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Incidental Takes of Marine Mammals During Specified Activities; Marine Seismic Survey in the Arctic Ocean, August to September, 2010; Notice

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XW05

Incidental Takes of Marine Mammals During Specified Activities; Marine Seismic Survey in the Arctic Ocean, August to September, 2010

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; proposed incidental take authorization; request for comments.

SUMMARY: NMFS has received an application from the U.S. Geological Survey (USGS) for an Incidental Harassment Authorization (IHA) to take small numbers of marine mammals, by harassment, incidental to conducting a marine seismic survey in the Arctic Ocean during August to September, 2010. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS requests comments on its proposal to authorize USGS to incidentally take, by Level B harassment only, small numbers of marine mammals during the aforementioned activity.

DATES: Comments and information must be received no later than August 9, 2010.

ADDRESSES: Comments on the application should be addressed to P. Michael Payne, Chief, Permits, Conservation, and Education Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910. The mailbox address for providing e-mail comments is *PR1.0648–XW05@noaa.gov.* NMFS is not responsible for e-mail comments sent to addresses other than the one provided here. Comments sent via e-mail, including all attachments, must not exceed a 10-megabyte file size.

All comments received are a part of the public record and will generally be posted to *http://www.nmfs.noaa.gov/pr/permits/incidental.htm* without change. All Personal Identifying Information (for example, name, address, *etc.*) voluntarily submitted by the commenter may be publicly accessible. Do not submit Confidential Business Information or otherwise sensitive or protected information.

A copy of the application containing a list of the references used in this document may be obtained by writing to the address specified above, telephoning the contact listed below (*see* **FOR FURTHER INFORMATION CONTACT**), or visiting the Internet at: *http://www.nmfs.noaa.gov/pr/permits/incidental.htm.* Documents cited in this notice may be viewed, by appointment, during regular business hours, at the aforementioned address.

FOR FURTHER INFORMATION CONTACT: Howard Goldstein or Jolie Harrison, Office of Protected Resources, NMFS, 301–713–2289.

SUPPLEMENTARY INFORMATION:

Background

Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 *et seq.*) direct the Secretary of Commerce (Secretary) to allow, upon request, the incidental, but not intentional, taking of marine mammals by United States citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of a proposed authorization is provided to the public for review.

An authorization for incidental taking of small numbers of marine mammals shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and if the permissible methods of taking and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth. NMFS has defined "negligible impact" in 50 CFR 216.103 as "* * * an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

Section 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization not to exceed one year to incidentally take small numbers of marine mammals by harassment. Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

> Any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild ["Level A harassment"]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering ["Level B harassment"].

16 U.S.C. 1362(18)

Section 101(a)(5)(D) establishes a 45-day time limit for NMFS' review of an application followed by a 30-day public notice and comment period for any proposed authorizations for the incidental harassment of marine mammals. Within 45 days of the close of the comment period, NMFS, MMPA must either issue or deny the authorization.

Summary of Request

On March 9, 2010, NMFS received an IHA application and an Environmental Assessment (EA) from USGS for the taking, by Level B harassment only, of small numbers of several species of marine mammals incidental to conducting a marine seismic survey in the Arctic Ocean during August to September, 2010. NMFS received a revised IHA application and a revised EA on June 1, 2010.

Description of the Specified Activity

USGS plans to conduct a marine geophysical (seismic reflection/refraction) and bathymetric survey in the Arctic Ocean in August and September, 2010 (*see* Tables 1 and 2, and Figure 3 of the IHA application). The survey will be conducted from the Canadian Coast Guard (CCG) vessel CCGS *Louis S. St. Laurent* (*St. Laurent*) which will be accompanied by the U.S. Coast Guard Cutter (USCGC) *Healy,* both of which are polar-class icebreakers. Descriptions of the vessels and their specifications are presented in Appendix A of the IHA application. The two vessels will operate in tandem in the presence of ice but may diverge and operate independently in open water. Some minor deviation of the dates is possible, depending on logistics and weather (*i.e.,* the cruise may depart earlier or be extended due to poor weather; there could be extra days of seismic operations if collected data are of sub-standard quality).

One CCG helicopter will be available for deployment from the *St. Laurent* for ice reconnaissance and crew transfers between the vessels during survey operations. Helicopters transfer of crew from the *Healy* is also planned for approximately one day during a ship-to-shore crew change at Barrow, Alaska at the end of the survey. The helicopter operations in Barrow will be conducted under Department of Interior (DOI) contract. Daily helicopter operations are anticipated pending weather conditions. Spot bathymetry will also be conducted from the helicopter outside U.S. waters.

Acoustic sources onboard the *St. Laurent* will include an airgun array comprised of three Sercel G-airguns and a Knudsen 320BR "Chirp" pulse echosounder operating at 12 kHz. The *St. Laurent* will also tow a 3 to 5 kHz sub-bottom profiler while in open water and when not working with the *Healy.* The airgun array consists of two 500 in^3 and one 150 in^3 airguns for an overall discharge of 1,150 in^3. Table 2 of the IHA application presents different sound pressure level (SPL) radii of the airgun array. Acoustic sources that will be operated on the *St. Laurent* are described in detail in Section VII and Appendix B in the IHA application. The seismic array and a hydrophone streamer towed from the *St. Laurent* will operate under the provisions of a Canadian authorization based on Canada's environmental assessment of the proposed survey while in Canadian or international waters, and under the provisions of an IHA issued to the USGS by NMFS in U.S. waters. NMFS cannot issue an IHA directly to a non-U.S. citizen, however, the Geological Survey of Canada (GSC) has written a Categorical Declaration stating that "while in U.S. waters (*i.e.,* the U.S. 200 mile Exclusive Economic Zone), the GSC will comply with any and all environmental mitigation measures required by the U.S. NMFS and/or the U.S. Fish and Wildlife Service." The *St. Laurent* will follow the lead of the *Healy.* The *Healy* will break and clear ice approximately 1.6 to 3.2 km (1 to 2 miles [mi]) in advance of the *St. Laurent.* In situations where the array (and hydrophone streamer) cannot be towed safely due to ice cover, the *St. Laurent* may escort the *Healy.* The *Healy* will use a multi-beam echosounder (Kongsberg EM122), a sub-bottom profiler (Knudsen 3.5 kHz Chirp), and a "piloting" echosounder (ODEC 1500) continuously when underway and during the seismic profiling. Acoustic Doppler current profilers (75 kHz and 150 kHz) may also be used on the *Healy.* The *Healy's* acoustic systems are described in further detail in Section VII and Appendix B of the IHA application.

In addition to the hydrophone streamer, marine sonobuoys will be deployed to acquire wide angle reflection and refraction data for velocity determination to convert seismic reflection travel time to depth. Sonobuoys will be deployed off the stern of the *St. Laurent* approximately every eight hours during seismic operations with as many as three deployments per day. The sonobuoy's hydrophone will activate at a water depth of approximately 60 m (196.9 ft) and seismic signals will be communicated via radio to the *St. Laurent.* The sonobuoys are pre-set to scuttle (*i.e.,* deliberately sink) eight hours after activation.

The program within U.S. waters will consist of approximately 806 km (500.8 mi) of survey transect line, not including transits when the airguns are not operating (*see* Figure 1 and Table 1 of the IHA application). U.S. priorities include another 997 km (619.5 mi) of survey lines north of the U.S. Exclusive Economic Zone (EEZ), for a total of 1,803 km (1,120.3 mi) of tracklines of interest to the U.S. Table 1 of the IHA application lists all U.S. priority tracklines; Figure 1 of the IHA application includes all U.S. priority tracks and the area of interest to Canada near the proposed U.S. tracklines. Water depths within the U.S. study area will range from approximately 1,900 to 4,000 m (6,233.5 to 13,123.4 ft) (*see* Figure 1 of the IHA application). There may be additional seismic operations associated with airgun testing, start-up, and repeat coverage of any areas where initial data quality is sub-standard. The tracklines that will be surveyed in U.S. waters include the southern 263.8 km (164 mi) of the line that runs North-South in the western EEZ, the southern 264.5 km (164.4 mi) of the line that runs North-South in the central EEZ, and 277.7 km (172.6 mi) trackline of the line that connects the two (*see* Figure 1 and Table 1 of the IHA application). The IHA application requests the authorization of incidental takes of marine mammals for activities within U.S. waters.

TABLE 1—PROPOSED U.S. PRIORITY TRACKLINES FOR USGS AND GEOLOGICAL SURVEY OF CANADA (GSC) 2010 EXTENDED CONTINENTAL SHELF SURVEY IN THE NORTHERN BEAUFORT SEA AND ARCTIC OCEAN

Location	End point 1	End point 2	Kilometer (km)	Nautical Mile (nmi)	Time (hour [hr]) @ 4 nmi/hr
NS in central EEZ (south)	71.22° North; 145.17° West	72.27° North; 145.41° West	118	64	16
NS in central EEZ (north)	72.27° North; 145.41° West	73.92° North; 145.30° West	183	100	25
Central-western EEZ connector.	73.92° North; 145.30° West	71.84° North; 151.82° West	317	171	43
NS in western EEZ	71.84° North; 151.82° West	74.32° North; 150.30° West	281	152	39
South Northwind Ridge	74.32° North; 150.30° West	74.96° North; 158.01° West	239	129	32
Northwind Ridge connector	74.96° North; 158.01° West	76.30° North; 155.88° West	161	87	22
Mid-Northwind Ridge	76.30° North; 155.88° West	75.41° North; 146.50° West	274	148	37
Northwind Ridge connector	75.41° North; 146.50° West	76.57° North; 146.82° West	129	70	17
Mid-Northwind Ridge	76.57° North; 146.82° West	76.49° North; 150.73° West	102	55	14
Totals			1,804	976	245

Two vessels will operate cooperatively during the proposed seismic survey. The *St. Laurent* will conduct seismic operations using an airgun array and also operate a 12 kHz Chirp echosounder. The St. Laurent will also operate a 3 to 5 kHz sub-bottom profiler in open water when not working with the *Healy.* The *Healy* will normally escort the *St. Laurent* in ice cover, and will continuously operate a bathymetric multi-beam echosounder, a 3.5 kHz Chirp sub-bottom profiler, a piloting echosounder, and two acoustic Doppler current profilers.

The *St. Laurent* will access the survey area from Canada and rendezvous with the *Healy* on approximately August 7, 2010; the *Healy* will approach the survey area from the Bering Straits. The *St. Laurent* will deploy a relatively small airgun array comprised of three G-airguns and a single hydrophone streamer approximately 300 m (984 ft) in length. The airgun array consists of two 500 in^3 and one 150 in^3 airguns for an overall discharge of 1,150 in^3. The *St. Laurent* will follow the lead of the *Healy* which will operate approximately 1.9 to 3.8 km (1 to 2 nmi) ahead of the *St. Laurent.* In ice conditions where seismic gear cannot be safely towed, the *St. Laurent* will escort the *Healy* to optimize multi-beam bathymetry data collection. If extended open-water conditions are encountered, *Healy* and *St. Laurent* may operate independently.

The U.S. priority survey lines will consist of eight transect lines ranging in length from approximately 102 to 317 km (63.4 to 197 mi) of trackline (*see* Table 1 and Figure 1 of the IHA application). These tracklines are planned in water depths of 1,900 to 4,000 m (6,234 to 13,123 ft). Approximately 806 km (500.8 mi) of trackline will be surveyed within U.S. waters. The survey line nearest to shore in U.S. waters is approximately 116 km (63 nmi) offshore at its closest point. After completion of the survey the *St. Laurent* will return to port in Canada, and the *Healy* will change crew at Barrow via helicopter or surface conveyance before continuing on another project.

Vessel Specifications

The CCGS *St. Laurent* was built in 1969 by Canadian Vickers Ltd. in Montreal, Quebec, and underwent an extensive modernization in Halifax, Nova Scotia between 1988 to 1993. The *St. Laurent* is based at CCG Base Dartmouth in Dartmouth, Nova Scotia. Current vessel activities involve summer voyages to the Canadian Arctic for sealifts to various coastal communities and scientific expeditions. A description of the *St. Laurent* with vessel specifications is presented in Appendix A of the IHA application and is available online at: *http://www.ccg-gcc.gc.ca/eng/Fleet/Vessels?id=1111&info=5&subinfo.*

The *Healy* is designed to conduct a wide range of research activities, providing more than 390.2 m^2 (4,200 ft^2) of scientific laboratory space, numerous electronic sensor systems, oceanographic winches, and accommodations for up to 50 scientists. The *Healy* is designed to break 1.4 m (4.5 ft) of ice continuously at 5.6 km/hour (three knots) and can operate in temperatures as low as −45.6 C (−50 degrees F). The science community provided invaluable input on lab lay-outs and science capabilities during design and construction of the ship. The *Healy* is also a capable platform for supporting other potential missions in the polar regions, including logistics, search and rescue, ship escort, environmental protection, and enforcement of laws and treaties.

The *Healy* is a USCG icebreaker, capable of traveling at 5.6 km/hour (three knots) through 1.4 m (4.5 ft) of ice. A "Central Power Plant," four Sultzer 12Z AU40S diesel generators, provides electric power for propulsion and ship's services through a 60 Hz, three-phase common bus distribution system. Propulsion power is provided by two electric AC Synchronous, 11.2 MW drive motors, fed from the common bus through a Cycloconverter system, that turn two fixed-pitch, four-bladed propellers. The *Healy* will also serve as the platform from which vessel-based Protected Species Observers (PSOs) will watch for marine mammals before and during airgun operations. Other details of the *Healy* can be found in Appendix A of the IHA application.

NMFS believes that the realistic possibility of a ship-strike of a marine mammal by the vessel during research operations and in-transit during the proposed survey is discountable. The probability of a ship strike resulting in an injury or mortality of an animal has been associated with ship speed; however, it is highly unlikely that the proposed seismic survey would increase the rate of serious injury or mortality given the *St. Laurent* and *Healy*'s slow survey speed.

Acoustic Source Specifications—Seismic Airguns and Radii

The seismic source for the proposed seismic survey will be comprised of three Sercel G-airguns with a total volume of 1,150 in^3. The three-airgun array will be comprised of two 500 in^3 and one 150 in^3 G-airguns in a triangular configuration (*see* Figure B–1 in the IHA application). The single 150 in^3 G-airgun will be used if a power-down is necessary for mitigation. The G-airgun array will be towed behind the *St. Laurent* at a depth of approximately 11 m (36.1 ft) (*see* Figure B–2 in the IHA application) along predetermined lines in water depths ranging from 1,900 to 4,000 m (6,233.6 to 13,123.4 ft). One streamer approximately 232 m (761.2 ft) in length with a single hydrophone will be towed behind the airgun array at a depth of approximately 9 to 30 m (29.5 to 98.4 ft).

A square wave trigger signal will be supplied to the firing system hardware by a FEI–Zyfer GPStarplus Clock model 565, based on GPS time (typically at approximately 14 to 20 sec intervals). Vessel speed will be approximately 10.2 km/hour (5.5 knots) resulting in a shot interval ranging from approximately 39 to 56 m (128 to 183.7 ft). G-airgun firing and synchronization will be controlled by a RealTime Systems LongShot fire controller, which will send a voltage to the airgun solenoid to trigger firing with approximately 54.8 ms delay between trigger and fire point.

Pressurized air for the pneumatic G-airguns will be supplied by two Hurricane compressors, model 6T–276–44SB/2500. These are air cooled, containerized compressor systems. Each compressor will be powered by a C13 Caterpillar engine which turns a rotary screw first stage compressor and a three stage piston compressor capable of developing a total air volume of 600 SCFM @ 2,500 pounds per square inch (PSI). The seismic system will be operated at 1,950 PSI and one compressor could easily supply sufficient volume of air under appropriate pressure.

Seismic acquisition will require a watchkeeper in the seismic lab and another in the compressor container. The seismic lab watchkeeper is responsible for data acquisition/recording, watching over-the-side equipment, airgun firing and log keeping. A remote screen will permit monitoring of compressor pressures and alerts, as well as communication with the compressor watchkeeper. The compressor watchkeeper will be required to monitor the compressor for any emergency shut-down and provide general maintenance that might be required during operations.

Sound level radii for the proposed three airgun array were measured in 2009 during a seismic calibration (Mosher *et al.,* 2009; Roth and Schmidt, 2010). A transmission loss model was then constructed assuming spherical (20LogR) spreading and using the source level estimate 235 dB re 1 μPa (rms) 0-peak; 225 dB re 1 μPa (rms) from the measurements. The use of 20LogR spreading fit the data well out to approximately 1 km (0.6 mi) where variability in measured values increased (*see* Appendix B in the IHA application for more details and a figure of the transmission loss model compared to the measurement data). Additionally, the Gundalf modeling package was used to model the airgun array and estimated a source level output of 236.7 dB 0-peak (226.7 dB [rms]). Using this slightly stronger source level estimate and a 20LogR spreading the 180 and 190 dB (rms) radii are estimated to be 216 m (708.7 ft) and 68 m (223.1 ft), respectively. As a conservation measure for the proposed safety radii, the sound level radii indicated by the empirical data and source models have been increased to 500 m (1,640.4 ft) for the 180 dB isopleths and to 100 m (328 ft) of the 190 dB isopleths.

The rms received levels that are used as impact criteria for marine mammals are not directly comparable to the peak or peak-to-peak values normally used to characterize source levels of airguns. The measurement units used above to describe the airgun source, peak or peak-to-peak dB, are always higher than the rms dB referred to in much of the biological literature. A measured received level of 160 dB (rms) in the far field would typically correspond to a peak measurement of about 170 to 172 dB, at the same location (Greene, 1997;

McCauley *et al.,* 1998, 2000). 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 for an airgun-type source.

