DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XA811

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to an Exploration Drilling Program in the Chukchi Sea, Alaska

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

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

SUMMARY: NMFS received an application from Shell Offshore Inc. (Shell) for an Incidental Harassment Authorization (IHA) to take marine mammals, by harassment, incidental to offshore exploration drilling on Outer Continental Shelf (OCS) leases in the Chukchi Sea, Alaska. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an IHA to Shell to take, by Level B harassment only, 12 species of marine mammals during the specified activity.

DATES: Comments and information must be received no later than December 9, 2011.

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

Instructions: 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, which contains several attachments, including Shell's marine mammal mitigation and monitoring plan and Plan of Cooperation, 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 also be viewed, by appointment, during regular business hours, at the aforementioned address.

FOR FURTHER INFORMATION CONTACT: Candace Nachman, Office of Protected Resources, NMFS, (301) 427–8401.

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 to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. 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.

Authorization for incidental takings 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 (where relevant), 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 U.S. can apply for an authorization to incidentally take small numbers of marine mammals by harassment. 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 on any proposed authorizations for the incidental harassment of marine mammals. Within 45 days of the close of the comment period, NMFS must either issue or deny the authorization.

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''].

Summary of Request

NMFS received an application on June 30, 2011, from Shell for the taking, by harassment, of marine mammals incidental to offshore exploration drilling on OCS leases in the Chukchi Sea, Alaska. NMFS reviewed Shell's application and identified a number of issues requiring further clarification. After addressing comments from NMFS, Shell modified its application and submitted a revised application on September 12, 2011. NMFS carefully evaluated Shell's application, including their analyses, and determined that the application is complete. The September 12, 2011, application is the one available for public comment (see **ADDRESSES**) and considered by NMFS for this proposed IHA.

Shell plans to drill up to three exploration wells at three possible drill sites and potentially a partial well at a fourth drill site on OCS leases offshore in the Chukchi Sea, Alaska, during the 2012 Arctic open-water season (July through October). Impacts to marine mammals may occur from noise produced by the drillship, zero-offset vertical seismic profile (ZVSP) surveys, and supporting vessels (including icebreakers) and aircraft. Shell has requested an authorization to take 13 marine mammal species by Level B harassment. However, the narwhal (*Monodon monoceros*) is not expected to be found in the activity area. Therefore, NMFS is proposing to authorize take of 12 marine mammal species, by Level B harassment, incidental to Shell's offshore exploration drilling in the Chukchi Sea. These species include: Beluga whale (*Delphinapterus leucas*); bowhead whale (*Balaena mysticetus*); gray whale (*Eschrichtius robustus*); killer whale (*Orcinus orca*); minke whale (*Balaenoptera acutorostrata*); fin whale (*Balaenoptera physalus*); humpback whale (*Megaptera novaeangliae*); harbor porpoise (*Phocoena phocoena*); bearded seal (*Erignathus barbatus*); ringed seal (*Phoca hispida*); spotted seal (*P. largha*); and ribbon seal (*Histriophoca fasciata*).

Description of the Specified Activity and Specified Geographic Region

Shell plans to conduct an offshore exploration drilling program on U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM, formerly the Minerals Management

Service) Alaska OCS leases located greater than 64 mi (103 km) from the Chukchi Sea coast during the 2012 open-water season. The leases were acquired during the Chukchi Sea Oil and Gas Lease Sale 193 held in February 2008. During the 2012 drilling program, Shell plans to drill up to three exploration wells at three drill sites and potentially a partial well at a fourth drill site at the prospect known as Burger. See Figure 1–1 in Shell's application for the lease block and drill site locations (see **ADDRESSES**). All drilling is planned to be vertical.

Exploration Drilling

All of the possible Chukchi Sea offshore drill sites are located between 65 and 78 mi (105 and 125.5 km) from the Chukchi coast in water depths between 143 and 150 ft (43.7 and 45.8 m). Table 2–1 in Shell's application provides the coordinates for the drill sites (see **ADDRESSES**). All of the proposed wells would be at Shell's Burger prospect. Shell has identified a total of six lease blocks on this prospect where drilling could occur.

(1) Drilling Vessel

Shell proposes to use the ice strengthened drillship *Discoverer* to drill the wells. The *Discoverer* is a true drillship and is a largely self-contained drillship that offers full accommodations for a crew of up to 140 persons. The *Discoverer* is 514 ft (156.7 m) long with a maximum height (above keel) of 274 ft (83.7 m). It is an anchored drillship with an 8-point anchored mooring system and would likely have a maximum anchor radius of 2,969–2,986 ft (905–910 m) at either the Sivulliq or Torpedo drill sites. While on location at the drill sites, the *Discoverer* will be affixed to the seafloor using eight 7,000 kg (7.7 ton) Stevpris anchors arranged in a radial array. The underwater fairleads prevent ice fouling of the anchor lines. Turret mooring allows orientation of the vessel's bow into the prevailing ice drift direction to present minimum hull exposure to drifting ice. The vessel is rotated around the turret by hydraulic jacks. Rotation can be augmented by the use of the fitted bow and stern thrusters. The hull has been reinforced for ice resistance. Ice-strengthened sponsons have been retrofitted to the ship's hull. Additional details about the drillship can be found in Attachment A of Shell's IHA application (see **ADDRESSES**).

(2) Support Vessels

During the 2012 drilling season, the *Discoverer* will be attended by eight vessels that will be used for ice management, anchor handling, oil spill response (OSR), refueling, resupply, and servicing of the exploration drilling operations. The ice-management vessels will consist of an icebreaker and an anchor handler. The OSR vessels supporting the exploration drilling program include a dedicated OSR barge and an OSR vessel, both of which have associated smaller workboats, an oil spill tanker, and a containment barge. Tables 1–2a and 1–2b in Shell's application provide a list of the support and OSR vessels that will be used during the drilling program.

Shell's base plan is for the ice management vessel and the anchor handler, or similar vessels, the oil spill vessels (OSVs), and potentially some of the OSR vessels to accompany the *Discoverer* traveling north from Dutch Harbor through the Bering Strait, on or about July 1, 2012, then into the Chukchi Sea, before arriving on location approximately July 4. Exploration drilling is expected to be complete by October 31, 2012. At the completion of the drilling season, one or two ice-management vessels, along with various support vessels, such as the OSR fleet, will accompany the *Discoverer* as it travels south out of the Chukchi Sea and through the Bering Strait to Dutch Harbor. Subject to ice conditions, alternate exit routes may be considered.

The *M/V Fennica* (*Fennica*), or a similar vessel, will serve as the primary ice management vessel, and the *M/V Tor Viking* (*Tor Viking*), or a similar vessel, will serve as the primary anchor handling vessel in support of the *Discoverer.* The *Fennica* and *Tor Viking* will remain at a location approximately 25 mi (40 km) upwind and upcurrent of the drillship when not in use. Any ice management would be expected to occur within 0.6–6 mi (1–9.6 km) upwind from the *Discoverer.* When managing ice, the vessels will generally be confined to a 40° arc up to 3.1 mi (4.9 km) upwind originating at the drilling vessel (see Figure 1–3 in Shell's application). It is anticipated that the ice management vessels will be managing ice for up to 38% of the time when within 25 mi (40 km) of the *Discoverer.* Active ice management involves using the ice management vessel to steer larger floes so that their path does not intersect with the drill site. Around-the-clock ice forecasting using real-time satellite coverage (available through Shell Ice and Weather Advisory Center [SIWAC]) will support the ice management duties. The proposed exploration drilling operations will require two OSVs to resupply the *Discoverer* with exploration drilling materials and supplies from facilities in Dutch Harbor and fuel.

(3) Aircraft

Offshore operations will be serviced by helicopters operated out of onshore support base locations. A Sikorsky S–92 or Eurocopter EC225 capable of transporting 10 to 12 persons will be used to transport crews between the onshore support base and the drillship. The helicopters will also be used to haul small amounts of food, materials, equipment, and waste between vessels and the shorebase. The helicopter will be housed at facilities at the Barrow airport. Shell will have a second helicopter for Search and Rescue (SAR). The SAR helicopter is expected to be a Sikorsky S–61, S–92, Eurocopter EC225, or similar model. This aircraft will stay grounded at the Barrow shorebase location except during training drills, emergencies, and other non-routine events.

A fixed wing propeller or turboprop aircraft, such as a Saab 340–B 30-seat, Beechcraft 1900, or deHavilland Dash8 will be used to routinely transport crews, materials, and equipment between the shorebase and hub airports such as Barrow or Fairbanks. A fixed wing aircraft, deHavilland Twin Otter (DHC–6) will be used for marine mammal monitoring flights. Table 1–2c in Shell's application presents the aircraft planned to support the exploration drilling program.

