Request by U.S. Geological Survey for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Central-Western Bering Sea, August 2011

submitted by

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to

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SUMMARY

The U.S. Geological Survey (USGS), under the auspices of the Interagency Extended Continental Shelf Task Force, plans to conduct a marine seismic survey in the central-western Bering Sea during August 2011. The survey will take place in the U.S. Exclusive Economic Zone (EEZ) and adjacent International Waters >350 km from the coast, in water depths >3000 m. The airgun array will consist of a towed array of 36 airguns with a total volume of ~6600 in^3. USGS requests that it be issued an Incidental Harassment Authorization (IHA) allowing non-lethal takes of marine mammals incidental to the planned seismic survey. This request is submitted pursuant to Section 101 (a) (5) (D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a) (5).

Numerous species of cetaceans and pinnipeds inhabit the offshore waters of the Bering Sea. Several of these species are listed as ***endangered*** under the U.S. Endangered Species Act (ESA), including the North Pacific right, sperm, humpback, sei, fin, and blue whales, as well as the western stock of Steller sea lions. Critical habitat for the North Pacific right whale and Steller sea lion is also found in the Bering Sea. Other ESA-listed species that could occur in the area are the ***endangered*** short-tailed albatross, the ***threatened*** Steller's eider, and the ***endangered*** leatherback turtle. One candidate species under the ESA that is known to occur in the area is Kittlitz's murrelet.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, "Submission of Requests", are set forth below. They include descriptions of the specific operations to be conducted, the marine mammals occurring in the study area, proposed measures to mitigate against any potential injurious effects on marine mammals, and a plan to monitor any behavioral effects of the operations on those marine mammals.

I. OPERATIONS TO BE CONDUCTED

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

Overview of the Activity

USGS plans to conduct a seismic survey in the central-western Bering Sea, between ~350 and 800 km offshore, in the area 55–58.5°N, 177°W–175°E (Fig. 1). Water in the survey area is deeper than 3000 m. The project is scheduled to occur ~7 August–1 September 2011. Some minor deviation from these dates is possible, depending on logistics and weather.

The proposed seismic survey will collect seismic reflection and refraction profiles to be used to delineate the U.S. extended continental shelf (ECS) in the Bering Sea. The ECS is that region beyond 200 nautical miles (n.mi.) where a nation can show that it satisfies the conditions of Article 76 of the United Nations Convention on the Law of the Sea. One of the conditions in Article 76 is a function of sediment thickness. The seismic profiles are designed to identify the stratigraphic "basement" and to map the thickness of the overlying sediments. Acoustic velocities (required to convert measured travel times

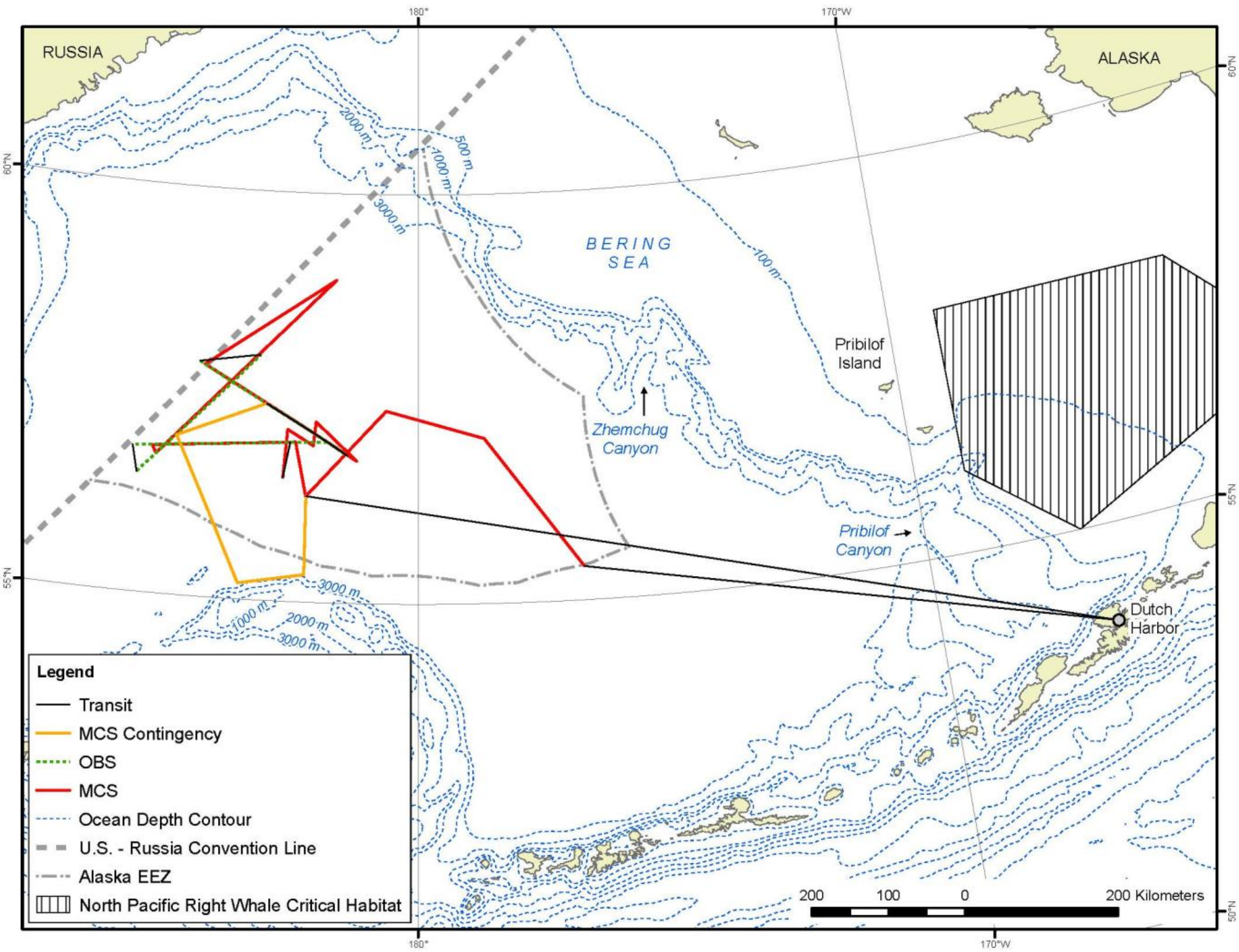

FIGURE 1. Proposed seismic transect lines for the central-western Bering Sea survey planned by USGS for August 2011. Also shown on the map is critical habitat for North Pacific right whales.

to true depth) will be measured directly using sonobuoys and ocean bottom seismometers (OBSs), as well as by analysis of hydrophone streamer data.

The survey will involve one source vessel, the R/V *Marcus G. Langseth*. The *Langseth* will deploy an array of 36 airguns as an energy source. The receiving system will consist of one 8-km long hydrophone streamer and/or 18 OBSs. As the airgun array is towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the on-board processing system. The OBSs record the returning acoustic signals internally for later analysis. During the seismic operations, sonobuoys will be deployed up to 4 times per day. The sonobuoys are deployed from the vessel, and consist of a hydrophone, electronics, and a radio transmitter. The seismic signal is measured by the hydrophone and transmitted by radio back to the source vessel. The sonobuoys are expendable, and after a pre-determined time (usually 8 hours), they self-scuttle and sink to the ocean bottom.

The planned seismic survey will consist of ~2420 km of transect lines in the central-western Bering Sea (Fig. 1). The array will be powered down to one 40-in^3 airgun during turns. All of the survey will take place in water deeper than 3000 m. A multichannel seismic (MCS) survey using the hydrophone streamer will take place along 14 lines. Following the MCS survey, 18 OBSs will be deployed and a refraction survey will take place along three of the 14 lines. If time permits, an additional 525 km of MCS survey lines will be conducted (Fig. 1). There will be additional seismic operations associated with equipment testing, startup, and possible line changes or repeat coverage of any areas where initial data quality is sub-standard. In our calculations (see § VII), 25% has been added for those contingency operations.

All planned geophysical data acquisition activities will be conducted by Lamont-Doherty Earth Observatory (L-DEO), the *Langseth*'s operator, with on-board assistance by the scientists who have proposed the study. The Principal Investigators are Drs. Jonathan R. Childs and Ginger Barth of the USGS. The vessel will be self-contained, and the crew will live aboard the vessel for the entire cruise.

Vessel Specifications

The R/V *Marcus G. Langseth* will be used as the source vessel. The *Langseth* will tow the 36-airgun array, as well as the hydrophone streamer, along predetermined lines (Fig. 1). The *Langseth* will also deploy and retrieve the OBSs. When the *Langseth* is towing the airgun array and the hydrophone streamer, the turning rate of the vessel is limited to five degrees per minute. Thus, the maneuverability of the vessel is limited during operations with the streamer.

The *Langseth* has a length of 71.5 m, a beam of 17.0 m, and a maximum draft of 5.9 m. The *Langseth* was designed as a seismic research vessel, with a propulsion system designed to be as quiet as possible to avoid interference with the seismic signals. The ship is powered by two Bergen BRG-6 diesel engines, each producing 3550 horsepower (hp), which drive the two propellers directly. Each propeller has four blades, and the shaft typically rotates at 600 or 750 revolutions per minute (rpm). The vessel also has an 800 hp bowthruster, which is not used during seismic acquisition. The operation speed during seismic acquisition is typically 7.4–9.3 km/h. When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km/h. The *Langseth* has a range of 25,000 km (the distance the vessel can travel without refueling).

The *Langseth* will also serve as the platform from which vessel-based protected species observers (PSOs) will watch for marine mammals and sea turtles before and during airgun operations, as described in § XIII, below.

Other details of the *Langseth* include the following:

Owner:	National Science Foundation
Operator:	Lamont-Doherty Earth Observatory of Columbia University
Flag:	United States of America
Date Built:	1991 (Refitted in 2006)
Gross Tonnage:	3834
Accommodation Capacity:	55 including ~35 scientists

Airgun Description

During the survey, the airgun array to be used will consist of 36 airguns[1], with a total volume of ~6600 in^3. The airgun array will consist of a mixture of Bolt 1500LL and Bolt 1900LLX airguns. The airguns will be configured as four identical linear arrays or "strings" (Fig. 2). Each string will have ten airguns; the first and last airguns in the strings are spaced 16 m apart. Nine airguns in each string will be fired simultaneously, whereas the tenth is kept in reserve as a spare, to be turned on in case of failure of

[1] A two-string, 3300-in^3 array will be used if field trials show that it will accomplish the geophysical objectives, but calculations are based on the eventuality that the full array is required.

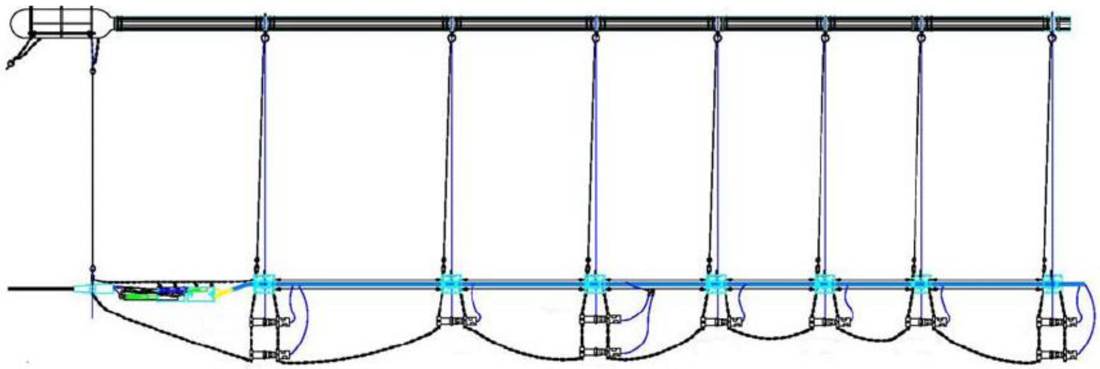

FIGURE 2. One linear airgun array or string with ten airguns, nine of which would be operating.

another airgun. The four airgun strings will be distributed across an area of ~24×16 m behind the *Langseth* and will be towed ~100 m behind the vessel. The shot interval will be 50 m or ~22 s for the MCS survey and 150 m or ~66 s for the OBS refraction survey. The firing pressure of the array is 1900 psi. During firing, a brief (~0.1 s) pulse of sound is emitted. The airguns will be silent during the intervening periods.

The tow depth of the array will be 9 m during OBS refraction and MCS surveys. Because the actual source is a distributed sound source (36 airguns) rather than a single point source, the highest sound levels measurable at any location in the water will be less than the nominal source level. In addition, the effective source level for sound propagating in near-horizontal directions will be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of the sound from the airgun array.

36-Airgun Array Specifications

Energy Source	Thirty-six 1900 psi Bolt airguns of 40–360 in^3, in four strings each containing nine operating airguns
Source output (downward)	0-pk is 84 bar-m (259 dB re 1 μPa·m); pk-pk is 177 bar·m (265 dB)
Air discharge volume	~6600 in^3
Dominant frequency components	2–188 Hz

Acoustic Measurement Units

Received sound levels have been predicted by L-DEO, in relation to distance and direction from the airguns, for the 36-airgun array and for a single 1900LL 40-in^3 airgun, which will be used during power downs. Results were recently reported for propagation measurements of pulses from the 36-airgun array in two water depths (~1600 m and 50 m) in the Gulf of Mexico in 2007–2008 (Tolstoy et al. 2009). It would be prudent to use the empirical values that resulted to determine exclusion zones for the airgun array. Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. During the proposed study, all survey effort will take place in deep (>1000 m) water, so propagation in shallow water is not relevant here. The depth of the array was different in the Gulf of Mexico calibration study (6 m) than in the proposed survey (9 m); thus, correction factors have been applied to the distances reported by Tolstoy et al. (2009). The correction factors used were the ratios of the 160-, 170-, 180-, and 190-dB distances from the modeled results for the 6600-in^3 airgun array towed at 6 m vs. 9 m, from LGL (2008): 1.285; 1.381; 1.338; and 1.364, respectively.

Measurements were not reported for a single airgun, so model results will be used. Figure 3 illustrates modeled received sound levels for a single airgun operating in deep water. The tow depth has minimal effect on the maximum near-field output and the shape of the frequency spectrum for the single airgun; thus, the predicted safety radii are essentially the same at different tow depths. A detailed description of the modeling effort is provided in Appendix A of the EA. The predicted sound contours for the 40-in^3 mitigation airgun are shown as sound exposure levels (SEL) in decibels (dB) re 1 $\mu Pa^2 \cdot s$. SEL is a measure of the received energy in the pulse and represents the sound pressure level (SPL) that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse (see Appendix B of the EA). The advantage of working with SEL is that the SEL measure accounts for the total received energy in the pulse, and biological effects of pulsed sounds are believed to depend mainly on pulse energy (Southall et al. 2007). In contrast, SPL for a given pulse depends greatly on pulse duration. A pulse with a given SEL can be long or short depending on the extent to which propagation effects have "stretched" the pulse duration. The SPL will be low if the duration is long and higher if the duration is short, even though the pulse energy (and presumably the biological effects) is the same.

Although SEL is now believed to be a better measure than SPL when dealing with biological effects of pulsed sound, SPL is the measure that has been most commonly used in studies of marine mammal reactions to airgun sounds and in National Marine Fisheries Service (NMFS) guidelines concerning levels above which "taking" might occur. SPL is often referred to as rms or "root mean square" pressure, averaged over the pulse duration. As noted above, the rms received levels that are used as impact criteria for marine mammals are not directly comparable to pulse energy (SEL). At the distances where rms levels are 160–190 dB re 1 μPa, the difference between the SEL and SPL values for the same pulse measured at the same location usually average ~10–15 dB, depending on the propagation characteristics of the location (Greene 1997; McCauley et al. 1998, 2000a; Appendix B of the EA). In this EA, we assume that rms pressure levels of received seismic pulses will be 10 dB higher than the SEL values predicted by L-DEO's model. Thus, we assume that 170 dB SEL ≈ 180 dB re 1 μPa_{rms}. It should be noted that neither the SEL nor the SPL (=rms) measure is directly comparable to the peak or peak-to-peak pressure levels normally used by geophysicists to characterize source levels of airguns. Peak and peak-to-peak pressure levels for airgun pulses are always higher than the rms dB referred to in much of the biological literature (Greene 1997; McCauley et al. 1998, 2000a). For example, a measured received level of 160 dB re 1 μPa_{rms} in the far field typically would correspond to a peak measurement of ~170–172 dB re 1 μPa, and to a peak-to-peak measurement of ~176–178 dB re 1 μPa, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000a). (The SEL value for the same pulse would normally be 145–150 dB re 1 $\mu Pa^2 \cdot s$). The precise difference between rms and peak or peak-to-peak values for a given pulse depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level and (for an airgun-type source at the ranges relevant here) higher than the SEL value.

Predicted Sound Levels

Using the corrected empirical measurements (array) or model (single airgun), Table 1 shows the distances at which four rms sound levels are expected to be received from the 36-airgun array and a single airgun. The 180- and 190-dB re 1 μPa_{rms} distances are the safety criteria as specified by NMFS (2000) and are applicable to cetaceans and pinnipeds, respectively. The 180-dB distance will also be used as the exclusion zone for sea turtles, as required by NMFS in most other recent seismic projects (e.g., Smultea et al. 2004; Holst et al. 2005b; Holst and Beland 2008; Holst and Smultea 2008; Hauser et al. 2008). If

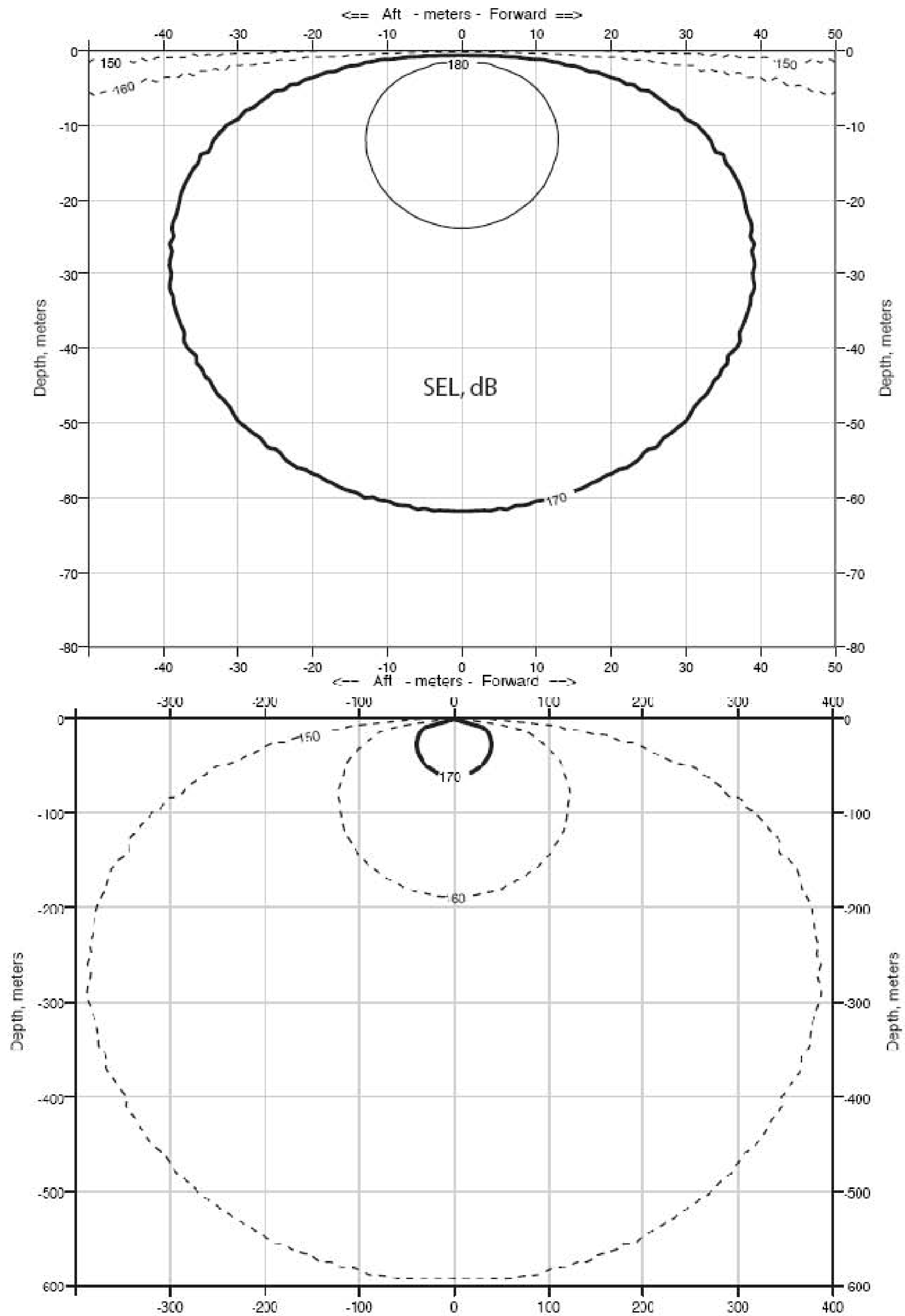

FIGURE 3. Modeled received sound levels (SELs) from a single 40-in^3 airgun operating in deep water, which is planned for use as a mitigation airgun during the central-western Bering Sea survey. Received rms levels (SPLs) are expected to be ~10 dB higher.