TABLE 2—DISTANCES TO WHICH SOUND LEVELS GREATER THAN OR EQUAL TO 190, 180, AND 160 dB RE 1 μPA (RMS) COULD BE RECEIVED IN DEEP (GREATER THAN 1,000 m) WATER DURING THE PROPOSED SURVEY IN THE ARCTIC OCEAN, AUGUST 7 TO SEPTEMBER 3, 2010

Source and volume	Tow depth (m) Ice/open water	Water depth	*Predicted received RMS distances (m)*		
			190 dB	180 dB	160 dB
Single Mitigation Airgun (150 in³)	11/6–7	Deep (>1,000 m)	30	75	750
3 G-airguns (1,190 in³)	11/6–7	Deep (>1,000 m)	100	500	2,500

Acoustic Source Specifications—Multibeam Echosounders (MBES), Sub-Bottom Profiler (SBP) and Acoustic Doppler Current Profilers (ADCP)

Along with the airgun operations, additional acoustic systems that will be operated during the cruise include a 12 kHz Chirp echosounder and a 3–5 kHz SBP from the *St. Laurent.* The Healy will operate a 12 kHz Kongsberg MBES, a Knudsen 320BR profiler, a piloting echosounder, and two ADCPs. These sources will be operated throughout most of the cruise to map bathymetry, as necessary, to meet the geophysical science objectives. During seismic operations, these sources will be deployed from the *St. Laurent* and the *Healy* and will generally operate simultaneously with the airgun array deployed from the *St. Laurent.*

The Knudsen 320BR echosounder will provide information on depth and bottom profile. The Knudsen 320BR is a dual-frequency system with operating frequencies of 3.5 and 12 kHz, however, the unit will be functioning at the higher frequency, 12 kHz, because the 3.5 kHz transducer is not installed.

While the Knudsen 320BR operates at 12 kHz, its calculated maximum source level (downward) is 215 dB re μPa at 1 m. The pulse duration is typically 1.5 to 5 ms with a bandwidth of 3 kHz (FM sweep from 3 kHz to 6 kHz). The repetition rate is range dependent, but the maximum is a one percent duty cycle. Typical repetition rate is between ½ s (in shallow water) to 8 s in deep water. A single 12 kHz transducer (sub-bottom) array, consisting of 16 elements in a 4x4 array will be used for the Knudsen 320BR. The 12 kHz transducer (TC–12/34) emits a conical beam with a width of 30°.

The 3–5 kHz chirp SBP will be towed by and operated from the *St. Laurent* in open water when the *St. Laurent* is not working in tandem with the *Healy.* The SBP provides information about sedimentary features and bottom topography. The chirp system has a maximum 7.2 kW transmit capacity into the towed array. The energy from the towed unit is directed downward by an array of eight transducers in a conical beamwidth of 80 degrees. The interval between pulses will be no less than one pulse per second. SBPs of that frequency can produce sound levels 200 to 230 dB re 1 μPa at 1 m (Richardson *et al.,* 1995).

The Kongsberg EM 122 MBES operates at 10.5 to 13 (usually 12) kHz and is hull-mounted on the *Healy.* The transmitting beamwidth is 1° or 2° fore-aft and 150° athwartship. The maximum source level is 242 dB re 1 μPam (rms). Each "ping" consists of eight (in water greater than 1,000 m deep) or four (less than 1,000 m) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore-aft. Continuous-wave (CW) pulses increase from two to 15 ms long in water depths up to 2,600 m (8,530 ft), and FM chirp pulses up to 100 ms long are used in water greater than 2,600 m (8,530 ft). The successive transmissions span an overall cross-track angular extent of about 150°, with 2 ms gaps between pulses for successive sectors.

The Knudsen 320BR hydrographic SBP will provide information on sedimentary layering, down to between 20 and 70 m (65.6 to 229.7 ft), depending on bottom type and slope. The Knudsen 320 BR is a dual-frequency system with operating frequencies of 3.5 and 12 kHz; only the low frequency will be used during this survey. At 3.5 kHz, the maximum output power into the transducer array, as wired on the *Healy* (where the array impedance is approximately 125 ohms), is approximately 6,000 watts (electrical), which results in a maximum source level of 221 dB re 1 μPa at 1 m downward. Pulse lengths range from 1.5 to 24 ms with a bandwidth of 3 kHz (FM sweep from 3 kHz to 6 kHz). The repetition rate is range dependent, but the maximum is a one percent duty cycle. Typical repetition rate is between ½ s (in shallow water) to 8 s in deep water. The 3.5 kHz transducer array on the *Healy,* consisting of 16 (TR109) elements in a 4x4 array, will be used for the Knudsen 320BR. At 3.5 kHz the SBP emits a downward conical beam with a width of approximately 26°.

The piloting echosounder on the *Healy* is an Ocean Data Equipment Corporation (ODEC) Bathy-1500 that will provide information on water depth below the vessel. The ODEC system has a maximum 2 kW transmit capacity into the transducer and has two operating modes, single or interleaved dual frequency, with available frequencies of 12, 24, 33, 40, 100, and 200 kHz.

The 150 kHz ADCP has a minimum ping rate of 0.65 ms. There are four beam sectors and each beamwidth is 3°. The pointing angle for each beam is 30° off from vertical with one each to port, starboard, forward, and aft. The four beams do not overlap. The 150 kHz ADCP's maximum depth range is 300 m (984.3 ft).

The Ocean Surveyor 75 is an ADCP operating at a frequency of 75 kHz, producing a ping every 1.4 s. The system is a four-beam phased array with a beam angle of 30°. Each beam has a width of 4° and there is no overlap. Maximum output power is 1 kW with a maximum depth range of 700 m (2,296.6 ft).

Acoustic Source Specifications—Icebreaking

Icebreaking is considered by NMFS to be a continuous sound and NMFS estimates that harassment occurs when marine mammals are exposed to continuous sounds at a received sound level of 120 dB SPL or above. Potential takes of marine mammals may ensue from icebreaking activity in which the *Healy* is expected to engage outside of U.S. waters, *i.e.,* north of approximately 74.1° North. While breaking ice, the noise from the ship, including impact with ice, engine noise, and propeller cavitation, will exceed 120 dB continuously. If icebreaking does occur in U.S. waters, USGS expects it will occur during seismic operations. The exclusion zone (EZ) for the marine mammal Level B harassment threshold during the proposed seismic activities is greater than the calculated radius during icebreaking. Therefore, if the *Healy* breaks ice during seismic operations within the U.S. waters, the greater radius, *i.e,* that for seismic operations, supersedes that for icebreaking, so no additional takes have been estimated within U.S. waters.

Proposed Dates, Duration, and Specific Geographic Area

The proposed seismic survey will be conducted for approximately 30 days from approximately August 7 to September 3, 2010. The approximately 806 km (501 mi) of tracklines within U.S. waters will be surveyed first. These survey lines are expected to be completed by approximately August 12, 2010. The seismic vessel *St. Laurent* will depart from Kugluktuk, Nunavut, Canada on August 2, 2010 and return to the same port on approximately September 16, 2010. The *Healy* will depart from Dutch Harbor, Alaska on August 3, 2010 to meet the *St. Laurent* by August 7, 2010. After completion of this survey, the *Healy* will change crew through Barrow via helicopter or surface vessel on September 4, 2010 (*see* Table 3 of the IHA application). The entire survey area will be bounded approximately by 145° to 158° West longitude and 71° to 84° North latitude in water depths ranging from approximately 1,900 to 4,000 m (6,234 to 13,123 ft) (*see* Figure 1 and Table 1 of the IHA application). Ice conditions are expected to range from open water to 10/10 ice cover. See Table 3 of the IHA application for a synopsis of the 2010 *St. Laurent* and *Healy* Extended Continental Shelf expeditions in the Arctic Ocean, August 3 to September 16, 2010.

Icebreaking outside U.S. waters will occur between the latitudes of approximately 74° to 84° North. Vessel operations and ice conditions from similar survey activities and timing in 2008 and 2009 were used to estimate the amount of icebreaking (in trackline km) that is likely to occur in 2010. USGS expects that the *St. Laurent* and the *Healy* will be working in tandem through the ice for a maximum of 23 to 25 days while outside of U.S. waters. The average distance travelled in 2008 and 2009 when the *Healy* broke ice for the *St. Laurent* was 135 km/day (83.9 mi/day). Based on the 23 to 25 day period of icebreaking, USGS calculated that, at most approximately 3,102 to 3,372 km (1,927.5 to 2,095.3 mi) of vessel trackline may involve icebreaking. This calculation is likely an overestimation because icebreakers often follow leads when they are available and thus do not break ice at all times.

TABLE 3—PROJECTED 2010 ICEBREAKING EFFORT FOR USGS/GSC 2010 EXTENDED CONTINENTAL SHELF SURVEY IN THE NORTHERN BEAUFORT SEA AND ARCTIC OCEAN

2008	19	2,469	130
2009	27	37,744	140
Average 2008 to 2009	23	3,122	135
Projected 2010	23 to 25	3,102 to 3,372	—

Description of Marine Mammals in the Proposed Activity Area

Regarding marine mammals, a total of nine cetacean species, including four odontocete (dolphins, porpoises, and small- and large-toothed whales) species, five mysticete species (baleen whales), and five pinniped species (seals, sea lions, and walrus) and the polar bear are known to occur in the area affected by the specified activities associated with the proposed Arctic Ocean marine seismic survey (*see* Table 3 of USGS's application). Cetaceans and pinnipeds, which are the subject of this IHA application, are protected by the MMPA and managed by NMFS in accordance with its requirements. In the U.S., the walrus and polar bear are managed under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) and are not considered further in this analysis. Information on the occurrence, distribution, population size, and conservation status for each of the 14 marine mammal species that may occur in the proposed project area is presented in Table 4 of USGS's application as well as here in the table below (Table 4). Several marine mammal species that may be affected by the proposed IHA are listed as Endangered or Threatened under Section 4 of the ESA, including the bowhead, fin and humpback whale, and polar bear. The bowhead whale is common in the Arctic, but unlikely in the survey area. Based on a small number of sightings in the Chukchi Sea, the fin whale is unlikely to be encountered along the planned trackline in the Arctic Ocean. Humpback whales are uncommon in the Chukchi Sea and normally do not occur in the Beaufort Sea. Several humpback sightings were recorded during vessel-based surveys in the Chukchi Sea in 2007 (three sightings) and 2008 (one sighting; Haley *et al.,* 2009). The only known occurrence of humpback whale in the Beaufort Sea was a single sighting of a cow and calf reported and photographed in 2007 (Green *et al.,* 2007). Based on the low number of sightings in the Chukchi and Beaufort seas, humpback whales would be unlikely to occur in the vicinity of the proposed geophysical activities.

The marine mammal species under NMFS jurisdiction most likely to occur in the seismic survey area include two cetacean species (beluga and bowhead whales), and two pinniped species (ringed and bearded seals). These species however, will likely occur in low numbers and most sightings will likely occur in locations within 100 km (62 mi) of shore where no seismic work is planned. The marine mammal most likely to be encountered throughout the cruise is the ringed seal.

Seven additional cetacean species—narwhal, killer whale, harbor porpoise, gray whale, minke whale, fin whale, and humpback whale—could occur in the project area. Gray whales occur regularly in continental shelf waters along the Chukchi Sea coast in summer and to a lesser extent along the Beaufort Sea coast. Recent evidence from monitoring activities in the Chukchi and Beaufort seas during industry seismic surveys suggests that harbor porpoise and minke whales, which have been considered uncommon or rare in the Chukchi and Beaufort seas, may be increasing in numbers in these areas (Funk *et al.,* 2009). Small numbers of killer whales have also been recorded during these industry surveys, along with a few sightings of fin and humpback whales. The narwhal occurs in Canadian waters and occasionally in the Beaufort Sea, but is rare there and not expected to be encountered. Each of these species is uncommon or rare in the Chukchi and Beaufort seas, and relatively few if any encounters with these species are expected during the seismic program.

Additional pinniped species that could be encountered during the proposed seismic survey include spotted and ribbon seals, and Pacific walrus. Spotted seals are more abundant in the Chukchi Sea and occur in small numbers in the Beaufort Sea. The ribbon seal is uncommon in the Chukchi Sea and there are few sightings in the Beaufort Sea. The Pacific walrus is common in the Chukchi Sea, but uncommon in the Beaufort Sea and not likely to occur in the deep waters of the proposed survey area. None of these species would likely be encountered during the proposed cruise other than perhaps transit periods to and from the survey area.

Table 4 below outlines the marine mammal species, their habitat and abundance in the proposed project area, their conservation status, and density. Additional information regarding the distribution of these species expected to be found in the proposed project area and how the estimated densities were calculated may be found in USGS's application.

TABLE 4—THE HABITAT, REGIONAL ABUNDANCE, CONSERVATION STATUS, AND BEST AND MAXIMUM DENSITY ESTIMATES OF MARINE MAMMALS THAT COULD OCCUR IN OR NEAR THE PROPOSED SEISMIC SURVEY AREA IN THE ARCTIC OCEAN. SEE TABLE 4 IN USGS'S APPLICATION FOR FURTHER DETAIL

Species	Habitat	Abundance/regional population size[a]	ESA[a]	Best[b] Density (#/km^2) open water, ice margin, polar pack	Max[c] Density (#/km^2) open water, ice margin, polar pack
Odontocetes:					
Beluga whale (*Delphinapterus leucas*).	Offshore, coastal, ice edges	3,710[d], 39,257[e]	NL	0.0354 0.0354 0.0035	0.0709 0.0709 0.0071
Narwhal (*Monodon monocerus*).	Offshore, ice edge	Rare[f]	NL	0.0000 0.0000 0.0000	0.0001 0.0002 0.0001
Killer whale (*Orcinus orca*)	Widely distributed	Rare	NL	0.0000 0.0000 0.0000	0.0001 0.0001 0.0001
Harbor porpoise (*Phocoena phocoena*).	Coastal, inland waters, shallow offshore waters.	Common (Chukchi), Uncommon (Beaufort).	NL	0.0000 0.0000 0.0001	0.0001 0.0001 0.0001
Mysticetes:					
Bowhead whale (*Balaena mysticetus*).	Pack ice and coastal	10,545[g]	EN	0.0061 0.0061 0.0006	0.0122 0.0122 0.0012
Eastern Pacific gray whale (*Eschrichtius robustus*).	Coastal, lagoons	488[h], 17,500[i]	NL	0.0000 0.0000 0.0000	0.0001 0.0001 0.0001
Minke whale (*Balaenoptera acutorostrata*).	Shelf, coastal	Small numbers	NL	0.0000 0.0000 0.0000	0.0001 0.0001 0.0001
Fin whale (*Balaenoptera physalus*).	Slope, mostly pelagic	Rare (Chukchi)	E	0.0000 0.0000 0.0000	0.0001 0.0001 0.0001
Humpback whale (*Megaptera novaeangliae*).	Shelf, coastal	Rare	EN	0.0000 0.0000 0.0000	0.0001 0.0001 0.0001
Pinnipeds:					
Bearded seal (*Erignathus barbatus*).	Pack ice, open water	300,000–450,000[j]	C	0.0096 0.0128 0.0013	0.0384 0.0512 0.0051
Spotted seal (*Phoca largha*).	Pack ice, open water, coastal haul-outs.	59,214[k]	P–T	0.0001 0.0001 0.0000	0.0004 0.0004 0.0000
Ringed seal (*Pusa hispida*)	Landfast and pack ice, open water.	18,000[l], 208,000–252,000[m]	C	0.1883 0.2510 0.0251	0.7530 1.0040 0.1004
Ribbon seal (*Histriophoca fasciata*).	Pack ice, open water	90,000–100,000[n]	NL	N.A.	N.A.
Pacific walrus (*Odobenus rosmarus divergens*).	Ice, coastal	N.A.	NL	N.A.	N.A.
Carnivores:					
Polar bear (*Ursus maritimus marinus*).	Ice, coastal	N.A.	T	N.A.	N.A.

N.A.—Data not available or species status was not assessed,

[a] U.S. Endangered Species Act: EN = Endangered, T = Threatened, C = Candidate, P = Proposed, NL = Not listed.

[b] Best estimate as listed in Table 5 and Add-3 of the application.

[c] Maximum estimate as listed in Table 5 and Add-3 of the application.

[d] Eastern Chukchi Sea stock based on 1989 to 1991 surveys with a correction factor (Angliss and Allen, 2009).

[e] Beaufort Sea stock based on surveys in 1992 (Angliss and Allen, 2009).

[f] DFO (2004) states the population in Baffin Bay and the Canadian Arctic archipelago is approximately 60,000; very few of these enter the Beaufort Sea.

[g] Abundance of bowhead whales surveyed near Barrow, as of 2001 (George *et al.,* 2004). Revised to 10,545 by Zeh and Punt (2005).
[h] Southern Chukchi Sea and northern Bering Sea (Clarks and Moore, 2002).
[i] Eastern North Pacific gray whale population (Rugh *et al.,* 2008).
[j] Based on earlier estimates, no current population estimate available (Angliss and Allen, 2009).
[k] Alaska stock based on aerial surveys in 1992 (Angliss and Allen, 2009).
[l] Beaufort Sea minimum estimate with no correction factor based on aerial surveys in 1996 to 1999 (Frost *et al.,* 2002 in Angliss and Allen, 2009).
[m] Eastern Chukchi Sea population (Bengston *et al.,* 2005).
[n] Bering Sea population (Burns, 1981a in Angliss and Allen, 2009).

Within the latitudes of the proposed survey when the *Healy* will be breaking ice outside of U.S. waters, no cetaceans were observed by PSOs along approximately 21,322 km (13,248.9 mi) of effort during projects in 2005, 2006, 2008, and 2009 (Haley and Ireland, 2006; Haley, 2006; Jackson and DesRoches, 2008; Mosher *et al.,* 2009). The estimated maximum amount of icebreaking outside of U.S. waters for this project, *i.e.,* 3,372 line km (2,095.3 mi), is considerably less than the combined trackline for the aforementioned projects. At least one PSO will stand watch at all times while the *Healy* is breaking ice for the *St. Laurent.* USGS does not expect that PSOs will observe any cetaceans during the proposed survey. Seals were reported by PSOs during the 2005, 2006, 2008, and 2009 effort within the latitudes of the proposed survey.