Zero-Offset Vertical Seismic Profile

At the end of each drill hole, Shell may conduct a geophysical survey referred to as ZVSP at each drill site where a well is drilled in 2012. During ZVSP surveys, an airgun array is deployed at a location near or adjacent to the drilling vessel, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically in a string, are then raised up to the next interval in the wellbore, and the process is repeated until the entire wellbore has been surveyed. The purpose of the ZVSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell intends to conduct a particular form of vertical seismic profile known as a ZVSP, in which the sound source is maintained at a constant location near the wellbore (see Figure 1–2 in Shell's application). A typical sound source that would be used by Shell in 2012 is the ITAGA eight-airgun array, which consists of four 150 in^3 airguns and four 40 in^3 airguns. These airguns can be activated in any combination, and Shell intends to utilize the minimum airgun volume required to obtain an acceptable signal. Current specifications of the array are provided in Table 1–3 of Shell's application. The airgun array is depicted within its frame or sled, which is approximately 6 ft x 5 ft x 10 ft (1.8 m x 1.5 m x 3 m) (see photograph in Shell's application). Typical receivers would consist of a Schlumberger wireline four level Vertical Seismic Imager (VSI) tool, which has four receivers 50-ft (15-m) apart.

A ZVSP survey is normally conducted at each well after total depth is reached but may be conducted at a shallower depth. For each survey, Shell plans to deploy the airgun array over the side of the *Discoverer* with a crane (sound source will be 50–200 ft [15–61 m] from the wellhead depending on crane location) to a depth of approximately 10–23 ft (3–7 m) below the water surface. The VSI, with its four receivers, will be temporarily anchored in the wellbore at depth. The sound source will be pressured up to 2,000 pounds per square inch (psi) and activated 5–7 times at approximately 20-second intervals. The VSI will then be moved to the next interval of the wellbore and reanchored, after which the airgun array will again be activated 5–7 times. This process will be repeated until the entire well bore is surveyed in this manner. The interval between anchor points for the VSI usually is between 200 and 300 ft (61 and 91 m). A normal ZVSP survey is conducted over a period of about 10–14 hours, depending on the depth of the well and the number of anchoring points. Therefore, considering a few different scenarios, the airgun array could be fired between 117 and 245 times during the 10–14 hour period. For example, a 7,000-ft (2,133.6-m) well with 200-ft (61-m) spacing and seven activations per station would result in the airgun array being fired 245 times to survey the entire well. That same 7,000-ft (2,133.6-m) well with 300-ft (91-m) spacing and five activations would result in the airgun array being fired 117 times to survey the entire well. The remainder of the time during those 10–14 hours when the airgun is not firing is used to move and anchor the geophone array.

Ice Management and Forecasting

Shell recognizes that the drilling program is located in an area that is characterized by active sea ice movement, ice scouring, and storm surges. In anticipation of potential ice hazards that may be encountered, Shell has developed and will implement an Ice Management Plan (IMP; see Attachment B in Shell's IHA application) to ensure real-time ice and weather forecasting is conducted in order to identify conditions that might put operations at risk and will modify its activities accordingly. The IMP also contains ice threat classification levels depending on the time available to suspend drilling operations, secure the well, and escape from advancing hazardous ice. Real-time ice and weather forecasting will be available to operations personnel for planning purposes and to alert the fleet of impending hazardous ice and weather conditions. Ice and weather forecasting is provided by SIWAC. The center is continuously manned by experienced personnel, who rely on a number of data sources for ice forecasting and tracking, including:

- Radarsat and Envisat data—satellites with Synthetic Aperture Radar, providing all-weather imagery of ice conditions with very high resolution;
- Moderate Resolution Imaging Spectroradiometer—a satellite providing lower resolution visual and near infrared imagery;
- Aerial reconnaissance—provided by specially deployed fixed wing or rotary wing aircraft for confirmation of ice conditions and position;
- Reports from ice specialists on the ice management and anchor handling vessels and from the ice observer on the drillship;
- Incidental ice data provided by commercial ships transiting the area; and
- Information from NOAA ice centers and the University of Colorado.

Drift ice will be actively managed by ice management vessels, consisting of an ice management vessel and an anchor handling vessel. Ice management for safe operation of Shell's planned exploration drilling program will occur far out in the OCS, remote from the vicinities of any routine marine vessel traffic in the Chukchi Sea causing no threat to public safety or services that occur near to shore. Shell vessels will also communicate movements and activities through the 2012 North Slope Communications Centers. Management of ice by ice management vessels will occur during a drilling season predominated by open water and thus is not expected to contribute to ice hazards, such as ridging, override, or pileup in an offshore or nearshore environment.

The ice-management/anchor handling vessels would manage the ice by deflecting any ice floes that could affect the *Discoverer* when it is drilling and would also handle the *Discoverer's* anchors during connection to and separation from the seafloor. When managing ice, the ice management and anchor handling vessels will generally be operating at a 40° arc up to 3.1 mi (4.9 km) upwind originating at the *Discoverer* (see Figure 1–3 in Shell's application).

The ice-management/anchor handling vessels would manage any ice floes upwind of the *Discoverer* by deflecting those that could affect the *Discoverer* when it is on location conducting exploration drilling operations. The ice-management/anchor handling vessels would also manage the *Discoverer's* anchors during connection to and separation from the seafloor. The ice floe frequency and intensity are unpredictable and could range from no ice to ice sufficiently dense that the fleet has insufficient capacity to continue operating, and the *Discoverer* would need to disconnect from its anchors and move off site. If ice is present, ice management activities may be necessary in early July and towards the end of operations in late October, but it is not expected to be needed throughout the proposed drilling season. Shell has indicated that when ice is present at the drill site, ice disturbance will be limited to the minimum needed to allow drilling to continue. First-year ice (*i.e.,* ice that formed in the most recent autumn-winter period) will be the type most likely to be encountered. The ice management vessels will be tasked with managing the ice so that it will flow easily around and past the *Discoverer* without building up in front of or around it. This type of ice is managed by the ice management vessel continually moving back and forth across the drift line, directly up-drift of the *Discoverer* and making turns at both ends. During ice management, the vessel's propeller is rotating at approximately 15–20 percent of the vessel's propeller rotation capacity. Ice management occurs with slow movements of the vessel using lower power and therefore slower propeller rotation speed (*i.e.,* lower cavitation), allowing for fewer repositions of the vessel, thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice (*i.e.,* ice that has survived at least one summer melt season) ridges that would be managed at a much slower speed than that used to manage first-year ice.

During Chukchi Sea exploration drilling operations, Shell has indicated that they do not intend to conduct any icebreaking activities; rather, Shell would deploy its support vessels to manage ice as described here. As detailed in Shell's IMP (see Attachment B of Shell's IHA application), actual breaking of ice would occur only in the unlikely event that ice conditions in the immediate vicinity of operations create a safety hazard for the drilling vessel. In such a circumstance, operations personnel will follow the guidelines established in the IMP to evaluate ice conditions and make the formal designation of a hazardous, ice alert condition, which would trigger the procedures that govern any actual icebreaking operations. Historical data relative to ice conditions in the Chukchi Sea in the vicinity of Shell's planned operations, and during the timeframe for those operations, establish that there is a very low probability (*e.g.,* minimal) for the type of hazardous ice conditions that might necessitate icebreaking (*e.g.,* records of the National Naval Ice Center archives). This probability could be greater at the shoulders of the drilling season (early July or late October); therefore, for purposes of evaluating possible impacts of the planned activities, Shell has assumed limited icebreaking activities for a very limited period of time, and estimated incidental takes of marine mammals from such activities.

Timeframe of Activities

Shell proposes to mobilize the drillship and its fleet of vessels from Dutch Harbor and to travel through the Bering Strait on or about July 1, 2012. The vessels would then travel into the Chukchi Sea, arriving on location at the Burger prospect in the Chukchi Sea on approximately July 4, 2012. Shell proposes to conduct the exploration drilling program through October 31, 2012. At the end of the exploration drilling season, the *Discoverer* and its support vessels would travel south out of the Chukchi Sea through the Bering Strait to Dutch Harbor. Subject to ice conditions, alternate exit routes may be considered.

Shell anticipates that the exploration drilling program will require approximately 32 days per well, including mudline cellar construction. Therefore, if Shell is able to drill three exploration wells during the 2012 open-water season, it would require a total of 96 days. If Shell is able to drill part of a fourth well, it would add an additional 1–32 days to the season but would not extend beyond October 31, 2012. These estimates do not include any downtime for weather or other operational delays. Time to conduct the ZVSP surveys for each well is included in the 32 drilling days for each well. Shell also assumes approximately 10 additional days will be needed for transit, drillship mobilization and mooring, drillship moves between locations, and drillship demobilization.

Activities associated with the 2012 Chukchi Sea exploration drilling program include operation of the *Discoverer,* associated support vessels, crew change support, and resupply, ZVSP surveys, and icebreaking. The *Discoverer* will remain at the location of the designated exploration drill sites except when mobilizing and demobilizing to and from the Chukchi Sea, transiting between drill sites, and temporarily moving off location if it is determined ice conditions require such a move to ensure the safety of personnel and/or the environment in accordance with Shell's IMP. The anchor handler and OSR vessels will remain in close proximity to the drillship during drilling operations.

