and fishing, and recreational fishing and boating.
W Gulf of Alaska	• Temporary, localized reduced fish catch to some species – not significant to commercial fisheries. • No significant impacts to commercial shipping, research and exploration activities, subsistence hunting and fishing, and recreational fishing and boating.

Cultural Resources

Based on available information, there would be no significant impacts to cultural resources with implementation of Alternative A or B within the exemplary analysis areas (Table 14). The analysis is limited to the DAAs and QAAs found within the U.S. EEZ.

Table 14. Summary of Potential Impacts to Cultural Resources with Implementation of Alternative A or B (Preferred Alternative)

DAA	*Alternative A or B*
NW Atlantic	• No significant impacts to archaeological resources. • No traditional cultural resources present.
S California	• No significant impacts to archaeological resources. • No traditional cultural resources present.
W Gulf of Alaska	• No significant impacts to archaeological and traditional cultural resources.

Cumulative Impacts

The results of this cumulative impacts analysis indicate that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research. All seismic cruises would be permitted according to the rules and regulations of the applicable agencies of U.S. federal, state, and foreign governments.

While there are uncertainties about the location and timing of future human activities in relation to the seismic surveys described in the Final PEIS, should it be necessary in the future, cruise-specific NEPA documentation could be prepared when a particular seismic research activity is proposed. A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the area of the proposed seismic survey that may result in cumulative impacts to environmental resources. These cruise-specific EAs would also take into consideration the seasonal distribution of marine resources and acoustic properties of a proposed site to develop site-specific mitigation measures. These additional mitigation measures would be followed to ensure that potential cumulative impacts would not become significant. For example, if modeling results indicate that Level A (injury) harassment impacts to marine mammals or threatened and endangered marine mammal species may occur, then additional mitigation measures would be added to the cruise parameters to reduce and eliminate the potential for Level A harassment impacts to marine mammals that could occur in the project area.

B. ESA COMPLIANCE

The ESA of 1973 and subsequent amendments provide for the protection and conservation of threatened and endangered species of animals (including some marine mammals) and plants, and the ecosystems on which they depend. The ESA prohibits federal agencies from funding, authorizing or carrying out actions likely to jeopardize endangered or threatened species or result in the destruction or adverse modification of critical habitat designated for them. Section 7 of the ESA requires consultation with NMFS and the USFWS when any endangered or threatened species under their jurisdiction may be affected by a proposed action. Generally, the USFWS manages land and freshwater species while NMFS manages marine species, including anadromous salmon. However, the USFWS has responsibility for some marine animals such as nesting sea turtles, walruses, polar bears, sea otters, and manatees.

For actions that could result in prohibited "take" of a listed species, federal agencies must obtain authorization for incidental take through the section 7 formal consultation process. Under ESA "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt any such conduct to species listed as threatened or endangered in 50 CFR 402.12(b)." NMFS has further defined harm as follows: "harm" is "...an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR 222.102)." "Harass" as defined by the USFWS means an "intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)." NMFS has not defined the term "harass" by regulation.

Under section 7 of the ESA, federal agencies consult with the USFWS and/or NMFS and submit a consultation package for proposed actions that may affect listed species or critical habitat. If a listed species or critical habitat is likely to be affected by a proposed federal action, the federal agency must provide the USFWS and NMFS with an evaluation whether or not the effect on the listed species or critical habitat is likely to be adverse. Often this information is referred to as a "consultation package" or Biological Assessment (BA). The USFWS and/or NMFS uses this documentation along with any other available information to determine if a formal consultation or a conference is necessary for actions likely to result in adverse effects to a listed species or its designated critical habitat. After USFWS and NMFS review the BA, these agencies provide their determinations regarding the nature of any effects on each listed species or critical habitat. For each species that is likely to be adversely affected (i.e., subject to take or adverse effect on critical habitat), formal consultation with the agency is required, culminating in the agency's issuance of a BO, which contains the necessary and sufficient terms and conditions under which the action can proceed. For each species not likely to be adversely affected, informal consultation is required, the conclusion of which is the agency's written concurrence with the findings, including any additional measures mutually agreed upon as necessary and sufficient to minimize adverse impacts to listed species and/or designated critical habitat.