TABLE 5—NUMBER OF PINNIPEDS REPORTED DURING 2005, 2006, 2008, AND 2009 PROJECTS WITHIN THE LATITUDES WHERE THE HEALY WILL BE BREAKING ICE OUTSIDE OF U.S. WATERS FOR THE PROPOSED ARCTIC OCEAN SURVEY (HALEY AND IRELAND, 2006; HALEY, 2006, GSC UNPUBLISHED DATA, 2008; MOSHER *et al.,* 2009)

Pinniped species	Number of sightings	Number of individuals
Ringed seal	116	125
Bearded seal	24	26
Unidentified seal	128	140
Totals	268	291

Potential Effects on Marine Mammals

Potential Effects of Airgun Sounds

The effects of sounds from airguns might result in one or more of the following: Tolerance, masking of natural sounds, behavioral disturbances, 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. NMFS concurs with this determination.

The root mean square (rms) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak or peak-to-peak values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received level of 160 dB (rms) in the far field would typically correspond to a peak measurement of approximately 170 to 172 dB, and to a peak-to-peak measurement of approximately 176 to 178 dB, as measured for the same pulse received at the same location (Greene, 1997; McCauley *et al.,* 1998, 2000a). The precise difference between rms and peak or peak-to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

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 D (3) of the IHA application. Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response—see Appendix D (5) of the IHA application. 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 the 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 relative responsiveness of baleen and toothed whales being variable.

Masking

Obscuring of sounds of interest by interfering sounds, generally at similar frequencies, is known as 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 few specific data of relevance. 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 (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. The airgun sounds are pulsed, with quiet periods between the pulses, and whale calls often can be heard between the seismic pulses (Richardson *et al.,* 1986; McDonald *et al.,* 1995; Greene *et al.,* 1999; Nieukirk *et al.,* 2004; Smultea *et al.,* 2004; Holst *et al.,* 2005a,b, 2006; Dunn *et al.,* 2009). In the northeast Pacific Ocean, blue whale calls have been recorded during a seismic survey off Oregon (McDonald *et al.,* 1995). 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 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). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced in the presence of airgun pulses (Richardson *et al.,* 1986; Greene *et al.,* 1999; Blackwell *et al.,* 2008). Dolphins and porpoises commonly are heard calling while airguns are operating (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 the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor (in the case of smaller odontocetes), given the normally intermittent nature of seismic pulses. Masking effects on marine mammals are discussed further in Appendix D (4) of the IHA application.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. 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 to an underwater sound by changing its behavior or moving a small distance, the response may or may not rise to the level of "harassment" to the individual, or affect the stock or the species population as a whole. 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 are likely to be present within a particular distance of industrial activities, and/or exposed to a particular level of industrial sound. In most cases, this practice potentially overestimates the numbers of marine mammals that would be affected in some biologically-important manner.

The sound exposure 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 during studies of several species. However, information is lacking for many species. Detailed studies have been done on humpback, gray, bowhead, and on ringed seals. Less detailed data are available for some other species of baleen whales, sperm 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 D (5) of the USGS IHA application, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding activities and moving away from the sound source. In the case of the 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 demonstrated that seismic pulses with received levels of 160 to 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 (2.8 to 9 mi) 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 D (5) of the USGS IHA application have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160 to 170 dB re 1 μPa (rms).

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 to 30 km (12.4 to 18.6 mi) from a medium-sized airgun source at received sound levels of around 120 to 130 dB re 1 μPa (rms) (Miller *et al.,* 1999; Richardson *et al.,* 1999; see Appendix D (5) of the IHA application). However, more recent research on bowhead whales (Miller *et al.,* 2005a; Harris *et al.,* 2007; Lyons *et al.,* 2009; Christi *et al.,* 2009) 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 statistical analysis (Richardson *et al.,* 1986). In summer, bowheads typically begin to show avoidance reactions at a received level of about 152 to 178 dB re 1 μPa (rms) (Richardson *et al.,* 1986, 1995; Ljungblad *et al.,* 1988; Miller *et al.,* 2005a). The USGS project will be conducted during fall migration at locations greater than 200 nmi offshore, well north of the known bowhead migration corridor. Recent evidence suggests that some bowheads feed during migration and feeding bowheads might be encountered in the central Alaska Beaufort Sea during transit periods to and from Barrow (Lyons *et al.,* 2009; Christi *et al.,* 2009). The primary bowhead summer feeding grounds however, are far to the east in the Canadian Beaufort Sea.

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. Malme *et al.* (1986, 1988) estimated, based on small sample sizes, that 50 percent of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10 percent 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 with observations of Western Pacific gray whales feeding off Sakhalin Island, Russia, when a seismic survey was underway just offshore of their feeding area (Wursig *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, Bryde's, and minke whales) have occasionally been reported 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 *et al.,* 2009). 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 and not shooting (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). In a study off of Nova Scotia, Moulton and Miller (2005) found little difference in sighting rates (after accounting for water depth) and initial sighting distances of balaenopterid whales when airguns were operating vs. silent. However, there were indications that these whales were more likely to be moving away when seen during airgun operations. Similarly, ship-based monitoring studies of blue, fin, sei, and minke whales offshore of Newfoundland (Orphan Basin and Laurentian Sub-basin) found no more than small differences in sighting rates and swim direction during seismic vs. non-seismic periods (Moulton *et al.,* 2005, 2006a,b).

Data on short-term reactions (or lack of reactions) of 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 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 (*see* Appendix A in Malme *et al.,* 1984; Richardson *et al.,* 1995; Angliss and Outlaw, 2008). The Western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a prior 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; Angliss and Outlaw, 2008). Populations of both gray whales and bowhead whales grew substantially during this time. In any event, the brief exposures to sound pulses from the proposed airgun source are highly unlikely to result in prolonged effects.

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 D of the IHA application have been reported for toothed whales. However, recent systematic studies on sperm whales have been done (Gordon *et al.*, 2006; Madsen *et al.*, 2006; Winsor and Mate, 2006; Jochens *et al.*, 2008; Miller *et al.*, 2009). There is 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).

Seismic operators and observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of operating seismic vessels with large airgun arrays (Goold, 1996a,b,c; Calambokidis and Osmek, 1998; Stone, 2003; Moulton and Miller, 2005; Holst *et al.*, 2006; Stone and Tasker, 2006; Weir, 2008; Richardson *et al.*, 2009; Barkaszi *et al.*, 2009). However, 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 airgun arrays are firing (Moulton and Miller, 2005). Nonetheless, there have been indications that 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 (Goold, 1996a,b,c; Calambokidis and Osmek, 1998; Stone, 2003; Stone and Tasker, 2006; Weir, 2008). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km (0.62 mi) or 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 during seismic operations in the southeastern Beaufort Sea during summer found that sighting rates of beluga whales were significantly lower at distances 10 to 20 km (6.2 to 12.4 mi) compared with 20 to 30 km (12.4 to 18.6 mi) 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; Finneran and Schlundt, 2004). However, the animals tolerated high received levels of sound (pk-pk level greater than 200 dB re 1 μPa) before exhibiting aversive behaviors. With the presently-planned source, such levels would be limited to distances less than 200 m (656.2 ft) of the three airgun array. The reactions of belugas to the USGS survey are likely to be more similar to those of free-ranging belugas exposed to airgun sound (Miller *et al.*, 2005) than to those of captive belugas exposed to a different type of strong transient sound (Finneran *et al.*, 2000, 2002).

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; 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 operations 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 in general (Richardson *et al.*, 1995; Southall *et al.*, 2007).

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 C of the IHA application).

Pinnipeds—Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources that will be used. 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 D (5) of the IHA application. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris *et al.*, 2001; Moulton and Lawson, 2002; Miller *et al.*, 2005). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinnipeds reactions to airguns (Thompson *et al.*, 1998). Even if reactions of the species occurring in the present study area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds, but there has been no specific documentation of this for marine mammals exposed to sequences of airgun pulses.

NMFS is presently developing new noise exposure criteria for marine mammals that take account of the now-available scientific data on temporary threshold shift (TTS), the expected offset between the TTS and permanent threshold shift (PTS) thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. Detailed recommendations for new science-based noise exposure criteria were published in late 2007 (Southall *et al.*, 2007).

Several aspects of the planned monitoring and mitigation measures for this project (*see* below) are designed to detect marine mammals occurring near the airguns to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to 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 pulsed 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 and beaked whales do not occur in the proposed study area. It is especially 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 proposed 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).

For toothed whales exposed to single short pulses, the TTS threshold appears to be, to a first approximation, a function of the energy content of the pulse (Finneran *et al.*, 2002, 2005). Given the available data, the received level of a single seismic pulse might need to be approximately 210 dB re 1 μPa (rms) (approximately 221 to 226 dB pk-pk) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200 to 205 dB (rms) might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. Seismic pulses with received levels of 200 to 205 dB or more are usually restricted to a radius of no more than 200 m (656.2 ft) around a seismic vessel operating a large array of airguns.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound required to induce TTS. The frequencies to which baleen whales are most sensitive are lower than those to which odontocetes are more 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). However, no cases of TTS are expected given the moderate size of the source and the strong likelihood that baleen whales (especially migrating bowheads) would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak *et al.*, 1999, 2005; Ketten *et al.*, 2001; Au *et al.*, 2000). For harbor seal, which is closely related to the ringed seal, TTS onset apparently occurs at somewhat lower received energy levels than for odontocetes (*see* Appendix D of the IHA application).

A marine mammal within a radius of less than or equal to 100 m (328 ft) around a typical large array of operating airguns might be exposed to a few seismic pulses with levels of greater than 205 dB (rms), and possibly more pulses if the mammal moved with the seismic vessel. The received sound levels will be reduced for the proposed three airgun array to be used during the current survey compared to the larger arrays thus reducing the potential for TTS for the proposed survey. (As noted above, most cetacean species trend to avoid operating airguns, although not all individuals do so.) However, several of the considerations that are relevant in assessing the impact of typical seismic surveys with arrays of airguns are not directly applicable here:

- "Ramping-up" (soft-start) is standard operational protocol during start-up of large airgun arrays. Ramping-up involves starting the airguns in sequence, usually commencing with a single airgun and gradually adding additional airguns.
- It is unlikely that cetaceans would be exposed to airgun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS, given the relative movement of the vessel and the marine mammal. For the proposed project, the seismic survey will be in deep water where the radius of influence and duration of exposure to strong pulses is smaller compared to shallow locations.
- With a large array of airguns, TTS would be most likely in any odontocetes that bow-ride or in any odontocetes or pinnipeds that linger near the airguns. For the proposed survey, the anticipated 180 dB and 190 dB (re 1 μPa 1m rms) exclusion zone in deep water are expected to extend 483 m (1,584.7 ft) and 153m (502 ft), respectively, from the airgun array which could result in effects to bow-riding species. However, no species that occur within the project area are expected to bow-ride.

- There is a possibility that a small number of seals (which often show little or no avoidance of approaching seismic vessels) could occur close to the airguns and that they might incur slight TTS if no mitigation action (shut-down) were taken.

To avoid the potential for injury, NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding 180 and 190 dB re 1 μPa (rms), respectively. All airgun activity will occur in water depths ranging from approximately 2,000 to 4,000 m (6,561.7 to 13,123.4 ft). Sound level radii of the proposed three airgun array were measured in 2009 during a seismic calibration experiment (Mosher *et al.*, 2009; Roth and Schmidt, 2010). A transmission loss model was then constructed assuming spherical (20LogR) spreading and using the source level estimate (235 dB re 1 μPa 0-peak; 225 dB re 1 μPa rms) from the measurements. The use of 20LogR spreading fit the data well out to approximately one km (0.6 mi) where variability in measures values increased (*see* Appendix B of the IHA application for more details and a figure of the transmission loss model compared to the measurement data). Additionally, the Gundalf modeling package was used to model the airgun array and estimated a source level output of 236.7 dB 0-peak (226.7 dB rms). Using this slightly stronger source level estimate and 20LogR spreading the 180 and 190 dB rms radii are estimated to be 216 m (708.7 ft) and 68 m (223.1 ft), respectively. As a conservative measure for the proposed EZ, the sound-level radii indicated by the empirical data and source models have been increased to 500 m (1,640.4 ft) for the 180 dB (rms) isopleths and to 100 m (328 ft) for the 190 dB isopleth (*see* Table 2 of the IHA application). These distances will be used as power-down/shut-down criteria described in the Proposed Mitigation and Proposed Monitoring and Reporting sections below. Furthermore, established 180 and 190 dB (rms) criteria are not considered to be the level above which TTS might occur. Rather, they are 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 cetaceans. 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 180 or 190 dB re 1 μPa (rms). Since no bow-riding species occur in the study area, it is unlikely such exposures will occur.

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 (Richardson *et al.,* 1995; 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 D (6) of the IHA application). 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 greater than 6 dB (Southall *et al.,* 2007). On an SEL basis, Southall *et al.* (2007) 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 approximately 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.

Southall *et al.* (2007) also note that, regardless of the SEL, there is concern about the possibility of PTS if a cetacean or pinniped receives 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 greater than or equal to 198 dB re 1 $\mu Pa^2 \cdot s$ or peak pressure greater than or equal to 230 dB re 1 μPa. Corresponding proposed dual criteria for pinnipeds (at least harbor seals) are greater than or equal to 186 dB SEL and greater than or equal to 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), which would only be found within a few meters of the largest (360 in ^{3}) airguns in the planned airgun array (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 could 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, power-downs, and shut-downs of the airguns when mammals are seen within or approaching the EZs will further reduce the probability of exposure of marine mammals to sounds strong enough to induce PTS.

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. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for sufficiently long that significant physiological stress would develop. That is especially so in the case of the proposed project where the airgun configuration focuses most energy downward, the ship will typically be moving at four to five knots, and for the most part, the tracklines will not "double back" through the same area. 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. Beaked whales do not occur in the proposed survey area.

In general, 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 and some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur non-auditory physical effects. Also, the planned monitoring and mitigation measures, including shut-down of the airguns, will reduce any such effects that might otherwise occur.

Strandings and Mortality—Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and their 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 proof that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass 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 (Hildebrand, 2005; Southall *et al.,* 2007). Appendix D(6) of the USGS IHA application 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 vetibular 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. 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. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonars operate at frequencies of 2 to 10 kHz, generally with a relatively narrow bandwidth at any one time. 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 pulses can, in special circumstances, lead (at least indirectly) to physical damage and mortality (Balcomb and Claridge, 2001; NOAA and USN, 2001; Jepson *et al.,* 2003; Fernández *et al.,* 2004, 2005a; 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) was not well founded based on available data (IAGC, 2004; IWC, 2007b). 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* (*Ewing*) was operating a 20 airgun, 8,490 in^3 array in the general area. The link between the stranding and the seismic survey 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 when conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand, 2005). However, no beaked whales are found within this project area and the planned monitoring and mitigation measures are expected to minimize any possibility for mortality of other species.

Potential Effects of Chirp Echosounder Signals

A Knudsen 320BR Plus echosounder will be operated from the source vessel at nearly all times during the planned study. Details about the equipment are provided in Appendix B of the IHA application. The Knudsen 320BR produces sound pulses with lengths up to 24 ms every 0.5 to approximately 8 s, depending on water depth. The energy in the sound pulses emitted by the Chirp echosounder is of moderately high frequency. The Knudsen can be operated with either a 3.5 kHz transducer, for sub-bottom profiling, or a 12 kHz transducer for sounding. The lower frequency (3.5 kHz) transducer is not installed and will not be used. The conical beamwidth for the 12 kHz transducer is 30°, and is directed downward.

Source levels for the Knudsen 320 operating at 12 kHz has been measured as a maximum of 215 dB re 1 μPam. Received levels would diminish rapidly with increasing depth. Assuming spherical spreading, received level directly below the transducer(s) would diminish to 180 dB re 1 μPa at distances of about 56 m (183.7 ft) when operating at 12 kHz. The 180 dB distance in the horizontal direction (outside the downward-directed beam) would be substantially less. Kremser *et al.* (2005) noted that the probability of a cetacean swimming through the area of exposure when a bottom profiler emits a pulse is small, and if the animal was in the area, it would have to pass the transducer at close range in order to be subjected to sound levels that could cause TTS.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans (1) generally are more powerful than the Knudsen 320BR operating with the 12 kHz transducer,

(2) have longer pulse duration, and (3) are directed close to horizontally vs. downward for the Knudsen 320. The area of possible influence of the Chirp echosounder is much smaller—a narrow conical beam spreading downward from the vessel. Marine mammals that encounter the sounder at close range are unlikely to be subjected to repeated pulses because of the narrow width of the beam, and will receive only small amounts of pulse energy because of the short pulses.

Marine mammal communications will not be masked appreciably by the Chirp echosounder signals given its relatively low duty cycle, directionality, and the brief period when an individual mammal is likely to be within its beam. Belugas can, however, hear sounds ranging from 1.2 to 120 kHz; their peak sensitivity is approximately 10 to 15 kHz, overlapping with the 12 kHz signals (Fay, 1988). Some level of masking could result for beluga whales in close proximity to the survey vessel during brief periods of exposure to the sound. However, masking is unlikely to be an issue for beluga whales because belugas are likely to avoid survey vessels. The 12 kHz frequency signals will not overlap with the predominant low frequencies in baleen whale calls, thus reducing potential for masking in this group.

Marine mammal behavioral reactions to pulsed sound sources from an active airgun array are discussed above, and responses to the echosounder are likely to be similar to those for other pulsed sources if received at the same levels. When the 12 kHz transducer is in operation, the behavioral responses to the Knudsen 320BR are expected to be similar to those reactions to the active airgun array (as discussed above). Because of the lower source level and high directionality, NMFS expects animals to be only infrequently exposed to higher levels of sound and in short durations, and therefore NMFS does not anticipate that exposure to the echosounder will result in a "take" by harassment.