Exploratory Drilling Program Sound Characteristics

Potential impacts to marine mammals could occur from the noise produced by the drillship and its support vessels (including the icebreakers), aircraft, and the airgun array during ZVSP surveys. The drillship produces continuous noise into the marine environment. NMFS currently uses a threshold of 120 dB re 1 μPa (rms) for the onset of Level B harassment from continuous sound sources. This 120 dB threshold is also applicable for the icebreakers when actively managing or breaking ice. The drilling vessel to be used will be the *Discoverer.* The airgun array proposed to be used by Shell for the ZVSP surveys produces pulsed noise into the marine environment. NMFS currently uses a threshold of 160 dB re 1 μPa (rms) for the onset of Level B harassment from pulsed sound sources.

(1) Drilling Sounds

Exploratory drilling will be conducted from the *Discoverer,* a vessel specifically designed for such operations in the Arctic. Underwater sound propagation results from the use of generators, drilling machinery, and the rig itself. Received sound levels during vessel-based operations may fluctuate depending on the specific type of activity at a given time and aspect from the vessel. Underwater sound levels may also depend on the specific equipment in operation. Lower sound levels have been reported during well logging than during drilling operations (Greene, 1987b), and underwater sound levels appeared to be lower at the bow and stern aspects than at the beam (Greene, 1987a).

Most drilling sounds generated from vessel-based operations occur at relatively low frequencies below 600 Hz although tones up to 1,850 Hz were recorded by Greene (1987a) during drilling operations in the Beaufort Sea. At a range of 558 ft (170 m) the 20–1000 Hz band level was 122–125 dB for the drillship *Explorer I.* Underwater sound levels were slightly higher (134 dB) during drilling activity from the *Northern Explorer II* at a range of 656 ft (200 m), although tones were only recorded below 600 Hz. Underwater sound measurements from the *Kulluk* at 0.62 mi (1 km) were higher (143 dB) than from the other two vessels.

Sound measurements from the *Discoverer* have not previously been conducted in the Arctic. However, measurements of sounds produced by the *Discoverer* were made in the South China Sea in 2009 (Austin and Warner, 2010). The results of those measurements were used to model the sound propagation from the *Discoverer* (including a nearby support vessel) at planned exploration drilling locations in the Chukchi Sea (Warner and Hannay, 2011). Broadband source levels of sounds produced by the *Discoverer* varied by activity and direction from the ship but were generally between 177 and 185 dB re 1 μPa at 1 m (rms) (Austin and Warner, 2010). Once on location at the drill sites in Chukchi Sea, Shell plans to take measurements of the drillship to quantify the absolute sound levels produced by drilling and to monitor their variations with time, distance, and direction from the drilling vessel.

(2) Vessel Sounds

In addition to the drillship, various types of vessels will be used in support of the operations, including ice management vessels, anchor handlers, offshore supply vessels, barges and tugs, and OSR vessels. Sounds from boats and vessels have been reported extensively (Greene and Moore, 1995; Blackwell and Greene, 2002, 2005, 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort Seas. Results of these measurements were reported in various 90-day and comprehensive reports since 2007 (*e.g.,* Aerts *et al.,* 2008; Hauser *et al.,* 2008; Brueggeman, 2009; Ireland *et al.,* 2009). For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB at distances ranging from approximately 1.5 to 2.3 mi (2.4 to 3.7 km) from various types of barges. MacDonald *et* *al.* (2008) estimated higher underwater sound pressure levels (SPLs) from the seismic vessel *Gilavar* of 120 dB at approximately 13 mi (21 km) from the source, although the sound level was only 150 dB at 85 ft (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies.

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross, 1976). Propeller cavitation and singing are produced outside the hull, whereas propulsion or other machinery noise originates inside the hull. There are additional sounds produced by vessel activity, such as pumps, generators, flow noise from water passing over the hull, and bubbles breaking in the wake. Icebreakers contribute greater sound levels during icebreaking activities than ships of similar size during normal operation in open water (Richardson *et al.,* 1995a). This higher sound production results from the greater amount of power and propeller cavitation required when operating in thick ice.

Measurements of the icebreaking supply ship *Robert Lemeur* pushing and breaking ice during exploration drilling operations in the Beaufort Sea in 1986 resulted in an estimated broadband source level of 193 dB re 1 μPa at 1 m (Greene, 1987a; Richardson *et al.,* 1995a).

Sound levels during ice management activities would not be as intense as during icebreaking, and the resulting effects to marine species would be less significant in comparison. During ice management, the vessel's propeller is rotating at approximately 15–20 percent of the vessel's propeller rotation capacity. Instead of actually breaking ice, during ice management, the vessel redirects and repositions the ice by pushing it away from the direction of the drillship at slow speeds so that the ice floe does not slip past the vessel bow. Basically, ice management occurs at slower speed, lower power, and slower propeller rotation speed (*i.e.,* lower cavitation), allowing for fewer repositions of the vessel, thereby reducing cavitation effects in the water than would occur during icebreaking. Once on location at the drill sites in the Chukchi Sea, Shell plans to measure the sound levels produced by vessels operating in support of drilling operations. These vessels will include crew change vessels, tugs, ice management vessels, and OSR vessels.

(3) Aircraft Sound

Helicopters may be used for personnel and equipment transport to and from the drillship. Under calm conditions, rotor and engine sounds are coupled into the water within a 26° cone beneath the aircraft. Some of the sound will transmit beyond the immediate area, and some sound will enter the water outside the 26° area when the sea surface is rough. However, scattering and absorption will limit lateral propagation in the shallow water.

Dominant tones in noise spectra from helicopters are generally below 500 Hz (Greene and Moore, 1995). Harmonics of the main rotor and tail rotor usually dominate the sound from helicopters; however, many additional tones associated with the engines and other rotating parts are sometimes present.

Because of doppler shift effects, the frequencies of tones received at a stationary site diminish when an aircraft passes overhead. The apparent frequency is increased while the aircraft approaches and is reduced while it moves away.

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drillship will generally maintain straight-line routes at altitudes of at least 1,500 ft (457 m) above sea level, thereby limiting the received levels at and below the surface. Aircraft travel would be controlled by Federal Aviation Administration approved flight paths.

(4) Vertical Seismic Profile Sound

A typical eight airgun array (4×40 in^3 airguns and 4×150 in^3 airguns, for a total discharge volume of 760 in^3) would be used to perform ZVSP surveys, if conducted after the completion of each exploratory well. Typically, a single ZVSP survey will be performed when the well has reached proposed total depth or final depth; although, in some instances, a prior ZVSP will have been performed at a shallower depth. A typical survey will last 10–14 hours, depending on the depth of the well and the number of anchoring points, and include firings of the full array, plus additional firing of a single 40-in^3 airgun to be used as a ''mitigation airgun'' while the geophones are relocated within the wellbore. The source level for the airgun array proposed for use by Shell will differ based on source depth. At a depth of 9.8 ft (3 m), the SPL is 238 dB re 1 μPa at 1 m, and at a depth of 16.4 ft (5 m), the SPL is 241 dB re 1 μPa at 1 m, with most energy between 20 and 140 Hz.

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle. Typical high-energy airgun arrays emit most energy at 10–120 Hz. However, the pulses contain significant energy up to 500–1,000 Hz and some energy at higher frequencies (Goold and Fish, 1998; Potter *et al.,* 2007).

Although there will be several support vessels in the drilling operations area, NMFS considers the possibility of collisions with marine mammals highly unlikely. Once on location, the majority of the support vessels will remain in the area of the drillship throughout the 2012 drilling season and will not be making trips between the shorebase and the offshore vessels. When not needed for ice management/icebreaking operations, the icebreaker and anchor handler will remain approximately 25 mi (40 km) upwind and upcurrent of the drillship. Any ice management/icebreaking activity would be expected to occur at a distance of 0.6–12 mi (1–19 km) upwind and upcurrent of the drillship. As the crew change/resupply activities are considered part of normal vessel traffic and are not anticipated to impact marine mammals in a manner that would rise to the level of taking, those activities are not considered further in this document.

Description of Marine Mammals in the Area of the Specified Activity

The Chukchi Sea supports a diverse assemblage of marine mammals, including: bowhead, gray, beluga, killer, minke, humpback, and fin whales; harbor porpoise; ringed, ribbon, spotted, and bearded seals; narwhals; polar bears (*Ursus maritimus*); and walruses (*Odobenus rosmarus divergens;* see Table 4–1 in Shell's application). The bowhead, humpback, and fin whales are listed as ''endangered'' under the Endangered Species Act (ESA) and as depleted under the MMPA. Certain stocks or populations of gray, beluga, and killer whales and spotted seals are listed as endangered or are proposed for listing under the ESA; however, none of those stocks or populations occur in the proposed activity area. On December 10, 2010, NMFS published a notice of proposed threatened status for subspecies of the ringed seal (75 FR 77476) and a notice of proposed threatened and not warranted status for subspecies and distinct population segments of the bearded seal (75 FR 77496) in the **Federal Register.** Neither of these two ice seal species is considered depleted under the MMPA. Additionally, the ribbon seal is considered a ''species of concern'' under the ESA. Both the walrus and the polar bear are managed by the U.S. Fish and Wildlife Service (USFWS) and are not considered further in this proposed IHA notice.