TABLE 1. Measured (array) or predicted (single airgun) distances to which sound levels ≥190, 180, 170, and 160 dB re 1 μPa$_{rms}$ could be received in water depths >1000 m during the proposed central-western Bering Sea survey, August 2011. Measured radii for the array are based on Tolstoy at al. (2009), corrected for deployment depth, and predicted radii for a single airgun are based on Figure 3, assuming that received levels on an RMS basis are, numerically, 10 dB higher than the SEL values shown in Figure 3.

	Predicted RMS Distances (m) in deep (>1000 m) water			
Source and Volume	**190 dB**	**180 dB**	**170 dB**	**160 dB**
Single Bolt airgun, 40 in^3	12	40	120	385
4 strings, 36 airguns, 6600 in^3, 9 m depth	400	940	2200	3850

marine mammals or turtles are detected within or about to enter the appropriate exclusion zone, the airguns will be powered down (or shut down if necessary) immediately.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. USGS and NSF will be prepared to revise the procedures for estimating numbers of mammals "taken", exclusion zones, etc., as may be required by any new guidelines established by NMFS as a result of these recommendations. However, currently the procedures are based on best practices noted by Pierson et al. (1998) and Weir and Dolman (2007) as NMFS has not yet specified a new procedure for determining exclusion zones.

Description of Operations

The source vessel, the R/V *Marcus G. Langseth*, will deploy an array of 36 airguns with a discharge volume of 6600 in^3 as an energy source at a tow depth of ~9 m. The receiving system will consist of one 8-km long hydrophone streamer and/or 18 OBSs. As the airgun array is towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the on-board processing system. The OBSs record the returning acoustic signals internally for later analysis. During the seismic operations, sonobuoys will be deployed up to 4 times per day. The sonobuoys are deployed from the vessel, and consist of a hydrophone, electronics, and a radio transmitter. The seismic signal is measured by the hydrophone and transmitted by radio back to the source vessel. The sonobuoys are expendable, and after a pre-determined time (usually 8 hours), they self-scuttle and sink to the ocean bottom.

The planned seismic survey will consist of ~2420 km of transect lines in the central-western Bering Sea survey area (Fig. 1). The array will be powered down to one 40-in^3 airgun during turns. All of the survey will take place in water deeper than 3000 m. An MCS survey using the hydrophone streamer will take place along 14 lines. Following the MCS survey, 18 OBSs will be deployed and a refraction survey will take place along three of the 14 lines. If time permits, an additional 525 km of MCS survey lines will conducted (Fig. 1). In addition to the operations of the airgun array, a Kongsberg EM 122 multibeam echosounder (MBES), a Knudsen Chirp 3260 sub-bottom profiler (SBP), and a hull-mounted acoustic Doppler current profiler (ADCP) will also be operated from the *Langseth* continuously throughout the cruise.

OBS Description and Deployment

The study will include a refraction survey using OBSs. Eighteen OBSs will be deployed by the R/V *Langseth* at the beginning of the survey along three transects. After data are collected along these transect lines, the OBSs will be retrieved.

Scripps Institution of Oceanography LC4x4 OBSs will be used during the cruise. This OBS has a volume of ~1 m^3, with an anchor that consists of a large piece of steel grating (~1 m^2). Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the OBS at a frequency of 9–11 kHz, and a response is received at a frequency of 9–13 kHz. The burn-wire release assembly is then activated, and the instrument is released from the anchor to float to the surface.

Multibeam Echosounder, Sub-bottom Profiler, and ADCP

Along with the airgun operations, two additional acoustical data acquisition systems will be operated during the survey. The ocean floor will be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sound sources will be operated from the *Langseth* continuously throughout the cruise.

The Kongsberg EM 122 MBES operates at 10.5–13 (usually 12) kHz and is hull-mounted on the *Langseth*. The transmitting beamwidth is 1 or 2° fore–aft and 150° athwartship. The maximum source level is 242 dB re 1 μPa·m_{rms}. Each "ping" consists of eight (in water >1000 m deep) or four (<1000 m) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore–aft. Continuous-wave (CW) pulses increase from 2 to 15 ms long in water depths up to 2600 m, and frequency-modulated (FM) chirp pulses up to 100 ms long are used in water >2600 m. The successive transmissions span an overall cross-track angular extent of about 150°, with 2-ms gaps between the pulses for successive sectors.

The Knudsen Chirp 3260 SBP is normally operated to provide information about the sedimentary features and the bottom topography that is being mapped simultaneously by the MBES. The SBP is capable of reaching depths of 10,000 m. The beam is transmitted as a 27º cone, which is directed downward by a 3.5-kHz transducer in the hull of the *Langseth*. The nominal power output is 10 kW, but the actual maximum radiated power is 3 kW or 222 dB re 1 μPa·m. The ping duration is up to 64 ms, and the ping interval is 1 s. A common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

***Langseth* Sub-bottom Profiler Specifications**

Maximum source output (downward)	222 dB re 1 μPa·m
Dominant frequency components	3.5 kHz
Nominal beam width	~27 degrees
Pulse duration	up to 64 ms

A Teledyne RDI hull-mounted acoustic Doppler current profiler will be used continuously to measure ocean currents to depths of ~400 meters beneath the vessel. The ADCP pings at a maximum rate of 1 s, and has a beam angle of 30° directed vertically downwards.

II. Dates, Duration, and Region of Activity

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

The survey will occur in the central-western Bering Sea, between ~350 and 800 km offshore, in the area 55–59°N, 174°E–176°W (Fig. 1). The seismic survey will take place in water depths >3000 m. The exact dates of the activities depend on logistics and weather conditions. The *Langseth* will depart from Dutch Harbor on ~7 August 2011 and spend ~1.5 days in transit to the study area. The program will start with the MCS survey for ~10 days. Subsequently, 18 OBSs will be deployed along three lines. OBS deployment will take ~1 day, the refraction survey will take ~4 days, and OBS recovery will take ~2 days.

The additional MCS line survey would take ~3 days. On completion of seismic operations, the vessel will return to Dutch Harbor, for arrival on 1 September 2011. Some minor deviation from this schedule is possible, depending on logistics and weather.

III. Species and Numbers of Marine Mammals in Area

The species and numbers of marine mammals likely to be found within the activity area

Twenty species of marine mammals, including six odontocetes, eight mysticetes, and six pinnipeds (Table 2) could occur in the offshore waters of the central-western Bering Sea. Seven cetaceans species and one pinniped species are listed under the ESA as ***Endangered*** or ***Threatened***: the North Pacific right, bowhead, blue, fin, sei, humpback, and sperm whales, and the Steller sea lion. The ice seals (ribbon, ringed and spotted seals) and walrus are not listed under the ESA, but the ribbon seal is a species of concern and the others are proposed for ESA listing, mainly because of predicted habitat loss because of global warming. However, these seals are uncommon in the Bering Sea in late summer. No U.S.-designated critical habitat for any marine mammal species occurs in or near the proposed survey area. The Pacific walrus is managed by the U.S. Fish and Wildlife Service (USFWS); all others are managed by NMFS.

To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below.

IV. Status, Distribution and Seasonal Distribution of Affected Species or Stocks of Marine Mammals

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities

Sections III and IV are integrated here to minimize repetition.

The marine mammals that occur in the proposed survey area belong to three taxonomic groups: odontocetes (toothed cetaceans, such as dolphins), mysticetes (baleen whales), and pinnipeds (seals, sea lions, and walrus). Cetaceans and pinnipeds are the subject of the IHA application to NMFS. The Pacific walrus is managed by the U.S. Fish and Wildlife Service (USFWS); all others are managed by NMFS. Of the 20 species of marine mammals that could occur in the offshore waters of the central-western Bering Sea, six are at least seasonally common during summer. The other 14 species are uncommon to extremely rare (Table 2). Coastal cetacean species (beluga and harbor porpoise) and pinniped species (harbor and bearded seal) likely would not be encountered in the deep, offshore waters of the proposed study area. Therefore, the beluga, harbor porpoise, harbor seal, and bearded seal are not analyzed further and are not included in the density table in § VII or as take requests.

There are no systematic data on the numbers and densities of marine mammals in the deep waters of the central-western Bering Sea. The closest survey data are from Moore et al. (2002a), who conducted vessel-based surveys in the Bering Sea during 5 July–5 August 1999 and during 10 June–3 July 2000. The area surveyed extended from the Alaska Peninsula to ~58.5ºN and was separated into two areas: the Central-eastern Bering Sea (CEBS) and the Southeastern Bering Sea (SEBS). Most of the area covered was in water depths <500 m. Similar surveys were conducted during 17 July–5 August 1997 and 7 June–2 July 1999 (Tynan 2004) and during June–July 2002, 2008, and 2010 (Friday et al. 2008, 2011).

Most surveys for pinnipeds in Alaskan waters have estimated the number of animals at haulout sites, not in the water (e.g., Loughlin 1994; Sease et al. 2001; Withrow and Cesarone 2002; Sease and

TABLE 2. The habitat, regional abundance, and conservation status of marine mammals that may occur or are known to occur in the offshore waters of the Bering Sea in summer.

Species	Habitat	Summer occurrence, Bering Sea	Abundance estimates for stocks	ESA[1]	IUCN[2]	CITES[3]
Mysticetes North Pacific right whale *Eubalaena japonica*	Coastal, shelf, offshore	Rare	Low hundreds[4]	EN	EN/CE[5]	I
Bowhead whale *Balaena mysticetus*	Pack ice, coastal	Uncommon	12,631[6]	EN	LC	I
Gray whale *Eschrichtius robustus*	Coastal, shallow shelf	Common	NW Pacific: 19,126 NE Pacific: ~100[7]	NL/E[8]	LC/CE[9]	I
Humpback whale *Megaptera novaeangliae*	Offshore, near-shore in winter	Common	20,808[10]	EN	LC	I
Minke whale *Balaenoptera acutorostrata*	Nearshore, off-shore, ice	Common	25,000[11]	NL	LC	I
Sei whale *Balaenoptera borealis*	Offshore, shelf	Uncommon	7260–12,620[12]	EN	EN	I
Fin whale *Balaenoptera physalus*	Offshore, deep waters	Common	13,620–18,680[13]	EN	EN	I
Blue whale *Balaenoptera musculus*	Offshore, coastal, shelf	Rare	3500[14]	EN	EN	I
Odontocetes Sperm whale *Physeter macrocephalus*	Offshore	Common	24,000[15]	EN	VU	I
Cuvier's beaked whale *Ziphius cavirostris*	Offshore	Very rare	20,000[16]	NL	LC	II
Baird's beaked whale *Berardius bairdii*	Offshore	Uncommon	6000[17]	NL	DD	I
Stejneger's beaked whale *Mesoplodon stejnegeri*	Offshore	Uncommon	N.A.	NL	DD	II
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	Pelagic, shelf, coastal	Rare	988,000[18]	NL	LC	II
Killer whale *Orcinus orca*	Pelagic, shelf, coastal	Common	8500[19]	NL/EN[20]	DD	II
Dall's porpoise *Phocoenoides dalli*	Nearshore, offshore	Common	1,186,000[21]	NL	LC	II
Pinnipeds Northern fur seal *Callorhinus ursinus*	Offshore and coastal	Common	1.1 million[22]	NL	VU	NL
Steller sea lion *Eumetopias jubatus*	Coastal	Common	58,334–72,223[23] 42,366[24]	EN	EN	NL
Pacific walrus *Odobenus rosmarus*	Ice	Rare	201,039[25]	NL	DD	NL
Spotted seal *Phoca largha*	Ice	Uncommon	Alaska: ~59,214[26]	C	DD	NL
Ringed seal *Pusa hispida*	Ice, landfast, pack	Uncommon	Alaska: 249,000[26]	C	LC	NL
Ribbon seal *Histriophoca fasciata*	Ice	Rare	Bering Sea: 90,000–100,000[26]	SOC	DD	NL

[1] U.S. EN Species Act: EN = Endangered, T = Threatened, NL = Not listed, C = Candidate, SOC = Species of concern
[2] IUCN Red list. CE = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient (IUCN 2010)
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2010); NL = Not listed
[4] Western population (Brownell et al. 2001)
[5] Northeast Pacific population is listed as Critically Endangered.
[6] Based on 2003-2005 surveys (Koski et al. 2010).
[7] Northwest (NW) Pacific (Allen and Angliss 2010); Northeast (NE) Pacific (Reilly et al. 2008).
[8] The western (Northeast Pacific) subpopulation is listed as Endangered.
[9] The western (Northeast Pacific) subpopulation is listed as Critically Endangered.
[10] North Pacific Ocean (Barlow et al. 2011).
[11] Northwest Pacific (Buckland et al. 1992; IWC 2010).
[12] North Pacific (Tillman 1977).
[13] North Pacific (Ohsumi and Wada 1974).

[14] Eastern North Pacific (NMFS 1998).
[15] Eastern temperate North Pacific (Whitehead 2002).
[16] Eastern Tropical Pacific (Wade and Gerrodette 1993).
[17] Western North Pacific (Reeves and Leatherwood 1994; Kasuya 2002).
[18] North Pacific Ocean (Miyashita 1993).
[19] Eastern Tropical Pacific (Ford 2002).
[20] The Eastern North Pacific Southern Resident Stock of killer whales is listed as Endangered under the ESA.
[21] North Pacific Ocean and Bering Sea (Houck and Jefferson 1999).
[22] North Pacific (Gelatt and Lowry 2008).
[23] Eastern U.S. Stock (Allen and Angliss 2010).
[24] Western U.S. Stock (Allen and Angliss 2010).
[25] Speckman (2010).
[26] Burns (1981a).

York 2003). To our knowledge, there are no at-sea estimates of pinnipeds in offshore waters of the Bering Sea.

Mysticetes

North Pacific Right Whale

The North Pacific right whale is listed as ***Endangered*** under the ESA and on the IUCN Red List of Threatened Species (IUCN 2010), and it is listed in Appendix I of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2010). NMFS designated Critical Habitat for this species on 8 May 2008 to include recently discovered summer feeding areas in the south-eastern Bering Sea and Gulf of Alaska (NMFS 2008a; Fig. 1). A reliable estimate of abundance is currently not available for this species, and there has been little indication of population recovery since whaling depleted the population (Carretta et al. 2008). The western North Pacific population "may number at least in the low hundreds" (Brownell et al. 2001), whereas the eastern North Pacific population may number 28 animals based on genotyping or 31 animals based on photo-identification (Wade et al. 2011).

Right whales are generally considered migratory, with at least a proportion of the population feeding during summer in temperate or high-latitude waters and breeding and calving in warmer, lower-latitude waters (Clapham et al. 2004). Historical whaling records indicate that right whales were abundant in the waters of the SEBS during summer months (Scarff 1991; Clapham et al. 2004; Shelden et al. 2005). However, since the 1960s, sightings have been rare. Despite considerable survey effort in the eastern Bering Sea from 1964 to 1990, right whales were sighted only in the southeast part of the survey area (55–60°N; 165–170°W; Shelden et al. 2005). From 1996 to 2009, right whales were sighted annually in the SEBS (Bristol Bay) during summer months (Goddard and Rugh 1998; LeDuc et al. 2001; Moore et al. 2000, 2002a; Wade et al. 2006; Clapham et al. 2009; Zerbini et al. 2009, 2011; Rone et al. 2010) and were also detected acoustically when sonobuoys were deployed in the SEBS (McDonald and Moore 2002; Munger et al. 2005, 2008; Stafford et al. 2008; Clapham et al. 2009; Zerbini et al. 2010). Right whales have not been sighted or acoustically detected outside the localized area designated as Critical Habitat during recent summer surveys (Moore et al. 2000, 2002a; Friday et al. 2009, 2011; Zerbini et al. 2006, 2009, 2010; Clapham et al. 2009; Rone et al. 2010). Between 1983 and 2003, only one sighting occurred west of 168°W; two right whales were sighted in July 1982 west of Saint Matthew Island at ~61°N, 175°W in ~100 m depth (Shelden et al. 2005). This sighting occurred >500 km from the proposed survey area.

Based on a small number of recent sightings, North Pacific right whales tend to occur alone (Brownell et al. 2001), except in an area of the SEBS where small groups of up to 5–7 have been documented in several successive years (Tynan et al. 2001). While feeding, North Atlantic right whales typically dive to depths of 80–175 m for 5–14 min (Baumgartner and Mate 2003).

Considering the rarity of right whale sightings, and the generally restricted area in the SEBS where sightings have been made, it is highly unlikely that any right whales will be seen during the proposed seismic surveys.

Bowhead Whale

The Bering–Chukchi–Beaufort (BCB) bowhead population is listed as ***Endangered*** under the ESA, and the species is listed as ***Least Concern*** on the IUCN Red List of Threatened Species (IUCN 2010) and in CITES Appendix I (UNEP-WCMC 2010). The latest abundance estimate is 12,631 (95% CI = 7,900–19,700), based on a photographic survey conducted in spring 2003–2005 (Koski et al. 2010). Between 1978 and 2001, the population is estimated to have increased at a rate of ~3.4% per year (George et al. 2004; Zeh and Punt 2005).

The BCB Stock winters in the central and western Bering Sea and summers in the Canadian Beaufort Sea and Amundsen Gulf (Moore and Reeves 1993). Spring migration through the western Beaufort Sea occurs through offshore ice leads, generally from mid April to mid June (Braham et al. 1984; Moore and Reeves 1993). In recent years whale migration has occurred in early April and at times in late March (Quakenbush and Huntington 2010). Fall migration into Alaskan waters is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region (~70.3°N; 148.3°W) during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997b; Greene et al. 1999; Blackwell et al. 2004).

Bowheads tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage than in years with less ice (Moore 2000). In addition, the sighting rate tends to be lower in heavy ice years (Treacy 1997). During fall migration, most bowheads migrate west in water depths 15–200 m (Miller et al. 2002 *in* Richardson and Thomson 2002); some individuals enter shallower water, particularly in light ice years, but very few whales are ever seen shoreward of the barrier islands. Survey coverage far offshore in deep water is usually limited, and offshore movements may have been underestimated. However, the main migration corridor is over the continental shelf.

Most (77%) of dives recorded for eight satellite-tagged bowhead whales in the Beaufort Sea were less than 1 min. long; maximum dive times were 62–64 min, mostly occurring in ≥90% ice cover. Overall, the whales spent 60% of time in water depths ≤16 m, 33% at depths of 17–96 m, and <3% at depths >96 m. The maximum dive depth recorded was 352 m (Krutzikowsky and Mate 2000).