When the 12 kHz transducer is operating, the pulses are brief and concentrated in a downward beam. A marine mammal would be in the beam of the echosounder only briefly, reducing its received sound energy. Thus, it is unlikely that the chirp echosounder produces pulse 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 Knudsen 320 BR will be operated simultaneously with the airgun array. Many marine mammals will move away in response to the approaching higher-power sources of the vessel itself before the mammals would be close enough for there to be any possibility of effects from the Chirp echosounder (*see* Appendix D of the IHA application).

Potential Effects of Other Acoustic Devices—Chirp SBP Signals

A Knudsen 3260 SBP will be operated from the *St. Laurent* in open water when the *St. Laurent* is not working in tandem with the *Healy* during the planned study. The Knudsen's transducer will be towed behind the *St. Laurent.* Details about the equipment are provided in Appendix B of the IHA application. The chirp system has a maximum 7.2 kW transmit capacity into the towed array and generally operated at 3 to 5 kHz. The energy from the towed unit is directed downward by an array of eight transducers in a conical beamwidth of 80°. The interval between pulses will be no less than one pulse per second. SBPs of that frequency can produce sound levels of 200 to 230 dB re 1 μPa at 1 m (Richardson *et al.,* 1995).

Marine mammal communications will not be masked appreciably by the SBP signals given their relatively low duty cycle, directionality of the signal and the brief period when an individual mammal is likely to be within its beam. In the case of the most odontocetes, the 3 to 5 kHz chirp signals do not overlap with the predominant frequencies in their calls, which would avoid significant masking. Beluga whale is the only odontocete anticipated in the area of the proposed survey. Though belugas can hear sounds ranging from 1.2 to 120 kHz, their peak sensitivity is approximately 10 to 15 kHz, not overlapping with the 3 to 5 kHz signals (Fay, 1988). Furthermore, in the case of most baleen whales, the low-energy SBP signals do not overlap with the predominant low frequencies in the calls, which would reduce potential for masking.

Marine mammal behavioral reactions to other pulsed sound sources are discussed above, and responses to the SBP are likely to be similar to those for other pulsed sources if received at the same levels. The pulsed signals from the SBP are somewhat weaker than those from the airgun array. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

The pulses from the chirp profiler are brief and directed downward. A marine mammal would be in the beam of the SBP only briefly, reducing its received sound energy. Thus, it is unlikely that the SBP produces pulse levels strong enough to cause hearing impairment or other physical injuries even if an animal is (briefly) in a position near the surface. It is unlikely that the SBP produces pulse 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 the 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, monitoring and mitigation measures that would be applied to minimize effects of other sources would further reduce or eliminate any minor effects of the SBP.

Potential Effects of Other Acoustic Devices—MBES Signals

The Kongsberg EM 122 MBES will be operated from the *Healy* continuously during the planned study. Sounds from the MBES are very short pulses, depending on water depth. Most of the energy in the sound pulses emitted by the MBES is at frequencies centered at 12 kHz. The beam is narrow (approximately 2°) in fore-aft extent and wide (approximately 130°) in the cross-track extent. Any given mammal at depth near the trackline would be in the main beam for only a fraction of a second. Therefore, marine mammals that encounter sound from the MBES at close range are unlikely to be subjected to repeated pulses because of the narrow fore-aft width of the beam and will receive only limited amounts of pulse energy because of the short pulses. Similarly, Kremser *et al.* (2005) noted that the probability of a cetacean swimming through the area of exposure when an MBES emits a pulse 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 be subjected to sound levels that could cause TTS. In 2008 and 2009 the *St. Laurent* and the *Healy* surveyed together with a cooperative strategy similar to that proposed for 2010. The director of NOAA's Office of Ocean Exploration and Research deemed that the use of the *Healy'*s MBES would not have significant impacts on marine mammals of a direct or cumulative nature. The U.S. portions of the projects were granted a Categorical Exclusion from the need to prepare an EA.

Navy echosounders that have been linked to avoidance reactions and stranding of cetaceans (1) generally are more powerful than the Kongsberg EM122 echosounder, (2) generally have a longer pulse duration than the Kongsberg EM 122, and (3) 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 oriented in the cross-track direction below the source vessel. Marine mammals that encounter the MBES at close range are unlikely to be subjected to repeated pulses because of the narrow fore-aft width of the beam, and will receive only small amounts of pulse energy because of the short pulse. In assessing the possible impacts of a similar MBES system (the 15.5 kHz Atlas Hydrosweep MBES), Boebel *et al.* (2004) noted that the critical sound pressure level at which TTS may occur is 203.2 dB re 1 μPa (rms). The critical region included an area of 43 m (141.1 ft) in depth, 46 m (151 ft) wide athwartship, and 1 m fore-and-aft (Boebel *et al.*, 2004). In the more distant parts of that (small) critical region, only slight TTS would be incurred.

Marine mammal communications will not be masked appreciably by the MBES signals given its low duty cycle of the MBES and the brief period when an individual mammal is likely to be within its beam. Furthermore, the MBES signals (12 kHz) do not overlap with the predominant frequencies in the baleen whale calls, further reducing any potential for masking in that group.

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. Also, Navy personnel have described observations of dolphins bow-riding adjacent to bow-mounted mid-frequency sonars during sonar transmissions. During exposure to a 21 to 25 kHz “whale-finding” sonar with a source level of 215 dB re 1 μPam, gray whales reacted by orienting slightly away from the source and being deflected from their course by approximately 200 m (656 ft) (Frankel, 2005). However, all of those observations are of limited relevance to the present situation. Pulse durations from the Navy sonars were much longer than those of the MBESs to be used during the proposed study, and a given mammal would have received many pulses from the naval sonars. During the USGS operations, the individual pulses will be very short, and a given marine mammal would not receive many of the downward-directed pulses as the vessel passes by.

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 s pulsed signals at frequencies similar to those that will be emitted by the MBES used by USGS, 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 either duration or bandwidth as compared with those from a MBES.

USGS is not aware of any data on the reactions of pinnipeds to echosounder sounds at frequencies similar to those of the MBES (12 kHz). Based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to the MBES, pinniped reactions to the echosounder sounds are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

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 from sonars used for Navy operations. Pulse duration of the bathymetric echosounder is very short relative to the naval sonars. Also, at any given location, an individual cetacean or pinniped 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 bathymetric echosounder relative to that from the sonars used by the Navy.

NMFS believes that the brief exposure of marine mammals to one pulse, or small numbers of signals, from the MBES are not likely to result in the harassment of marine mammals.

Possible Effects of Helicopter Activities

It is anticipated that a helicopter will be deployed daily, weather permitting to conduct ice reconnaissance as well as to periodically transfer personnel between the two vessels. The helicopter will also be used to collect spot bathymetry data during operations in Canadian and international waters, outside of U.S. waters. The spot soundings will be recorded to maximize the area surveyed and the data will be collected off the ship’s survey lines. A 12 kHz transducer will be slung by the helicopter and placed in the water down to a mark affixed to the tether. Data will then be logged to a laptop computer in the helicopter.

Levels and duration of sounds received underwater from a passing helicopter are a function of the type of helicopter used, orientation of the helicopter, the depth of the marine mammal, and water depth. A CCG helicopter, a Messerschmitt MBB BO105, will be providing air support for this project. Helicopter sounds are detectable underwater at greater distances when the receiver is at shallow depths. Generally, sound levels received underwater decrease as the altitude of the helicopter increases (Richardson *et al.*, 1995). Helicopter sounds are audible for much greater distances in air than in water.

Cetaceans—The nature of sounds produced by helicopter activities above the surface of the water do not pose a direct threat to the hearing of marine mammals that are in the water; however minor and short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including the Beaufort Sea (Richardson *et al.*, 1985a,b; Patenaude *et al.*, 2002). Cetacean reactions to helicopters depend on several variables including the animal’s behavioral state, activity, group size, habitat, and the flight patterns used, among other variables (Richardson *et al.*, 1995). During spring migration in the Beaufort Sea, beluga whales reacted to helicopter noise more frequently and at greater distances than did bowhead whales (38 percent vs. 14 percent of observations, respectively). Most reaction occurred when the helicopter passed within 250 m (820.2 ft) lateral distance at altitudes less than or equal to 150 m (492.1 ft). Neither species exhibited noticeable reactions to single passes at altitudes greater than 150 m (492.1 ft). Belugas within 250 m (820.2 ft) of stationary helicopters on the ice with the engine showed the most overt reactions (Patenaude *et al.*, 2002). Whales were observed to make only minor changes in direction in response to sounds produced by helicopters, so all reactions to helicopters were considered brief and minor. Cetacean reactions to helicopter disturbance are difficult to predict and may range from no reaction at all to minor changes in course or (infrequently) leaving the immediate area of the activity.

Pinnipeds—Few systematic studies of pinniped reactions to aircraft overflights have been completed. Documented reactions range from simply becoming alert and raising the head to escape behavior such as hauled-out animals rushing to the water. Ringed seals hauled out on the surface of the ice have shown behavioral responses to aircraft overflights with escape responses most probable at lateral distances greater than 200 m (656.2 ft) and overhead distances less than or equal to 150 m (492.1 ft) (Born *et al.*, 1999). Although specific details of altitude and horizontal distances are lacking from many largely anecdotal reports, escape reactions to a low flying helicopter (less than 150 m [492.1 ft] altitude) can be expected from all four species of pinnipeds potentially encountered during the proposed operations. These responses would likely be relatively minor and brief in nature. Whether any response would occur when a helicopter is at the higher suggested operational altitudes (below) is difficult to predict and probably a function of several other variables including wind chill, relative wind chill, and time of day (Born *et al.*, 1999).

As mentioned in the previous section, momentary behavioral reactions "do not rise to the level of taking" (NMFS, 2001). In order to limit behavioral reactions of marine mammals during ice reconnaissance and spot bathymetry work outside of U.S. waters, the helicopter will maintain a minimum altitude of 200 m (656 ft) above the sea ice except when taking off, landing, or conducting spot bathymetry. Sea-ice landings are not planned at this time.

Possible Effects of Icebreaking Activities

Icebreakers produce more noise while breaking ice than ships of comparable size due, primarily, to the sounds of the propeller cavitating (Richardson *et al.*, 1995). Multi-year ice, which is expected to be encountered in the northern and eastern areas of the proposed survey, is thicker than younger ice. Icebreakers commonly back and ram into heavy ice until losing momentum to make way. The highest noise levels usually occur while backing full astern in preparation to ram forward through the ice. Overall, the noise generated by an icebreaker pushing ice was 10 to 15 dB greater than the noise produced by the ship underway in open water (Richardson *et al.*, 1995). In general, the Arctic Ocean is a noisy environment. Greening and Zakarauskas (1993) reported ambient sound levels of up to 180 dB/μPa²/Hz under multi-year pack ice in the central Arctic pack ice. Little information is available about the effect to marine mammals of the increased sound levels due to icebreaking.

Cetaceans—Few studies have been conducted to evaluate the potential interference of icebreaking noise with marine mammal vocalizations. Erbe and Farmer (1998) measured masked hearing thresholds of a captive beluga whale. They reported that the recording of a CCG ship, *Henry Larsen*, ramming ice in the Beaufort Sea, masked recordings of beluga vocalizations at a noise to signal pressure ratio of 18 dB, when the noise pressure level was eight times as high as the call pressure. Erbe and Farmer (2000) also predicted when icebreaker noise would affect beluga whales through software that combined a sound propagation model and beluga whale impact threshold models. They again used the data from the recording of the *Henry Larsen* in the Beaufort Sea and predicted that masking of beluga vocalizations could extend between 40 and 71 km (24.9 and 44.1 mi) near the surface. Lesage *et al.* (1999) report that beluga whales changed their call type and call frequency when exposed to boat noise. It is possible that the whales adapt to the ambient noise levels and are able to communicate despite the sound. Given the documented reaction of belugas to ships and icebreakers it is highly unlikely that beluga whales would remain in the proximity of vessels where vocalizations would be masked.

Beluga whales have been documented swimming rapidly away from ships and icebreakers in the Canadian high Arctic when a ship approaches to within 35 to 50 km (21.4 to 31.1 mi), and they may travel up to 80 km (49.7 mi) from the vessel's track (Richardson *et al.*, 1995). It is expected that belugas avoid icebreakers as soon as they detect the ships (Cosens and Dueck, 1993). However, the reactions of beluga whales to ships vary greatly and some animals may become habituated to higher levels of ambient noise (Erbe and Darmber, 2000).

There is little information about the effects of icebreaking ships on baleen whales. Migrating bowhead whales appeared to avoid an area around a drill site by greater than 25 km (15.5 mi) where an icebreaker was working in the Beaufort Sea. There was intensive icebreaking daily in support of the drilling activities (Brewer *et al.*, 1993). Migrating bowheads also avoided a nearby drill site at the same time of year where little icebreaking was being conducted (LGL and Greeneridge, 1987). It is unclear as to whether the drilling activities, icebreaking operations, or the ice itself might have been the cause for the whales' diversion. Bowhead whales are not expected to occur in the proximity of the proposed action area.

Pinnipeds—Brueggeman *et al.* (1992) reported on the reactions of seals to an icebreaker during activities at two prospects in the Chukchi Sea. Reactions of seals to the icebreakers varied between the two prospects. Most (67 percent) seals did not react to the icebreaker at either prospect. Reaction at one prospect was greatest during icebreaking activity followed by general vessel activity (running/maneuvering/jogging) and was 0.23 km (0.14 mi) of the vessel and lowest for animals beyond 0.93 km (0.58 mi). At the second prospect however, seal reaction was lowest during icebreaking activity with higher and similar levels of response during general (non-icebreaking) vessel operations and when the vessel was at anchor or drifting. The frequency of seal reaction generally declined with increasing distance from the vessel except during general vessel activity where it remained consistently high to about 0.46 km (0.29 mi) from the vessel before declining.

Similarly, Kanik *et al.* (1980) found that ringed and harp seals often dove into the water when an icebreaker was breaking ice within 1 km (0.6 mi) of the animals. Most seals remained on the ice when the ship was breaking ice 1 to 2 km (0.6 to 1.2 mi) away.

Estimated Take of Marine Mammals by Incidental Harassment

All anticipated takes would be "takes by Level B harassment," involving temporary changes in behavior. The proposed monitoring and mitigation measures are expected to minimize the possibility of injurious takes or mortality. However, as noted earlier, there is no specific information demonstrating that injurious "takes" or mortality would occur even in the absence of the planned monitoring and mitigation measures. NMFS believes, therefore, that injurious take or mortality to the affected species marine mammals is extremely unlikely to occur as a result of the specified activities within the specified geographic area for which USGS seeks the IHA. The sections below describe methods to estimate "take by harassment," and present estimates of the numbers of marine mammals that could be affected during the proposed seismic study in the Arctic Ocean. The estimates of "take by harassment," are based on data obtained during marine mammal surveys in and near the Arctic Ocean by Stirling *et al.* (1982), Kingsley (1986), Moore *et al.* (2000b), Haley and Ireland (2006), Haley (2006), GSC unpublished data (2008), and Mosher *et al.* (2009), Bowhead Whale Aerial Survey Program (BWASP), and on estimates of the sizes of the areas where effects could potentially occur. In some cases these estimates were made from data collected from regions and habitats that differed from the proposed project area.

Detectability bias, quantified in part by ƒ(0), is associated with diminishing sightability with increasing lateral distance from the trackline. Availability bias (g[0]) refers to the fact that there is less than 100 percent probability of sighting an animal that is present along the survey trackline. Some sources of densities used below included these correction factors in their reported densities. In other cases the best densities used below included these correction factors in their reported densities. In other cases the best available correction factors were applied to reported results when they had not been included in the reported data (Moore *et al.*, 2000b). Adjustments to reported population or density estimates were made on a case by case basis to take into account differences between the source data and the general information on the distribution and abundance of the species in the proposed project area.

Although several systematic surveys of marine mammals have been conducted in the southern Beaufort Sea, few data (systematic or otherwise) are available on the distribution and numbers of marine mammals in the northern Beaufort Sea or offshore water of the Arctic Ocean. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection. Both "maximum estimates" as well as "best estimates" of marine mammal densities (*see* Table 5 of the IHA application) and the numbers of marine mammals potentially exposed to underwater sound (*see* Table 6 of the IHA application) were calculated as described below. The best (or average) estimate is based on available distribution and abundance data and represents the most likely number of animals that may be encountered during the survey, assuming no avoidance of the airguns or vessel. The maximum estimate is either the highest estimate from applicable distribution and abundance data or the average estimate increased by a multiplier intended to produce a very conservative (over) estimate of the number of animals that may be present in the survey area. There is some uncertainty about how representative the available data are and the assumptions used below to estimate the potential "take by harassment." However, the approach used here is accepted by NMFS as the best available at this time.

USGS has calculated exposures to marine mammals within U.S. waters only. After the *St. Laurent* (a Canadian icebreaker) exits U.S. waters, their activities no longer fall under the jurisdiction of the U.S. or the MMPA.

The following estimates are based on a consideration of the number of marine mammals that might be disturbed appreciably over the approximately 806 line km (501 mi) of seismic surveys within U.S. waters across the Arctic Ocean. An assumed total of 1,007.5 km (626 mi) of trackline includes a 25 percent allowance over and above the planned approximately 806 km to allow for turns, lines that might have to be repeated because of poor data quality, or for minor changes to the survey design.

The anticipated radii of influence of the lower energy sound sources including Chirp echosounder (on the *St. Laurent*) and bathymetric echosounder (on the *Healy*) are less than that for the airgun configuration. It is assumed that during simultaneous operations of the airgun array and echosounder, any marine mammals close enough to be affected by the sounder would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the echosounder, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sounder given its characteristics (*e.g.*, narrow downward-directed beam) and other considerations described in the IHA application. Similar responses are expected from marine mammals exposed to the *Healy's* bathymetric profiler. Such reactions are not considered to constitute "taking" as defined by NMFS (NMFS, 2001). Therefore, no additional allowance is included for animals that might be exposed to sound sources other than the airguns.