Of these species, 12 are expected to occur in the area of Shell's proposed operations. These species include: The bowhead, gray, humpback, minke, fin, killer, and beluga whales; harbor porpoise; and the ringed, spotted, bearded, and ribbon seals. Beluga, bowhead, and gray whales, harbor porpoise, and ringed, bearded, and spotted seals are anticipated to be encountered more than the other marine mammal species mentioned here. The marine mammal species that is likely to be encountered most widely (in space and time) throughout the period of the proposed drilling program is the ringed seal. Encounters with bowhead and gray whales are expected to be limited to particular seasons, as discussed later in this document. Where available, Shell used density estimates from peer-reviewed literature in the application. In cases where density estimates were not readily available in the peer-reviewed literature, Shell used other methods to derive the estimates. NMFS reviewed the density estimate descriptions and articles from which estimates were derived and requested additional information to better explain the density estimates presented by Shell in its application. This additional information was included in the revised IHA application. The explanation for those derivations and the actual density estimates are described later in this document (see the ''Estimated Take by Incidental Harassment'' section).

The narwhal occurs in Canadian waters and occasionally in the Alaskan Beaufort Sea and the Chukchi Sea, but it is considered extralimital in U.S. waters and is not expected to be encountered. There are scattered records of narwhal in Alaskan waters, including reports by subsistence hunters, where the species is considered extralimital (Reeves *et al.,* 2002). Due to the rarity of this species in the proposed project area and the remote chance it would be affected by Shell's proposed Chukchi Sea drilling activities, this species is not discussed further in this proposed IHA notice.

Shell's application contains information on the status, distribution, seasonal distribution, abundance, and life history of each of the species under NMFS jurisdiction mentioned in this document. When reviewing the application, NMFS determined that the species descriptions provided by Shell correctly characterized the status, distribution, seasonal distribution, and abundance of each species. Please refer to the application for that information (see **ADDRESSES**). Additional information can also be found in the NMFS Stock Assessment Reports (SAR). The Alaska 2010 SAR is available at: *http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2010.pdf.*

Brief Background on Marine Mammal Hearing

When considering the influence of various kinds of sound on the marine environment, it is necessary to understand that different kinds of marine life are sensitive to different frequencies of sound. Based on available behavioral data, audiograms have been derived using auditory evoked potentials, anatomical modeling, and other data, Southall *et al.* (2007) designate ''functional hearing groups'' for marine mammals and estimate the lower and upper frequencies of functional hearing of the groups. The functional groups and the associated frequencies are indicated below (though animals are less sensitive to sounds at the outer edge of their functional range and most sensitive to sounds of frequencies within a smaller range somewhere in the middle of their functional hearing range):

- Low frequency cetaceans (13 species of mysticetes): functional hearing is estimated to occur between approximately 7 Hz and 22 kHz (however, a study by Au *et al.* (2006) of humpback whale songs indicate that the range may extend to at least 24 kHz);
- Mid-frequency cetaceans (32 species of dolphins, six species of larger toothed whales, and 19 species of beaked and bottlenose whales): functional hearing is estimated to occur between approximately 150 Hz and 160 kHz;
- High frequency cetaceans (eight species of true porpoises, six species of river dolphins, Kogia, the franciscana, and four species of cephalorhynchids): functional hearing is estimated to occur between approximately 200 Hz and 180 kHz; and
- Pinnipeds in Water: functional hearing is estimated to occur between approximately 75 Hz and 75 kHz, with the greatest sensitivity between approximately 700 Hz and 20 kHz.

As mentioned previously in this document, 12 marine mammal species (four pinniped and eight cetacean species) are likely to occur in the proposed drilling area. Of the eight cetacean species likely to occur in Shell's project area, five are classified as low frequency cetaceans (*i.e.,* bowhead, gray, humpback, minke, and fin whales), two are classified as mid-frequency cetaceans (*i.e.,* beluga and killer whales), and one is classified as a high-frequency cetacean (*i.e.,* harbor porpoise) (Southall *et al.,* 2007).

Underwater audiograms have been obtained using behavioral methods for four species of phocinid seals: the ringed, harbor, harp, and northern elephant seals (reviewed in Richardson *et al.,* 1995a; Kastak and Schusterman, 1998). Below 30–50 kHz, the hearing threshold of phocinids is essentially flat down to at least 1 kHz and ranges between 60 and 85 dB re 1 μPa. There are few published data on in-water hearing sensitivity of phocid seals below 1 kHz. However, measurements for one harbor seal indicated that, below 1 kHz, its thresholds deteriorated gradually to 96 dB re 1 μPa at 100 Hz from 80 dB re 1 μPa at 800 Hz and from 67 dB re 1 μPa at 1,600 Hz (Kastak and Schusterman, 1998). More recent data suggest that harbor seal hearing at low frequencies may be more sensitive than that and that earlier data were confounded by excessive background noise (Kastelein *et al.,* 2009a,b). If so, harbor seals have considerably better underwater hearing sensitivity at low frequencies than do small odontocetes like belugas (for which the threshold at 100 Hz is about 125 dB).

Pinniped call characteristics are relevant when assessing potential masking effects of man-made sounds. In addition, for those species whose hearing has not been tested, call characteristics are useful in assessing the frequency range within which hearing is likely to be most sensitive. The four species of seals present in the study area, all of which are in the phocid seal group, are all most vocal during the spring mating season and much less so during late summer. In each species, the calls are at frequencies from several hundred to several thousand hertz—above the frequency range of the dominant noise components from most of the proposed oil exploration activities.

Cetacean hearing has been studied in relatively few species and individuals. The auditory sensitivity of bowhead, gray, and other baleen whales has not been measured, but relevant anatomical and behavioral evidence is available. These whales appear to be specialized for low frequency hearing, with some directional hearing ability (reviewed in Richardson *et al.,* 1995a; Ketten, 2000). Their optimum hearing overlaps broadly with the low frequency range where exploration drilling activities, airguns, and associated vessel traffic emit most of their energy.

The beluga whale is one of the better-studied species in terms of its hearing ability. As mentioned earlier, the auditory bandwidth in mid-frequency odontocetes is believed to range from 150 Hz to 160 kHz (Southall *et al.,* 2007); however, belugas are most sensitive above 10 kHz. They have relatively poor sensitivity at the low frequencies (reviewed in Richardson *et al.,* 1995a) that dominate the sound from industrial activities and associated vessels. Nonetheless, the noise from strong low frequency sources is detectable by belugas many kilometers away (Richardson and Wursig, 1997). Also, beluga hearing at low frequencies in open-water conditions is apparently somewhat better than in the captive situations where most hearing studies were conducted (Ridgway and Carder, 1995; Au, 1997). If so, low frequency sounds emanating from drilling activities may be detectable somewhat farther away than previously estimated.

Call characteristics of cetaceans provide some limited information on their hearing abilities, although the auditory range often extends beyond the range of frequencies contained in the calls. Also, understanding the frequencies at which different marine mammal species communicate is relevant for the assessment of potential impacts from manmade sounds. A summary of the call characteristics for bowhead, gray, and beluga whales is provided next.

Most bowhead calls are tonal, frequency-modulated sounds at frequencies of 50–400 Hz. These calls overlap broadly in frequency with the underwater sounds emitted by many of the activities to be performed during Shell's proposed exploration drilling program (Richardson *et al.,* 1995a). Source levels are quite variable, with the stronger calls having source levels up to about 180 dB re 1 μPa at 1 m. Gray whales make a wide variety of calls at frequencies from < 100–2,000 Hz (Moore and Ljungblad, 1984; Dalheim, 1987).

Beluga calls include trills, whistles, clicks, bangs, chirps and other sounds (Schevill and Lawrence, 1949; Ouellet, 1979; Sjare and Smith, 1986a). Beluga whistles have dominant frequencies in the 2–6 kHz range (Sjare and Smith, 1986a). This is above the frequency range of most of the sound energy produced by the proposed exploratory drilling activities and associated vessels. Other beluga call types reported by Sjare and Smith (1986a,b) included sounds at mean frequencies ranging upward from 1 kHz.

The beluga also has a very well developed high frequency echolocation system, as reviewed by Au (1993). Echolocation signals have peak frequencies from 40–120 kHz and broadband source levels of up to 219 dB re 1 μPa-m (zero-peak). Echolocation calls are far above the frequency range of the sounds produced by the devices proposed for use during Shell's Chukchi Sea exploratory drilling program. Therefore, those industrial sounds are not expected to interfere with echolocation.