Given the migratory patterns of bowhead whales in the western Beaufort Sea and results of other recent cruises (Harwood et al. 2005), it is unlikely that bowheads would be encountered during the proposed seismic surveys.

Gray Whale

The two extant populations of gray whales are the Eastern North Pacific Stock, which ranges between summers in the Chukchi and Beaufort Seas to wintering lagoons in Baja California, and the remnant Western North Pacific Stock, which summers mainly in the Sea of Okhotsk, particularly in the waters off northeastern Sakhalin Island. The Eastern North Pacific Stock of the gray whale was ***Delisted*** from the ESA in 1994, and the Western North Pacific Stock is listed as ***Endangered*** under the ESA. The species is listed as ***Least Concern*** on the IUCN Red List of Threatened Species (IUCN 2010) and is listed in CITES Appendix I (UNEP-WCMC 2010). The western subpopulation is listed separately as ***Critically Endangered*** (IUCN 2010).

The latest estimate for the Eastern North Pacific Stock in 2006–2007 is 19,126 (Allen and Angliss 2010). The Western North Pacific Stock was thought to be extinct as recently as 1972, but a small number are now known to survive; it is estimated to number about 100 individuals, of which 20–30 are mature females (Reilly et al. 2008).

The eastern North Pacific gray whale breeds and winters in Baja, California, and migrates north to summer feeding grounds in the northern Bering Sea, the Chukchi Sea, and the western Beaufort Sea (Rice and Wolman 1971; Jefferson et al. 2008); some individuals also summer along the west coast of North America from Canada to central California (Rice and Wolman 1971; Darling 1984; Nerini 1984). In October and November, gray whales begin to migrate south, following the shoreline south to breeding grounds on the west coast of Baja California and the southeastern Gulf of California (Braham 1984; Rugh 1984).

The western North Pacific gray whale summers in the Okhotsk Sea, primarily off the northeastern coast of Sakhalin Island. Its migration routes and wintering grounds are poorly known. There are occasional records of gray whales off Japan (Kato et al. 2006) and along the Chinese coast (Zhu and Yue 1998).

Gray whales usually migrate alone, with the exception of cow/calf pairs, and groups of >6 whales are unusual (Rice and Wolman 1971; Leatherwood et al. 1988). Foraging gray whales commonly dive to depths of 50–60 m, and the maximum known dive depth is 170 m (Jones and Swartz 2002). Migrating gray whales typically dive for 3–5 min and spend 1–2.5 min on the surface between dives (Jones and Swartz 2002).

Gray whales are found primarily in shallow water. Most follow the coast during migration, staying within 2 km of the shoreline except when crossing major bays, straits, and inlets from southeastern Alaska to the eastern Bering Sea (Braham 1984). However, on 4 October 2010, the first western North Pacific gray whale was satellite-tagged off Sakhalin Island. Within a few weeks the whale rounded the Sakhalin peninsula, left the east coast of Kamchatka, crossed the Bering Sea and arrived at the Bering Sea shelf break in the central Bering Sea. One week later, the whale was on the south side of the Alaska Peninsula near the Shumagin Islands (OSUMMI 2011). The path traveled by the whale overlaps with the proposed seismic survey area.

Humpback Whale

The humpback whale is listed as ***Endangered*** under the ESA and ***Least Concern*** on the IUCN Red List of Threatened Species (IUCN 2010), and is listed in CITES Appendix I (UNEP-WCMC 2010). There are no reliable estimates for the Western North Pacific Stock of humpback whales because surveys of the known feeding grounds are incomplete, and because not all feeding areas are known (Allen and Angliss 2010). Moore et al. (2002a) estimated the abundance of humpback whales in the central Bering Sea at 1175 (95% CI: 197-7009) in 1999, although the authors cautioned that sightings were too clumped to provide a reliable estimate for the area.

Humpback whales occur worldwide, migrating from tropical breeding areas to polar or sub-polar feeding areas (Jefferson et al. 2008). Although the humpback whale is considered mainly a coastal species, it often traverses deep pelagic areas while migrating (Clapham and Mattila 1990; Norris et al. 1999; Calambokidis et al. 2001). The Western North Pacific Stock migrates from breeding areas off the coast of Japan to feeding areas in the Bering Sea, Aleutian Islands, waters west of Kodiak Island and possibly the Kuril Islands, Gulf of Anadyr, and southeastern Chukotka.

Humpback whales are often sighted singly or in groups of two or three, but while on breeding and feeding grounds, they may occur in groups of >20 (Jefferson et al. 2008). Based on data from vessel-based surveys in the Bering Sea in 1999–2000 (Moore et al. 2002a) and in 2002, 2008, and 2010 (Friday et al. 2011), average group sizes were 1.6 (n = 11 sightings), 2.9 (n = 18), 2.7 (n = 46), and 3.1 (n = 39), respectively. In summer feeding areas, humpbacks typically forage in the upper 120 m of the water column, with a maximum recorded dive depth of 500 m (Dolphin 1987; Dietz et al. 2002). On winter breeding grounds, humpback dives have been recorded at depths >100 m (Baird et al. 2000). All humpback sightings during vessel-based surveys in the eastern Bering Sea in 1999 and 2000 were in water depths of 50–100 m (Moore et al. 2002a).

Moore et al. (2002) reported six humpback whale sightings in the CEBS in 1999 and five sightings in the SEBS in 2000, all in water depths 50–100 m. Friday et al. (2011) reported 18, 46, and 39 humpbacks whale sightings during surveys in the southeast Bering Sea shelf and slope in 2002, 2008, and 2009, respectively. On 1 August 2010, a humpback whale tagged off Unalaska Island in the Aleutians traveled northward to the Pribilof Islands and then traveled along the Bering Sea outer shelf to southern Chukotka, Russia. Four days later the whale traversed deep oceanic waters across the Bering Sea basin to the Navarin Canyon (60.5°N, 179.3°W), ~ 200 km northeast of the proposed survey area (Zerbini et al. 2010). Two humpback whale sightings were reported during surveys in the Navarin Canyon in 2008, and four humpback whale sightings were reported in the Pervenets Canyon in 2010, ~ 200 km from the proposed survey area (Friday et al. 2011).

Minke Whale

Current estimates of abundance for the Alaska stock of minke whales are not available (Allen and Angliss 2010). Moore et al. (2002a) estimated the abundance of minke whales in the CEBS at 810.

The minke whale inhabits all oceans of the world from the high latitudes to near the equator (Jefferson et al. 2008). Minke whales are relatively solitary, but can occur in aggregations when food resources are concentrated (Jefferson et al. 2008). Moore et al. (2002a) reported a mean group size of 1.05 (n = 50) in the eastern Bering Sea. Little is known about the diving behavior of minke whales, but they are not known to make prolonged deep dives (Leatherwood and Reeves 1983).

In Alaska, the minke whale is migratory, feeding during summer in the colder waters of Alaska, including the Gulf of Alaska, Bering Sea, Chukchi Sea, and Beaufort Sea (Wynne 1997; Allen and Angliss 2010). Minke whales are relatively common in the Bering Sea and in the Gulf of Alaska, where they are usually found within the 200-m depth contour (Brueggeman et al. 1987, Moore et al. 2002a). During surveys in the CEBS and SEBS in 1999 and 2000, the sighting rate of minke whales was three times higher in coastal waters <50 m deep than in waters >100 m deep (3.99 vs. 1.27 sightings/100 km; Moore et al. 2002a). All seven minke whale sightings during surveys in the eastern Bering Sea in 2008 were in waters >200 m deep (Friday et al. 2009).

Minke whales were consistently sighted during summer surveys in the CEBS and SEBS in 1999, 2000, 2002, 2008 and 2010 (Moore et al 2002a; Tynan 2004, Friday et al. 2009, 2011). Minke whale sightings were abundant during surveys of the Navarin and Pervenets Canyon in 2010 (Friday et al. 2011).

Sei Whale

The sei whale is listed as ***Endangered*** under the ESA and on the IUCN Red List of Threatened Species (IUCN 2010), and is listed in CITES Appendix I (UNEP-WCMC 2010). The size of the North Pacific population in 1974 was estimated at 7260–12,620, depending on the method used (Tillman 1977). There is no abundance estimate for Alaskan waters.

The sei whale has a nearly cosmopolitan distribution, with a marked preference for temperate pelagic waters, and is rarely seen in coastal waters (Gambell 1985b). In the open ocean, sei whales generally migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985b). In the eastern Pacific, sei whales range in the summer from the Bering Sea and the northern Gulf of Alaska to the coast of southern California (Sobolevsky and Mathisen

1996). Sei whales appear to prefer regions of steep bathymetric relief such as the continental shelf break, seamounts, and canyons (Kenney and Winn 1987; Gregr and Trites 2001).

Sei whales are frequently seen in small groups of 2–5 (Jefferson et al. 2008), although larger groups sometimes form on feeding grounds (Gambell 1985b). Sei whales generally do not dive deeply, and dive durations are 15 min or longer (Gambell 1985b).

Sei whales have been sighted during recent Bering Sea surveys. Four sightings were made in the CEBS and two sightings were recorded in the SEBS during surveys in 1999–2000, one of which was in water >1000 m deep (Moore et al. 2002a). One sei whale was sighted on the southeast Bering shelf during surveys in 2008 in waters ≤100 m deep, and another was sighted in the same area in 2010 (Friday et al. 2011). Given these low sighting rates, sei whale sightings likely would be rare in the vicinity of the proposed seismic surveys.

Fin Whale

The fin whale is listed as ***Endangered*** under the ESA and on the IUCN Red List of Threatened Species (IUCN 2010), and is listed in CITES Appendix I (UNEP-WCMC 2010). The size of the North Pacific population was estimated at 13,620–18,680 in 1973 (Ohsumi and Wada 1974). There is no reliable estimate of current abundance for the northeast Pacific stock because the full range of the stock in Alaskan waters has not been surveyed (Allen and Angliss 2010). A provisional minimum estimate of 5700 has been suggested for the population occurring in waters west of the Kenai Peninsula (150°W; Allen and Angliss 2010) based on the sum of the estimates from surveys in the CEBS and SEBS (Moore et al. 2002a) and the coastal waters of Western Alaska and the eastern and central Aleutian Islands (Zerbini et al. 2006).

Fin whales are widely distributed in all the world's oceans in coastal, shelf, and oceanic waters, but typically occur in temperate and polar regions (Gambell 1985a; Perry et al. 1999; Gregr and Trites 2001; Jefferson et al. 2008). The North Pacific population of fin whales summers from the Chukchi Sea to California, and winters from California southward (Gambell 1985a). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily or because biological productivity is high along steep contours because of tidal mixing and perhaps current mixing.

Fin whales are typically observed alone or in pairs, but also in groups of up to seven or more, with the largest aggregations occurring on feeding grounds (Jefferson et al. 2008). Based on vessel-based surveys in the Bering Sea in 1999–2000 (Moore et al. 2002a) and in 2002, 2008, and 2010 (Friday et al. 2011), average group sizes were 3.1 (n = 88 sightings), 2.6 (n = 28), 2.6 (n = 78), and 1.9 (n = 60), respectively. Croll et al. (2001) reported a mean dive depth and time of 98 m and 6.3 min for foraging fin whales, and a mean dive depth and time of 59 m and 4.2 min for non-foraging individuals.

Fin whales of the Alaska stock are known to feed during summer in the Bering Sea (Jefferson et al. 2008). The fin whale was the most commonly-encountered baleen whale during dedicated vessel surveys conducted in the eastern Bering Sea in 1999–2000 (Moore et al. 2002a) and in 2008 (Friday et al. 2009). Overall, the highest sighting rate of fin whales (3.55 sightings/100 km) during the 1999–2000 Bering Sea surveys were in waters >100 m deep (Moore et al. 2002a). In 2008, ~18 fin whales were recorded in the slope waters of the Bering Sea during vessel surveys (Friday et al. 2009). The fin whale was the most commonly sighted whale during southeast Bering Sea shelf and slope surveys (Moore et al. 2002a; Tynan 2004; Friday et al. 2009, 2011).

Blue Whale

The blue whale is listed as ***Endangered*** under the ESA and on the IUCN Red List of Threatened Species (IUCN 2010), and is listed in CITES Appendix I (UNEP-WCMC 2010). The worldwide population has been estimated at 15,000 (Gambell 1976), with 3500 in the North Pacific Ocean (NMFS 1998). The best abundance estimate for the eastern North Pacific stock is 2842 (Carretta et al. 2009).

During summer, the eastern North Pacific blue whale stock feeds near the U.S. west coast, in the Gulf of Alaska extending to the Aleutian Islands and the Bering Sea, and in central North Pacific waters (Wynne 1997; Stafford 2003). Little is known about the movements and wintering grounds of the stock (Mizroch et al. 1984). Some individuals may stay in low or high latitudes throughout the year (Reilly and Thayer 1990; Watkins et al. 2000; Moore et al. 2002b). Stafford et al. (2001) reported that blue whale calls are received in the North Pacific year-round, indicating that this area is suitable habitat for blue whales in all seasons. However, the number of whales producing the calls remains unknown.

Blue whales are typically found singly or in groups of two or three (Yochem and Leatherwood 1985; Jefferson et al. 2008). They commonly form scattered aggregations on feeding grounds (Jefferson et al. 2008), and apparent single whales are likely part of a large, dispersed group (Wade and Friedrichsen 1979). Four satellite-radio-tagged blue whales in the northeast Pacific Ocean spent 94% of their time underwater, 72% of dives were <1 min long, and "true" dives (>1 min) were 4.2–7.2 min long. Shallow (<16 m) dives were most common (75%), and the average depth of deep (>16-m) dives was 105 m (Lagerquist et al. 2000). Croll et al. (2001) reported mean dive depths and times of 140 m and 7.8 min for foraging blue whales, and 68 m and 4.9 min for non-foraging individuals. Dives of up to 300 m were recorded for tagged blue whales (Calambokidis et al. 2003).

No blue whales were sighted during vessel-based surveys of the southeastern Bering shelf and slope in 1999, 2000, 2002, 2008, or 2010 (Moore et al. 2002a; Tynan 2004; Friday et al. 2009, 2011). Given their overall low abundance, blue whales sightings likely would be rare during the proposed seismic surveys.

Odontocetes

Sperm Whale

The sperm whale is listed as ***Endangered*** under the ESA and ***Vulnerable*** on the IUCN Red List of Threatened Species (IUCN 2010), and is listed in CITES Appendix I (UNEP-WCMC 2010). There is no reliable estimate of sperm whale abundance available for Alaska or the North Pacific (Allen and Angliss 2010).

Sperm whales range between the northern and southern edges of the polar pack ice, although they are most abundant in tropical and temperate waters >1000 m deep over the continental shelf edge and slope, and in pelagic waters (e.g., Rice 1989; Gregr and Trites 2001; Waring et al. 2001). Adult females and juveniles generally occur in tropical and subtropical waters, whereas males are commonly alone or in same-sex aggregations, often occurring in higher latitudes outside of the breeding season (Best 1979; Watkins and Moore 1982; Arnbom and Whitehead 1989; Whitehead and Waters 1990). Males may migrate north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Allen and Angliss 2010).

Sperm whales occur singly (older males) or in groups, with mean group sizes of 20–30 but as many as 50 (Whitehead 2003; Jefferson et al. 2008). Waite (2003) and Wade et al. (2003) noted an average group size of 1.2 in the western Gulf of Alaska. Sperm whales undertake some of the deepest-known dives for the longest durations among cetaceans. They can dive as deep as ~2 km and possibly deeper on rare occasions, for periods of over 1 h; however, most of their foraging occurs at depths of ~300–800 m for 30–45 min (Whitehead 2003). A recent study of tagged male sperm whales feeding at high latitudes (off Norway) found that foraging dives extended to highly variable maximum depths, ranging from 14 to

1860 m, with a median of 175 m (Teloni et al. 2008). During a foraging dive, sperm whales typically travel ~3 km horizontally and 0.5 km vertically (Whitehead 2003).

In the North Pacific Ocean, sperm whales are distributed widely, with the northernmost occurrences at Cape Navarin (62ºN; Omura 1955). Sperm whales are commonly sighted during summer surveys in the Aleutian Islands and the eastern Bering Sea (e.g., Forney and Brownell 1996; Waite 2003; Wade et al. 2003; Barlow and Henry 2005; Ireland et al. 2005; Allen and Angliss 2010).

All sperm whales sighted (n = 23) during vessel-based surveys in the northwest Gulf of Alaska were beyond the continental slope in waters ~3,500–4,000 m deep (Brueggeman et al. 1987). Sperm whale sightings were rare during surveys of the southeastern Bering Sea shelf and slope: 0 in 1999–2000 (Moore et al. 2002a), and two in 2002, four in 2008, and six in 2010 (Friday et al. 2011). Five of the 12 sightings were in water depths >1000 m.

Cuvier's Beaked Whale

Cuvier's beaked whale is probably the most widespread of the beaked whales, although it is not found in high-latitude polar waters (Heyning 1989). This species prefers deep pelagic waters, usually >1000 m over the continental slope and other steep geographic features, such as seamounts and underwater canyons (NMFS 2009; Wynne 1997). Little is known about their migration patterns or life history. The abundance for the Alaska Stock is currently unknown (Allen and Angliss 2010).

Cuvier's beaked whale is most commonly seen in groups of 2–7 but also up to 15, with a reported mean group size of 2.3 (MacLeod and D'Amico 2006; Jefferson et al. 2008). Cuvier's beaked whales make long (30–60 min), deep dives with reported maximum depths of 1267 m (Johnson et al. 2004) and 1450 m (Baird et al. 2006).

The Alaska Stock generally occurs from the Gulf of Alaska to the southern Aleutian Islands. However, one Cuvier's beaked whale has been reported in deep water north of the Aleutian Islands at ~168°W (Allen and Angliss 2010). The species has not been sighted during recent surveys over the eastern Bering Sea shelf and slope (Moore et al. 2002a; Tynan 2004; Friday et al. 2008, 2011).

This species is considered very rare in vicinity of the proposed seismic survey area.

Baird's Beaked Whale

There is no population estimate for Baird's beaked whale in the eastern Pacific Ocean, but it is estimated that ~7000 Baird's beaked whales inhabit the western North Pacific (Kasuya 2002). The abundance of the Bering Sea/Eastern North Pacific Stock is unknown (Allen and Angliss 2010).

Baird's beaked whale has a fairly extensive range across the North Pacific north of 30˚N, and strandings have occurred as far north as the Pribilof Islands (Rice 1986). Concentrations are thought to occur in the Sea of Okhotsk and Bering Sea throughout summer (Rice 1998; Kasuya 2002). Their winter distribution is unknown (Kasuya 2002).

Baird's beaked whales sometimes are seen close to shore, but their primary habitat is over or near the continental slope, underwater canyons, and oceanic seamounts in waters 1000–3000 m deep (Kasuya 1986; Jefferson et al. 2008). There are several sighting records in the southern Bering Sea (Brueggeman et al. 1987; Moore et al. 2002a; Waite 2003).

Baird's beaked whales usually travel in groups of a few to several dozen, although groups of up to 50 have been recorded (Balcomb 1989; Jefferson et al. 2008). Wade et al. (2003) reported a mean group size of 10.8 during vessel-based surveys in the Gulf of Alaska and Aleutian Islands. Baird's beaked whales are deep, long divers; dives of 25–35 min are typical (Balcomb 1989). Most (66%) dives are

<20 min long, and time at the surface is 1–14 min (Kasuya 2002). Whalers reported that when struck, they could dive to depths >1000 m and remain submerged for >1 hr (Balcomb 1989).

Moore et al. (2002a) reported a sighting of 18 Baird's beaked whales at the edge of the continental slope waters in the Pribilof Canyon during vessel-based survey in the southeastern Bering Sea during 2000. Two Baird's beaked whales were sighted in waters >1000 m just off the bottom of the slope south of the Pribilof Canyon in 2008 (Friday et al. 2009) and one was sighted in shallow water just off the Alaska Peninsula in 2010 (Friday et al. 2011). Given their preference for deep oceanic waters, Baird's beaked whales likely would occur in the vicinity of the proposed seismic survey area.