Marine Mammal Density Estimates

Numbers of marine mammals that might be present and potentially disturbed are estimated based on available data about marine mammal distribution and densities in the Arctic Ocean study area during the summer. "Take by harassment" is calculated by multiplying expected densities of marine mammals likely to occur in the survey area by the area of water potentially ensonified to sound levels ≥160 dB re 1 μPa (rms) for the airgun operations and ≥120 dB re 1 μPa (rms) for icebreaking activities. Estimates for icebreaking are based on a consideration of the number of marine mammals that might be disturbed appreciably over the approximately 3,102 to 3,372 line km (1,927.5 to 2,095.3 mi) of icebreaking that may occur during the proposed project. This section provides descriptions of the estimated densities of marine mammals that may occur in the proposed survey area. The area of water that may be ensonified to the indicated sound level is described further below. There is no evidence that avoidance at received sound levels ≥160 dB would have significant effects on individual animals or that the subtle changes in behavior or movements would rise to the level of taking according to guidance by NMFS (NMFS, 2001).

Some surveys of marine mammals have been conducted near the southern end of the proposed project area, but few data are available on the species and abundance of marine mammals in the northern Beaufort Sea and the Arctic Ocean. No published densities of marine mammals are available for the region of the proposed survey (including between 74° and 84° North where the *Healy* will be breaking ice outside U.S. waters), although vessel-based surveys through the general area in 2005, 2006, 2008, and 2009 encountered few marine mammals. A total of two polar bears, 36 seals, and a single beluga whale sighting(s) were recorded along approximately 2,299 km (1,429 mi) of monitored trackline between 71° North and 74° North (Haley and Ireland, 2006; Haley, 2006; GSC unpublished data, 2008; Mosher *et al.,* 2009). PSOs recorded 268 sightings of 291 individual seals along approximately 21,322 km (13,248.9 mi) of monitored trackline between 74° and 84° North (Haley and Ireland, 2006; Haley, 2006; GSC unpublished data, 2008; Mosher *et al.,* 2009). No cetaceans were observed during the surveys between 74° and 84° North. Given the few sightings of marine mammals along the 21,322 km (13,248.9 mi) vessel trackline in previous years, USGS estimate that the densities of marine mammals encountered while breaking ice will be 1/10 of the estimated densities of marine mammals encountered within the ice margin habitat described in the original application.

Given that the survey lines within U.S. waters extend from latitudes 71° to 74° North, it is likely that seismic operations will be conducted in both open-water and sea-ice conditions. Because densities of marine mammals often differ between open-water and pack-ice areas, the likely extent of the pack-ice at the time of the survey was estimated. Images of average monthly sea ice concentration for August from 2005 through 2009, available from the National Snow and Ice Data Center

(NISDC), were used to identify 74° North latitude as a reasonable ice-edge boundary applicable to the proposed study period and location. Based on these satellite data, the majority of the survey in U.S. waters will be conducted in open water and unconsolidated pack ice, in the southern latitudes of the survey area. This region will include the ice margin where the highest densities of cetaceans and pinnipeds are likely to be encountered. The proposed survey lines within U.S. waters reach approximately 74.10° North, extending within the estimated ice-edge boundary for August, 2010 by approximately 19 km (10 mi). This comprises less than 3 percent of the total trackline within U.S. waters. USGS has divided the survey effort between the two habitat zones of open water and ice margin based on the 2005 to 2009 NSIDC satellite data described above and the planed location of the tracklines. NSIDC data from 2005 to 2009 suggests little ice will be present south of 74° North, although data from the 2009 cruise (Moser *et al.,* 2009) shows that inter-annual variability could result in a greater amount of ice being encountered than expected. As a conservative measure, USGS estimated that, within U.S. waters, 80 percent of the survey tracklines will occur in open water and 20 percent of the tracklines will occur within the ice margin.

The NSIDC (2009) reported that more Arctic sea ice cover in 2009 remained after the summer than in the record-setting low years of 2007 and 2008. USGS expects that sea ice density and extent in 2010 will be closer to the density and extent of sea ice in 2009 rather than the record-setting low years of 2007 and 2008. All animals observed during the 2009 survey (Mosher *et al.,* 2009) were north of the proposed seismic survey area, *i.e.,* north of 74° North.

Cetaceans—Average and maximum densities for each cetacean species or species group reported to occur in U.S. waters of the Arctic Ocean, within the study area, are presented in Table 5 of the IHA application. Densities were calculated based on the sightings and effort data from available survey reports. No cetaceans were observed during surveys near the proposed study area in August/September, 2005 (Haley and Ireland, 2006), August, 2006 (Haley, 2006), August/September, 2008 (GSC unpublished data, 2008) or August/September, 2009 (Mosher *et al.,* 2009).

Seasonal (summer and fall) differences in cetacean densities along the north coast of Alaska have been documented by Moore *et al.* (2000b). The proposed survey will be conducted in U.S. waters from approximately August 6 to 12, 2010 and is considered to occur during the summer season.

The summer beluga density (*see* Table 5 of the IHA application) was based on 41 sightings along 9,022 km (5,606 mi) of on-transect effort that occurred over water greater than 2,000 m (6,561.7 ft) during the summer in the Beaufort Sea (Moore *et al.,* 2000b; see Table 2 of the IHA application). A mean group size of 2.8 derived from BWASP data of August beluga sightings in the Beaufort Sea in water depths greater than 2,000 m was used in the density calculation. A $f(0)$ value of 2.326 from Innes *et al.* (1996) and a g(0) value of 0.419 from Innes *et al.* (1996) and Harwood *et al.* (1996) were also used in the density computation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in the proposed study area within U.S. waters. Most Moore *et al.* (2000b) sightings were south of the proposed seismic survey. However, Moore *et al.* (2000b) found that beluga whales were associated with both light (1 to 10 percent) and heavy (70 to 100 percent) ice cover. Five of 23 beluga whales that Suydam *et al.* (2005) tagged in Kaseglauk Lagoon (northeast Chukchi Sea) traveled to 79 to 80° North into the pack ice and within the region of the proposed survey. These and other tagged whales moved into areas as far as 1,100 km (594 nmi) offshore between Barrow and the Mackenzie River delta, spending time in water with 90 percent ice coverage. Therefore, we applied the observed density calculated from the Moore *et al.* (2000b) sightings as the average density for both "open water" and "ice margin" habitats. Because no beluga whales were sighted during surveys in the proposed survey area (Harwood *et al.,* 2005; Haley and Ireland, 2006; Haley, 2006; GSC unpublished data, 2008; and Mosher *et al.,* 2009) the densities in Table 5 of the IHA application are probably higher than densities likely to be encountered.

By the time the survey begins in early August, most bowhead whales have typically traveled east of the proposed project area to summer in the eastern Beaufort Sea and Amundsen Gulf. Industry aerial surveys of the continental shelf near Camden Bay in 2008 recorded eastward migrating bowhead whales until July 12 (Lyons and Christie, 2009). No bowhead sightings were recorded again despite continued flights until August 19, 2010. A summer bowhead whale density was derived from 9,022 km (5,606 mi) of summer (July/August) aerial survey effort reported by Moore *et al.* (2000b) in the Alaska Beaufort Sea during which six sightings of bowhead whales were documented in water greater than 2,000 m (6,561.7 ft). A mean group size of bowhead whale sightings in September, in waters greater than 2,000 m deep, was calculated to be 1.14 (CV= 0.4) from BWASP data. A $f(0)$ value of 2.33 and g(0) value of 0.073, both from Thomas *et al.* (2002) were used to estimate a summer density for bowhead whales of 0.0122 whales/km^2. This density falls within the range of densities, *i.e.,* 0.0099 to 0.0717 whales/km^2, reported by Lyons and Christie (2009) based on data from three July, 2008 surveys.

Treacy *et al.* (2006) reported that in years of heavy ice conditions, bowhead whales occur farther offshore than in years of light to moderate ice. NSIDC (2009) reported that September, 2009 had the third lowest sea ice extent since the start of their satellite records in 1979. The extent of sea ice at the end of the 2009 Arctic summer, however, was greater than in 2007 or 2008. USGS does not expect 2010 to be a heavy ice year during which bowhead whales might occur farther offshore in the area of the proposed survey. During the lowest ice-cover year on record (2007), BWASP reported no bowhead whale sightings in the greater than 2,000 m depth waters far offshore. Because few bowhead whales have been documented in the deep offshore waters of the proposed survey area, half of the bowhead whale density estimate from size and standard error reported in Thomas *et al.* (2002) for $f(0)$ and g(0) correction factors suggest that an inflation factor of two is appropriate for estimating the maximum density from the average density. NSIDC did not forecast that 2010 would be a heavy ice year and USGS anticipates that bowheads will remain relatively close to shore, and in areas of light ice coverage. Therefore, USGS has applied the same density for bowheads to the open-water and ice-margin categories. Bowhead whales were not sighted during recent surveys in the Arctic Ocean (Haley and Ireland, 2006; Haley, 2006; GSC unpublished data, 2008; Mosher *et al.,* 2009), suggesting that the bowhead whale densities shown in Table 5 are likely higher than actual densities in the survey area.

For other cetacean species that may be encountered in the Beaufort Sea, densities are likely to be very low in the summer when the survey is scheduled. Fin and humpback whales are unlikely to occur in the Beaufort Sea. No gray whales were observed in the Beaufort Sea by Moore *et al.* (2000b) during summer aerial surveys in water greater than 2,000 m. Gray whales were not recorded in water greater than 2,000 m by the BWASP during August in 29 years of survey operation. Harbor porpoises are not expected to be present in large numbers in the Beaufort Sea during the fall although small numbers may be encountered during the summer. Neither gray whales nor harbor porpoises are likely to occur in the far-offshore waters of the proposed survey area (Table 5 of the IHA application). Narwhals are not expected to be encountered within the survey area although a few individuals could be present if ice is nearby. Because these species occur so infrequently in the Beaufort Sea, little to no data are available for the calculation of densities. Minimal cetacean densities have therefore been assigned to these three species for calculation purposes and to allow for chance encounters (*see* Table 5 of the IHA application). Those densities include "0" for the average and 0.0001 individuals/km^2 for the maximum.

Pinnipeds—Extensive surveys of ringed and bearded seals have been conducted in the Beaufort Sea, but most surveys were conducted over the landfast ice during aerial surveys, and few seal surveys have occurred in open water or in the pack ice. Kingsley (1986) conducted ringed seal surveys of the offshore pack ice in the central and eastern Beaufort Sea during the late spring (late June). These surveys provide the most relevant information on densities of ringed seals in the ice margin zone of the Beaufort Sea. The density estimate in Kingsley (1986) was used as the average density of ringed seals that may be encountered in the ice-margin area of the proposed survey (*see* Table 5 of the IHA application). The average density was multiplied by four to estimate maximum density, as was done for all seal species likely to occur within the survey area. Ringed seals are closely associated with sea ice therefore the ice-margin densities were multiplied by a factor of 0.75 to estimate a summer open-water ringed-seal density for locations with water depth greater than 2,000 m (6,561.7 ft).

Densities of bearded seals were estimated by multiplying the ringed seal densities by 0.051 based on the proportion of bearded seals to ringed seals reported in Stirling *et al.,* (1982; see Table 6–3 of IHA application). Because bearded seals are associated with the pack ice edge and shallow water, their estimated summer ice-margin density was also multiplied by a factor of 0.75 for the open-water density estimate. Minimal values were used to estimate spotted seal densities because they are uncommon offshore in the Beaufort Sea and are not likely to be encountered.

Numbers of marine mammals that might be present and potentially disturbed are estimated below based on available data about marine mammal distribution and densities in the three different habitats during the summer as described in Table 5 of the IHA application.

The number of individuals of each species potentially exposed to received levels greater than or equal to 160 dB re 1 μPa (rms) (for seismic airgun operations) or 120 dB re 1 μPa (rms) (for icebreaking) was estimated by multiplying

- The anticipated area to be ensonified to the specified sound level in both open water, the ice margin, and polar pack by
- The expected species density.

Some of the animals estimated to be exposed to sound levels greater than or equal to 160 dB re 1 μPa (rms) or 120 dB re 1 μPa (rms), particularly migrating bowhead whales, might show avoidance reactions before actual exposure to this sound level (*see* Appendix D of the IHA application). Thus, these calculations actually estimate the number of individuals potentially exposed to greater than or equal to 160 dB (rms) or 120 dB re 1 μPa (rms) that would occur if there were no avoidance of the area ensonified to that level.

Estimated Area Exposed to ≥ 160 dB (rms)

The area of water potentially exposed to received levels greater than or equal to 160 dB by the proposed operations was calculated by multiplying the planned trackline distance within U.S. waters by the cross-track distance of the sound propagation. The airgun array of two 500 in^3 and one 150 in^3 G-airguns that will be used for the proposed 2010 survey within U.S. waters was measured during a 2009 project in the Arctic Ocean. The propagation experiment took place at 74° 50.4′ North; 156° 34.31′ West, in 3,863 m (12,674 ft) of water. The location was near the northern end of the two proposed survey lines in U.S. waters. USGS expects the sound propagation by the airgun array in the planned 2010 survey will be the same as that measured in 2009, because of the similar water depths and relative locations of the test site and proposed survey area. The greater than or equal to 160 dB (rms) sound level radius was estimated to be approximately 2,500 m (8,202.1 ft) based on modeling of the 0 to peak energy of the airgun array (Roth and Schmidt, 2010). The 0 to peak values were corrected to rms by subtracting 10 dB.

Closely spaced survey lines and large cross-track distances of the greater than or equal to 160 dB radii can result in repeated exposure of the same area of water. Excessive amounts of repeated exposure can lead to overestimation of the number of animals potentially exposed through double counting. The trackline for the proposed USGS survey in U.S. waters, however, covers a large geographic area without adjacent tracklines and the potential for multiple or repeated exposure is unlikely to be a concern.

The USGS 2010 geophysical survey is planned to occur approximately 108 km (67.1 mi) offshore, along approximately 806 km (501 mi) of survey lines in U.S. waters, during the first half of August exposing a total of approximately 4,109 km^2 (1,586.5 mi^2) of water to sound levels of greater than or equal to 160 dB (rms).USGS included an additional 25 percent allowance over and above the planned tracklines within U.S. waters to allow for turns, lines that might have to be repeated because of poor data quality, or for minor changes to the survey design. The resulting estimate of 5,136.5 km^2 (1,983.2 mi^2) was used to estimate the numbers of marine mammals exposed to underwater sound levels greater than or equal to 160 dB (rms).

Based on the operational plans and marine mammal densities described in Table 5 of the IHA application, the estimates of marine mammals potentially exposed to sounds greater than or equal to 160 dB (rms) in the proposed survey area within U.S. waters are presented in Table 6 of the IHA application. For the common species, the requested numbers are calculated as described above and based on the average densities from the data reported in the different studies mentioned above. For less common species, estimates were set to minimal values to allow for chance encounters. Discussion of the number of potential exposures is summarized by species in the following subsections.

Cetaceans—Based on density estimates and area ensonified, one endangered cetacean species (bowhead whale) is expected to be exposed to received levels greater than or equal to 160 dB unless bowheads avoid the survey vessel before the received levels reach 160 dB. Migrating bowheads are likely to do so, though many of the bowheads engaged in other activities, particularly feeding and socializing may not. The USGS estimate of the number of bowhead whales potentially exposed to sound levels greater than or equal to 160 dB in the portion of the survey area in U.S. waters in between 31 and 63 (*see* Table 6 of the IHA application). Although take was calculated based on density estimates in the proposed action area, the proposed seismic survey will be conducted during the fall migration for bowhead whales, but at locations starting at greater than 185.2 km (100 nmi) offshore, well north of the known bowhead migration corridor and well beyond distances (20 to 30 km [12.4 to 18.6], Miller *et al.,* 1999; Richardson *et al.,* 1999) known to potentially effect this species. Other endangered cetacean species that may be encountered in the area are fin and humpback whales; both are unlikely to be exposed given their minimal density in the area.

The only other cetacean species likely to occur in the proposed survey area is the beluga whale. Average (best) and maximum estimates of the number of exposures of belugas to sound levels greater than or equal to 160 dB (rms) are 182 and 364, respectively. Estimates for other cetacean species are minimal (*see* Table 6 of the IHA application).

Pinnipeds—The ringed seal is the most widespread and abundant pinniped in ice-covered arctic waters, and there is a great deal of annual variation in abundance and distribution of these marine mammals. Ringed seals account for the vast majority of marine mammals expected to be encountered, and hence exposed to airgun sounds with received levels greater than or equal to 160 dB (rms) during the proposed marine seismic survey. The average (best) and maximum number of exposures of ringed seals to sound levels greater than or equal to 160 dB (rms) were estimated to be 1,031 and 4,126, respectively.

Two additional pinniped species (other than the Pacific walrus) are likely to occur in the proposed project area. The average and maximum numbers of exposures of bearded seals to sound levels greater than or equal to 160 dB (rms) were estimated to be 53 and 210, respectively. The ribbon seal is unlikely to be encountered in the survey area, but a chance encounter could occur.

Estimated Area Exposed to ≥ 120 dB (rms)

The area potentially exposed to received levels greater than or equal to 120 dB (rms) due to icebreaking operations was estimated by multiplying the anticipated trackline distance breaking ice by the estimated cross-track distance to received levels of 120 dB caused by icebreaking.