Potential Effects of the Specified Activity on Marine Mammals

The likely or possible impacts of the proposed exploratory drilling program in the Chukchi Sea on marine mammals could involve both non-acoustic and acoustic effects. Potential non-acoustic effects could result from the physical presence of the equipment and personnel. Petroleum development and associated activities introduce sound into the marine environment. Impacts to marine mammals are expected to primarily be acoustic in nature. Potential acoustic effects on marine mammals relate to sound produced by drilling activity, vessels, and aircraft, as well as the ZVSP airgun array. The potential effects of sound from the proposed exploratory drilling program might include one or more of the following: tolerance; masking of natural sounds; behavioral disturbance; non-auditory physical effects; and, at least in theory, temporary or permanent hearing impairment (Richardson *et al.,* 1995a). However, for reasons discussed later in this document, it is unlikely that there would be any cases of temporary, or especially permanent, hearing impairment resulting from these activities. As outlined in previous NMFS documents, the effects of noise on marine mammals are highly variable, and can be categorized as follows (based on Richardson *et al.,* 1995a):

(1) The noise may be too weak to be heard at the location of the animal (*i.e.,* lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both);

(2) The noise may be audible but not strong enough to elicit any overt behavioral response;

(3) The noise may elicit reactions of variable conspicuousness and variable relevance to the well being of the marine mammal; these can range from temporary alert responses to active avoidance reactions such as vacating an area at least until the noise event ceases but potentially for longer periods of time;

(4) Upon repeated exposure, a marine mammal may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, infrequent, and unpredictable in occurrence, and associated with situations that a marine mammal perceives as a threat;

(5) Any anthropogenic noise that is strong enough to be heard has the potential to reduce (mask) the ability of a marine mammal to hear natural sounds at similar frequencies, including calls from conspecifics, and underwater environmental sounds such as surf noise;

(6) If mammals remain in an area because it is important for feeding, breeding, or some other biologically important purpose even though there is chronic exposure to noise, it is possible that there could be noise-induced physiological stress; this might in turn have negative effects on the well-being or reproduction of the animals involved; and

(7) Very strong sounds have the potential to cause a temporary or permanent reduction in hearing sensitivity. In terrestrial mammals, and presumably marine mammals, received sound levels must far exceed the animal's hearing threshold for there to be any temporary threshold shift (TTS) in its hearing ability. For transient sounds, the sound level necessary to cause TTS is inversely related to the duration of the sound. Received sound levels must be even higher for there to be risk of permanent hearing impairment. In addition, intense acoustic or explosive events may cause trauma to tissues associated with organs vital for hearing, sound production, respiration and other functions. This trauma may include minor to severe hemorrhage.

Potential Acoustic Effects From Exploratory Drilling Activities

(1) Tolerance

Numerous studies have shown that underwater sounds from industry activities are often readily detectable by marine mammals in the water at distances of many kilometers. Numerous studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response to industry activities of various types (Miller *et al.,* 2005; Bain and Williams, 2006). This is often true even in cases when the sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to underwater sound such as airgun pulses or vessels under some conditions, at other times mammals of all three types have shown no overt reactions (*e.g.,* Malme *et al.,* 1986; Richardson *et al.,* 1995; Madsen and Mohl, 2000; Croll *et al.,* 2001; Jacobs and Terhune, 2002; Madsen *et al.,* 2002; Miller *et al.,* 2005). In general, pinnipeds and small odontocetes seem to be more tolerant of exposure to some types of underwater sound than are baleen whales. Richardson *et al.* (1995a) found that vessel noise does not seem to strongly affect pinnipeds that are already in the water. Richardson *et al.* (1995a) went on to explain that seals on haul-outs sometimes respond strongly to the presence of vessels and at other times appear to show considerable tolerance of vessels, and Brueggeman *et al.* (1992, cited in Richardson *et al.,* 1995a) observed ringed seals hauled out on ice pans displaying short-term escape reactions when a ship approached within 0.25–0.5 mi (0.4–0.8 km).

(2) Masking

Masking is the obscuring of sounds of interest by other sounds, often at similar frequencies. Marine mammals are highly dependent on sound, and their ability to recognize sound signals amid other noise is important in communication, predator and prey detection, and, in the case of toothed whales, echolocation. Even in the absence of manmade sounds, the sea is usually noisy. Background ambient noise often interferes with or masks the ability of an animal to detect a sound signal even when that signal is above its absolute hearing threshold. Natural ambient noise includes contributions from wind, waves, precipitation, other animals, and (at frequencies above 30 kHz) thermal noise resulting from molecular agitation (Richardson *et al.,* 1995a). Background noise also can include sounds from human activities. Masking of natural sounds can result when human activities produce high levels of background noise. Conversely, if the background level of underwater noise is high (*e.g.,* on a day with strong wind and high waves), an anthropogenic noise source will not be detectable as far away as would be possible under quieter conditions and will itself be masked.

Although some degree of masking is inevitable when high levels of manmade broadband sounds are introduced into the sea, marine mammals have evolved systems and behavior that function to reduce the impacts of masking. Structured signals, such as the echolocation click sequences of small toothed whales, may be readily detected even in the presence of strong background noise because their frequency content and temporal features usually differ strongly from those of the background noise (Au and Moore, 1988, 1990). The components of background noise that are similar in frequency to the sound signal in question primarily determine the degree of masking of that signal.

Redundancy and context can also facilitate detection of weak signals. These phenomena may help marine mammals detect weak sounds in the presence of natural or manmade noise. Most masking studies in marine mammals present the test signal and the masking noise from the same direction. The sound localization abilities of marine mammals suggest that, if signal and noise come from different directions, masking would not be as severe as the usual types of masking studies might suggest (Richardson *et al.,* 1995a). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these noises by improving the effective signal-to-noise ratio. In the cases of high-frequency hearing by the bottlenose dolphin, beluga whale, and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking noise (Penner *et al.,* 1986; Dubrovskiy, 1990; Bain *et al.,* 1993; Bain and Dahlheim, 1994). Toothed whales, and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background noise. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient noise toward frequencies with less noise (Au *et al.,* 1974, 1985; Moore and Pawloski, 1990; Thomas and Turl, 1990; Romanenko and Kitain, 1992; Lesage *et al.,* 1999). A few marine mammal species are known to increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim, 1987; Au, 1993; Lesage *et al.,* 1993, 1999; Terhune, 1999; Foote *et al.,* 2004; Parks *et al.,* 2007, 2009; Di Iorio and Clark, 2009; Holt *et al.,* 2009).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva *et al.* (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kHz, in contrast to the pronounced effect at higher frequencies. Directional hearing has been demonstrated at frequencies as low as 0.5–2 kHz in several marine mammals, including killer whales (Richardson *et al.,* 1995a). This ability may be useful in reducing masking at these frequencies. In summary, high levels of noise generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such masking.

Masking effects of underwater sounds from Shell's proposed activities on marine mammal calls and other natural sounds are expected to be limited. For example, beluga whales primarily use high-frequency sounds to communicate and locate prey; therefore, masking by low-frequency sounds associated with drilling activities is not expected to occur (Gales, 1982, as cited in Shell, 2009). If the distance between communicating whales does not exceed their distance from the drilling activity, the likelihood of potential impacts from masking would be low (Gales, 1982, as cited in Shell, 2009). At distances greater than 660–1,300 ft (200–400 m), recorded sounds from drilling activities did not affect behavior of beluga whales, even though the sound energy level and frequency were such that it could be heard several kilometers away (Richardson *et al.,* 1995b). This exposure resulted in whales being deflected from the sound energy and changing behavior. These minor changes are not expected to affect the beluga whale population (Richardson *et al.,* 1991; Richard *et al.,* 1998). Brewer *et al.* (1993) observed belugas within 2.3 mi (3.7 km) of the drilling unit *Kulluk* during drilling; however, the authors do not describe any behaviors that may have been exhibited by those animals. Please refer to the Arctic Multiple-Sale Draft Environmental Impact Statement (USDOI MMS, 2008), available on the Internet at: *http://www.mms.gov/alaska/ref/EIS%20EA/ArcticMultiSale_209/_DEIS.htm,* for more detailed information.

There is evidence of other marine mammal species continuing to call in the presence of industrial activity. Annual acoustical monitoring near BP's Northstar production facility during the fall bowhead migration westward through the Beaufort Sea has recorded thousands of calls each year (for examples, see Richardson *et al.,* 2007; Aerts and Richardson, 2008). Construction, maintenance, and operational activities have been occurring from this facility for over 10 years. To compensate and reduce masking, some mysticetes may alter the frequencies of their communication sounds (Richardson *et al.,* 1995a; Parks *et al.,* 2007). Masking processes in baleen whales are not amenable to laboratory study, and no direct measurements on hearing sensitivity are available for these species. It is not currently possible to determine with precision the potential consequences of temporary or local background noise levels. However, Parks *et al.* (2007) found that right whales (a species closely related to the bowhead whale) altered their vocalizations, possibly in response to background noise levels. For species that can hear over a relatively broad frequency range, as is presumed to be the case for mysticetes, a narrow band source may only cause partial masking. Richardson *et al.* (1995a) note that a bowhead whale 12.4 mi (20 km) from a human sound source, such as that produced during oil and gas industry activities, might hear strong calls from other whales within approximately 12.4 mi (20 km), and a whale 3.1 mi (5 km) from the source might hear strong calls from whales within approximately 3.1 mi (5 km). Additionally, masking is more likely to occur closer to a sound source, and distant anthropogenic sound is less likely to mask short-distance acoustic communication (Richardson *et al.,* 1995a).