Stejneger's Beaked Whale

Stejneger's beaked whale occurs in subarctic and cool temperate waters of the North Pacific (Mead 1989). In the North Pacific, it is distributed from Alaska to southern California (Mead 1989). There are currently no reliable estimates of the abundance of the Alaskan Stock of Stejneger's beaked whales (Allen and Angliss 2010).

Stejneger's beaked whale is the only mesoplodont species known to occur in Alaskan waters, ranging from Southeast Alaska through the Aleutian Chain to the central Bering Sea, with most sightings reported in the Aleutian Islands (Rice 1986; Wade et al. 2003; Jefferson et al. 2008). This species occurs in groups of 5 to 15 (Jefferson et al. 2008). They are observed mainly in continental slope and oceanic waters (Jefferson et al. 2008).

This species is considered rare in the vicinity of the proposed seismic survey area. There was one sighting of two whales on the slope in the CEBS just south of Zhemchug Canyon in 2002 (Friday et al. 2011).

Pacific White-sided Dolphin

The Pacific white-sided dolphin is found throughout the temperate North Pacific, in a relatively narrow distribution between 38°N and 47°N (Brownell et al. 1999). Recently it has been suggested that the species could be experiencing a poleward shift in occurrence at both the northern and southern limits of its range associated with increases in water temperature (Salvadeo et al. 2010). From surveys conducted in the North Pacific, Buckland et al. (1993a) estimated that there were a total of 931,000 Pacific white-sided dolphins, and Miyashita (1993) estimated an abundance of 988,000. Two stocks are identified in the U.S: the North Pacific and the California/Oregon/Washington stocks (Allen and Angliss 2010). As there have been no comprehensive surveys for Pacific white-sided dolphins in Alaska, the portion of the Buckland et al. (1993a) estimate derived from sightings north of 45ºN in the Gulf of Alaska (26,880) is used as the minimum population estimate of the North Pacific stock (Allen and Angliss 2010).

The species is common both on the high seas and along the continental margins, and animals are known to enter the inshore passes of southeast Alaska, British Columbia, and Washington (Leatherwood et al. 1984; Dahlheim and Towell 1994; Ferrero and Walker 1996). Pacific white-sided dolphins form large groups, averaging 90, with groups of more than 3000 known (Van Waerebeek and Würsig 2002). Pacific white-sided dolphins often associate with other species, including cetaceans, pinnipeds, and sea-birds. In particular, they are frequently seen in mixed-species schools with Risso's and northern right whale dolphins (Green et al. 1993). Pacific white-sided dolphins are very inquisitive and are known to approach stationary boats (Carwardine 1995). They are highly acrobatic, commonly bowriding, and often leaping, flipping, or somersaulting (Jefferson et al. 1993).

During summer, Pacific white-sided dolphins occur north into the Gulf of Alaska and west to Amchitka in the Aleutian Islands, but rarely in the southern Bering Sea (Allen and Angliss 2010). Sightings in the Gulf of Alaska and Aleutian Islands have been documented in the summer by Waite

(2003) and Wade et al. (2003), and in the spring in shelf waters southeast of Kodiak Island by Rone et al. (2010). Moore et al. (2002a) reported one sighting of eight just north of the Alaska Peninsula in 2000, and Friday et al. (2011) reported two sightings of 19 just north of Unimak Island and the Alaska Peninsula in 2000.

The Pacific white-sided dolphin likely would not be encountered during the proposed survey.

Killer Whale

Most (7 of 8) killer whale stocks in the northeast Pacific are not listed under the ESA; however, the Southern Resident Killer Whale Stock, occurring in inland waters of Washington and southern British Columbia, is listed as ***Endangered*** under the ESA. The northeast Pacific population is estimated at 2250–2700 (NMFS 2009).

Killer whales are cosmopolitan and globally abundant; they have been observed in all oceans of the world (Ford 2002). High densities occur in high latitudes, especially in areas where prey is abundant. The greatest abundance is thought to occur within 800 km of major continents (Mitchell 1975). Killer whales appear to prefer coastal areas, but are also known to occur in deep water (Dahlheim and Heyning 1999).

Killer whales are segregated socially, genetically, and ecologically into three distinct groups: resident, transient, and offshore animals. Offshore whales do not appear to mix with the other types of killer whales (Black et al. 1997; Dahlheim et al. 1997). Killer whales often travel in close-knit matrilineal groups of a few to tens of individuals (Dahlheim and Heyning 1999). Groups sizes generally range from 1 to 75, though offshore transient groups generally contain <10 (Jefferson et al. 2008). Waite et al. (2002) reported a mean group size of 5.0 in the CEBS. Based on vessel-based surveys in the Bering Sea in 2002, 2008, and 2010 (Friday et al. 2011), average group sizes were 10.45 (n = 20 sightings), 5.7 (n = 35), and 4.9 (n = 23), respectively. Zerbini et al (2007) reported an average group size of 40, 16, and 3.9 for offshore, resident, and transient ecotypes. The maximum depth to which 28 tagged killer whales dove off British Columbia was 264 m (Baird et al. 2005). Less than 1% of dives by seven tagged whales were in water depths >30 m (Baird et al. 2003).

Killer whales are known to occur year-round in the ice-free waters of the Bering seas and move as far north as the Beaufort Sea during summer (Allen and Angliss 2010). Two stocks occur in the Bering Sea: the Eastern North Pacific Alaska Resident Stock and the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock. There is currently no way to reliably distinguish the different stocks of killer whales from sightings at sea (Allen and Angliss 2010).

Killer whales are regularly sighted in the Bering Sea. Barretta and Hunt (1994) reported 15 killer whales in waters 200–1000 m deep near the Pribilof Islands in 1987–1989. Killer whale sightings during surveys in 1999 and 2000 in the eastern Bering Sea were scattered around the 100-m isobath between 160°W and 174°W near the Alaska Peninsula and the Pribilof Islands (Waite et al. 2002). During surveys of the southeast Bering shelf and slope in 2002, 2008, and 2010, there were 20, 35, and 23 killer whale sightings, respectively (Friday et al. 2011). Sightings were mostly in slope waters, but some were on the shelf or in water depths >1000 m.

Killer whales are likely to be common in the vicinity of the seismic survey.

Dall's Porpoise

Dall's porpoise is found only in temperate to cold, ice-free waters of the North Pacific and adjacent seas. It is widely distributed across the North Pacific over the continental shelf and slope waters, and over deep (>2500 m) oceanic waters (Hall 1979; Allen and Angliss 2010). It is probably the most abundant small cetacean in the North Pacific Ocean, and its abundance changes seasonally, likely in relation to water temperature (Becker 2007; Jefferson et al. 2008). Based on vessel surveys conducted from 1987 to 1991, the Alaska Stock is estimated at 83,400 individuals (Allen and Angliss 2010).

Dall's porpoises are typically seen in groups of 2–12, and groups of >20–30 are uncommon although aggregations of several thousands have been reported (Jefferson et al. 2008). Based on vessel-based surveys in the Bering Sea in 1999–2000 (Moore et al. 2002a) and in 2002, 2008, and 2010 (Friday et al. 2011), average group sizes were 3.1 (n = 143 sightings), 4.9 (n = 180), 4.9 (n = 171), and 3.6 (n = 93), respectively. They are fast-swimming and active porpoises, and readily approach vessels to ride the bow wave. Data from one tagged Dall's porpoise showed a mean dive depth of 33.4 m for a mean duration of 1.3 min (Hanson and Baird 1998).

Dall's porpoise occurs throughout Alaska; the only apparent gaps in distribution in Alaskan waters south of the Bering Strait are for upper Cook Inlet and the Bering Sea shelf. They are common in the Bering Sea from spring to summer (Brueggeman et al. 1987; Wynne 1997; Moore et al. 2002a; Tynan 2004; Friday et al. 2009, 2011). This species was the most frequently seen cetacean during vessel-based surveys in the eastern Bering Sea in 1999–2000, and sighting rates were highest (6.28 sightings/100 km) in water depths >100 m (Moore et al. 2002a). Dall's porpoises were also the most numerous cetacean sighted during vessel-based surveys of the SEBS in 1997 and 1999, and the highest density of Dall's porpoises (2007 groups/1000 km^2) was in water depths >2000 m (Tynan 2004). Dall's porpoise was the most commonly reported cetacean during surveys of the southeastern Bering Sea shelf and slope in 2002 (180 sightings), 2008 (171), and 2010 (93) (Friday et al. 2011). Almost all sightings were in slope waters, and they were common over the Navarin, Pervenets, and Pribilof canyons (Friday et al. 2011).

Pinnipeds

Steller Sea Lion

The Steller sea lion is listed under the ESA as ***Threatened*** in the eastern portion of its range and as ***Endangered*** in the western portion, west of 144°W. It is listed as ***Endangered*** on the IUCN Red List of Threatened Species (IUCN 2010). The population estimate for the Western U.S. Stock of Steller sea lions in 2004–2005 is estimated at 50,035 (Allen and Angliss 2010).

Federally Designated Critical Habitat for Steller sea lions includes all rookeries and major haulouts including those in the Aleutian, Pribilof, St. Matthew, and St. Lawrence islands (NMFS 1993a). The critical habitat areas are defined as 37 km seaward and 0.9 km landward of any major rookeries and haulouts. Critical habitat also includes air zones extending 0.9 km above these terrestrial and aquatic zones (NMFS 1993a). The closest seismic survey line to the critical habitat is ~350 km away.

In the eastern North Pacific Ocean, Steller sea lions are currently distributed from the Bering Strait along the coast of North America south to central California, although they formerly inhabited the Channel Islands (Rice 1998; Jefferson et al. 2008). During the breeding season, some haulouts are used as rookeries, but haulouts are also used at other times. Steller sea lions spend more time at sea in the winter than during the breeding season; after the breeding season from late May-early July, they disperse to sea (Sease and York 2003). Steller sea lions typically inhabit waters from the coast to the outer continental shelf and slope throughout their range; they are not considered migratory, although foraging animals can travel long distances (Raum-Suryan et al. 2002; Loughlin et al. 2003). Loughlin et al. (2003) reported that most (88%) at-sea movements of juvenile Steller sea lions were short (<15 km) foraging trips. The mean distance of juvenile sea lion trips at sea was 16.6 km, and the maximum trip distance recorded was 447 km. Long-range trips represented 6% of all trips at sea, and trip distance and duration increase with age (Loughlin et al. 2003; Call et al. 2007). Bonnell and Bowlby (1992) estimated that 25% of the population was feeding at any given time.

While at sea, Steller sea lions usually occur in groups of 1–12 (Jefferson et al. 2008). At rookeries and haulouts they typically occur in the hundreds to thousands. Juvenile Steller sea lions make relatively shallow dives, generally <250 m, and the maximum known dive depth is 328 m (Loughlin et al. 2003). Mean dive depth of adult female Steller sea lions in the Kuril Islands was 53 m, and most (94%) trips were <10 km, with a maximum of 263 km (Loughlin et al. 1998).

The proposed seismic survey is located ~350 km of the closest haulout sites in the Aleutian islands, possibly within Steller sea lion foraging range. Given the relatively low occurrence of long-distance travel, at least for juvenile sea lions, sightings of this species near the proposed seismic survey area likely would be rare.

Northern Fur Seal

In the eastern North Pacific Ocean, northern fur seals range from southern California north to the Bering Sea (Carretta et al. 2009; Allen and Angliss 2010). Northern fur seals are highly migratory, moving south in October and November. Adult males migrate to the Gulf of Alaska, whereas females and pups migrate through the Aleutian Islands into the North Pacific, remaining offshore until spring (March–June) when they move north to the Pribilof Islands to breed in late June–July (NMFS 2009a; Wynne 1997). Males arrive in mid-May, abandon their territories and return to sea in early August (NMFS 2007). During the first months at sea, pups generally disperse southward (Lea et al. 2009). Female northern fur seals depart from the Pribilof Islands in November and travel in a southeasterly direction over the continental shelf (Ream et al. 2005).

Most of the worldwide population breeds on the Pribilof Islands, and the remaining animals breed on rookeries in Russia, with approximately 1% breeding on Bogoslof Island in the southern Bering Sea and San Miguel Island off southern California (NMFS 1993b). The estimated size of the Eastern Pacific Stock is 653,171 (Allen and Angliss 2010).

This species spends ~90% of its time at sea, typically in areas of upwelling along the continental slopes and over seamounts (Gentry 1981, 2002a; Jefferson et al. 2008). The remaining ~10% of its life is spent on or near rookery islands or haulouts on rocky shorelines, primarily on the Pribilof and Bogoslof islands (Carretta et al. 2009). Juvenile northern fur seals travel significant distances to forage at sea (average of 961 km; Sterling and Ream 2004). Robson et al. (2004) found that the home ranges of lactating fur seals were extensive at the Pribilof Islands, with foraging ranges 40–450 km offshore. Adult females mostly use continental slope areas of the eastern Bering Sea for foraging in summer (Baird and Hanson 1997).

While at sea, northern fur seals usually occur singly or in pairs, although larger groups can form in waters rich with prey (Antonelis and Fiscus 1980; Gentry 1981). Thousands to tens of thousands of seals typically aggregate on terrestrial rookeries (Jefferson et al. 2008). Northern fur seals dive to relatively shallow depths to feed: 100–200 m for females and <400 m for males (Gentry 2002a).

Given that the proposed seismic survey is located ~460 km west of the closest haulout sites on the Pribilof Islands, beyond female northern fur seal foraging range, and given that fur seals tend to move southward when they leave the haulout sites, sightings of this species near the proposed seismic survey area are likely to be uncommon. No density information is available.

Pacific Walrus

Walrus are currently not listed under the ESA, but a petition was submitted in February 2008 to consider ESA listing (CBD 2008; USFWS 2008). On 10 September 2009, NMFS published a positive 90-day finding in the *Federal Register* indicating that the petitioned action may be warranted (Garlich-Miller et al. 2011). The species is listed as ***Data Deficient*** on the IUCN Red List of Threatened Species

(IUCN 2010). The current size of the Pacific walrus population is estimated at 129,000 (Speckman et al. 2010 *in* Garlich-Miller et al. 2011).

Walrus have a circumpolar distribution and follow the seasonal movement of the ice pack. The Pacific walrus ranges from the Bering Sea north to the Chukchi Sea, and extends to the northeastern coast of Siberia and the Beaufort Sea (Garlich-Miller et al. 2011). Walruses generally stay in advance of the ice edge, moving north in summer to the Chukchi Sea and south in the winter into the Bering Sea, but several thousand animals, primarily males, remain in coastal haulouts in the Gulf of Anadyr (northeast Siberia) and Bristol Bay during the summer (Garlich-Miller et al. 2011).

Walruses prefer shallow, coastal waters and use the ice pack for resting, pupping, and molting. They also haul out on shore in years of reduced pack ice (Jefferson et al. 2008; Wynne 1997).

The occurrence of the Pacific walrus in the seismic survey area during late August–early September is highly unlikely.

Spotted seal

The spotted seal is listed as a ***Candidate Species*** under the ESA, which means that it is actively being considered for listing. The spotted seal is listed as ***Data Deficient*** on the IUCN Red List of Threatened Species (IUCN 2010). The current abundance estimate for the Alaska Stock of spotted seals is 59,214 (Allen and Angliss 2010)

Spotted seals are distributed from the northern Yellow Sea and western Sea of Japan to the Bering and Okhotsk seas, and north to the Chukchi and Beaufort seas (Allen and Angliss 2010). Spotted seals migrate south in October from the Chukchi Sea and pass through the Bering Strait in November to spend their winters along the southern margin of the ice edge in the Bering Sea (Lowry et al. 1998, 2000). Spotted seals are known to prefer nearshore areas and use coastal haulouts in the Chukchi and Beaufort Seas during summer. Twelve spotted seals tagged in the eastern Chukchi Sea and the western Bering Sea all remained within 100 km of land during August–October (Lowry et al. 2000). In winter, spotted seals are known to occur generally near the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands (Allen and Angliss 2010).

The occurrence of spotted seals near the survey area is unlikely.

Ringed seal (*Pusa hispida*)

The ringed seal is listed as a ***Candidate Species*** under the ESA, which means that it is actively being considered for listing. The species is listed as ***Least Concern*** on the IUCN Red List of Threatened Species (IUCN 2010). Ringed seals have a circumpolar distribution in the northern hemisphere from 35ºN to the North Pole, and the only U.S. stock, the Alaska stock, is found in the Bering, Chukchi, and Beaufort seas (Allen and Angliss 2010). The minimum abundance estimate for the Alaska Stock of ringed seals is 249,000 (Allen and Angliss 2010).

Ringed seals are associated with sea ice year-round. There is a net movement of ringed seals northward as the ice retreats during late spring and summer (Allen and Angliss 2010).

The occurrence of ringed seals near the seismic survey area is unlikely.

Ribbon seal

The ribbon seal is listed as a ***Species of Concern*** under the ESA, which means that NMFS has some concerns regarding status and threats, but insufficient information is available to indicate a need for listing. The species is listed as ***Data Deficient*** on the IUCN Red List of Threatened Species (IUCN 2010). No recent abundance estimate is available of the Alaska Stock (Allen and Angliss 2010). Burns (1981a) estimated the Bering Sea population at 90,000–100,000 in the mid 1970s. A provisional estimate of 49,000 ribbon seals in the eastern and central Bering Sea is based on aerial surveys conducted in portions of the Bering Sea in 2003, 2007 and 2008 (Allen and Angliss 2010).

Ribbon seals inhabit the North Pacific and Arctic oceans, and are found in the open sea and on pack ice. Only rarely do ribbon seals haul out on land or shorefast ice (NMFS 2009a; Wynne 1997). From January to May, adults generally remain with the pack ice of the Bering, Chukchi, and western Beaufort seas, moving with the ice farther south in colder years. Most ribbon seals are likely pelagic in the Bering and Chukchi seas during summer (Wynne 1997; Jefferson et al. 2008; Allen and Angliss 2010). Ribbon seals are solitary most of their lives (Jefferson et al. 2008).

The ribbon seal is likely to be the most common pinniped sighted during the proposed seismic survey. No density information is available.

V. Type of Incidental Take Authorization Requested

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

USGS requests an IHA pursuant to Section 101 (a) (5) (D) of the Marine Mammal Protection Act (MMPA) for incidental take by harassment during its planned seismic survey in the central-western Bering Sea during August 2011.

The operations outlined in § I have the potential to take marine mammals by harassment. Sounds will be generated by the airguns used during the survey, by echosounders, and by general vessel operations. "Takes" by harassment will potentially result when marine mammals near the activities are exposed to the pulsed sounds generated by the airguns or echosounders. The effects will depend on the species of marine mammal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see § VII). Disturbance reactions are likely amongst some of the marine mammals near the tracklines of the source vessel. No take by serious injury is anticipated, given the nature of the planned operations and the mitigation measures that are planned (see § XI, Mitigation Measures). No lethal takes are expected.

VI. Numbers of Marine Mammals That Could be Taken

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in [section V], and the number of times such takings by each type of taking are likely to occur.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

VII. Anticipated Impact on Species or Stocks

The anticipated impact of the activity upon the species or stock of marine mammal.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

- First we summarize the potential impacts on marine mammals of airgun operations, as called for in § VII. A more comprehensive review of the relevant background information appears in Appendix B of the EA.
- Then we discuss the potential impacts of operations by the echosounders.

- Finally, we estimate the numbers of marine mammals that could be affected by the proposed survey in the Bering Sea during August 2011. This section includes a description of the rationale for the estimates of the potential numbers of harassment "takes" during the planned survey, as called for in § VI.