In 2008, acousticians from Scripps Institution of Oceanography Marine Physical Laboratory and University of New Hampshire Center for Coastal and Ocean Mapping conducted measurements of SPLs of *Healy* icebreaking under various conditions (Roth and Schmidt, 2010). The results indicated that the highest mean SPL (185 dB [rms]) was measured at survey speeds of 4 to 4.5 knots in conditions of 5/10 ice and greater. Mean SPL under conditions where the ship was breaking heavy ice by backing and ramming was actually lower (180 dB). In addition, when backing and ramming, the vessel is essentially stationary, so the ensonified area is limited for a short period (on the order of minutes to tens of minutes) to the immediate vicinity of the boat until the ship breaks free and once again makes headway.

Although the report by Roth and Schmidt has not yet been reviewed externally nor peer-reviewed for publication, the SPL results reported are consistent with previous studies (Thiele, 1981, 1988; LGL and Greenridge, 1986; Richardson *et al.,* 1995).

The existing threshold for Level B harassment for continuous sounds is a received sound level of 120 dB SPL. Using a spherical spreading model, a source level of 185 dB decays to 120 dB in about 1,750 m (5,741.5 ft). This model is corroborated by Roth and Schmidt (2010). Therefore, as the ship travels through the ice, a swath 3,500 m (11,483 ft) wide would be subjected to sound levels greater than or equal to 120 dB (rms). This results in the potential exposure of 11,802 km^2 (4,557.8 mi^2) to sounds greater than or equal to 120 dB (rms) from icebreaking.

Based on the operational plans and marine mammal densities described above, the estimates of marine mammals exposed to sounds greater than or equal to 120 dB (rms) during the maximum estimation of icebreaking outside of U.S. waters (3,372 km [2,095.3 mi]) are presented in Table Add-4 of the IHA application. For the common marine mammal species, the requested numbers are calculated as described above and based on the average densities from the data reported in the different studies mentioned above. For less common species, estimates were set to minimal values to allow for chance encounters.

Based on models, bowhead whales likely would respond to the sound of the icebreakers at distances of 2 to 25 km (1.2 to 15.5 mi) from the icebreakers (Miles *et al.,* 1987). This study predicts that roughly half of the bowhead whales show avoidance responses to an icebreaker underway in open water at a range of 2 to 12 km (1.3 to 7.5 mi) when the sound-to-noise ratio is 30 dB (rms). The study also predicts that roughly half of the bowhead whales would show avoidance response to an icebreaker pushing ice at a range of 4.6 to 6.2 km (2.9 to 12.4 mi) when the sound-to-noise ratio is 30 dB.

Richardson *et al.* (1995b) found that bowheads migrating in the nearshore lead during the spring migration often tolerated exposure to playbacks of recorded icebreaker sounds at received levels up to 20 dB or more above the natural ambient noise levels at corresponding frequencies. The source level of an actual icebreaker is much higher than that of the projectors (projecting the recorded sound) used in this study (median difference 34 dB over the frequency range 40 Hz to 6.3 kHz). Over the two season period (1991 and 1994) when icebreaker playbacks were attempted, an estimated 93 bowheads (80 groups) were seen near the ice camp when the projectors were transmitting icebreaker sounds into the water, and approximately 158 bowheads (116 groups) were seen near there during quiet periods. Some bowheads diverted from their course when exposed to levels of projected icebreaker sound greater than 20 dB above the natural ambient noise level in the ⅓ octave band of the strongest icebreaker noise. However, not all bowheads diverted at that sound-to-noise ratio, and a minority of whales apparently diverted at a lower sound-to-noise ratio. The study concluded that exposure to a single playback of variable icebreaker sounds can cause statistically, but probably not biologically significant effects on movements and behavior of migrating whales in the lead system during the spring migration east of Point Barrow, Alaska. The study indicated the predicted response distances for bowheads around an actual icebreaker would be highly variable; however, for typical traveling bowheads, detectable effects on movements and behavior are predicted to extend commonly out to radii of 10 to 30 km (6.2 to 18.6 mi). Predicting the distance a whale would respond to an icebreaker like the Healy is difficult because of propagation conditions and ambient noise varies with time and with location. However, because the closest survey activities and icebreaking are approximately 116 km (72.1 mi) away and are of limited duration (5 days), and the next closest survey activities are 397 km (246.7 mi) away to the north and west in the Arctic ocean, NMFS does not anticipate that icebreaking activities would have biologically significant effects on the movements and behavior of bowhead whales.

TABLE 6—THE ESTIMATES OF THE POSSIBLE NUMBERS OF MARINE MAMMALS EXPOSED TO SOUND LEVELS GREATER THAN OR EQUAL TO 120 dB (RMS) (FOR ICEBREAKING) OR 160 dB (RMS) (FOR SEISMIC AIRGUN OPERATIONS) DURING USGS'S PROPOSED SEISMIC SURVEY IN U.S. WATERS IN THE NORTHERN BEAUFORT SEA AND ARCTIC OCEAN, IN AUGUST, 2010. RECEIVED LEVELS 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). SEE TABLES 4 TO 5 AND ADD-3 AND ADD-4 IN USGS'S APPLICATION FOR FURTHER DETAIL.

Species	Number of individuals exposed (best) [1] open water, ice margin, polar pack	Number of individuals exposed (max) [2] open water, ice margin, polar pack	Total (best)	Approximate percent of regional population best) [2]
Odontocetes	146	291		
Beluga whale	36	73	224	0.57
(*Delphinapterus leucas*)	42	84		
Narwhal	0	1		
(*Monodon monocerus*)	0	1	0	0
	0	1		
Killer whale	0	0		
(*Orcinus orca*)	0	0	0	0
	0	1		
Harbor porpoise	0	0		
(*Phocoena phocoena*)	0	0	0	0
	0	1		
Mysticetes	25	50		
Bowhead whale	6	13	38	0.36
(*Balaena mysticetus*)	7	1		
Eastern Pacific gray whale	0	0		
(*Eschrichtius robustus*)	0	0	0	0
	0	1		
Minke whale	0	0		
(*Balaenoptera acutorostrata*)	0	0	0	0
	0	1		
Fin whale	0	0		
(*Balaenoptera physalus*)	0	0	0	0
	0	1		
Humpback whale	0	0		
(*Megaptera novaeangliae*)	0	0	0	0
	0	0		
Pinnipeds	39	158		
Bearded seal	13	53	67	0.02
(*Erignathus barbatus*)	15	60		
Spotted seal	0	2		
(*Phoca largha*)	0	0	0	0
	0	0		
Ringed seal	774	3,094		
(*Pusa hispida*)	258	1,031	1,328	7.38
	296	1,185		
Ribbon seal (*Histriophoca fasciata*)	N.A.	N.A.	N.A.	N.A.
Pacific walrus (*Odobenus rosmarus divergens*)	N.A.	N.A.	N.A.	N.A.
Carnivores				
Polar bear (*Ursus maritimus marinus*)	N.A.	N.A.	N.A.	N.A.

N.A.—Data not available or species status was not assessed.

[1] Best estimate and maximum density estimates are from Table 5 and Table Add-3 of USGS's application.

[2] Regional population size estimates are from Table 4.

Conclusions—Bowhead whales are considered by NMFS to be disturbed after exposure to underwater sound levels greater than or equal to 160 dB (rms) for impulse sources and 120 dB (rms) for continuous sources. The relatively small airgun array proposed for use in this survey limits the size of the 160 dB (rms) EZ around the vessel and is not expected to result in any bowhead whale exposures to underwater sound levels sufficient to reach the disturbance criterion as defined by NMFS.

Odontocete reactions to seismic energy pulses are usually assumed to be limited to lesser distances from the airgun(s) than are those of mysticetes, probably in part because odontocete low-frequency hearing is assumed to be less sensitive than that of mysticetes. However, at least when in the Canadian Beaufort Sea in summer, belugas appear to be fairly responsive to seismic energy, with few being sighted within 10 to 20 km (6.2 to 12.4 mi) of seismic vessels during aerial surveys (Miller *et al.,* 2005). Belugas will likely occur in small numbers in the project area within U.S. waters during the survey period. Most belugas will likely avoid the vicinity of the survey activities and few will likely be affected.

Taking into account the mitigation measures that are planned, effects on cetaceans are generally expected to be restricted to avoidance of a limited area around the survey operation and short-term changes in behavior, falling within the MMPA definition of "Level B harassment." Furthermore, the estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are very low percentages of the population sizes in the Bering-Chukchi-Beaufort Seas.

Based on the ≥ 160 dB disturbance criterion, the best estimates of the numbers of cetacean exposures to sounds ≥ 160 dB re 1 μPa (rms) represent less than one percent of the populations of each species in the Chukchi Sea and adjacent waters. For species listed as Endangered under the ESA, USGS estimates suggest it is unlikely that fin whales or humpback whales will be exposed to received levels ≥ 160 dB and/or ≥ 120 dB, but that approximately 38 bowheads (0.36 percent of the regional population) may be exposed at this level. The latter is less than one percent of the Bering-Chukchi-Beaufort population of greater than 14,247 assuming 3.4 percent population growth from the 2001 estimate of greater than 10,545 animals (Zeh and Punt, 2005). NMFS does not anticipate bowhead whales to be potentially affected by the proposed survey activities due to its location far offshore of the bowhead fall migration pathway.

Some monodontids may be exposed to sounds produced by the airgun arrays during the proposed survey, and the numbers potentially affected are small relative to the population sizes (*see* Table 6 of the IHA application). The best estimate of the number of belugas (224 animals) that might be exposed to ≥ 160 dB and/or ≥ 120 dB represents less than one percent (0.57 percent) of their regional population.

The many reported cases of apparent tolerance by cetaceans of seismic exploration, vessel traffic, and some other human activities show that co-existence is possible. Monitoring and mitigation measures such as controlled vessel speed, dedicated PSOs, non-pursuit, shut-downs or power-downs when marine mammals are seen within defined ranges will further reduce short-term reactions and minimize any effects on hearing sensitivity. In all cases, the effects are expected to be short-term, with no lasting biological consequence.

Several pinniped species may be encountered in the study area, but the ringed seal is by far the most abundant marine mammal species in the survey area. The best (average) estimates of the numbers of individual seals exposed to airgun sounds at received levels ≥ 160 dB re 1 μPa (rms) and/or ≥ 120 dB re 1 μPa (rms) for icebreaking during the marine survey are as follows: Ringed seals (1,328 animals; 7.4 percent of the regional population), bearded seals (67 animals; 0.02 percent of the regional population), and spotted seals (0 animals, 0 percent of the regional population), representing less than a few percent of the Bering-Chukchi-Beaufort populations for each species. It is probable that only a small percentage of the pinnipeds exposed to sound level ≥ 160 dB (rms) or 120 dB (rms) would actually be disturbed. The short-term exposures of pinnipeds to airgun sounds are not expected to result in any long-term negative consequences for the individuals or their populations.

Potential Effects on Habitat

The proposed USGS seismic survey will not result in any permanent impact on habitats used by marine mammals, including the food sources they use. The proposed activities will be of short duration in any particular area at any given time; thus any effects would be localized and short-term. However, the main impact issue associated with the proposed activity will be temporarily elevated noise levels and the associated direct effects on marine mammals, as described above.

Icebreaking could alter ice conditions in the immediate area around the vessels. However, ice conditions at this time of year are typically highly variable and relatively unstable in most locations the survey will take place. Although there is the potential for the destruction of ringed seal lairs or polar bear dens due to icebreaking, these animals will not be using lairs or dens at the time of the planned survey.

One of the reasons for the adoption of airguns as the standard energy source for marine seismic surveys was that, unlike explosives, they do not result in any appreciable fish kill. However, the existing body of information relating to the impacts of seismic on marine fish and invertebrate species, the primary food sources of pinnipeds and belugas, is very limited.

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 (Hubbs and Rechnitzer, 1952; Wardle *et al.,* 2001). Generally, the higher the received pressure and less time required for the pressure to rise and decay, the greater the chance of acute pathological effects. Considering the peak pressure and rise/decay time characteristics of seismic airgun arrays used today, the pathological zone for fish and invertebrates would be expected to be within a few meters of the seismic source (Buchanan *et al.,* 2004). For the proposed survey, any injurious effects on fish would be limited to very short distances from the sound source and well away from the nearshore waters where most subsistence fishing activities occur.

The only designated Essential Fish Habitat (EFH) species that may occur in the area of the project during the seismic survey are salmon (adult), and their occurrence in waters north of the Alaska coast is limited. Adult fish near seismic operations are likely to avoid the immediate vicinity of the source, thereby avoiding injury (*see* Appendix E of the IHA application). No EFH species will be present as very early life stages when they would be unable to avoid seismic exposure that could otherwise result in minimal mortality.

Studies have been conducted on the effects of seismic activities on fish larvae and a few other invertebrate animals. Generally, seismic was found to only have potential harmful effects to larvae and invertebrates that are in direct proximity (a few meters) of an active airgun array (*see* Appendix E and F of the IHA application). The proposed Arctic Sea seismic program for 2010 is predicted to have negligible to low physical effects on the various life stages of life and invertebrates. Therefore, physical effects of the proposed program on fish and invertebrates would not be significant.

The *Healy* is designed for continuous passage at 5.6 km (3 knots) through ice 1.4 m (4.6 ft) thick. During this project the *Healy* will typically encounter first- or second-year ice while avoiding thick ice floes, particularly large intact multi-year ice, whenever possible. In addition, the icebreaker will follow leads when possible while following the survey route. As the icebreaker passes through the ice, the ship causes the ice to part and travel alongside the hull. This ice typically returns to fill the wake as the ship passes. The effects are transitory, *i.e.,* hours at most, and localized, *i.e.,* constrained to a relatively narrow swath perhaps 10 m (32.8 ft) to each side of the vessel.

The *Healy's* maximum beam is 25 m (82 ft). Applying the maximum estimated amount of icebreaking, *i.e.,* 3,372 km (2,095.3 mi), to the corridor opened by the ship, USGS anticipates that a maximum of approximately 152 km^2 (58.7 mi^2) of ice may be disturbed. This encompasses an insignificant amount (less than 0.005 percent) of the total Arctic ice extent in August and September of 2008 and 2009 which ranged from 3.24 million to 4.1 million km^2 (1,235,527 to 1,583,019 mi^2).

Potential Effects on Marine Mammal Habitat

The proposed airgun operations 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 activities will be temporarily elevated noise levels and the associated direct effects on marine mammals, as well as the potential effects of icebreaking. The potential effects of icebreaking include locally altered ice conditions which may temporarily alter the haul-out pattern of seals in the immediate vicinity of the vessel. The destruction of ringed seal lairs or polar bear dens is not expected to be a concern at this time of year.

During the seismic survey only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species would be short-term and fish would return to their pre-disturbance behavior once the seismic activity ceases. Thus, the proposed survey would have little, if any, impact on the abilities of marine mammals to feed in the area where seismic work is planned.

Some mysticetes, including bowhead whales, feed on concentrations of zooplankton. Some feeding bowhead whales may occur in the Alaskan Beaufort Sea in July and August, and other feed intermittently during their westward migration in September and October (Richardson and Thomson, 2002; Lowry *et al.,* 2004; Lyons *et al.,* 2009; Christi *et al.,* 2009). A reaction by zooplankton to a seismic impulse would only be relevant to whales if it caused concentrations of zooplankton to scatter. Pressure changes of sufficient magnitude to cause that type of reaction would probably occur only very close to the source. Impacts on zooplankton behavior are predicted to be negligible, and that would translate into negligible impacts on feeding mysticetes.

Thus, 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, since operations at any specific location will be limited in duration.

Icebreaking will create temporary leads in the ice and could possibly destroy unoccupied seal lairs. Seal pups are born in the spring, therefore, pupping and nursing will have concluded and the lairs will be vacated at the time of the proposed survey. Breaking ice may damage seal breathing holes and will also reduce the haul-out area in the immediate vicinity of the ship's track.

Icebreaking along a maximum of 3,372 km (2,095.3 mi) of trackline will alter local ice conditions in the immediate vicinity of the vessel. This has the potential to temporarily lead to a reduction of suitable seal haul-out habitat. However the dynamic sea-ice environment requires that seals be able to adapt to changes in sea, ice, and snow conditions, and they therefore create new breathing holes and lairs throughout winter and spring (Hammill and Smith, 1989). In addition, seals often use open leads and cracks in the ice to surface and breathe (Smith and Stirling, 1975). Disturbance to the ice will occur in a very small area (less than 0.005 percent) relative to the Arctic icepack and no significant impact on marine mammals is anticipated by icebreaking during the proposed project.

Proposed Mitigation

In order to issue an Incidental Take Authorization (ITA) for small numbers of marine mammals under Section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses. For the proposed seismic survey in the Arctic Ocean, USGS will deploy an airgun array of three G-airguns. The source will be relatively small in size and source level, relative to airgun arrays typically used for industry seismic surveys. Important mitigation factors built into the design of the survey include the following:

- In deep offshore waters (where the survey will occur), sound from the airguns is expected to attenuate relatively rapidly as compared with attenuation in shallower waters;
- The airguns comprising the array will be clustered with only limited horizontal separation (*see* Appendix B of the IHA application), so the arrays will be less directional than is typically the case with larger airgun arrays. This will result in less downward directivity than is often present during seismic surveys, and more horizontal propagation of sound; and
- Airgun operations will be limited to offshore waters, far from areas where there is subsistence hunting or fishing, and in waters where marine mammal densities are generally low.

In addition to the mitigation measure that are built into the general project design, several specific mitigation measures will be implemented to avoid or minimize effects on marine mammals encountered along the tracklines. These include ramping-up the airguns at the beginning of operations, and power-downs or shut-downs when marine mammals are detected within specified distances from the source. The GSC has written a Categorical Declaration (*see* Appendix C of the IHA application) stating that: "While in U.S. waters (*i.e.,* the U.S. 200 mile EEZ), the GSC operators will comply with any and all environmental mitigation measures required by the U.S. National Marine Fisheries Service (NMFS) and/or the U.S. Fish and Wildlife Service (USFWS)."