Although some masking by marine mammal species in the area may occur, the extent of the masking interference will depend on the spatial relationship of the animal and Shell's activity. Almost all energy in the sounds emitted by drilling and other operational activities is at low frequencies, predominantly below 250 Hz with another peak centered around 1,000 Hz. Most energy in the sounds from the vessels and aircraft to be used during this project is below 1 kHz (Moore *et al.,* 1984; Greene and Moore, 1995; Blackwell *et al.,* 2004b; Blackwell and Greene, 2006). These frequencies are mainly used by mysticetes but not by odontocetes. Therefore, masking effects would potentially be more pronounced in the bowhead and gray whales that might occur in the proposed project area. If, as described later in this document, certain species avoid the proposed drilling locations, impacts from masking are anticipated to be low.

(3) Behavioral Disturbance Reactions

Behavioral responses to sound are highly variable and context-specific. Many different variables can influence an animal's perception of and response to (in both nature and magnitude) an acoustic event. An animal's prior experience with a sound or sound source affects whether it is less likely (habituation) or more likely (sensitization) to respond to certain sounds in the future (animals can also be innately pre-disposed to respond to certain sounds in certain ways; Southall *et al.,* 2007). Related to the sound itself, the perceived nearness of the sound, bearing of the sound (approaching vs. retreating), similarity of a sound to biologically relevant sounds in the animal's environment (*i.e.,* calls of predators, prey, or conspecifics), and familiarity of the sound may affect the way an animal responds to the sound (Southall *et al.,* 2007). Individuals (of different age, gender, reproductive status, *etc.*) among most populations will have variable hearing capabilities and differing behavioral sensitivities to sounds that will be affected by prior conditioning, experience, and current activities of those individuals. Often, specific acoustic features of the sound and contextual variables (*i.e.,* proximity, duration, or recurrence of the sound or the current behavior that the marine mammal is engaged in or its prior experience), as well as entirely separate factors such as the physical presence of a nearby vessel, may be more relevant to the animal's response than the received level alone.

Exposure of marine mammals to sound sources can result in (but is not limited to) no response or any of the following observable responses: Increased alertness; orientation or attraction to a sound source; vocal modifications; cessation of feeding; cessation of social interaction; alteration of movement or diving behavior; avoidance; habitat abandonment (temporary or permanent); and, in severe cases, panic, flight, stampede, or stranding, potentially resulting in death (Southall *et al.,* 2007). On a related note, many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (24-hr cycle). Behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall *et al.,* 2007). Consequently, a behavioral response lasting less than one day and not recurring on subsequent days is not considered particularly severe unless it could directly affect reproduction or survival (Southall *et al.,* 2007).

Detailed studies regarding responses to anthropogenic sound have been conducted on humpback, gray, and bowhead whales and ringed seals. Less detailed data are available for some other species of baleen whales, sperm whales, small toothed whales, and sea otters. The following sub-sections provide examples of behavioral responses that provide an idea of the variability in behavioral responses that would be expected given the different sensitivities of marine mammal species to sound.

Baleen Whales—Richardson *et al.* (1995b) reported changes in surfacing and respiration behavior and the occurrence of turns during surfacing in bowhead whales exposed to playback of underwater sound from drilling activities. These behavioral effects were localized and occurred at distances up to 1.2–2.5 mi (2–4 km).

Some bowheads appeared to divert from their migratory path after exposure to projected icebreaker sounds. Other bowheads however, tolerated projected icebreaker sound at levels 20 dB and more above ambient sound levels. The source level of the projected sound however, was much less than that of an actual icebreaker, and reaction distances to actual icebreaking may be much greater than those reported here for projected sounds.

Brewer *et al.* (1993) and Hall *et al.* (1994) reported numerous sightings of marine mammals including bowhead whales in the vicinity of offshore drilling operations in the Beaufort Sea. One bowhead whale sighting was reported within approximately 1,312 ft (400 m) of a drilling vessel although most other bowhead sightings were at much greater distances. Few bowheads were recorded near industrial activities by aerial observers. After controlling for spatial autocorrelation in aerial survey data from Hall *et al.* (1994) using a Mantel test, Schick and Urban (2000) found that the variable describing straight line distance between the rig and bowhead whale sightings was not significant but that a variable describing threshold distances between sightings and the rig was significant. Thus, although the aerial survey results suggested substantial avoidance of the operations by bowhead whales, observations by vessel-based observers indicate that at least some bowheads may have been closer to industrial activities than was suggested by results of aerial observations.

Richardson *et al.* (2008) reported a slight change in the distribution of bowhead whale calls in response to operational sounds on BP's Northstar Island. The southern edge of the call distribution ranged from 0.47 to 1.46 mi (0.76 to 2.35 km) farther offshore, apparently in response to industrial sound levels. This result however, was only achieved after intensive statistical analyses, and it is not clear that this represented a biologically significant effect.

Patenaude *et al.* (2002) reported fewer behavioral responses to aircraft overflights by bowhead compared to beluga whales. Behaviors classified as reactions consisted of short surfacings, immediate dives or turns, changes in behavior state, vigorous swimming, and breaching. Most bowhead reaction resulted from exposure to helicopter activity and little response to fixed-wing aircraft was observed. Most reactions occurred when the helicopter was at altitudes ≤492 ft (150 m) and lateral distances ≤820 ft (250 m; Nowacek *et al.,* 2007).

During their study, Patenaude *et al.* (2002) observed one bowhead whale cow-calf pair during four passes totaling 2.8 hours of the helicopter and two pairs during Twin Otter overflights. All of the helicopter passes were at altitudes of 49–98 ft (15–30 m). The mother dove both times she was at the surface, and the calf dove once out of the four times it was at the surface. For the cow-calf pair sightings during Twin Otter overflights, the authors did not note any behaviors specific to those pairs. Rather, the reactions of the cow-calf pairs were lumped with the reactions of other groups that did not consist of calves.

Richardson *et al.* (1995b) and Moore and Clarke (2002) reviewed a few studies that observed responses of gray whales to aircraft. Cow-calf pairs were quite sensitive to a turboprop survey flown at 1,000 ft (305 m) altitude on the Alaskan summering grounds. In that survey, adults were seen swimming over the calf, or the calf swam under the adult (Ljungblad *et al.,* 1983, cited in Richardson *et al.,* 1995b and Moore and Clarke, 2002). However, when the same aircraft circled for more than 10 minutes at 1,050 ft (320 m) altitude over a group of mating gray whales, no reactions were observed (Ljungblad *et al.,* 1987, cited in Moore and Clarke, 2002). Malme *et al.* (1984, cited in Richardson *et al.,* 1995b and Moore and Clarke, 2002) conducted playback experiments on migrating gray whales. They exposed the animals to underwater noise recorded from a Bell 212 helicopter (estimated altitude = 328 ft [100 m]), at an average of three simulated passes per minute. The authors observed that whales changed their swimming course and sometimes slowed down in response to the playback sound but proceeded to migrate past the transducer. Migrating gray whales did not react overtly to a Bell 212 helicopter at greater than 1,394 ft (425 m) altitude, occasionally reacted when the helicopter was at 1,000–1,198 ft (305–365 m), and usually reacted when it was below 825 ft (250 m; Southwest Research Associates, 1988, cited in Richardson *et al.,* 1995b and Moore and Clarke, 2002). Reactions noted in that study included abrupt turns or dives or both. Green *et al.* (1992, cited in Richardson *et al.,* 1995b) observed that migrating gray whales rarely exhibited noticeable reactions to a straight-line overflight by a Twin Otter at 197 ft (60 m) altitude. Restrictions on aircraft altitude will be part of the proposed mitigation measures (described in the ''Proposed Mitigation'' section later in this document) during the proposed drilling activities, and overflights are likely to have little or no disturbance effects on baleen whales. Any disturbance that may occur would likely be temporary and localized.

Southall *et al.* (2007, Appendix C) reviewed a number of papers describing the responses of marine mammals to non-pulsed sound, such as that produced during exploratory drilling operations. In general, little or no response was observed in animals exposed at received levels from 90–120 dB re 1 μPa (rms). Probability of avoidance and other behavioral effects increased when received levels were from 120–160 dB re 1 μPa (rms). Some of the relevant reviews contained in Southall *et al.* (2007) are summarized next.

Baker *et al.* (1982) reported some avoidance by humpback whales to vessel noise when received levels were 110–120 dB (rms) and clear avoidance at 120–140 dB (sound measurements were not provided by Baker but were based on measurements of identical vessels by Miles and Malme, 1983).

Malme *et al.* (1983, 1984) used playbacks of sounds from helicopter overflight and drilling rigs and platforms to study behavioral effects on migrating gray whales. Received levels exceeding 120 dB induced avoidance reactions. Malme *et al.* (1984) calculated 10%, 50%, and 90% probabilities of gray whale avoidance reactions at received levels of 110, 120, and 130 dB, respectively. Malme *et al.* (1986) observed the behavior of feeding gray whales during four experimental playbacks of drilling sounds (50 to 315 Hz; 21- min overall duration and 10% duty cycle; source levels of 156–162 dB). In two cases for received levels of 100–110 dB, no behavioral reaction was observed. However, avoidance behavior was observed in two cases where received levels were 110–120 dB.