Summary of Potential Effects of Airgun Sounds

The effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). Permanent hearing impairment, in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not an injury (Southall et al. 2007). Although the possibility cannot be entirely excluded, it is unlikely that the project would result in any cases of temporary or especially permanent hearing impairment, or any significant non-auditory physical or physiological effects. Some behavioral disturbance is expected, but this would be localized and short-term.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. For a summary of the characteristics of airgun pulses, see Appendix B (3) in the EA. Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response—see Appendix B (5) in the EA. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. In general, pinnipeds usually seem to be more tolerant of exposure to airgun pulses than are cetaceans, with the relative responsiveness of baleen and toothed whales being variable.

Masking

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006) which could mask calls. Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999a,b; Nieukirk et al. 2004; Smultea et al. 2004; Holst et al. 2005a,b, 2006; Dunn and Hernandez 2009). However, Clark and Gagnon (2006) reported that fin whales in the northeast Pacific Ocean went silent for an extended period starting soon after the onset of a seismic survey in the area. Similarly, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994). However, more recent studies found that they continued calling in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004; Holst et al. 2006; Jochens et al. 2008). Dolphins and porpoises commonly are heard calling while airguns are operating (e.g., Gordon et al. 2004; Smultea et al. 2004; Holst et al. 2005a,b; Potter et al. 2007). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. Masking effects on marine mammals are discussed further in Appendix B (4) of the EA.

Disturbance Reactions

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

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically-important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales, small toothed whales, and sea otters, but for many species there are no data on responses to marine seismic surveys.

Baleen Whales.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, as reviewed in Appendix B (5) of the EA, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have shown that seismic pulses with received levels of 160–170 dB re 1 μPa_{rms} seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed (Richardson et al. 1995). In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 4 to 15 km from the source. A substantial proportion of the baleen whales within those distances may show avoidance or other strong behavioral reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and studies summarized in Appendix B (5) of the EA have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 μPa_{rms}.

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. McCauley et al. (1998, 2000a) studied the responses of humpback whales off Western Australia to a full-scale seismic survey with a 16-airgun, 2678-in^3 array, and to a single 20-in^3 airgun with source level 227 dB re 1 µPa·m_{p-p}. McCauley et al. (1998) documented that avoidance reactions began at 5–8 km from the array, and that those reactions kept most pods ~3–4 km from the operating seismic boat. McCauley et al. (2000a) noted localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs. Avoidance distances with respect to the single airgun were smaller but consistent with the results from the full array in terms of the received sound levels. The mean received level for initial avoidance of an approaching airgun was 140 dB re 1 μPa_{rms} for humpback pods containing females, and at the mean closest point of approach (CPA) distance the received level was 143 dB re 1 μPa_{rms}. The initial avoidance response generally occurred at distances of 5–8 km from the airgun array and 2 km from the single airgun. However, some individual humpback whales, especially males, approached within distances of 100–400 m, where the maximum received level was 179 dB re 1 μPa_{rms}.

Data collected by observers during several seismic surveys in the Northwest Atlantic showed that sighting rates of humpback whales were significantly greater during periods of no seismic compared with periods when a full array was operating (Moulton and Holst 2010). In addition, humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010).

Humpback whales on their summer feeding grounds in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 1.64-L (100-in^3) airgun (Malme et al. 1985). Some humpbacks seemed "startled" at received levels of 150–169 dB re 1 µPa. Malme et al. (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 µPa on an approximate rms basis. However, Moulton and Holst (2010) reported that humpback whales monitored during seismic surveys in the Northwest Atlantic had lower sighting rates and were most often seen swimming away from the vessel during seismic periods compared with periods when airguns were silent.

It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004). The evidence for this was circumstantial and subject to alternative explanations (IAGC 2004). Also, the evidence was not consistent with subsequent results from the same area of Brazil (Parente et al. 2006), or with direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was "no observable direct correlation" between strandings and seismic surveys (IWC 2007:236).

There are no data on reactions of *right whales* to seismic surveys, but results from the closely-related *bowhead whale* show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source at received sound levels of around 120–130 dB re 1 μPa_{rms} [Miller et al. 1999; Richardson et al. 1999; see Appendix B (5) of the EA]. However, more recent research on bowhead whales (Miller et al. 2005; Harris et al. 2007) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. Nonetheless, subtle but statistically significant changes in surfacing–respiration–dive cycles were evident upon analysis (Richardson et al. 1986). In summer, bowheads typically begin to show avoidance reactions at received levels of about 152–178 dB re 1 μPa_{rms} (Richardson et al. 1986, 1995; Ljungblad et al. 1988; Miller et al. 2005).

Reactions of migrating and feeding (but not wintering) *gray whales* to seismic surveys have been studied. Malme et al. (1986, 1988) studied the responses of feeding eastern Pacific gray whales to pulses from a single 100-in^3 airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1 μPa_{rms}. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al. 1984; Malme and Miles 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (Würsig et al. 1999; Gailey et al. 2007; Johnson et al. 2007; Yazvenko et al. 2007a,b), along with data on gray whales off British Columbia (Bain and Williams 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses (Stone 2003; MacLean and Haley 2004; Stone and Tasker 2006), and calls from blue and fin whales have been localized in areas with airgun operations (e.g., McDonald et al. 1995; Dunn and Hernandez 2009; Castellote et al. 2010). Sightings by observers on seismic vessels off the United Kingdom from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were shooting vs. silent (Stone 2003; Stone and Tasker 2006). However, these whales tended to exhibit localized avoidance, remaining significantly further (on average) from the airgun array during seismic operations compared with non-seismic periods (Stone and Tasker 2006). Castellote et al. (2010) reported that singing fin whales in the Mediterranean moved away from an operating airgun array.

Ship-based monitoring studies of baleen whales (including blue, fin, sei, minke, and humpback whales) in the Northwest Atlantic found that overall, this group had lower sighting rates during seismic vs. non-seismic periods (Moulton and Holst 2010). Baleen whales as a group were also seen significantly farther from the vessel during seismic compared with non-seismic periods, and they were more often seen to be swimming away from the operating seismic vessel (Moulton and Holst 2010). Blue and minke whales were initially sighted significantly farther from the vessel during seismic operations compared to non-seismic periods; the same trend was observed for fin whales (Moulton and Holst 2010). Minke whales were most often observed to be swimming away from the vessel when seismic operations were underway (Moulton and Holst 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A *in* Malme et al. 1984; Richardson et al. 1995; Allen and Angliss 2010). The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year (Johnson et al. 2007). Similarly, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987; Allen and Angliss 2010).

Toothed Whales.—Little systematic information is available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above and (in more detail) in Appendix B of the EA have been reported for toothed whales. However, there are recent systematic studies on sperm whales (e.g., Gordon et al. 2006; Madsen et al. 2006; Winsor and Mate 2006; Jochens et al. 2008; Miller et al. 2009). There is also an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea et al. 2004; Moulton and Miller 2005; Bain and Williams 2006; Holst et al. 2006;

Stone and Tasker 2006; Potter et al. 2007; Hauser et al. 2008; Holst and Smultea 2008; Weir 2008; Barkaszi et al. 2009; Richardson et al. 2009; Moulton and Holst 2010).

Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003; Moulton and Miller 2005; Holst et al. 2006; Stone and Tasker 2006; Weir 2008; Barkaszi et al. 2009; Richardson et al. 2009; Moulton and Holst 2010). Some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing (e.g., Moulton and Miller 2005). Nonetheless, small toothed whales more often tend to head away, or to maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Stone and Tasker 2006; Weir 2008; Barry et al. 2010; Moulton and Holst 2010). In most cases the avoidance radii for delphinids appear to be small, on the order of 1 km less, and some individuals show no apparent avoidance. The beluga is a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys conducted in the southeastern Beaufort Sea during summer found that sighting rates of beluga whales were significantly lower at distances 10–20 km compared with 20–30 km from an operating airgun array, and observers on seismic boats in that area rarely see belugas (Miller et al. 2005; Harris et al. 2007).

Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2000, 2002, 2005). However, the animals tolerated high received levels of sound before exhibiting aversive behaviors.

Results for porpoises depend on species. The limited available data suggest that harbor porpoises show stronger avoidance of seismic operations than do Dall's porpoises (Stone 2003; MacLean and Koski 2005; Bain and Williams 2006; Stone and Tasker 2006). Dall's porpoises seem relatively tolerant of airgun operations (MacLean and Koski 2005; Bain and Williams 2006), although they too have been observed to avoid large arrays of operating airguns (Calambokidis and Osmek 1998; Bain and Williams 2006). This apparent difference in responsiveness of these two porpoise species is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Most studies of sperm whales exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses (e.g., Stone 2003; Stone and Tasker 2006; Weir 2008; Moulton and Holst 2010). In most cases the whales do not show strong avoidance, and they continue to call (see Appendix B of the EA for review). However, controlled exposure experiments in the Gulf of Mexico indicate that foraging behavior was altered upon exposure to airgun sound (Jochens et al. 2008; Miller et al. 2009; Tyack 2009).

There are almost no specific data on the behavioral reactions of beaked whales to seismic surveys. However, some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (Gosselin and Lawson 2004; Laurinolli and Cochrane 2005; Simard et al. 2005). Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998). They may also dive for an extended period when approached by a vessel (e.g., Kasuya 1986), although it is uncertain how much longer such dives may be as compared to dives by undisturbed beaked whales, which also are often quite long (Baird et al. 2006; Tyack et al. 2006). In any event, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel, although this has not been documented explicitly. In fact, Moulton and Holst (2010) reported 15 sightings of beaked whales during seismic studies in the Northwest Atlantic; seven of those sightings were made at times when at least one airgun was operating. There was little evidence to indicate that beaked whale behavior was affected by airgun operations; sighting rates and distances were similar during seismic and non-seismic periods (Moulton and Holst 2010).

There are increasing indications that some beaked whales tend to strand when naval exercises involving mid-frequency sonar operation are ongoing nearby (e.g., Simmonds and Lopez-Jurado 1991; Frantzis 1998; NOAA and USN 2001; Jepson et al. 2003; Hildebrand 2005; Barlow and Gisiner 2006; see also the "Strandings and Mortality" subsection, later). These strandings are apparently at least in part a disturbance response, although auditory or other injuries or other physiological effects may also be involved. Whether beaked whales would ever react similarly to seismic surveys is unknown (see "Strandings and Mortality", below). Seismic survey sounds are quite different from those of the sonars in operation during the above-cited incidents.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids and Dall's porpoises, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes, belugas, and harbor porpoises (Appendix B of the EA). A ≥170 dB re 1 µPa disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, Dall's porpoise, and pinnipeds, which tend to be less responsive than the more responsive cetaceans.

Pinnipeds.—Pinnipeds are not likely to show a strong avoidance reaction to the airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior—see Appendix B (5) of the EA. In the Beaufort Sea, some ringed seals avoided an area of 100 m to (at most) a few hundred meters around seismic vessels, but many seals remained within 100–200 m of the trackline as the operating airgun array passed by (e.g., Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). Ringed seal sightings averaged somewhat farther away from the seismic vessel when the airguns were operating than when they were not, but the difference was small (Moulton and Lawson 2002). Similarly, in Puget Sound, sighting distances for harbor seals and California sea lions tended to be larger when airguns were operating (Calambokidis and Osmek 1998). Previous telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998).

Additional details on the behavioral reactions (or the lack thereof) by all types of marine mammals to seismic vessels can be found in Appendix B (5) of the EA.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al. 2007). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., permanent threshold shift (PTS), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds with received levels ≥180 dB and 190 dB re 1 μPa_{rms}, respectively (NMFS 2000). These criteria have been used in establishing the exclusion (=shut-down) zones planned for the proposed seismic survey. However, these criteria were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals. As discussed in Appendix B (6) of the EA and summarized here,

- the 180-dB criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid temporary auditory impairment let alone permanent auditory injury, at least for delphinids.
- TTS is not injury and does not constitute "Level A harassment" in U.S. MMPA terminology.

- the minimum sound level necessary to cause permanent hearing impairment ("Level A harassment") is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.
- the level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage. The actual PTS threshold is likely to be well above the level causing onset of TTS (Southall et al. 2007).

Recommendations for new science-based noise exposure criteria for marine mammals, frequency-weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations have not, as of early 2011, been formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys. However, some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. NMFS has indicated that it may issue new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS, the expected offset between the TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive (e.g., M-weighting or generalized frequency weightings for various groups of marine mammals, allowing for their functional bandwidths), and other relevant factors. Preliminary information about possible changes in the regulatory and mitigation requirements, and about the possible structure of new criteria, was given by Wieting (2004) and NMFS (2005).

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

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong transient sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. It is unlikely that any effects of these types would occur during the present project given the brief duration of exposure of any given mammal, the deep water in the study area, and the planned monitoring and mitigation measures (see below). The following subsections discuss in somewhat more detail the possibilities of TTS, PTS, and non-auditory physical effects.

Temporary Threshold Shift.—TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound. Available data on TTS in marine mammals are summarized in Southall et al. (2007). Based on these data, the received energy level of a single seismic pulse (with no frequency weighting) might need to be ~186 dB re 1 $\mu Pa^2 \cdot s$

(i.e., 186 dB SEL or ~196–201 dB re 1 μPa_{rms}) in order to produce brief, mild TTS[2]. Exposure to several strong seismic pulses that each have received levels near 190 dB re 1 μPa_{rms} might result in cumulative exposure of ~186 dB SEL and thus slight TTS in a small odontocete assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy; however, this 'equal-energy' concept is an oversimplification. The distances from the *Langseth*'s airguns at which the received energy level (per pulse, flat-weighted) would be expected to be ≥190 dB re 1 μPa_{rms} are estimated in Table 1. Levels ≥190 dB re 1 μPa_{rms} are expected to be restricted to radii no more than 400 m (Table 1). For an odontocete closer to the surface, the maximum radius with ≥190 dB re 1 μPa_{rms} would be smaller.

The above TTS information for odontocetes is derived from studies on the bottlenose dolphin and beluga. For the one harbor porpoise tested, the received level of airgun sound that elicited onset of TTS was lower (Lucke et al. 2009). If these results from a single animal are representative, it is inappropriate to assume that onset of TTS occurs at similar received levels in all odontocetes (*cf.* Southall et al. 2007). Some cetaceans apparently can incur TTS at considerably lower sound exposures than are necessary to elicit TTS in the beluga or bottlenose dolphin.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are assumed to be lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales (Southall et al. 2007). In any event, no cases of TTS are expected given the strong likelihood that baleen whales would avoid the approaching airguns (or vessel) before being exposed to levels high enough for TTS to occur, and the mitigation measures that are planned.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from more prolonged (non-pulse) exposures suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001). The TTS threshold for pulsed sounds has been indirectly estimated as being an SEL of ~171 dB re 1 $\mu Pa^2 \cdot s$ (Southall et al. 2007), which would be equivalent to a single pulse with received level ~181–186 dB re 1 μPa_{rms}, or a series of pulses for which the highest rms values are a few dB lower. Corresponding values for California sea lions and northern elephant seals are likely to be higher (Kastak et al. 2005).

NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed under-water noise at received levels exceeding, respectively, 180 and 190 dB re 1 μPa_{rms}. Those sound levels are ***not*** considered to be the levels above which TTS might occur. Rather, they were the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As summarized above and in Southall et al. (2007), data that are now available imply that TTS is unlikely to occur in most odontocetes (and probably mysticetes as well) unless they are exposed to a sequence of several airgun pulses stronger than 190 dB re 1 μPa_{rms}. For the harbor seal and any species with similarly low TTS thresholds, TTS may occur upon exposure to one or

[2] If the low frequency components of the watergun sound used in the experiments of Finneran et al. (2002) are downweighted as recommended by Miller et al. (2005) and Southall et al. (2007) using their M_{mf}-weighting curve, the effective exposure level for onset of mild TTS was 183 dB re 1 $\mu Pa^2 \cdot s$ (Southall et al. 2007).

more airgun pulses whose received level equals the NMFS "do not exceed" value of 190 dB re 1 μPa_{rms}. That criterion corresponds to a single-pulse SEL of 175–180 dB re 1 $\mu Pa^2 \cdot s$ in typical conditions, whereas TTS is suspected to be possible (in harbor seals) with a cumulative SEL of ~171 dB re 1 $\mu Pa^2 \cdot s$.

Permanent Threshold Shift.—When PTS occurs, there is physical damage to the sound receptors in the ear. In severe cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter 1985).

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372*ff*; Gedamke et al. 2008). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above that inducing mild TTS if the animal were exposed to strong sound pulses with rapid rise time—see Appendix B (6) of the EA. Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is *at least* 6 dB higher than the TTS threshold on a peak-pressure basis, and probably >6 dB (Southall et al. 2007). On an SEL basis, Southall et al. (2007:441-4) estimated that received levels would need to exceed the TTS threshold by at least 15 dB for there to be risk of PTS. Thus, for cetaceans they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of ~198 dB re 1 $\mu Pa^2 \cdot s$ (15 dB higher than the M_{mf}-weighted TTS threshold, in a beluga, for a watergun impulse), where the SEL value is cumulated over the sequence of pulses. Additional assumptions had to be made to derive a corresponding estimate for pinnipeds, as the only available data on TTS-thresholds in pinnipeds pertain to non-impulse sound. Southall et al. (2007) estimate that the PTS threshold could be a cumulative M_{pw}-weighted SEL of ~186 dB re 1 $\mu Pa^2 \cdot s$ in the harbor seal exposed to impulse sound. The PTS threshold for the California sea lion and northern elephant seal would probably be higher, given the higher TTS thresholds in those species.

Southall et al. (2007) also noted that, regardless of the SEL, there is concern about the possibility of PTS if a cetacean received one or more pulses with peak pressure exceeding 230 or 218 dB re 1 μPa (peak), respectively. Thus, PTS might be expected upon exposure of cetaceans to *either* SEL ≥198 dB re 1 $\mu Pa^2 \cdot s$ *or* peak pressure ≥ 230 dB re 1 μPa. Corresponding proposed dual criteria for pinnipeds (at least harbor seals) are ≥ 186 dB SEL and ≥ 218 dB peak pressure (Southall et al. 2007). These estimates are all first approximations, given the limited underlying data, assumptions, species differences, and evidence that the "equal energy" model may not be entirely correct. A peak pressure of 230 dB re 1 μPa (3.2 bar · m, 0-pk) would only be found within a few meters of the largest (360-in^3) airguns in the planned airgun array (e.g., Caldwell and Dragoset 2000). A peak pressure of 218 dB re 1 μPa could be received somewhat farther away; to estimate that specific distance, one would need to apply a model that accurately calculates peak pressures in the near-field around an array of airguns.

Given the higher level of sound necessary to cause PTS as compared with TTS, it is considerably less likely that PTS would occur. Baleen whales generally avoid the immediate area around operating seismic vessels, as do some other marine mammals. The planned monitoring and mitigation measures, including visual monitoring, passive acoustic monitoring (PAM), power downs, and shut downs of the airguns when mammals are seen within or approaching the "exclusion zones", will further reduce the probability of exposure of marine mammals to sounds strong enough to induce PTS.

***Stranding and Mortality*.**—Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). However, explosives are no longer used for marine waters for commercial seismic surveys or (with rare exceptions) for seismic research; they have been replaced entirely by airguns or related non-explosive pulse generators. Airgun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of strandings of beaked whales with naval exercises and, in one case, an L-DEO seismic survey (Malakoff 2002; Cox et al. 2006), has raised the possibility that beaked whales exposed to strong "pulsed" sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding (e.g., Hildebrand 2005; Southall et al. 2007). Appendix B (6) of the EA provides additional details.