Received sound fields were measured for the airgun configuration, in relation to distance and direction from the airgun(s). The proposed radii around the airgun(s) where received levels would be 180 and 190 dB (rms) are shown in Table 2 of the IHA application. The 180 and 190 dB (rms) levels are used to initiate a power-down or, if necessary, shut-down criteria applicable to cetaceans and pinnipeds, respectively, as specified by NMFS (2000).

Vessel-based PSOs will watch for marine mammals near the airgun(s) when they are in use. Mitigation and monitoring measures proposed to be implemented for the seismic survey have been developed and refined in cooperation with NMFS during previous seismic studies in the Arctic and described in associated EAs, IHA applications, and IHAs. The mitigation and monitoring measures described herein represent a combination of the procedures required by past IHAs for Arctic projects.

Some cetacean species (such as bowhead whales) may be feeding or migrating in the Beaufort Sea during August and September. However, most of the proposed geophysical activities will occur north of the main migration corridor and the number of individual animals expected to closely approach the vicinity of the proposed activity will be small in relation to regional population sizes. With the proposed monitoring, ramp-up, power-down, and shut-down provisions (*see* below), any effects on individuals are expected to be limited to behavioral disturbance. The following subsections provide more detailed information about the mitigation measures that are integral part of the planned activity.

Proposed Exclusion Zones (EZ)

Mosher *et al.* (2009) collected received sound level data for the airgun configuration that will be used in the proposed survey in similar water depths, *i.e.,* greater than 2,000 m (6,561.7 ft). The empirical data were plotted in relation to distance and direction from the three airguns by Roth and Schmidt (2010; *see* Figure B–3). Based on model fit to the measured received levels and source modeling estimates from Gundalf, the 180 and 190 dB (rms) EZ are estimated to be 216 m (708.7 ft) and 68 m (223.1 ft), respectively. As a conservation measure for the proposed EZ, the sound-level EZ indicated by the empirical data have been increased to 500 m (1,640.4 ft) for the 180 dB isopleths and to 100 m (328 ft) for the 190 dB isopleths (*see* Table 2 of the IHA application). 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 EZs. If the PSO detects marine mammal(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 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 yet, NMFS has not specified a new procedure for determining EZs. Such procedures, if applicable would be implemented through a modification to the IHA if issued.

In addition to monitoring, mitigation measures that will be adopted during the proposed Arctic Ocean survey include:

(1) Speed or course alteration, provided that doing so will not comprise operational safety requirements;

(2) Power-down procedures;

(3) Shut-down procedures; and

(4) Ramp-up procedures.

No start-up of airgun operations would be permitted unless the full 180 dB (rms) EZ is visible for at least 30 min during day or night. Other proposed provisions associated with operations at night or in periods of poor visibility include the following:

- During foggy conditions or darkness (which may be encountered starting in late August), the full 180 dB (rms) EZ may not be visible. In that case, the airguns could not start-up after a full shut-down until the entire 180 dB (rms) radius was visible.
- During any nighttime operations, if the entire 180 dB (rms) EZ is visible using vessel lights, then start-up of the airgun array may occur following a 30 min period of observation without sighting marine mammals in the EZ.
- If one or more airguns have been operational before nightfall, they can remain operational throughout the night, even though the entire EZ may not be visible.

Speed or Course Alteration—If a marine mammal (in water) is detected outside the EZ and, based on its position and relative motion, is likely to enter the EZ, the vessel's speed and/or direct course may, when practical and safe, be changed in a manner that also minimizes the effect on the planned science objectives. The marine mammal activities and movements relative to the seismic vessel will be closely monitored to ensure that the marine mammal does not approach within the EZ. If the mammal appears likely to enter the EZ, further mitigative actions will be taken, *i.e.,* either further course alterations or power-down or shut-down of the airgun(s).

Power-down Procedures—A power-down involves reducing the number of airguns in use such that the radius of the 180 dB or 190 dB (rms) EZ are decreased to the extent that marine mammals are no longer in or about to enter the EZ. A power-down of the airgun array can also occur when the vessel is moving from one seismic line to another. During a power-down for mitigation, one airgun (or some other number of airguns less than the full airgun array) will be operated. The continued operation of one airgun is intended to alert (1) marine mammals to the presence of the seismic vessel in the area, and (2) retain the option of initiating a ramp-up to full operations under poor visibility conditions. In contrast, a shut-down occurs when all airgun activity is suspended.

If a marine mammal is detected outside the EZ but is likely to enter the EZ, and if the vessel's speed and/or course cannot be changed to avoid having the marine mammal enter the EZ, the airguns (as an alternative to a complete shut-down) will be powered-down to a single airgun before the animal is within the EZ. Likewise, if a mammal is already within the EZ when first detected, the airguns will be powered-down immediately if this is a reasonable alternative to a complete shut-down. During a power-down of the airgun array, the number of airguns will be reduced to a single 150 in^3 G-airgun will be operated. The 180 dB (rms) EZ for the power-down sound source has been estimated to be 62 m (203 ft), the proposed distance for use by PSOs is 75 m (246 ft). If a marine mammal is detected within or near the smaller EZ around that single 150 in^3 airgun (*see* Table 2 of USGS's application and Table 2 above), all airguns will be shut-down (*see* next subsection).

Following a power-down, operation of the full airgun array will not resume until the marine mammal is outside the EZ for the full array. The animal will be considered to have cleared the EZ if it:

(1) Is visually observed to have left the EZ, or

(2) Has not been seen within the EZ for 15 minutes in the case for species with shorter dive durations (*e.g.,* small odontocetes and pinnipeds); or

(3) Has not been seen within the EZ for 30 minutes in the case for species with longer dive durations (*e.g.,* mysticetes and large odontocetes, including killer whales).

During airgun operations following a power-down (or shut-down) whose duration has exceeded the limits specified above and subsequent animal departures, 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 is detected within or approaching the EZ for a single airgun source (*i.e.,* a power-down is not practical or adequate to reduce exposure to less than 190 or 180 dB (rms), as appropriate). Shut-downs will be implemented (1) if an animal approaches or 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 a single airgun when more than one airgun (typically the full array) is operating. Airgun activity will not resume until the marine mammal has cleared the EZ, or until the PSVO is confident that the animal has left the vicinity of the vessel (or the PSVO not observing the animal(s) within the EZ for 15 or 30 min depending upon the species). Criteria for judging that the animal has cleared the EZ will be as described in the preceding subsection. Ramp-up procedures will be followed during resumption of full seismic operations after a shut-down of the airgun array.

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 (or reduced airgun operations) has exceeded that specified duration period. The specified period depends on the speed of the source vessel, the size of the airgun array that is being used, and the size of the EZ, but is often about 10 min. NMFS normally requires that, once ramp-up commences, the rate of ramp-up be no more than 6 dB per 5 min period. Ramp-up will begin with a single airgun (the smallest airgun in the array). 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 approximately 10 minutes. During ramp-up, the PSVOs will monitor the EZ, and if marine mammals are sighted, a power-down or shut-down will be implemented as though the full array were operational.

If the complete 180 dB (rms) 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 (150 in^3 or similar) has been operating during the interruption of seismic survey operations. Given these provisions, it is likely that the three G-airgun array will not be ramped-up from a complete shut-down at night or in thick fog, because the outer part of the EZ for that array will not be visible during those conditions. If the entire EZ is visible using vessel lights, then start-up of the airguns from a complete shut-down may occur at night. 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 will be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away if they choose. Given the responsiveness of bowhead and beluga whales to airgun sounds, it can be assumed that those species in particular will move away during a ramp-up. Ramp-up of the airguns will not be initiated during the day or at night if a marine mammal is sighted within or near the applicable EZ during the previous 15 or 30 min, as applicable.

Helicopter Flights—The use of a helicopter to conduct ice reconnaissance flights and vessel-to-vessel personnel transfers is likely to occur during survey activities in U.S. waters. However, collection of spot bathymetry data or on-ice landings, both of which required low altitude flight patterns, will not occur in U.S. waters.

Proposed Monitoring and Reporting

In order to issue an ITA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking." The MMPA implementing regulations at 50 CFR 216.104(a)(13) require that requests for IHAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present.

USGS proposes to sponsor marine mammal monitoring during the proposed project, in order to implement the proposed mitigation measures that require real-time monitoring, to satisfy the anticipated monitoring requirements of the IHA proposed by NMFS, and to meet any monitoring requirements agreed to as part of the Plan of Cooperation. USGS's proposed Monitoring Plan is described below as well as in their IHA application. USGS understands that this Monitoring Plan will be subject to review by NMFS and others, and that refinements may be required as part of the MMPA consultation process.

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

Vessel-based Protected Species Observers (PSOs) will monitor for marine mammals near the seismic source vessel during all daytime airgun operations and during any nighttime start-ups of the airguns. The survey area within U.S. waters is located within high latitudes (approximately 72° to 74° North) and the project will take place during the summer when little darkness will be encountered (*see* Table 9 of the IHA application). Some periods of darkness will be encountered towards the end of the survey when there will be several hours between sunset and sunrise.

The PSO's observations will provide the real-time data needed to implement the key mitigation measures. Airgun operations will be powered-down or (if necessary) shut-down when marine mammals are observed within, or about to enter, designated EZ where there is a possibility of effects on hearing or other physical effects. Vessel-based PSOs will also watch for marine mammals near the seismic vessel for at least 30 min prior to the planned start of airgun operations after an extended shut-down of the airgun. When feasible, observations will also be made during daytime periods without seismic operations (*e.g.,* during transits).

TABLE 7—THE DAYLIGHT TIMES AND PERIODS WITHIN THE PROPOSED PROJECT AREA FROM BEGINNING (AUGUST 7, 2010) TO END (SEPTEMBER 3, 2010) OF THE PLANNED SURVEY ACTIVITIES WITHIN LATITUDES OF THE PLANNED SURVEY WITHIN U.S. WATERS. TIME IS IN ALASKA DAYLIGHT TIME (AKDT).

	72° North		*74° North*	
	August 7	*September 3*	*August 7*	*September 3*
Sunrise	*09:29*	*12:14*		*12:00*
Sunset	*06:42*	*03:45*		*03:59*
Period of daylight (hours)	*21:13*	*15:31*	*24:00*	*15:59*

• During daylight, vessel-based PSOs will watch for marine mammals near the seismic vessel during all periods of airgun activity and for a minimum of 30 min prior to the planned start of airgun operations after an extended *shut-down.*

• Although there will be only a brief period during the survey when darkness will be encountered in U.S. waters, USGS proposes to conduct nighttime as well as daytime operations. PSOs dedicated to protected species observations are proposed not to be on duty during ongoing seismic operations at night, given the very limited effectiveness of visual observation at night. At night, bridge personnel will watch for marine mammals (insofar as practical at night) and will call for the airguns to be shut-down if marine mammals are observed in or about to enter the EZ.

PSOs will be stationed aboard both the seismic source vessel (*St. Laurent*) and *Healy* during the proposed survey. The vessels will typically work together in tandem while making way through heavy ice with the Healy in the lead breaking ice and collecting multi-beam data. The St. Laurent will follow collecting seismic reflection and refraction data. In light ice conditions, the vessels will separate to maximize data collection. "Real-time" communication between the two vessels regarding marine mammal detections will be available through VHF radio.

During operations in U.S. EEZ waters, a complement of five PSOs will work on the source vessel, the *St. Laurent,* and two will be stationed on the *Healy.* Three trained PSOs will board the *St. Laurent* in Kagluktuk, Nunavut, Canada. Three experienced PSOs and one Alaska Native community observer will be aboard the *Healy* at the outset of the project. Before survey operations begin in U.S. waters, two of the PSOs on the *Healy* will transfer to the *St. Laurent* to provide additional observers during airgun operations. When not surveying in U.S. waters, the distribution of PSOs will return to three on the *St. Laurent* and four on the *Healy.*

PSOs on the *St. Laurent* will monitor for marine mammals during all daylight airgun operations. Airgun operations will be shut-down when marine mammals are observed within, or about to enter, designated EZ (*see* below) where there may be a possibility of significant effects on hearing or other physical effects. PSOs on both the source vessel and the Healy will also watch for marine mammals within or near the EZ for at least 30 min prior to the planned start of airgun operations after an extended shut-down of the airgun array. When feasible, observations will also be made during periods without seismic operations (*e.g.,* during transits). Environmental conditions will be recorded every half hour during PSO watch.

The PSOs aboard the *Healy* will also watch for marine mammals during daylight seismic activities conducted in both U.S. and international waters. They will maximize their time on watch but will not watch continuously, as will those on the *St. Laurent,* because they will not have mitigation duties and there will be only two PSOs aboard the *Healy.* The *Healy* PSOs will report sightings to the PSOs on the *St. Laurent* to alert them of possible needs for mitigation.

In U.S. waters, at least one observer, and when practical two observers, will monitor for marine mammals from the *St. Laurent* during ongoing daytime operations and nighttime start-ups (when darkness is encountered). Use of two simultaneous observers will increase the proportion of the animals present near the source vessel that are detected. PSOs will normally be on duty in shifts of no longer than four hours duration although more than one hour shift may be worked per day with a maximum of 12 hour of daily watch time. During seismic operations in international waters, PSOs aboard the *St. Laurent* will conduct eight hour watches. This schedule accommodates 24 hour/day monitoring by three PSOs which will be necessary during most of the survey when daylight will be continuous. *Healy* PSOs will limit watches to four hours in U.S. waters.

The *St. Laurent* crew will be instructed to assist in detecting marine mammals and implementing required mitigation (if practical). The crew will be given instruction on mitigation requirements and procedures for implementation of mitigation prior to the start of the seismic survey. Members of the *Healy* crew will be trained to monitor for marine mammals and asked to contact the *Healy* observers for sightings that occur while the PSOs are off-watch.

The *St. Laurent* and *Healy* are suitable platforms for observations for marine mammals. When stationed on the flying bridge, eye level will be approximately 15.4 m (51 ft) above sea level on the *St. Laurent* and approximately 24 m (78.7 ft) above sea level on the *Healy.* On both vessels the PSO will have an unobstructed view around the entire vessel from the flying bridge. If surveying from the bridge of the *St. Laurent* or the *Healy* the PSO's eye level will be approximately 12.1 m (40 ft) above sea level or 21.2 m (69 ft) above sea level, respectively. The PSO(s) will scan the area around the vessel systematically with laser range finding binoculars and with the unaided eye.

The survey will be conducted at high latitudes and continuous daylight will persist through much of the proposed survey area through the month of August. Day length will decrease to approximately 18 hours in the northern portion of the survey area by about early September. Laser range-finding binoculars (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation; this equipment is useful in training observers to estimate distances visually, but is generally not useful in measuring distances to animals directly.

When marine mammals are detected within or about to enter the designated EZ, the airgun(s) will be powered-down or shut-down immediately. The distinction between power-downs and shut-downs is described in the IHA application. Channels of communication between the PSOs and the airgun technicians will be established to assure prompt implementation of shut-downs when necessary as has been done in other recent seismic survey operations in the Arctic (*e.g.,* Haley, 2006). During power-downs and shut-downs, PSOs will continue to maintain watch to determine when the animal(s) are outside the EZ. Airgun operations will not resume until the animal is outside the EZ. The animal will be considered to have cleared the EZ if it is visually observed to have left the EZ. Alternatively, in U.S. waters the EZ will be considered clear if the animal has not been seen within the EZ for 15 min for small odontocetes and pinnipeds or 30 min for mysticetes. Within international waters the PSOs will apply a 30 min period for all species.

PSO Data and Documentation

PSOs will record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data 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 seismic source when a marine mammal is within or near the EZ.

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

(1) Species, group size, and 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 seismic source 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) above 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, as well as information regarding seismic source power-downs and shut-downs, will be recorded in a standardized format. Data will be entered into a custom database using a notebook computer. The accuracy of 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 for 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 per terms of MMPA authorizations or regulations.

(3) Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted.

(4) Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity.

(5) Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

A report on USGS activities and on the relevant monitoring and mitigation results will be submitted to NMFS within 90 days after the end of the cruise. The report will describe the operations that were conducted and sightings of marine mammals near the operations. The report will be submitted to NMFS, providing full documentation of methods, results, and interpretation pertaining to all acoustic characterization work and vessel-based monitoring. The 90-day report will summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The number and circumstances of ramp-ups, power-downs, shut-downs, and other mitigation measures will be reported. Sample size permitting, the report will also include estimates of the amount and nature of potential "take" of marine mammals by harassment or in other ways.

All injured or dead marine mammals (regardless of cause) will be reported to NMFS as soon as practicable. Report should include species or description of animal, condition of animal, location, time first found, observed behaviors (if alive) and photo or video, if available.

Encouraging and Coordinating Research

USGS will coordinate the planned marine mammal monitoring program associated with the seismic survey in the Arctic Ocean with other parties that may have interest in this area and/or be conducting marine mammal studies in the same region during operations. No other marine mammal studies are expected to occur in the main (northern) parts of the study area at the proposed time. However, other industry-funded seismic surveys may be occurring in the northeast Chukchi and/or western Beaufort Sea closer to shore, and those projects are likely to involve marine mammal monitoring. USGS has coordinated, and will continue to coordinate, with other applicable Federal, State and Borough agencies, and will comply with their requirements.

Negligible Impact and Small Numbers of Marine Mammals Analysis and Determination

The Secretary, in accordance with paragraph 101(a)(5)(D) of the MMPA, shall authorize the take of small numbers of marine mammals incidental to specified activities other than commercial fishing within a specific geographic region if, among other things, he determines that the authorized incidental take will have a "negligible impact" on species or stocks affected by the authorization. NMFS implementing regulations codified at 50 CFR 216.103 states that a "negligible impact is an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

Based on the analysis contained herein, of the likely effects of the specified activity on marine mammals and their habitat within the specific area of study for the Arctic Ocean marine geophysical survey, and taking into consideration the implementation of the mitigation and monitoring measures NMFS, on behalf of the Secretary, preliminary finds that USGS's proposed activities would result in the incidental take of small numbers of marine mammals, by Level B harassment only, and that the total taking from the proposed seismic survey would have a negligible impact on the affected species or stocks of marine mammals. As a basis for its small numbers determination, NMFS evaluated the number of individuals taken by Level B harassment relative to the size of the stock or population.