Richardson *et al.* (1990) performed 12 playback experiments in which bowhead whales in the Alaskan Arctic were exposed to drilling sounds. Whales generally did not respond to exposures in the 100 to 130 dB range, although there was some indication of minor behavioral changes in several instances.

McCauley *et al.* (1996) reported several cases of humpback whales responding to vessels in Hervey Bay, Australia. Results indicated clear avoidance at received levels between 118 to 124 dB in three cases for which response and received levels were observed/measured.

Palka and Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of minke whales. The authors developed a method to account for effects of animal movement in response to sighting platforms. Minor changes in locomotion speed, direction, and/or diving profile were reported at ranges from 1,847 to 2,352 ft (563 to 717 m) at received levels of 110 to 120 dB.

Biassoni *et al.* (2000) and Miller *et al.* (2000) reported behavioral observations for humpback whales exposed to a low-frequency sonar stimulus (160- to 330–Hz frequency band; 42-s tonal signal repeated every 6 min; source levels 170 to 200 dB) during playback experiments. Exposure to measured received levels ranging from 120 to 150 dB resulted in variability in humpback singing behavior. Croll *et al.* (2001) investigated responses of foraging fin and blue whales to the same low frequency active sonar stimulus off southern California. Playbacks and control intervals with no transmission were used to investigate behavior and distribution on time scales of several weeks and spatial scales of tens of kilometers. The general conclusion was that whales remained feeding within a region for which 12 to

30 percent of exposures exceeded 140 dB.

Frankel and Clark (1998) conducted playback experiments with wintering humpback whales using a single speaker producing a low-frequency ''M-sequence'' (sine wave with multiple-phase reversals) signal in the 60 to 90 Hz band with output of 172 dB at 1 m. For 11 playbacks, exposures were between 120 and 130 dB re 1 µPa (rms) and included sufficient information regarding individual responses. During eight of the trials, there were no measurable differences in tracks or bearings relative to control conditions, whereas on three occasions, whales either moved slightly away from (n = 1) or towards (n = 2) the playback speaker during exposure. The presence of the source vessel itself had a greater effect than did the M-sequence playback.

Finally, Nowacek *et al.* (2004) used controlled exposures to demonstrate behavioral reactions of northern right whales to various non-pulse sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-min ''alert'' sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB (*i.e.,* ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise, and the other four were exposed to both stimuli. These whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

Toothed Whales—Most toothed whales have the greatest hearing sensitivity at frequencies much higher than that of baleen whales and may be less responsive to low-frequency sound commonly associated with oil and gas industry exploratory drilling activities. Richardson *et al.* (1995b) reported that beluga whales did not show any apparent reaction to playback of underwater drilling sounds at distances greater than 656–1,312 ft (200–400 m). Reactions included slowing down, milling, or reversal of course after which the whales continued past the projector, sometimes within 164–328 ft (50–100 m). The authors concluded (based on a small sample size) that the playback of drilling sounds had no biologically significant effects on migration routes of beluga whales migrating through pack ice and along the seaward side of the nearshore lead east of Point Barrow in spring.

At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson *et al.,* 1995b). Received levels from the icebreaker playback were estimated at 78–84 dB in the 1/3-octave band centered at 5,000 Hz, or 8–14 dB above ambient. If beluga whales reacted to an actual icebreaker at received levels of 80 dB, reactions would be expected to occur at distances on the order of 6.2 mi (10 km). Finley *et al.* (1990) also reported beluga avoidance of icebreaker activities in the Canadian High Arctic at distances of 22–31 mi (35–50 km). In addition to avoidance, changes in dive behavior and pod integrity were also noted.

Patenaude *et al.* (2002) reported that beluga whales appeared to be more responsive to aircraft overflights than bowhead whales. Changes were observed in diving and respiration behavior, and some whales veered away when a helicopter passed at ≤820 ft (250 m) lateral distance at altitudes up to 492 ft (150 m). However, some belugas showed no reaction to the helicopter. Belugas appeared to show less response to fixed-wing aircraft than to helicopter overflights.

In reviewing responses of cetaceans with best hearing in mid-frequency ranges, which includes toothed whales, Southall *et al.* (2007) reported that combined field and laboratory data for mid-frequency cetaceans exposed to non-pulse sounds did not lead to a clear conclusion about received levels coincident with various behavioral responses. In some settings, individuals in the field showed profound (significant) behavioral responses to exposures from 90–120 dB, while others failed to exhibit such responses for exposure to received levels from 120–150 dB. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating noise exposure, may also explain why there was great disparity in results from field and laboratory conditions—exposures in captive settings generally exceeded 170 dB before inducing behavioral responses. A summary of some of the relevant material reviewed by Southall *et al.* (2007) is next.

LGL and Greeneridge (1986) and Finley *et al.* (1990) documented belugas and narwhals congregated near ice edges reacting to the approach and passage of icebreaking ships. Beluga whales responded to oncoming vessels by (1) fleeing at speeds of up to 12.4 mi/hr (20 km/hr) from distances of 12.4–50 mi (20–80 km), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a ''freeze'' response, lying motionless or swimming slowly away (as far as 23 mi [37 km] down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

The 1982 season observations by LGL and Greeneridge (1986) involved a single passage of an icebreaker with both ice-based and aerial measurements on June 28, 1982. Four groups of narwhals (n = 9 to 10, 7, 7, and 6) responded when the ship was 4 mi (6.4 km) away (received levels of approximately 100 dB in the 150- to 1,150-Hz band). At a later point, observers sighted belugas moving away from the source at more than 12.4 mi (20 km; received levels of approximately 90 dB in the 150- to 1,150-Hz band). The total number of animals observed fleeing was about 300, suggesting approximately 100 independent groups (of three individuals each). No whales were sighted the following day, but some were sighted on June 30, with ship noise audible at spectrum levels of approximately 55 dB/Hz (up to 4 kHz).

Observations during 1983 (LGL and Greeneridge, 1986) involved two icebreaking ships with aerial survey and ice-based observations during seven sampling periods. Narwhals and belugas generally reacted at received levels ranging from 101 to 121 dB in the 20- to 1,000-Hz band and at a distance of up to 40.4 mi (65 km). Large numbers (100s) of beluga whales moved out of the area at higher received levels. As noise levels from icebreaking operations diminished, a total of 45 narwhals returned to the area and engaged in diving and foraging behavior. During the final sampling period, following an 8-h quiet interval, no reactions were seen from 28 narwhals and 17 belugas (at received levels ranging up to 115 dB).

The final season (1984) reported in LGL and Greeneridge (1986) involved aerial surveys before, during, and after the passage of two icebreaking ships. During operations, no belugas and few narwhals were observed in an area approximately 16.8 mi (27 km) ahead of the vessels, and all whales sighted over 12.4–50 mi (20–80 km) from the ships were swimming strongly away. Additional observations confirmed the spatial extent of avoidance reactions to this sound source in this context.

Buckstaff (2004) reported elevated dolphin whistle rates with received levels from oncoming vessels in the 110 to 120 dB range in Sarasota Bay, Florida. These hearing thresholds were apparently lower than those reported by a researcher listening with towed hydrophones. Morisaka *et al.* (2005) compared whistles from three populations of Indo-Pacific bottlenose dolphins. One population was exposed to vessel noise with spectrum levels of approximately 85 dB/Hz in the 1- to 22-kHz band (broadband received levels approximately 128 dB) as opposed to approximately 65 dB/Hz in the same band (broadband received levels approximately 108 dB) for the other two sites. Dolphin whistles in the noisier environment had lower fundamental frequencies and less frequency modulation, suggesting a shift in sound parameters as a result of increased ambient noise.

Morton and Symonds (2002) used census data on killer whales in British Columbia to evaluate avoidance of non-pulse acoustic harassment devices (AHDs). Avoidance ranges were about 2.5 mi (4 km). Also, there was a dramatic reduction in the number of days ''resident'' killer whales were sighted during AHD-active periods compared to pre- and post-exposure periods and a nearby control site.

Monteiro-Neto *et al.* (2004) studied avoidance responses of tucuxi (*Sotalia fluviatilis*) to Dukane® Netmark acoustic deterrent devices. In a total of 30 exposure trials, approximately five groups each demonstrated significant avoidance compared to 20 pinger off and 55 no-pinger control trials over two quadrats of about 0.19 mi^2 (0.5 km^2). Estimated exposure received levels were approximately 115 dB.

Awbrey and Stewart (1983) played back semi-submersible drillship sounds (source level: 163 dB) to belugas in Alaska. They reported avoidance reactions at 984 and 4,921 ft (300 and 1,500 m) and approach by groups at a distance of 2.2 mi (3.5 km; received levels were approximately 110 to 145 dB over these ranges assuming a 15 log R transmission loss). Similarly, Richardson *et al.* (1990) played back drilling platform sounds (source level: 163 dB) to belugas in Alaska. They conducted aerial observations of eight individuals among approximately 100 spread over an area several hundred meters to several kilometers from the sound source and found no obvious reactions. Moderate changes in movement were noted for three groups swimming within 656 ft (200 m) of the sound projector.