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include (1) swimming in avoidance of a sound into shallow water; (2) a change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage or other forms of trauma; (3) a physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and (4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues. Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are increasing indications that gas-bubble disease (analogous to "the bends"), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. However, the evidence for this remains circumstantial and associated with exposure to naval mid-frequency sonar, not seismic surveys (Cox et al. 2006; Southall et al. 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonars emit non-impulse sounds at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time. A further difference between seismic surveys and naval exercises is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge 2001; NOAA and USN 2001; Jepson et al. 2003; Fernández et al. 2004, 2005; Hildebrand 2005; Cox et al. 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity pulsed sound.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well founded (IAGC 2004; IWC 2007). In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the L-DEO vessel R/V *Maurice Ewing* was operating a 20-airgun, 8490-in^3 airgun array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth 2002; Yoder 2002). Nonetheless, the Gulf of California incident plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand 2005). No injuries of beaked whales are anticipated during the proposed study because of (1) the high likelihood that any beaked whales nearby would avoid the approaching vessel before being exposed to high sound levels, (2) the proposed monitoring and mitigation measures, and (3) differences between the sound sources operated from the *Langseth* and those involved in the naval exercises associated with strandings.

Non-auditory Physiological Effects.—Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007). Studies examining such effects are limited. However, resonance effects (Gentry 2002) and direct noise-induced bubble formation (Crum et al. 2005) are implausible in the case of exposure to an impulsive broadband source like an airgun array. If seismic surveys disrupt diving patterns of deep-diving species, this might perhaps result in bubble formation and a form of "the bends", as speculated to occur in beaked whales exposed to sonar. However, there is no specific evidence of this upon exposure to airgun pulses.

In general, very little is known about the potential for seismic survey sounds (or other types of strong underwater sounds) to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected (Southall et al. 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds are especially unlikely to incur non-auditory physical effects. Also, the planned mitigation measures (§ XI), including shut downs of the airguns, will reduce any such effects that might otherwise occur.

Possible Effects of Multibeam Echosounder Signals

The Kongsberg EM 122 MBES will be operated from the source vessel during the planned study. Information about this equipment was provided in § I. Sounds from the MBES are very short pings, occurring for 2–15 ms once every 5–20 s, depending on water depth. Most of the energy in the sound emitted by this MBES is at frequencies near 12 kHz, and the maximum source level is 242 dB re 1 μPa · m_{rms}. The beam is narrow (1–2º) in the fore-aft extent and wide (150º) in the cross-track extent. Each ping consists of eight (in water >1000 m deep) or four (<1000 m deep) successive fan-shaped transmissions (segments) at different cross-track angles. Any given mammal at depth near the trackline would be in the main beam for only one or two of the nine segments. Also, marine mammals that encounter the Kongsberg EM 122 are unlikely to be subjected to repeated pings because of the narrow fore–aft width of the beam and will receive only limited amounts of energy because of the short pings. Animals close to the ship (where the beam is narrowest) are especially unlikely to be ensonified for more than one 2–15 ms ping (or two pings if in the overlap area). Similarly, Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when an MBES emits a ping is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pings that might result in sufficient exposure to cause TTS.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans (1) generally have a longer signal duration than the Kongsberg EM 122, and (2) are often directed close to horizontally vs. more downward for the MBES. The area of possible influence of the MBES is much smaller—a narrow band below the source vessel. The duration of exposure for a given marine mammal can be much longer for a naval sonar. During survey operations, the individual pings will be very short, and a given mammal would not receive many of the downward-directed pings as the vessel passes by. Possible effects of an MBES on marine mammals are outlined below.

Masking

Marine mammal communications will not be masked appreciably by the MBES signals given the low duty cycle of the echosounder and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of baleen whales, the MBES signals (12 kHz) do not overlap with the predominant frequencies in the calls, which would avoid any significant masking.

Behavioral Responses

Behavioral reactions of free-ranging marine mammals to sonars, echosounders, and other sound sources appear to vary by species and circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins et al. 1985), increased vocalizations and no dispersal by pilot whales (Rendell and Gordon 1999), and the previously-mentioned beachings by beaked whales. During exposure to a 21–25 kHz "whale-finding" sonar with a source level of 215 dB re 1 μPa·m, gray whales reacted by orienting slightly away from the source and being deflected from their course by ~200 m (Frankel 2005). When a 38-kHz echosounder and a 150-kHz acoustic Doppler current profiler were transmitting during studies in the eastern tropical Pacific, baleen whales showed no significant responses, whereas spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis 2005).

Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1-s tonal signals at frequencies similar to those that will be emitted by the MBES used on the *Langseth*, and to shorter broadband pulsed signals. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure (Schlundt et al. 2000; Finneran et al. 2002; Finneran and Schlundt 2004). The relevance of those data to free-ranging odontocetes is uncertain, and in any case, the test sounds were quite different in duration as compared with those from an MBES.

Very few data are available on the reactions of pinnipeds to echosounder sounds at frequencies similar to those used during seismic operations. Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375-kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. Because of the likely brevity of exposure to the MBES sounds, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Hearing Impairment and Other Physical Effects

Given recent stranding events that have been associated with the operation of naval sonar, there is concern that mid-frequency sonar sounds can cause serious impacts to marine mammals (see above). However, the MBES proposed for use by USGS is quite different than sonars used for navy operations. Ping duration of the MBES is very short relative to the naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; navy sonars often use near-horizontally-directed sound. Those factors would all reduce the sound energy received from the MBES rather drastically relative to that from the sonars used by the navy.

Given the maximum source level of 242 dB re 1 $\mu Pa \cdot m_{rms}$ (see § I), the received level for an animal within the MBES beam 100 m below the ship would be ~202 dB re 1 μPa_{rms}, assuming 40 dB of spreading loss over 100 m (circular spreading). Given the narrow beam, only one ping is likely to be received by a given animal as the ship passes overhead. The received energy level from a single ping of duration 15 ms would be about 184 dB re 1 $\mu Pa^2 \cdot s$, i.e., 202 dB + 10 log (0.015 s). That is below the

TTS threshold for a cetacean receiving a single non-impulse sound (195 dB re 1 $\mu Pa^2 \cdot s$) and even further below the anticipated PTS threshold (215 dB re 1 $\mu Pa^2 \cdot s$) (Southall et al. 2007). In contrast, an animal that was only 10 m below the MBES when a ping is emitted would be expected to receive a level ~20 dB higher, i.e., 204 dB re 1 $\mu Pa^2 \cdot s$ in the case of the EM 122. That animal might incur some TTS (which would be fully recoverable), but the exposure would still be below the anticipated PTS threshold for cetaceans. As noted by Burkhardt et al. (2007, 2008), cetaceans are very unlikely to incur PTS from operation of scientific sonars on a ship that is underway.

In the harbor seal, the TTS threshold for non-impulse sounds is about 183 dB re 1 $\mu Pa^2 \cdot s$, as compared with ~195 dB re 1 $\mu Pa^2 \cdot s$ in odontocetes (Kastak et al. 2005; Southall et al. 2007). TTS onset occurs at higher received energy levels in the California sea lion and northern elephant seal than in the harbor seal. A harbor seal as much as 100 m below the *Langseth* could receive a single MBES ping with received energy level of ≥184 dB re 1 $\mu Pa^2 \cdot s$ (as calculated in the toothed whale subsection above) and thus could incur slight TTS. Species of pinnipeds with higher TTS thresholds would not incur TTS unless they were closer to the transducers when a ping was emitted. However, the SEL criterion for PTS in pinnipeds (203 dB re 1 $\mu Pa^2 \cdot s$) might be exceeded for a ping received within a few meters of the transducers, although the risk of PTS is higher for certain species (e.g., harbor seal). Given the intermittent nature of the signals and the narrow MBES beam, only a small fraction of the pinnipeds below (and close to) the ship would receive a ping as the ship passed overhead.

Possible Effects of the Sub-bottom Profiler Signals

An SBP will also be operated from the source vessel during the planned study. Details about this equipment were provided in § I. Sounds from the SBP are very short signals, occurring for up to 64 ms once every second. Most of the energy in the sound emitted by the SBP is at 3.5 kHz, and the beam is directed downward. The sub-bottom profiler on the *Langseth* has a maximum source level of 222 dB re 1 µPa · m (see § I). Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when a bottom profiler emits a ping is small—even for an SBP more powerful than that on the *Langseth*—if the animal was in the area, it would have to pass the transducer at close range and in order to be subjected to sound levels that could cause TTS.

Masking

Marine mammal communications will not be masked appreciably by the SBP signals given the directionality of the signal and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of most baleen whales, the SBP signals do not overlap with the predominant frequencies in the calls, which would avoid significant masking.

Behavioral Responses

Marine mammal behavioral reactions to other sound sources are discussed above, and responses to the SBP are likely to be similar to those for other non-impulse sources if received at the same levels. However, the signals from the SBP are considerably weaker than those from the MBES. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

Hearing Impairment and Other Physical Effects

It is unlikely that the SBP produces sound levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source. The SBP is operated simultaneously with other higher-power acoustic sources, including airguns. Many marine mammals will move away in response to the approaching higher-power sources or the vessel itself before the mammals would be close enough for there to be any possibility of effects from the less intense sounds from the SBP. In the case of mammals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of other sources (see § XI) would further reduce or eliminate any minor effects of the SBP.

Possible Effects of Acoustic Release Signals

The acoustic release transponder used to communicate with the OBSs uses frequencies of 9–13 kHz. These signals will be used very intermittently. It is unlikely that the acoustic release signals would have a significant effect on marine mammals or sea turtles through masking, disturbance, or hearing impairment. Any effects likely would be negligible given the brief exposure at presumable low levels.

Possible Effects of Acoustic Doppler Current Profiler Signals

An ADCP will be operated during the proposed program. Sounds from the ADCP are very short, occurring every 0.65 ms to 1.4 s. Most of the energy in the sound emitted is at high frequencies (~75 kHz). The ADCP produces sounds that are within the range of frequencies used by odontocetes that occur or may occur in the area of the planned survey.

Masking

Whereas the ADCP produces sounds within the frequency range used by odontocetes that may be present in the survey area, marine mammal communications will not be masked appreciably by the signals. This is a consequence of the relatively low power output, low duty cycle, and brief period when an individual mammal is likely to be within the area of potential effects. In the case of mysticetes, the pulses do not overlap with the predominant frequencies in the calls, which would avoid significant masking.

Behavioral Responses

When a 38-kHz echosounder and a 150-kHz ADCP were transmitting during studies in the Eastern Tropical Pacific, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis 2005). Marine mammal behavioral reactions to other sound sources are discussed above. Responses to the ADCP are likely to be similar to those for other sources if received at the same levels. The signals from the ADCP are weaker than those from the echosounders and the airguns. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

Hearing Impairment and Other Physical Effects

Source levels of the ADCP are lower than those of the airguns, which are discussed above. It is unlikely that the ADCP produce sound levels strong enough to cause temporary hearing impairment or (especially) physical injuries even in an animal that is (briefly) in a position near the source.

Numbers of Marine Mammals that could be "Taken by Harassment"

All anticipated takes would be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied will minimize the possibility of injurious takes. (However, as noted earlier, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to various received sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic program. The estimates are based on a consideration of the number of marine mammals that could be disturbed appreciably by operations with the 36-airgun subarray to be used during ~2420 km of seismic surveys in the central-western Bering Sea. The sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

It is assumed that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES, SBP, and ADCP would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the other sources given their characteristics (e.g., narrow downward-directed beam) and other considerations described in § I. Such reactions are not considered to constitute "taking" (NMFS 2001). Therefore, no additional allowance is included for animals that could be affected by sound sources other than airguns.

Basis for Estimating "Take by Harassment"

There are no systematic data on the numbers or densities of marine mammals in deep waters adjacent to the survey area in the central-western Bering Sea. The closest survey data are from the shelf and slope waters of the CEBS and SEBS, mostly in water depths <500 m, collected during walleye pollock assessment cruises (Fig. 4). Tynan (2004) reported densities of common species in the SEBS during July 1997 and June 1999. Moore et al. (2002a) and Waite et al. (2002) reported densities for the CEBS during July 1999 and the SEBS during June 2000. Friday et al. (2009, 2011) reported marine mammal sightings, numbers, and survey effort in the CEBS and SEBS during June–July 2002, 2008, and 2010.

Table 6 gives the estimated average and maximum densities of marine mammals expected to occur in the deep, offshore waters of the proposed survey area. For cetaceans, we used the densities reported by Moore et al. (2002a) for the CEBS, which were corrected for *f*(0) but not *g*(0)[3]; g(0) was assumed to be 1. We calculated density estimates from the Friday et al. (2011) effort and sightings northwest of the Pribilof Islands, using values for *f*(0) and *g*(0) from Barlow and Forney (2007). For two species sighted in the SEBS but not the CEBS (Baird's beaked whale and Pacific white-sided dolphin), we assigned small arbitrary densities.

As discussed in § IV, only three pinniped species are expected to be encountered during the August survey: Steller sea lions, northern fur seals, and ribbon seals. No open-water density estimates are available for these pinnipeds because population estimates are based on counts at haul-outs (Seller sea lion and northern fur seals) or surveys during spring (ribbon seals) when animals are hauled out on sea ice. For ribbon seals, we assumed that the Bering Sea population of 100,000 (Burns 1981a) is evenly distributed in the Bering Sea (an area of 2.29 million km^2 [NOAA 2008]) during August, resulting in a density of $0.0436/km^2$. That is likely an overestimate, because some Bering Sea ribbon seals are known to move into the Chukchi Sea as the ice retreats (Allen and Angliss 2010). For Steller sea lions, we assumed that the Western Stock of 50,035 was evenly distributed in an area twice the size of the Bering Sea (including the Gulf of Alaska and the Sea of Okhotsk) and that 25% of the population is feeding at any given time (Bonnell and Bowlby 1992), resulting in a density of $0.0027/km^2$. That is likely an overestimate, as Steller sea lions typically inhabit waters from the coast to the outer continental shelf and slope (see § IV), and the proposed survey will be conducted in water depths >3000 m. For northern fur seals, we assume that 10% of the population is in the waters of the Bering Sea in August; others would be at rookeries or would have begun to migrate south through the Aleutian Islands. With a population size of 653,171, the resulting density in the Bering Sea would be $0.028/km^2$. This is also likely an

[3] *f*(0) or trackline detection probability bias is the probability density function of the perpendicular sighting distances evaluated at the center line and is calculated from the survey data. *g*(0) has two components: detectability bias and availability bias. Detectability bias accounts for the fact that some sightings along the center line that are at the surface and could be seen are missed by observers. Availability bias refers to the fact that there is less-than-100% probability of sighting an animal that is present along the survey trackline because animals are sometimes below the surface when the survey vessel passes, and it is measured by $g_a(0)$.

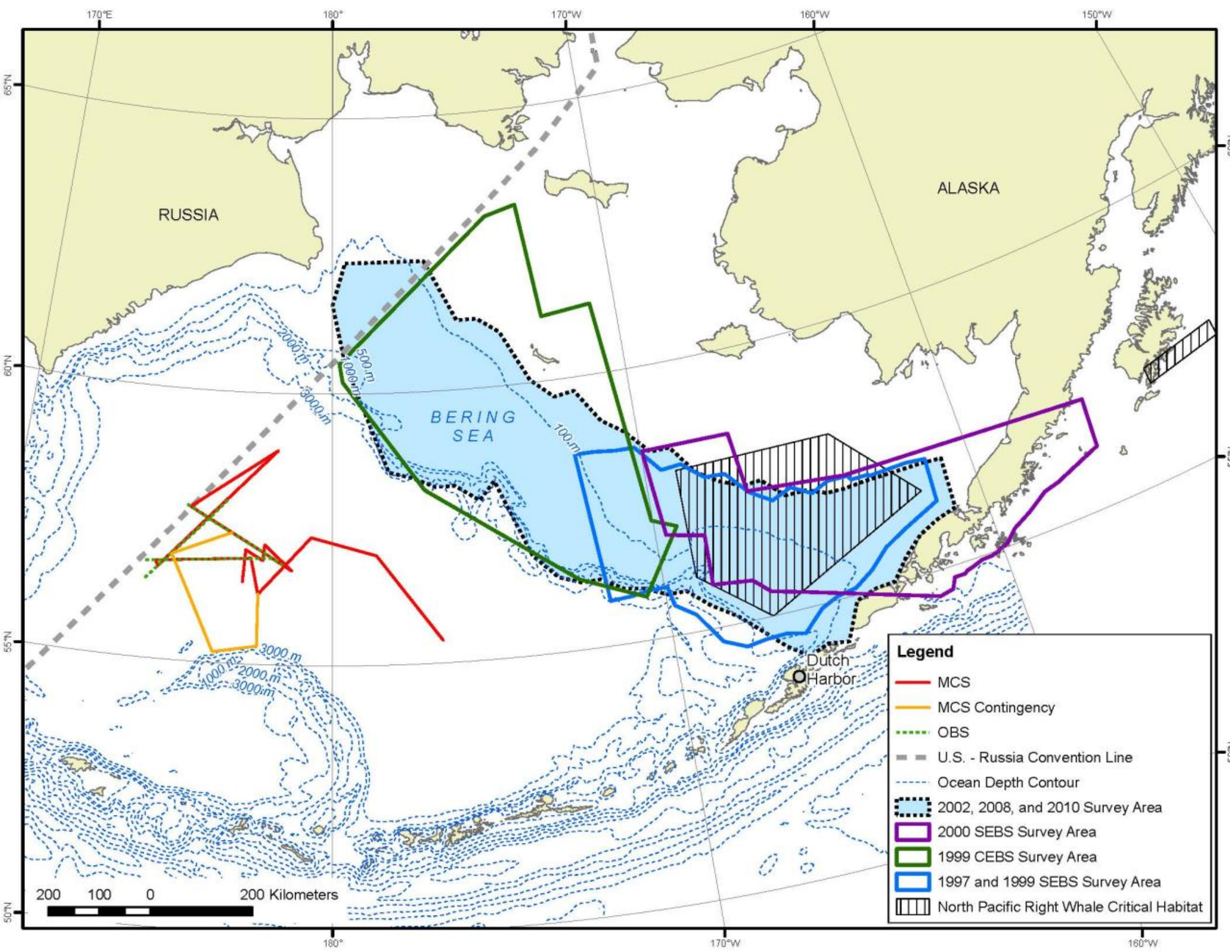

FIGURE 4. Proposed seismic track lines in relation to marine mammal survey areas in the central-eastern and south-eastern Bering Sea.

overestimate, as adult females mostly use continental slope areas of the eastern Bering Sea for foraging in summer (Baird and Hanson 1997), not the deep, offshore waters of the survey area.

There is some uncertainty about the representativeness of the data and the assumptions used in the calculations below for two main reasons: the surveys from which cetacean densities were derived were conducted in June–July whereas the proposed seismic survey is in August, and they were in shelf and slope waters, where most marine mammals are expected to occur in much higher densities than in the deep, offshore waters of the proposed survey area. However, the densities are based on a considerable survey effort (19,160 km), and the marine mammal surveys and the proposed seismic survey are in the same season; therefore, the approach used here is believed to be the best available approach.

Also, to provide some allowance for these uncertainties, "maximum estimates" as well as "best estimates" of the densities present and numbers potentially affected have been derived. Best estimates of cetacean density are effort-weighted mean densities from the various surveys, whereas maximum estimates of density come from the individual survey that provided the highest density. For marine mammals where only one density estimate was available, the maximum is 1.5× the best estimate.

For one species, Dall's porpoise, density estimates in the original reports are much higher than densities expected during the proposed survey, because this porpoise is attracted to vessels. Our estimates for Dall's porpoise are from vessel-based surveys without seismic survey activity; they are overestimates,

TABLE 6. Densities of marine mammals sighted during various surveys in the central-western Bering Sea in deep water. Densities are from various sources (see text); they are corrected for *f*(0) and *g*(0). Species listed as endangered or threatened under the ESA are in italics.