While the number of marine mammals potentially incidentally harassed will depend on the distribution and abundance of marine mammals in the vicinity of the survey activity, the number of potential Level B incidental harassment takings (*see* Table 6 above) is estimated to be small, less than a few percent of any of the estimated population sizes based on the data disclosed in Table 4 and 6 of this notice, and has been mitigated to the lowest level practicable through the incorporation of the monitoring and mitigation measures mentioned previously in this document. Tables 4 and 6 in this notice disclose the habitat regional abundance, conservation status, density, and the number of individuals exposed to sound levels greater than or equal to 120 dB (rms) (for icebreaking) or 160 dB (rms) (for seismic airgun operations). Also, there are no known important reproduction or feeding areas in the proposed action area.

For reasons stated previously in this document, the specified activities associated with the proposed survey are not likely to cause TTS, PTS or other non-auditory injury, serious injury, or death to affected marine mammals because:

(1) The likelihood that, given sufficient notice through relatively slow ship speed, marine mammals are expected to move away from a noise source that is annoying prior to its becoming potentially injurious;

(2) The fact that cetaceans and pinnipeds would have to be closer than 500 m (1,640.4 ft) and 30 m (98.4 ft), in deep water when the full array is in use at tow depth from the vessel to be exposed to levels of sound (180 dB and 190 dB, respectively) believed to have even a minimal chance of causing PTS;

(3) The fact that marine mammals would have to be closer than 2,500 m (8,202.1 ft) in deep water when the full array is in use at tow depth from the vessel to be exposed to levels of sound (160 dB) believed to have even a minimal chance at causing TTS; and

(4) The likelihood that marine mammal detection ability by trained observers is high at that short distance from the vessel.

As a result, no take by injury, serious injury, or death is anticipated or authorized, and the potential for temporary or permanent hearing impairment is very low and will be avoided through the incorporation of the proposed monitoring and mitigation measures.

In making a negligible impact determination NMFS evaluated factors such as: no anticipated injury, serious injury or mortality; the number, nature, intensity and duration of harassment (all relatively limited); the low probability that take will likely result in effects to annual rates of recruitment of survival; the context in which it occurs (*i.e.,* impacts to areas of significance, impacts to local populations, and cumulative impacts when taking into account successive/contemporaneous actions when added to baseline data); the status of stock or species of marine mammal (*i.e.,* depleted, not depleted, decreasing, increasing, stable, impact relative to the size of the population); impacts on habitat affecting rates of recruitment/survival; and the effectiveness of monitoring and mitigation measures

Impact on Availability of Affected Species for Taking for Subsistence Uses

There is subsistence hunting for marine mammals in the waters off of the coast of Alaska, in the Arctic Ocean, that implicates MMPA Section 101(a)(5)(D). Subsistence hunting and fishing continue to be prominent in the household economies and social welfare of some Alaska residents, particularly among those living in small, rural villages (Wolfe and Walker, 1987; Braund and Kruse, 2009). Subsistence remains the basis for Alaska Native culture and community. In rural Alaska, subsistence activities are often central to many aspects of human existence, including patterns of family life, artistic expression, and community religious and celebratory activities.

Subsistence Hunting

Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives; species hunted include bowhead and beluga whales; ringed, spotted, and bearded seals; walruses, and polar bears. The importance of each of the various species varies among the communities based largely on availability. Bowhead whales, belugas, and walruses are the marine mammal species primarily harvested during the time of the proposed seismic survey. Subsistence remains the basis for Alaska Native culture and community, and subsistence activities are often central to many aspects of human existence, including patterns of family life, artistic expression, and community religious and celebratory activities.

Bowhead whale hunting is a key activity in the subsistence economies of Barrow and other Native communities along the Beaufort Sea coast. The whale harvests have a great influence on social relations by strengthening the sense of Inupiat culture and heritage in addition to reinforcing family and community ties.

An overall quota system for the hunting of bowhead whales was established by the International Whaling Commission in 1977. The quota is now regulated through an agreement between NMFS and the Alaska Eskimo Whaling Commission (AEWC) which extends to 2012 (NMFS, 2008b). The AEWC allows the number of bowhead whales that each whaling community may harvest annually during five-year periods (USDI/BLM, 2005; NMFS, 2008).

The community of Barrow hunts bowhead whales in both the spring and fall during the whales' seasonal migration along the coast (*see* Figure 2 of the IHA application). Often the bulk of the Barrow bowhead harvest is taken during the spring hunt. However, with larger quotas in recent years, it is common for a substantial fraction of the annual Barrow quota to remain available for the fall hunt (*see* Table 7 of the IHA application). The communities of Nuiqsut and Kaktovik participate only in the fall bowhead harvest. The fall migration of bowhead whales that summer in the eastern Beaufort Sea typically begins in late August or September. 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 during the last week of August (Treacy, 1993; LGL and Greenridge, 1996; Greene, 1997; Greene *et al.,* 1999; Blackwell *et al.,* 2004).

TABLE 8—NUMBER OF BOWHEAD WHALE LANDING BY YEAR AT BARROW, CROSS ISLAND (NUIQSUT), AND KAKTOVIK, 1993 TO 2008. BARROW NUMBERS INCLUDE THE TOTAL NUMBER OF WHALES LANDED FOR THE YEAR FOLLOWED BY THE NUMBERS LANDED DURING THE FALL HUNT IN PARENTHESES. CROSS ISLAND (NUIQSUT) AND KAKTOVIK LANDINGS ARE IN AUTUMN.

Year	Point hope	Wainwright	Barrow	Cross island	Kaktovik
1993	2	5	23 (7)	3	3
1994	5	4	16 (1)	0	3
1995	1	5	19 (11)	4	4
1996	3	3	24 (19)	2	1
1997	4	3	30 (21)	3	4
1998	3	3	25 (16)	4	3
1999	2	5	24 (6)	3	3
2000	3	5	18 (13)	4	3
2001	4	6	27 (7)	3	4
2002	0	1	22 (17)	4	3
2003	4	5	16 (6)	4	3
2004	3	4	21 (14)	3	3
2005	7	4	29 (13)	1	3
2006	0	2	22 (19)	4	3
2007	3	4	20 (7)	3	3
2008	2	2	21 (12)	4	3

Sources: USDI/BLM and references therein; Burns *et al.,* 1993; Koski *et al.,* 2005; Suydam *et al.,* 2004, 2005, 2006, 2007, 2008, and 2009.

The spring hunt at Barrow occurs after leads open due to the deterioration of pack ice; the spring hunt typically occurs from early April until the first week of June. The location of the fall subsistence hunt depends on ice conditions and (in some years) industrial activities that influence the bowheads as they move west (Brower, 1996). In the fall, subsistence hunters use aluminum or fiberglass boats with outboards. Hunters prefer to take bowheads close to shore to avoid a long tow during which the meat can spoil, but Braund and Moorehead (1995) report that crews may (rarely) pursue whales as far as 80 km (49.7 mi). The fall hunts begin in late August or early September in Kaktovik and at Cross Island. At Barrow the fall hunt usually begins in mid-September, and mainly occurs in the waters east and northeast of Point Barrow in the Chukchi Sea (Suydam *et al.,* 2008). The whales have usually left the Beaufort Sea by late October (Treacey, 2002a,b).

The scheduling of this seismic survey has been discussed with representatives of those concerned with the subsistence bowhead hunt, most notably the AEWC, the Barrow Whaling Captains' Association, and the North Slope Borough (NSB) Department of Wildlife Management. The timing of the proposed seismic survey in early to mid-August will affect neither the spring nor the fall bowhead hunt. The *Healy* is planning to change crew after the completion of the seismic survey through Barrow via helicopter or boat. That crew change is scheduled for approximately September 4 to 5, 2010, well before the fall bowhead whaling which typically begins late September or early October. All of the proposed geophysical activities will occur offshore between 71° and 84° North latitude well north of Beaufort Sea whaling activities.

Beluga whales are available to subsistence hunters at Barrow in the spring when pack-ice conditions deteriorate and leads open up. Belugas may remain in the area through June and sometimes into July and August in ice-free waters. Hunters usually wait until after the spring bowhead whale hunt is finished before turning their attention to hunting belugas. The average annual harvest of beluga whales taken by Barrow for 1962 to 1982 was five (MMS, 1996). The Alaska Beluga Whale Committee recorded that 23 beluga whales had been harvested by Barrow hunters from 1987 to 2002, ranging from zero in 1987, 1988 and 1995 to the high of eight in 1997 (Fuller and George, 1997; Alaska Beluga Whale Committee, 2002 in USDI/BLM, 2005). The proposed seismic survey is unlikely to overlap with the beluga harvest, and the survey initiates well outside the area where impacts to beluga hunting by Barrow villagers could occur.

Ringed seals are hunted mainly from October through June. Hunting for these smaller mammals is concentrated during winter because bowhead whales, bearded seals, and caribou are available through other seasons. In winter, leads and cracks in the ice off points of land and along barrier islands are used for hunting ringed seals. The average annual ringed seal harvest by the community of Barrow from the 1960s through much of the 1980s has been estimated as 394 (*see* Table 8 of the IHA application). More recently Bacon *et al.* (2009) estimated that 586, 287, and 413 ringed seals were harvest by villagers at Barrow in 2000, 2001, and 2003, respectively. Although ringed seals are available year-round, the seismic survey will not occur during the primary period when these seals are typically harvested. Also, the seismic survey will be largely in offshore waters where the activities will not influence ringed seals in the nearshore areas where they are hunted.

The spotted seal subsistence hunt peaks in July and August at least in 1987 to 1990, but involves few animals. Spotted seals typically migrate south by October to overwinter in the Bering Sea, Admiralty Bay, less than 60 km (37.3 mi) to the east of Barrow, is a location where spotted seals are harvested. Spotted seals are also occasionally hunted in the area off Point Barrow and along the barrier islands of Elson Lagoon to the east (USDI/BLM, 2005). The average annual spotted seal harvest by the community of Barrow from 1987 to 1990 was one (Braund *et al.,* 1993; *see* Table 7 of the IHA application). More recently however, Bacon *et al.* (2009) estimated that 32, 7, and 12 spotted seals were harvested by villagers at Barrow in 2000, 2001, and 2003, respectively. Spotted seals become less abundant at Nuiqsut and Kaktovik and few if any spotted seal are harvested at these villages. The seismic survey will commence at least 115 km (71.5 mi) offshore from the preferred nearshore harvest area of these seals.

Bearded seals, although not favored for their meat, are important to subsistence activities in Barrow because of their skins. Six to nine bearded seal hides are used by whalers to cover each of the skin-covered boats traditionally used for spring whaling. Because of their valuable hides and large size, bearded seals are specifically sought. Bearded seals are harvested during the summer months in the Beaufort Sea (USDI/BLM, 2005). The animals inhabit the environment around the ice floes in the drifting ice pack, so hunting usually occurs from boats in the drift ice. Braund *et al.* (1993) estimated that 174 bearded seals were harvested annually at Barrow from 1987 to 1990 (*see* Table 8 of the IHA application). More recently Bacon *et al.* (2009) estimated that 728, 327, and 776 bearded seals were harvested by villagers at Barrow in 2000, 2001, and 2003, respectively. Braund *et al.* (1003) mapped the majority of bearded seal harvest sites from 1987 to 1990 as being within approximately 24 km (14.9 mi) of Point Barrow, well inshore of the proposed survey which is to start approximately 115 km (71.5 mi) offshore and terminate greater than 200 km (124.3 mi) offshore. The average annual take of bearded seals by the Barrow community from 1987 to 1990 was 174 (*see* Table 8 of the IHA application).

TABLE 9—AVERAGE ANNUAL TAKE OF MARINE MAMMALS OTHER THAN BOWHEAD WHALES HARVEST BY THE COMMUNITY OF BARROW (COMPILED BY LGL ALASKA RESEARCH ASSOCIATES, 2004)

Beluga whales	Ringed seals	Bearded seals	Spotted seals
5**	394*	174*	1*

* Average annual harvest for years 1987 to 1990 (Braund *et al.,* 1993).
** Average annual harvest for years 1962 to 1982 (MMS, 1996).

Plan of Cooperation

The USGS has communicated with community authorities and residents of Barrow to foster understanding of the proposed survey. There are elements of the proposed survey, intrinsic to the project, that significantly limit the potential conflict with subsistence users. Operations will be conducted during early August before bowhead whale hunting typically occurs off Barrow and approximately 108 km (67.1 mi) offshore, farther offshore than traditional subsistence hunting grounds. USGS continues to work with the people of Barrow to identify and avoid areas of potential conflict.

- The USGS initiated contact with NSB scientists and the chair of the AEWC in mid-December, 2010 via an e-mailed description of the proposed survey that included components intended to minimize potential subsistence conflict.

- Invitations were extended December 31, 2009 to members of the NSB, AEWC, and North Slope Communities to attend a teleconference arranged for January 11, 2010. The teleconference served as a venue to promote understanding of the project and discuss shareholder concerns. Participants in the teleconference included Harry Brower, chair of the AEWC, and NSB wildlife biologist Dr. Robert Suydam.

- To further promote cooperation between the project researchers and the community, Dr. Deborah Hutchinson with USGS presented the proposed survey at a meeting of the AEWC in Barrow on February 11, 2010. Survey plans were explained to local hunters and whaling captains, including NSB Department of Wildlife Management biologists, Craig George and Dr. Robert Suydam. Dr. Hutchinson consulted with stakeholders about their concerns and discussed the aspects of the survey designed to mitigate impacts.

- Dr. Deborah Hutchinson of the USGS e-mailed a summary of the topics discussed during the teleconference and the AEWC meeting in Barrow to representatives of the NSB, AEWC, and North Slope communities. These included:
    - Surveying within U.S. waters is scheduled early (approximately August 7 to 12) to avoid conflict with hunters.
    - The EA and IHA application will be distributed as early as possible to NSB and AEWC.
    - A community observer will be present aboard the *Healy* during the project.
    - Mitigation of the one crew transfer near Barrow in early September will be arranged—probably through Barrow Volunteer Search and Rescue.
- Representatives of the USGS attended the Arctic Open-water Meeting in Anchorage, March 22 to 24, 2010.
    - Dr. Deborah Hutchinson presented information regarding the proposed survey to the general assembly.
    - Dr. Jonathan Childs and Dr. Deborah Hutchinson met with stakeholders and agency representatives while at the meeting.

Subsequent meetings with whaling captains, other community representatives, the AEWC, NSB, and any other parties to the plan will be held if necessary to coordinate the planned seismic survey operation with subsistence hunting activity. The USGS has informed the chairman of the Alaska Eskimo Whaling Committee (AEWC), Harry Brower, Jr., of its survey plan.

As noted above and in the IHA application, in the unlikely event that subsistence hunting or fishing is occurring within 5 km (3 mi) of the project vessel tracklines, or where potential impacts could occur, the airgun operations will be suspended until the vessel is greater than 5 km away and otherwise not interfering with subsistence activities.

Endangered Species Act (ESA)

On May 21, 2010, USGS initiated informal consultation, under Section 7 of the ESA, with the NMFS, Office of Protected Resources, Endangered Species Division, on this proposed seismic survey. Based on the information provided by USGS, NMFS concurred with their determination that the activities conducted during the proposed seismic survey are not likely to adversely affect endangered whales in the study area. No designated critical habitat occurs within the action area for this experiment, therefore, no critical habitat will be affected by the proposed bathymetric and seismic surveys and other associated activities.

National Environmental Policy Act (NEPA)

With its complete application, USGS provided NMFS an Environmental Assessment (EA) analyzing the direct, indirect and cumulative environmental impacts of the proposed specified activities on marine mammals including those listed as threatened or endangered under the ESA. The EA, prepared by LGL Environmental Research Associated (LGL) on behalf of USGS, USCG, and NOAA is titled Draft Environmental Assessment of a Marine Geophysical Survey of Portions of the Arctic Ocean, August–September, 2010 (EA). Prior to making a final decision on the IHA application, NMFS will either prepare an independent EA, or, after review and evaluation of the USGS EA for consistency with the regulations published by the Council of Environmental Quality (CEQ) and NOAA Administrative Order 216–6, Environmental Review Procedures for Implementing the National Environmental Policy Act, adopt the USGS EA and make a decision of whether or not to issue a Finding of No Significant Impact (FONSI).

Preliminary Determinations

NMFS has preliminarily determined that the impact of conducting the specific marine seismic survey activities described in this notice and the IHA request in the specific geographic region within the U.S. EEZ within the Arctic Ocean may result, at worst, in a temporary modification in behavior (Level B harassment) of small numbers of marine mammals. No take by injury (Level A harassment), serious injury, or mortality is anticipated, and take by harassment will be at the lowest level practicable due to incorporation of the mitigation and monitoring measures mentioned previously in this document. Further, this activity is expected to result in a negligible impact on the affected species or stocks of marine mammals. NMFS has preliminarily determined that this proposed activity will not have an unmitigable impact on the availability of the affected species or stock of marine mammals for subsistence uses. USGS will coordinate with local communities on a Plan of Cooperation.

Proposed Authorization

As a result of these preliminary determinations, NMFS proposes to issue an IHA to USGS for conducting a marine seismic survey in the Arctic Ocean from August to September, 2010, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. The duration of the IHA would not exceed one year from the date of its issuance.

Information Solicited

NMFS asks interested persons to submit comments and information concerning this proposed project and NMFS' preliminary determination of issuing an IHA (*see* **ADDRESSES**). Concurrent with the publication of this notice in the **Federal Register**, NMFS is forwarding copies of this application to the Marine Mammal Commission and its Committee of Scientific Advisors.

Dated: June 29, 2010.

Helen M. Golde,

Deputy Director, Office of Protected Resources, National Marine Fisheries Service.

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