Although an authorization is not required by the MMPA if marine mammals are not being taken, the NMFS and USFWS believe an incidental take authorization under the MMPA is warranted in an area where marine mammal species are likely to occur because seismic-survey sounds have the potential to harass marine mammals. In addition, NMFS cannot issue an exemption to the take prohibitions for harassment through an ITS unless appropriate MMPA incidental take is authorized. Because a BO, including an ITS, is issued under the ESA once the requirements of Section 101(a)(5) of the MMPA have been met, seismic surveys that could affect ESA-listed marine mammals shall not commence until such time that USFWS and NMFS issue the appropriate MMPA incidental take authorizations and coordinate its requirements with those in the ITS. Although NSF worked collaboratively with NMFS Office of Protected Resources (OPR) during the PEIS process, NMFS OPR determined that section 7 ESA consultation was not applicable. The PEIS may however contain information relevant and applicable to support future NSF consultations on ESA-listed species and critical habitat for site-specific marine seismic cruises as required under the ESA. NMFS and USFWS, at the request of NSF, would review any future seismic cruise activity that has the potential to affect a marine species listed as threatened or endangered under the ESA on a case-by-case basis to determine its effect and make necessary determinations and findings in accordance with section 7 of the ESA and its implementing regulations.

C. MMPA COMPLIANCE

The MMPA of 1972 protects marine mammals by strictly limiting their "taking" in waters or on lands under U.S. jurisdiction, and on the high seas by vessels or persons under U.S. jurisdiction. The term "take," as defined in Section 3 (16 USC 1362) of the MMPA and its implementing regulations, means "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.

The incidental, but not intentional, taking of marine mammals is allowed if certain findings are made and regulations are issued. In particular, application can be made for authorization to incidentally take marine mammals for specific activities such as seismic surveys. Permission for incidental taking of various marine mammals can be granted by NMFS or the USFWS through the issuance of regulations, which can cover a period of up to 5 consecutive years, and a Letter of Authorization (LOA) under those regulations. NMFS can issue regulations and LOAs concerning cetaceans, seals, and sea lions. USFWS can issue regulations and LOAs concerning walruses, polar bears, sea otters, and sirenians. LOAs for the incidental take of small numbers of marine mammals within a specified geographic area can only be issued if it is determined that the taking would have no more than a negligible impact on the species or stock, and would not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses (where relevant). Prior to issuing an LOA for a specific activity, NMFS or the USFWS develops and publishes regulations in the *Federal Register*, and holds public comment periods. The regulations must outline:

- the permissible methods and the specified geographical region of taking;
- the means of effecting the least practicable adverse impact on species or stock and its habitat, and on the availability of the species or stock for subsistence uses (where relevant); and
- the requirements pertaining to the monitoring and reporting of such taking.

Once the regulations are finalized, NMFS or the USFWS can move forward with authorizing the activity through issuance of an LOA.

In 1994, the MMPA was amended to establish an expedited process by which citizens of the U.S. can apply for an authorization to take small numbers of marine mammals incidental to specified activities (other than commercial fishing) within a specific geographic region by "harassment", referred to as Incidental Harassment Authorizations or IHAs. It established specific time limits for public notice and comment on any requests for authorization that are granted under the provision. IHAs are limited in duration to no longer than 1 year and may only be issued if the Secretary of Commerce makes the determinations and establishes conditions described above for regulations and LOAs. Because the IHA process has eliminated the need for promulgating specific regulations on the incidental taking, IHAs are generally used by individuals with relatively short-term activities that may incidentally harass marine mammals. The IHA process cannot be used where incidental take would likely result in serious injury or mortality to marine mammals.

In the past, NSF has applied for and received incidental take authorizations for marine mammals through the IHA process on a cruise-by-cruise basis. Although NSF and USGS did not request authorizations under section 101(a)(5) of the MMPA during the preparation of the PEIS, the PEIS may contain information relevant and applicable to support future NSF consultations in support of potential requests for future incidental take authorizations for site-specific marine seismic cruises for actions described and analyzed in the Final PEIS. Should marine seismic surveys funded by NSF be determined to have the potential to incidentally take marine mammals, an MMPA IHA application would be submitted by NSF to NMFS or USFWS. The application would be evaluated and considered based on the determinations and criteria required by Section 101(a)(5)(D) of the MMPA on a case-by-case basis.

In order to issue the MMPA authorization required for certain activities, it might be necessary for NMFS to require additional mitigation or monitoring measures beyond those addressed in the Final PEIS. These could include measures considered, but eliminated in the Final PEIS, or as yet undetermined measures. The public will have an opportunity to provide information to NMFS through the MMPA process during the 30-day comment period following NMFS' publication of a Notice of Proposed IHA in the *Federal Register*. Measures not considered in the mitigation and monitoring measures in the Final PEIS, but required through the MMPA process, might require evaluation in accordance with NEPA. In doing so, NMFS may consider "tiering," that is, incorporating the Final PEIS during the MMPA process.

III. DECISION

As previously described, NSF funds and has a need to continue to fund research to study the geology and geophysics of the seafloor by collecting seismic reflection and refraction data that reveal the structure and stratigraphy of the crust and/or overlying sediment below the world's oceans to further the understanding of the Earth and Earth processes.