Species[1]	Density in the central-western Bering Sea (#/1000 km^2) Average	Maximum
Mysticetes		
North Pacific right whale	*0*	*0*
Bowhead whale	*0*	*0*
Gray whale	0.01	0.12
Humpback whale	*0.40*	*1.04*
Minke whale	1.23	4.10
Sei whale	*0.05*	*0.58*
Fin whale	*3.94*	*17.00*
Blue whale	0	0
Odontocetes		
Sperm whale	*0.07*	*0.14*
Cuvier's beaked whale	0	0
Baird's beaked whale	0.07	0.10
Stejneger's beaked whale	0.04	0.12
Pacific white-sided dolphin	0.03	0.04
Killer whale	2.82	3.96
Dall's porpoise	8.86	18.25
Pinnipeds		
Steller sea lion	*2.70*	*4.05*
Northern fur seal	28.50	42.75
Ribbon seal	43.60	65.40

[1] Does not include other species listed in Table 2 that are coastal or seasonal migrants.

possibly by a factor of 5×, given the tendency of this species to approach vessels (Turnock and Quinn 1991). Sounds from the airgun array during the proposed survey is expected to at least reduce and possibly eliminate the tendency of this porpoise to approach the vessel. Dall's porpoises are tolerant of small airgun sources (MacLean and Koski 2005) and tolerated higher sound levels than other species during a large-array survey (Bain and Williams 2006); however, they did respond to that and another large airgun array by moving away (Calambokidis and Osmek 1998; Bain and Williams 2006). Because of the positive bias in vessel survey data (Turnock and Quinn 1991), the best and maximum estimates for Dall's porpoises shown in Table 6 are one-quarter of the reported or calculated densities from the CEBS. In fact, actual densities are probably slightly lower than that.

The estimated numbers of individuals potentially exposed are presented below based on the 160-dB re 1 μPa_{rms} criterion for all marine mammals, and the 170-dB re 1 μPa_{rms} criterion for delphinids, Dall's porpoise, and pinnipeds. It is assumed that marine mammals exposed to airgun sounds this strong might change their behavior sufficiently to be considered "taken by harassment".

It should be noted that the following estimates of "takes by harassment" assume that the surveys will be fully completed including the contingency lines; in fact, the ensonified areas calculated using the planned number of line-kilometers ***have been increased by 25%*** to accommodate lines that may need to be repeated, equipment testing, etc. As is typical during offshore ship surveys, inclement weather and equipment mal-functions are likely to cause delays and may limit the number of useful line-kilometers of seismic operations that can be undertaken. Furthermore, any marine mammal sightings within or near the designated exclusion zone will result in the shut down of seismic operations as a mitigation measure. Finally, as noted above, the densities used to estimate numbers exposed are from surveys in areas where densities of marine mammals are expected to be higher than the proposed seismic survey area. Thus, the following estimates of the numbers of marine mammals potentially exposed to 160- or 170-dB sounds are precautionary, and probably considerably overestimate the actual numbers of marine mammals that might be exposed. These estimates assume that there will be no weather, equipment, or mitigation delays, which is highly unlikely.

Potential Number of Marine Mammals Exposed to ≥160 and ≥170 dB

Number of Cetaceans that could be Exposed to ≥160 dB.— The number of different individuals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} on one or more occasions can be estimated by considering the expected density of animals in the area along with the total marine area that would be within the 160-dB radius around the operating airgun array on at least one occasion. The number of possible exposures (including repeated exposures of the same individuals) can be estimated by considering the total marine area that would be within the 160-dB radius around the operating airguns, including areas of overlap. In the proposed survey, the seismic lines are widely spaced in the survey area, so few individual mammals would be exposed more than once during the survey; the area including overlap is only 1.74× the area excluding overlap. Moreover, it is unlikely that a particular animal would stay in the area during the entire survey.

The numbers of different individuals potentially exposed to ≥160 dB re 1 μPa_{rms} were calculated by multiplying

- the expected species density, either "mean" (i.e., best estimate) or "maximum", times
- the anticipated area to be ensonified to that level during airgun operations excluding overlap.

The area expected to be ensonified was determined by entering the planned survey lines into a MapInfo Geographic Information System (GIS), using the GIS to identify the relevant areas by "drawing" the applicable 160-dB (or, in the next subsection, 170-dB) buffer (see Table 1) around each seismic line, and then calculating the total area within the buffers. Areas of overlap (because of lines being closer together than the 160 dB radius) were limited and included only once when estimating the number of individuals exposed.

Applying the approach described above, ~12,372 km^2 (~15,465 km^2 including the 25% contingency) would be within the 160-dB isopleth on one or more occasions during the survey, assuming that the contingency lines are completed. Because this approach does not allow for turnover in the mammal populations in the study area during the course of the survey, the actual number of individuals exposed could be underestimated in some cases. On the other hand, the approach assumes that no cetaceans will move away from or toward the trackline as the *Langseth* approaches in response to increasing sound levels before the levels reach 160 dB, which will result in overestimates for those species known to avoid seismic sounds and vessels.

Table 7 shows the best and maximum estimates of the number of different individual marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic survey if no animals moved away from the survey vessel. The ***Requested Take Authorization***, given in the far right column of Table 7, is based on the best estimates rather than the maximum estimates of the numbers exposed, because there was little uncertainty associated with the method of estimating densities. Also, the best estimates are likely overestimates because they are based on shelf and slope densities and the proposed survey is in deep (>3000 m), offshore waters.

The 'best estimate' of the number of individual cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} during the proposed survey is 271 (Table 7). That total includes 69 ***Endangered*** whales (1 sperm, 6 humpback, 1 sei, and 61 fin whales), which (if realistic) would

TABLE 7. Estimates of the possible numbers of marine mammals exposed to sound levels ≥160 and ≥170 dB during USGS' proposed seismic survey in the central-western Bering Sea in August 2011. The proposed sound source consists of a 36-airgun, 6600-in^3 array. Received levels of airgun sounds are expressed in dB re 1 μPa_{rms} (averaged over pulse duration), consistent with NMFS' practice. Not all marine mammals will change their behavior when exposed to these sound levels, but some may alter their behavior when levels are lower (see text). Delphinids, Dall's porpoise, and pinnipeds are unlikely to react to levels below 170 dB. Species in italics are listed under the ESA as endangered or threatened. The column of numbers in boldface shows the numbers of "takes" for which authorization is requested.

	Number of Individuals Exposed to Sound Levels ≥160 dB (≥170 dB, Delphinids, Porpoise, and Pinnipeds)					
	Best Estimate[1]					
Species	**Number**		**% of Regional Pop'n[2]**	**Maximum Estimate[1]**		**Requested Take Authorization**
Balaenopteridae						
North Pacific right whale	*0*		*0*	*0*		***0***
Bowhead whale	*0*		*0*	*0*		***0***
Gray whale	0		<0.01	2		**0**
Humpback whale	*6*		*0.03*	*16*		***6***
Minke whale	19		0.08	63		**19**
Sei whale	*1*		*0.01*	*9*		***1***
Fin whale	*61*		*0.38*	*263*		***61***
Blue whale	*0*		*0*	*0*		***0***
Physeteridae						
Sperm whale	*1*		*<0.01*	*2*		***1***
Ziphiidae						
Cuvier's beaked whale	0		0	0		**0**
Baird's beaked whale	1		0.02	2		**5**[3]
Stejneger's beaked whale	1		NA	2		**2**[3]
Delphinidae						
Pacific white-sided dolphin	0		<0.01	1	(0)	**0**
Killer whale	44	(27)	0.51	61	(38)	**44**
Phocoenidae						
Dall's porpoise	137	(85)	0.01	282	(175)	**137**
Pinnipeds						
Steller sea lion	*42*	*(26)*	*0.06*	*63*	*(39)*	***42***
Northern fur seal	441	(273)	0.04	661	(410)	**441**
Ribbon seal	674	(418)	0.71	1011	(627)	**674**

[1] Best and maximum estimates are based on densities from Table 6 and ensonified areas (including 25% contingency) of 15,465 km^2 for 160 dB and 9591 km^2 for 170 dB (identified in parentheses).

[2] Regional population size estimates are from Table 2.

[3] Increased to mean group size in the CEBS and SEBS based on Friday et al. (2011).

represent <0.01%, 0.03%, 0.01%, and 0.38%, respectively, of the regional populations (Table 7). Dall's porpoise is expected to be the most common species in the study area; the best estimate of the number of Dall's porpoises that could be exposed is 137 or 0.01% of the regional population (Table 7). This may be a slight overestimate because the estimated densities are likely slight overestimates (see previous section). Estimates for other species are lower (Table 7). The 'maximum estimate' column in Table 7 shows estimates totaling 703 cetaceans.

Number of Delphinids and Dall's Porpoise that could be Exposed to ≥170 dB.—The 160-dB criterion, on which the preceding estimates are based, was derived from studies of baleen whales.

Odontocete hearing at low frequencies is relatively insensitive, and delphinids and Dall's porpoise generally appear to be more tolerant of strong low-frequency sounds than are many baleen whales. As summarized in Appendix B (5), delphinids commonly occur within distances where received levels would be expected to exceed 160 dB re 1 μPa_{rms}. There is no generally accepted alternative "take" criterion for delphinids exposed to airgun sounds. However, the estimates in this subsection assume that only those delphinids and Dall's porpoises exposed to ≥170 dB re 1 μPa_{rms}, on average, would be affected sufficiently to be considered "taken by harassment". ("On average" means that some individuals might react significantly upon exposure to levels somewhat <170 dB, but others would not do so even upon exposure to levels somewhat >170 dB.)

The area ensonified by levels ≥170 dB was estimated to be ~7673 km^2 (~9591 km^2 including the 25% contingency). The best and maximum estimates of the numbers of individuals exposed to ≥170 dB for the killer whale, the only delphinid expected to be exposed to levels ≥170 dB during the survey, are 27 and 38, respectively, and the corresponding estimates for Dall's porpoise are 85 and 175 (Table 7). These values are based on the predicted 170-dB radii around the array to be used during the study and are considered to be more realistic estimates of the number of individual delphinids and Dall's porpoises that could be affected. However, the number of Dall's porpoises that might be exposed to ≥170 dB is probably slightly overestimated because of the (presumed) overestimated density as noted earlier.

Number of Pinnipeds that might be Exposed to ≥160 dB and ≥170 dB*.**—The methods described previously for cetaceans were also used to calculate numbers of pinnipeds that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms}. As summarized earlier and in Appendix B of the EA, most pinnipeds, like delphinids, seem to be less responsive to airgun sounds than are some mysticetes. Thus, the numbers of pinnipeds that could be exposed to received levels ≥170 dB re 1 μPa_{rms} were also calculated, based on the estimated 170-dB radii (Table 1). Based on the "best" densities, 42 ***Endangered Steller sea lions, 441 northern fur seals, and 674 ribbon seals could be exposed to airgun sounds ≥160 dB re 1 μPa_{rms}; the corresponding numbers that could be exposed to airgun sounds ≥170 dB re 1 μPa_{rms} are 26 Steller sea lions, 273 northern fur seals, and 418 ribbon seals (Table 7). The 'maximum estimate' column in Table 7 shows an estimated 63 or 39 Steller sea lions that could be exposed to airgun sounds ≥160 dB or ≥170 dB re 1 $\mu Pa_{rms,}$ respectively. The corresponding numbers for northern fur seals are 661 and 410, and for ribbon seals are 1011 and 627.

Conclusions

The proposed seismic survey will involve towing an airgun array that introduces pulsed sounds into the ocean, along with simultaneous operation of an MBES and SBP. The survey will employ a 36-airgun array similar to the airgun arrays used for typical high-energy seismic surveys. The total airgun discharge volume is ~6600 in^3. Routine vessel operations, other than the proposed airgun operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking". No "taking" of marine mammals is expected in association with echosounder operations given the considerations discussed in § I, i.e., sounds are beamed downward, the beam is narrow, and the pulses are extremely short.

Cetaceans.—Several species of mysticetes show strong avoidance reactions to seismic vessels at ranges up to 6–8 km and occasionally as far as 20–30 km from the source vessel when medium-large airgun arrays have been used. However, reactions at the longer distances appear to be atypical of most species and situations.

Odontocete reactions to seismic pulses, or at least the reactions of delphinids and Dall's porpoise, are expected to extend to lesser distances than are those of mysticetes. Odontocete low-frequency hearing is less sensitive than that of mysticetes, and dolphins are often seen from seismic vessels. In fact, there are documented instances of dolphins approaching active seismic vessels. However, delphinids (along with other cetaceans) sometimes show avoidance responses and/or other changes in behavior when near operating seismic vessels.

Taking into account the mitigation measures that are planned (see § XI), effects on cetaceans are generally expected to be limited to avoidance of the area around the seismic operation and short-term changes in behavior, falling within the MMPA definition of "Level B harassment".

Killer, humpback, and fin whales are expected to be relatively common in the survey area. For these three species, 0.03–0.51% of the regional populations is likely to be exposed (Table 7) unless additional mitigation measures are implemented. Thus, if concentrations of these species are sighted, the airgun array will be powered down until the animals move away or disperse from the area, or the vessel will move its operations to a different area.

Varying estimates of the numbers of marine mammals that might be exposed to strong airgun sounds during the proposed program have been presented, depending on the specific exposure criteria (≥160 or ≥170 dB) and density criterion used (best or maximum). The requested "take authorization" of the number of individuals that could be exposed to ≥160 dB re 1 μPa_{rms} likely overestimates the actual number of animals that will be exposed to and will react to the seismic sounds. The reasons for that conclusion are outlined above. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations.

The many cases of apparent tolerance by cetaceans of seismic exploration, vessel traffic, and some other human activities show that co-existence is possible. Mitigation measures such as look outs, ramp ups, and power downs or shut downs when marine mammals are seen within defined ranges, should further reduce short-term reactions, and avoid or minimize any effects on hearing sensitivity. In all cases, the effects are expected to be short-term, with no lasting biological consequence.

Pinnipeds.—Three pinniped species—the Steller sea lion, the northern fur seal, and the ribbon seal—could occur in the study area. Best estimates of 42 Steller sea lions, 441 northern fur seals, and 674 ribbon seals could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms}. These estimates represent 0.06% of the Steller sea lion regional population, 0.04% of the northern fur seal regional population, and 0.71% of the ribbon seal regional population. As for cetaceans, the estimated numbers of pinnipeds that could be exposed to received levels ≥160 dB are probably overestimates of the actual numbers that will be affected. The Pacific walrus, spotted seal, and ringed seal follow the seasonal movement of the ice pack, and are not expected in the Bering Sea in August.

VIII. ANTICIPATED IMPACT ON SUBSISTENCE

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

There is no subsistence hunting in the deep, offshore waters of the central-western Bering Sea, so the proposed activities will not have any impact on the availability of the species or stocks for subsistence users.

IX. ANTICIPATED IMPACT ON HABITAT

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

The proposed seismic survey will not result in any permanent impact on habitats used by marine mammals, or to the food sources they use. The main impact issue associated with the proposed activity will be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in § VII, above. The following sections briefly review effects of airguns on fish and invertebrates, and more details are included in Appendices C and D of the EA, respectively.

Effects on Fish

One reason for the adoption of airguns as the standard energy source for marine seismic surveys is that, unlike explosives, they have not been associated with large-scale fish kills. However, existing information on the impacts of seismic surveys on marine fish populations is limited (see Appendix D of the EA). There are three types of potential effects of exposure to seismic surveys: (1) pathological, (2) physiological, and (3) behavioral. Pathological effects involve lethal and temporary or permanent sub-lethal injury. Physiological effects involve temporary and permanent primary and secondary stress responses, such as changes in levels of enzymes and proteins. Behavioral effects refer to temporary and (if they occur) permanent changes in exhibited behavior (e.g., startle and avoidance behavior). The three categories are interrelated in complex ways. For example, it is possible that certain physiological and behavioral changes could potentially lead to an ultimate pathological effect on individuals (i.e., mortality).

The specific received sound levels at which permanent adverse effects to fish potentially could occur are little studied and largely unknown. Furthermore, the available information on the impacts of seismic surveys on marine fish is from studies of individuals or portions of a population; there have been no studies at the population scale. The studies of individual fish have often been on caged fish that were exposed to airgun pulses in situations not representative of an actual seismic survey. Thus, available information provides limited insight on possible real-world effects at the ocean or population scale. This makes drawing conclusions about impacts on fish problematic because, ultimately, the most important issues concern effects on marine fish populations, their viability, and their availability to fisheries.

Hastings and Popper (2005), Popper (2009), and Popper and Hastings (2009a,b) provided recent critical reviews of the known effects of sound on fish. The following sections provide a general synopsis of the available information on the effects of exposure to seismic and other anthropogenic sound as relevant to fish. The information comprises results from scientific studies of varying degrees of rigor plus some anecdotal information. Some of the data sources may have serious shortcomings in methods, analysis, interpretation, and reproducibility that must be considered when interpreting their results (see Hastings and Popper 2005). Potential adverse effects of the program's sound sources on marine fish are then noted.

Pathological Effects

The potential for pathological damage to hearing structures in fish depends on the energy level of the received sound and the physiology and hearing capability of the species in question (see Appendix D of the EA). For a given sound to result in hearing loss, the sound must exceed, by some substantial amount, the hearing threshold of the fish for that sound (Popper 2005). The consequences of temporary or permanent hearing loss in individual fish on a fish population are unknown; however, they likely depend on the number of individuals affected and whether critical behaviors involving sound (e.g., predator avoidance, prey capture, orientation and navigation, reproduction, etc.) are adversely affected.

Little is known about the mechanisms and characteristics of damage to fish that may be inflicted by exposure to seismic survey sounds. Few data have been presented in the peer-reviewed scientific literature. As far as we know, there are only two papers with proper experimental methods, controls, and careful pathological investigation implicating sounds produced by actual seismic survey airguns in causing adverse anatomical effects. One such study indicated anatomical damage, and the second indicated TTS in fish hearing. The anatomical case is McCauley et al. (2003), who found that exposure to airgun sound caused observable anatomical damage to the auditory maculae of "pink snapper" (*Pagrus auratus*). This damage in the ears had not been repaired in fish sacrificed and examined almost two months after exposure. On the other hand, Popper et al. (2005) documented only TTS (as determined by auditory brainstem response) in two of three fish species from the Mackenzie River Delta. This study found that broad whitefish (*Coregonus nasus*) that received a sound exposure level of 177 dB re 1 $\mu Pa^2 \cdot s$ showed no hearing loss. During both studies, the repetitive exposure to sound was greater than would have occurred during a typical seismic survey. However, the substantial low-frequency energy produced by the airguns [less than ~400 Hz in the study by McCauley et al. (2003) and less than ~200 Hz in Popper et al. (2005)] likely did not propagate to the fish because the water in the study areas was very shallow (~9 m in the former case and <2 m in the latter). Water depth sets a lower limit on the lowest sound frequency that will propagate (the "cutoff frequency") at about one-quarter wavelength (Urick 1983; Rogers and Cox 1988).

Wardle et al. (2001) suggested that in water, acute injury and death of organisms exposed to seismic energy depends primarily on two features of the sound source: (1) the received peak pressure and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. According to Buchanan et al. (2004), for the types of seismic airguns and arrays involved with the proposed program, the pathological (mortality) zone for fish would be expected to be within a few meters of the seismic source. Numerous other studies provide examples of no fish mortality upon exposure to seismic sources (Falk and Lawrence 1973; Holliday et al. 1987; La Bella et al. 1996; Santulli et al. 1999; McCauley et al. 2000a,b, 2003; Bjarti 2002; Thomsen 2002; Hassel et al. 2003; Popper et al. 2005; Boeger et al. 2006).

Some studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur close to seismic sources (Kostyuchenko 1973; Dalen and Knutsen 1986; Booman et al. 1996; Dalen et al. 1996). Some of the reports claimed seismic effects from treatments quite different from actual seismic survey sounds or even reasonable surrogates. However, Payne et al. (2009) reported no statistical differences in mortality/morbidity between control and exposed groups of capelin eggs or monkfish larvae. Saetre and Ona (1996) applied a 'worst-case scenario' mathematical model to investigate the effects of seismic energy on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic surveys are so low, as compared to natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Physiological Effects

Physiological effects refer to cellular and/or biochemical responses of fish to acoustic stress. Such stress potentially could affect fish populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear to be temporary in all studies done to date (Sverdrup et al. 1994; Santulli et al. 1999; McCauley et al. 2000a,b). The periods necessary for the biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus (see Appendix D of the EA).

Behavioral Effects

Behavioral effects include changes in the distribution, migration, mating, and catchability of fish populations. Studies investigating the possible effects of sound (including seismic survey sound) on fish behavior have been conducted on both uncaged and caged individuals (e.g., Chapman and Hawkins 1969; Pearson et al. 1992; Santulli et al. 1999; Wardle et al. 2001; Hassel et al. 2003). Typically, in these studies fish exhibited a sharp "startle" response at the onset of a sound followed by habituation and a return to normal behavior after the sound ceased.

There is general concern about potential adverse effects of seismic operations on fisheries, namely a potential reduction in the "catchability" of fish involved in fisheries. Although reduced catch rates have been observed in some marine fisheries during seismic testing, in a number of cases the findings are confounded by other sources of disturbance (Dalen and Raknes 1985; Dalen and Knutsen 1986; Løkkeborg 1991; Skalski et al. 1992; Engås et al. 1996). In other airgun experiments, there was no change in catch per unit effort (CPUE) of fish when airgun pulses were emitted, particularly in the immediate vicinity of the seismic survey (Pickett et al. 1994; La Bella et al. 1996). For some species, reductions in catch may have resulted from a change in behavior of the fish, e.g., a change in vertical or horizontal distribution, as reported in Slotte et al. (2004).

In general, any adverse effects on fish behavior or fisheries attributable to seismic testing may depend on the species in question and the nature of the fishery (season, duration, fishing method). They may also depend on the age of the fish, its motivational state, its size, and numerous other factors that are difficult, if not impossible, to quantify at this point, given such limited data on effects of airguns on fish, particularly under realistic at-sea conditions.

Effects on Invertebrates

The existing body of information on the impacts of seismic survey sound on marine invertebrates is very limited. However, there is some unpublished and very limited evidence of the potential for adverse effects on invertebrates, thereby justifying further discussion and analysis of this issue. The three types of potential effects of exposure to seismic surveys on marine invertebrates are pathological, physiological, and behavioral. Based on the physical structure of their sensory organs, marine invertebrates appear to be specialized to respond to particle displacement components of an impinging sound field and not to the pressure component (Popper et al. 2001; see also Appendix E of the EA).

The only information available on the impacts of seismic surveys on marine invertebrates involves studies of individuals; there have been no studies at the population scale. Thus, available information provides limited insight on possible real-world effects at the regional or ocean scale. The most important aspect of potential impacts concerns how exposure to seismic survey sound ultimately affects invertebrate populations and their viability, including availability to fisheries.

Literature reviews of the effects of seismic and other underwater sound on invertebrates were provided by Moriyasu et al. (2004) and Payne et al. (2008). The following sections provide a synopsis of available information on the effects of exposure to seismic survey sound on species of decapod crustaceans and cephalopods, the two taxonomic groups of invertebrates on which most such studies have been conducted. The available information is from studies with variable degrees of scientific soundness and from anecdotal information. A more detailed review of the literature on the effects of seismic survey sound on invertebrates is provided in Appendix E of the EA.

Pathological Effects

In water, lethal and sub-lethal injury to organisms exposed to seismic survey sound appears to depend on at least two features of the sound source: (1) the received peak pressure, and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. For the type of airgun array planned for the proposed program, the pathological (mortality) zone for crustaceans and cephalopods is expected to be within a few meters of the seismic source, at most; however, very few specific data are available on levels of seismic signals that might damage these animals. This premise is based on the peak pressure and rise/decay time characteristics of seismic airgun arrays currently in use around the world.

Some studies have suggested that seismic survey sound has a limited pathological impact on early developmental stages of crustaceans (Pearson et al. 1994; Christian et al. 2003; DFO 2004). However, the impacts appear to be either temporary or insignificant compared to what occurs under natural conditions. Controlled field experiments on adult crustaceans (Christian et al. 2003, 2004; DFO 2004) and adult cephalopods (McCauley et al. 2000a,b) exposed to seismic survey sound have not resulted in any significant pathological impacts on the animals. It has been suggested that exposure to commercial seismic survey activities has injured giant squid (Guerra et al. 2004), but there is no evidence to support such claims.

Physiological Effects

Physiological effects refer mainly to biochemical responses by marine invertebrates to acoustic stress. Such stress potentially could affect invertebrate populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses (i.e., changes in haemolymph levels of enzymes, proteins, etc.) of crustaceans have been noted several days or months after exposure to seismic survey sounds (Payne et al. 2007). The periods necessary for these biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus.

Behavioral Effects

There is increasing interest in assessing the possible direct and indirect effects of seismic and other sounds on invertebrate behavior, particularly in relation to the consequences for fisheries. Changes in behavior could potentially affect such aspects as reproductive success, distribution, susceptibility to predation, and catchability by fisheries. Studies investigating the possible behavioral effects of exposure to seismic survey sound on crustaceans and cephalopods have been conducted on both uncaged and caged animals. In some cases, invertebrates exhibited startle responses (e.g., squid in McCauley et al. 2000a,b). In other cases, no behavioral impacts were noted (e.g., crustaceans in Christian et al. 2003, 2004; DFO 2004). There have been anecdotal reports of reduced catch rates of shrimp shortly after exposure to seismic surveys; however, other studies have not observed any significant changes in shrimp catch rate (Andriguetto-Filho et al. 2005). Similarly, Parry and Gason (2006) did not find any evidence that lobster catch rates were affected by seismic surveys. Any adverse effects on crustacean and cephalopod behavior or fisheries attributable to seismic survey sound depend on the species in question and the nature of the fishery (season, duration, fishing method).

X. Anticipated Impact of Loss or Modification of Habitat on Marine Mammals

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations. However, a small minority of the marine mammals that are present near the proposed activity may be temporarily displaced as much as a few kilometers by the planned activity.

A total of 18 OBSs will be deployed during the study. Scripps LC4x4 OBSs will be used; this type of OBS has a volume of ~1 m^3, with an anchor that consists of a large piece of steel grating (~1 m^2). OBS anchors will be left behind upon equipment recovery. Also, expendable sonobuoys will be deployed up to 4 times per day during seismic operations; after 8 h, they will self-scuttle and sink. The sonobuoys consist of a hydrophone and electronics encased in an aluminum tube ~80 cm long and 10 cm in diameter. Although OBS placement and scuttled sonobuoys will disrupt a very small area of seafloor habitat and could disturb benthic invertebrates, the impacts are expected to be localized and transitory.

The proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, because operations will be limited in duration.

XI. MITIGATION MEASURES

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

Marine mammals and sea turtles are known to occur in the proposed study area. To minimize the likelihood that impacts will occur to the species and stocks, airgun operations will be conducted in accordance with the MMPA and the ESA, including obtaining permission for incidental harassment or incidental 'take' of marine mammals and other endangered species. The proposed activities will take place in the U.S. EEZ and in International Waters.

The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activities. The procedures described here are based on protocols used during previous USGS and L-DEO seismic research cruises as approved by NMFS, and on best practices recommended in Richardson et al (1995), Pierson et al. (1998), and Weir and Dolman (2007).

Planning Phase

In designing this proposed seismic survey, USGS has coordinated efforts with LDEO and NSF and has considered potential environmental impacts including seasonal, biological, and weather factors; ship schedules; and equipment availability. The scheduling of four NSF and ECS surveys from the Langseth in succession from the Gulf of Alaska to Bering Sea to Chukchi Sea has optimized the efficient use of the vessel. Some marine mammal species (e.g., killer whales, Steller sea lions) are year-round residents in the Bering Sea, so determining the schedule of the proposed survey likely would result in no net benefits for those species. Other species are absent from the Bering Sea in August—the bowhead whale spends the summer in the Beaufort Sea, migrating back to the Bering Sea in fall, and Pacific walrus, spotted seal, and ringed seal follow the seasonal movement of the ice pack northward—so scheduling the survey in August is a net benefit for those species. The array will be powered down to a single gun during turns, and the array will be shut down during OBS deployment and retrieval.

Proposed Exclusion Zones

Received sound levels have been predicted by L-DEO, in relation to distance and direction from the airguns, for the 36-airgun array and for a single 1900LL 40-in^3 airgun, which will be used during power downs. Results were recently reported for propagation measurements of pulses from the 36-airgun array in two water depths (~1600 m and 50 m) in the Gulf of Mexico in 2007–2008 (Tolstoy et al. 2009). It would be prudent to use the empirical values that resulted to determine exclusion zones for the airgun array. Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. During the proposed study, all survey effort will take place in deep (>1000 m) water, so propagation in shallow water is not relevant here. The depth of the array was different in the Gulf of Mexico calibration study (6 m) than in the proposed survey (9 m); thus, correction factors have been applied to the distances reported by Tolstoy et al. (2009). The correction factors used were the ratios of the 160-, 170-, 180-, and 190-dB distances from the modeled results for the 6600-in^3 airgun array towed at 6 m vs. 9 m, from LGL (2008): 1.285; 1.381; 1.338; and 1.364, respectively. Based on the propagation measurements and modeling, the distances from the source where sound levels are predicted to be 190, 180, 170, and 160 dB re 1 μPa_{rms} were determined (see Table 1 in § I). The 180- and 190-dB radii are to 940 m and 400 m, respectively. The 180- and 190-dB levels are shut-down criteria applicable to cetaceans and pinnipeds, respectively, as specified by NMFS (2000); these levels were used to establish the exclusion zones (EZs). If the PSO detects marine mammal(s) or turtle(s) within or about to enter the appropriate EZ, the airguns will be powered down (or shut down if necessary) immediately (see below).

Detailed recommendations for new science-based noise exposure criteria were published in early 2008 (Southall et al. 2007). USGS and NSF will be prepared to revise its procedures for estimating numbers of mammals “taken”, EZs, etc., as may be required by any new guidelines that result. As of early 2011, NMFS has not specified a new procedure for determining EZs.

Mitigation During Operations

Mitigation measures that will be adopted during the survey in the central-western Bering Sea include (1) power-down procedures, (2) shut-down procedures, (3) ramp-up procedures, and (4) special mitigation measures for situations or species of particular concern.

Power-down Procedures

A power down involves decreasing the number of airguns in use such that the radius of the 180-dB (or 190-dB) zone is decreased to the extent that marine mammals or turtles are no longer in or about to enter the EZ. A power down of the airgun array will also occur when the vessel is turning from one seismic line to another. During a power down, one airgun will be operated. The continued operation of one airgun is intended to alert marine mammals and turtles to the presence of the seismic vessel in the area. In contrast, a shut down occurs when all airgun activity is suspended.

If a marine mammal or turtle is detected outside the EZ but is likely to enter the EZ, the airguns will be powered down before the animal is within the EZ. Likewise, if a mammal or turtle is already within the EZ when first detected, the airguns will be powered down immediately. During a power down of the airgun array, the 40-in^3 airgun will be operated. If a marine mammal or turtle is detected within or near the smaller EZ around that single airgun (Table 1), it will be shut down (see next subsection).

Following a power down, airgun activity will not resume until the marine mammal or turtle has cleared the safety zone. The animal will be considered to have cleared the safety zone if

- it is visually observed to have left the EZ, or
- it has not been seen within the zone for 15 min in the case of small odontocetes (or pinnipeds), or
- it has not been seen within the zone 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 EZ for turtles, e.g., if a turtle is sighted close to the vessel and the ship speed is 7.4 km/h, it would take the vessel ~8 min to leave the turtle behind.

During airgun operations following a power down (or shut down) whose duration has exceeded the time limits specified above, the airgun array will be ramped up gradually. Ramp-up procedures are described below.

Shut-down Procedures

The operating airgun(s) will be shut down if a marine mammal or turtle is seen within or approaching the EZ for the single airgun. Shut downs will be implemented (1) if an animal enters the EZ of the single airgun after a power down has been initiated, or (2) if an animal is initially seen within the EZ of the single airgun when more than one airgun (typically the full array) is operating. Airgun activity will not resume until the marine mammal or turtle has cleared the safety zone, or until the PSO is confident that the animal has left the vicinity of the vessel. Criteria for judging that the animal has cleared the safety zone will be as described in the preceding subsection.

Ramp-up Procedures

A ramp-up procedure will be followed when the airgun array begins operating after a specified period without airgun operations or when a power down has exceeded that period. It is proposed that, for the present cruise, this period would be ~8 min. This period is based on the 180-dB radius for the 36-airgun array (940 m) in relation to the minimum planned speed of the *Langseth* while shooting (7.4 km/h). Similar periods (~8–10 min) were used during previous surveys.

Ramp up will begin with the smallest airgun in the array (40 in^3). Airguns will be added in a sequence such that the source level of the array will increase in steps not exceeding 6 dB per 5-min period over a total duration of ~35 min. During ramp up, the PSOs will monitor the exclusion zone, and if marine mammals or turtles are sighted, a power down or shut down will be implemented as though the full array were operational.

If the complete EZ has not been visible for at least 30 min prior to the start of operations in either daylight or nighttime, ramp up will not commence unless at least one airgun (40 in^3 or similar) has been operating during the interruption of seismic survey operations. Given these provisions, it is likely that the airgun array will not be ramped up from a complete shut down at night or in thick fog, because the outer part of the safety zone for that array will not be visible during those conditions. If one airgun has operated during a power-down period, ramp up to full power will be permissible at night or in poor visibility, on the assumption that marine mammals and turtles will be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away. Ramp up of the airguns will not be initiated if a sea turtle or marine mammal has not cleared the safety zone as described in the preceeding subsection on power-down procedures, or if it is sighted within or near the applicable EZs during the day or at night.

Special Procedures for Situations and Species of Particular Concern

Special mitigation procedures will be implemented as follows:

- The airguns will be shut down immediately if ESA-listed species for which no takes are being requested (North Pacific right or blue whale — see § VII) are sighted at any distance from the vessel. Ramp up will only begin if the whale has not been seen for 30 min.
- Concentrations of humpback whales, fin whales, and killer whales will be avoided if possible, and the array will be powered down if necessary.

XII. PLAN OF COOPERATION

> Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:
>
> (i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation;
>
> (ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation;
>
> (iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and
>
> (iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

Not applicable. The proposed activity will take place in the deep, offshore waters of the central-western Bering Sea, and no activities will take place in or near a traditional Arctic subsistence hunting area.

XIII. MONITORING AND REPORTING PLAN

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

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

The proposed Monitoring Plan is described below. USGS understands that this Monitoring Plan will be subject to review by NMFS, and that refinements may be required.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. USGS is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

PSOs will be based aboard the seismic source vessel and will watch for marine mammals and turtles near the vessel during daytime airgun operations and during any start-ups at night. PSOs will also watch for marine mammals and sea turtles near the seismic vessel for at least 30 min prior to the planned start of airgun operations. PSOs will also observe during daytime periods when the seismic system is not operating for comparison of sighting rates and behavior with vs. without airgun operations. Based on PSO observations, the airguns will be powered down or shut down when marine mammals are observed within or about to enter a designated EZ [see § XI above]. The EZ is a region in which a possibility exists of adverse effects on animal hearing or other physical effects.

During seismic operations in the central-western Bering Sea, five PSOs will be based aboard the *Langseth*. PSOs will be appointed by USGS with NMFS concurrence. Observations will take place during ongoing daytime operations and nighttime start ups of the airguns. During the majority of seismic operations, two PSOs will monitor for marine mammals and turtles around the seismic vessel. Use of two simultaneous observers will increase the effectiveness of detecting animals around the source vessel. However, during meal times, only one PSO may be on duty. PSO(s) will be on duty in shifts of duration no longer than 4 h. Other crew will also be instructed to assist in detecting marine mammals and turtles and implementing mitigation requirements. Before the start of the seismic survey, the crew will be given additional instruction regarding how to do so.

The *Langseth* is a suitable platform for marine mammal and turtle observations. When stationed on the observation platform, the eye level will be ~21.5 m above sea level, and the observer will have a good view around the entire vessel. During daytime, the PSO(s) will scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon), Big-eye binoculars (25×150), and with the naked eye. During darkness, night vision devices (NVDs) will be available (ITT F500 Series Generation 3 binocular-image intensifier or equivalent), when required. Laser rangefinding binoculars (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation. Those are useful in training observers to estimate distances visually, but are generally not useful in measuring distances to animals directly; that is done primarily with the reticles in the binoculars.

When mammals or turtles are detected within or about to enter the designated exclusion zone, the airguns will immediately be powered down or shut down if necessary. The PSO(s) will continue to maintain watch to determine when the animal(s) are outside the exclusion zone. Airgun operations will not resume until the animal has left the exclusion zone.

Passive Acoustic Monitoring

PAM will take place to complement the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Acoustical monitoring can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The acoustic monitoring will serve to alert visual observers (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or by night, and does not depend on good visibility. It will be monitored in real time so that the visual observers can be advised when cetaceans are detected.

The PAM system consists of hardware (i.e., hydrophones) and software. The "wet end" of the system consists of a towed hydrophone array that is connected to the vessel by a tow cable. The tow cable is 250 m long, and the hydrophones are fitted in the last 10 m of cable. A depth gauge is attached to the free end of the cable, and the cable is typically towed at depths <20 m. The array will be deployed from a winch located on the back deck. A deck cable will connect the tow cable to the electronics unit in the main computer lab where the acoustic station, signal conditioning, and processing system will be located. The acoustic signals received by the hydrophones are amplified, digitized, and then processed by the Pamguard software. The system can detect marine mammal vocalizations at frequencies up to 250 kHz.

The towed hydrophones will ideally be monitored 24 h per day while at the seismic survey area during airgun operations, and during most periods when the *Langseth* is underway while the airguns are not operating. However, PAM may not be possible if damage occurs to the array or back-up systems during operations. One PSO will monitor the acoustic detection system at any one time, by listening to the signals from two channels via headphones and/or speakers and watching the real-time spectrographic display for frequency ranges produced by cetaceans. The PSO monitoring the acoustical data will be on shift for 1–6 h at a time. All PSOs are expected to rotate through the PAM position, although the most experienced with acoustics will be on PAM duty more frequently.

When a vocalization is detected while visual observations are in progress, the acoustic PSO will contact the visual PSO immediately, to alert him/her to the presence of cetaceans (if they have not already been seen), and to allow a power down or shut down to be initiated, if required. The information regarding the call will be entered into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection can also be recorded for further analysis.

PSO Data and Documentation

PSOs will record data to estimate the numbers of marine mammals and turtles exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data will be used to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They will also provide information needed to order a power down or shut down of the airguns when a marine mammal or sea turtle is within or near the EZ. Observations will also be made during daytime periods when the *Langseth* is underway without seismic operations. In addition to the transits to, from, and through the study area, there will also be opportunities to collect baseline biological data during the deployment and recovery of OBSs.

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

1. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.
2. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

The data listed under (2) will also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

All observations and power downs or shut downs will be recorded in a standardized format. Data will be entered into an electronic database. The accuracy of the data entry will be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures will allow initial summaries of data to be prepared during and shortly after the field program, and will facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations will provide

1. The basis for real-time mitigation (airgun power down or shut down).
2. Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS.
3. Data on the occurrence, distribution, and activities of marine mammals and turtles in the area where the seismic study is conducted.

4. Information to compare the distance and distribution of marine mammals and turtles relative to the source vessel at times with and without seismic activity.
5. Data on the behavior and movement patterns of marine mammals and turtles seen at times with and without seismic activity.

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

XIV. Coordinating Research to Reduce and Evaluate Incidental Take

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

USGS will coordinate the planned marine mammal monitoring program associated with the seismic survey in the central-western Bering Sea (as summarized in § XI and XIII) with other parties that may have interest in the area and/or be conducting marine mammal studies in the same region during the proposed seismic survey. USGS will coordinate with applicable U.S. agencies (e.g., NMFS), and will comply with their requirements.

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