The process for determining and evaluating the environmental effects of marine seismic research funded by NSF spanned approximately 6 years during which NSF took great care to ensure that the environmental consequences and potential mitigation measures were fully developed and understood. This included direct and extensive involvement with NMFS on the PEIS, including the approach on associated underwater acoustic impacts to marine biota and the inclusion of a suite of mitigation measures that would reduce and minimize the potential for significant impacts to marine animals, particularly marine mammals. NSF will use an appropriate acoustic modeling method for determining the MZs, FMZs, and marine mammal take estimates, for future cruises taking into consideration suitable and available software applications and technology, agency feasibility to implement, and regulatory guidance/requirements.

The Final PEIS assesses two action alternatives and a No-Action Alternative:

- Alternative A: Conduct Marine Seismic Research Using Cruise-specific Mitigation Measures
- Alternative B: Conduct Marine Seismic Research Using Cruise-specific Mitigation Measures with Generic Mitigation Measures for Low-energy Acoustic Sources (Preferred Alternative)
- No-Action Alternative. Under this alternative, the NSF would not conduct marine seismic research using airguns and other acoustic sources (e.g., MBES, SBP, pingers, etc.). The seismic data from the proposed surveys have important implications for scientific research and, in some cases, human safety and well-being, and national security. The No-Action Alternative would result in a loss of important scientific data and knowledge relevant to a number of research fields (e.g., understanding of geohazards such as earthquake faults, the potential for submarine slide development and tsunami generation; information about marine habitats and offshore cultural features; and detection of offshore groundwater discharge, gas hydrates, or other resources). For geohazard or resource issues, this lack of further data acquisition could have a potentially harmful effect on marine or human populations.

I have considered the analysis in the PEIS, agency coordination efforts, public comments and all other influencing factors. Of the three alternatives that were analyzed in the Final PEIS (Alternative A, Alternative B, and No-Action Alternative), I have decided to select Alternative B as presented in the Final PEIS, which is also the preferred alternative. Alternative B best meets the purpose and need of marine seismic research funded by NSF while, at the same time, ensuring the protection of the marine environment. As explained above and more thoroughly in the Final PEIS, conducting marine seismic surveys will not result in significant impacts to any resource. While all efforts have been made to avoid and minimize impacts, some impacts may occur even with the implementation of mitigation measures. The mitigation measures to be implemented, however, are indeed considerable and represent a dedicated multi-year effort by NSF to identify ways to address and reduce potential impacts to marine biota, particularly marine mammals, to a level of insignificance.

While Alternative B sets forth a monitoring and mitigation framework for marine seismic surveys, it also allows NSF to tailor measures as necessary for future cruises based on, but not limited to, survey specific characteristics, consultation with regulatory agencies, requirements set forth in associated IHAs, or a need to reduce impacts to a level of insignificance. NSF will consider and incorporate new monitoring and mitigation measures as technology/research advances are made, or revise the generic measures should they be determined ineffective for their intended purpose. If NSF engages in any further analyses regarding monitoring and mitigation measures, such analyses will be tiered to this PEIS.

The Cooperating Agencies involved in the PEIS are in agreement to select Alternative B as the preferred alternative. USGS will prepare a separate ROD appropriate for their agency. NOAA NMFS will not prepare a ROD in response to this PEIS as they are not an action agency in this activity.

Increasing our understanding of the Earth and Earth system processes is critical for our society; advances made in geological processes further our understanding of ecosystems, climate, and hazards such as earthquakes and tsunamis. Accordingly, I hereby approve future NSF marine seismic research to be conducted consistent with Alternative B (Preferred Alternative) as described in detail in the Final PEIS and herein, and employing adaptive management as necessary.

6/12/12
Date

David Conover
Dr. David O. Conover
Ocean Sciences Division Director
National Science Foundation

From: Joyce Dillard [mailto:dillardjoyce@yahoo.com]
Sent: Monday, August 01, 2011 5:39 PM
To: NSF NEPA Comments
Subject: Comments to EIS 20110203 Marine Seismic Research due 8.1.2011

Comments to EIS 20110203 Marine Seismic Research due 8.1.2011

We ask why the Santa Monica Bay was omitted from your research. We understand that it has not been mapped for seismic activity. There are unmapped faults in that area and a concern of the knowledgeable residents in the area as it effects a wider region and economic hub in Southern California. Its geology may explain Clean Water Act impaired bodies, yet the science has not been done to justify the sources.

We cannot ascertain in Figure 2-20 Southern California that you cover that area.

Joyce Dillard
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