Two studies deal with issues related to changes in marine mammal vocal behavior as a function of variable background noise levels. Foote *et al.* (2004) found increases in the duration of killer whale calls over the period 1977 to 2003, during which time vessel traffic in Puget Sound, and particularly whale-watching boats around the animals, increased dramatically. Scheifele *et al.* (2005) demonstrated that belugas in the St. Lawrence River increased the levels of their vocalizations as a function of the background noise level (the ''Lombard Effect'').

Several researchers conducting laboratory experiments on hearing and the effects of non-pulse sounds on hearing in mid-frequency cetaceans have reported concurrent behavioral responses. Nachtigall *et al.* (2003) reported that noise exposures up to 179 dB and 55-min duration affected the trained behaviors of a bottlenose dolphin participating in a TTS experiment. Finneran and Schlundt (2004) provided a detailed, comprehensive analysis of the behavioral responses of belugas and bottlenose dolphins to 1-s tones (received levels 160 to 202 dB) in the context of TTS experiments. Romano *et al.* (2004) investigated the physiological responses of a bottlenose dolphin and a beluga exposed to these tonal exposures and demonstrated a decrease in blood cortisol levels during a series of exposures between 130 and 201 dB. Collectively, the laboratory observations suggested the onset of a behavioral response at higher received levels than did field studies. The differences were likely related to the very different conditions and contextual variables between untrained, free-ranging individuals vs. laboratory subjects that were rewarded with food for tolerating noise exposure.

Pinnipeds—Pinnipeds generally seem to be less responsive to exposure to industrial sound than most cetaceans. Pinniped responses to underwater sound from some types of industrial activities such as seismic exploration appear to be temporary and localized (Harris *et al.,* 2001; Reiser *et al.,* 2009).

Blackwell *et al.* (2004) reported little or no reaction of ringed seals in response to pile-driving activities during construction of a man-made island in the Beaufort Sea. Ringed seals were observed swimming as close as 151 ft (46 m) from the island and may have been habituated to the sounds which were likely audible at distances <9,842 ft (3,000 m) underwater and 0.3 mi (0.5 km) in air. Moulton *et al.* (2003) reported that ringed seal densities on ice in the vicinity of a man-made island in the Beaufort Sea did not change significantly before and after construction and drilling activities.

Southall *et al.* (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between approximately 90 and 140 dB generally do not appear to induce strong behavioral responses in pinnipeds exposed to non-pulse sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies, there are some apparent differences in responses between field and laboratory conditions. In contrast to the mid-frequency odontocetes, captive pinnipeds responded more strongly at lower levels than did animals in the field. Again, contextual issues are the likely cause of this difference.

Jacobs and Terhune (2002) observed harbor seal reactions to AHDs (source level in this study was 172 dB) deployed around aquaculture sites. Seals were generally unresponsive to sounds from the AHDs. During two specific events, individuals came within 141 and 144 ft (43 and 44 m) of active AHDs and failed to demonstrate any measurable behavioral response; estimated received levels based on the measures given were approximately 120 to 130 dB.

Costa *et al.* (2003) measured received noise levels from an Acoustic Thermometry of Ocean Climate (ATOC) program sound source off northern California using acoustic data loggers placed on translocated elephant seals. Subjects were captured on land, transported to sea, instrumented with archival acoustic tags, and released such that their transit would lead them near an active ATOC source (at 939-m depth; 75-Hz signal with 37.5- Hz bandwidth; 195 dB maximum source level, ramped up from 165 dB over 20 min) on their return to a haul-out site. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB (range 118 to 137) in the 60- to 90-Hz band. None of the instrumented animals terminated dives or radically altered behavior upon exposure, but some statistically significant changes in diving parameters were documented in nine individuals. Translocated northern elephant seals exposed to this particular non-pulse source began to demonstrate subtle behavioral changes at exposure to received levels of approximately 120 to 140 dB.

Kastelein *et al.* (2006) exposed nine captive harbor seals in an approximately 82 × 98 ft (25 × 30 m) enclosure to non-pulse sounds used in underwater data communication systems (similar to acoustic modems). Test signals were frequency modulated tones, sweeps, and bands of noise with fundamental frequencies between 8 and 16 kHz; 128 to 130 [± 3] dB source levels; 1- to 2-s duration [60–80 percent duty cycle]; or 100 percent duty cycle. They recorded seal positions and the mean number of individual surfacing behaviors during control periods (no exposure), before exposure, and in 15-min experimental sessions (n = 7 exposures for each sound type). Seals generally swam away from each source at received levels of approximately 107 dB, avoiding it by approximately 16 ft (5 m), although they did not haul out of the water or change surfacing behavior. Seal reactions did not appear to wane over repeated exposure (*i.e.,* there was no obvious habituation), and the colony of seals generally returned to baseline conditions following exposure. The seals were not reinforced with food for remaining in the sound field.

Potential effects to pinnipeds from aircraft activity could involve both acoustic and non-acoustic effects. It is uncertain if the seals react to the sound of the helicopter or to its physical presence flying overhead. Typical reactions of hauled out pinnipeds to aircraft that have been observed include looking up at the aircraft, moving on the ice or land, entering a breathing hole or crack in the ice, or entering the water. Ice seals hauled out on the ice have been observed diving into the water when approached by a low-flying aircraft or helicopter (Burns and Harbo, 1972, cited in Richardson *et al.,* 1995a; Burns and Frost, 1979, cited in Richardson *et al.,* 1995a). Richardson *et al.* (1995a) note that responses can vary based on differences in aircraft type, altitude, and flight pattern. Additionally, a study conducted by Born *et al.* (1999) found that wind chill was also a factor in level of response of ringed seals hauled out on ice, as well as time of day and relative wind direction.

Blackwell *et al.* (2004a) observed 12 ringed seals during low-altitude overflights of a Bell 212 helicopter at Northstar in June and July 2000 (9 observations took place concurrent with pipe-driving activities). One seal showed no reaction to the aircraft while the remaining 11 (92%) reacted, either by looking at the helicopter (n = 10) or by departing from their basking site (n = 1). Blackwell *et al.* (2004a) concluded that none of the reactions to helicopters were strong or long lasting, and that seals near Northstar in June and July 2000 probably had habituated to industrial sounds and visible activities that had occurred often during the preceding winter and spring. There have been few systematic studies of pinniped reactions to aircraft overflights, and most of the available data concern pinnipeds hauled out on land or ice rather than pinnipeds in the water (Richardson *et al.,* 1995a; Born *et al.,* 1999).

Born *et al.* (1999) determined that 49 percent of ringed seals escaped (*i.e.,* left the ice) as a response to a helicopter flying at 492 ft (150 m) altitude. Seals entered the water when the helicopter was 4,101 ft (1,250 m) away if the seal was in front of the helicopter and at 1,640 ft (500 m) away if the seal was to the side of the helicopter. The authors noted that more seals reacted to helicopters than to fixed-wing aircraft. The study concluded that the risk of scaring ringed seals by small-type helicopters could be substantially reduced if they do not approach closer than 4,921 ft (1,500 m).

Spotted seals hauled out on land in summer are unusually sensitive to aircraft overflights compared to other species. They often rush into the water when an aircraft flies by at altitudes up to 984–2,461 ft (300–750 m). They occasionally react to aircraft flying as high as 4,495 ft (1,370 m) and at lateral distances as far as 1.2 mi (2 km) or more (Frost and Lowry, 1990; Rugh *et al.,* 1997).

(4) Hearing Impairment and Other Physiological Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Non-auditory physiological effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might 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 later in this document, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to industrial sound sources, and beaked whales do not occur in the proposed activity area. Additional information regarding the possibilities of TTS, permanent threshold shift (PTS), and non-auditory physiological effects, such as stress, is discussed for both exploratory drilling activities and ZVSP surveys in the following section (''*Potential Effects from ZVSP Activities*'').

Potential Effects from ZVSP Activities

(1) Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Weir (2008) observed marine mammal responses to seismic pulses from a 24 airgun array firing a total volume of either 5,085 in^3 or 3,147 in^3 in Angolan waters between August 2004 and May 2005. Weir recorded a total of 207 sightings of humpback whales (n = 66), sperm whales (n = 124), and Atlantic spotted dolphins (n = 17) and reported that there were no significant differences in encounter rates (sightings/hr) for humpback and sperm whales according to the airgun array's operational status (*i.e.,* active versus silent). For additional information on tolerance of marine mammals to anthropogenic sound, see the previous subsection in this document (''*Potential Effects from Exploratory Drilling Activities*'').

(2) Masking

As stated earlier in this document, masking is the obscuring of sounds of interest by other sounds, often at similar frequencies. For full details about masking, see the previous subsection in this document (''*Potential Effects from Exploratory Drilling Activities*''). Some additional information regarding pulsed sounds is provided here.

There is evidence of some marine mammal species continuing to call in the presence of industrial activity. McDonald *et al.* (1995) heard blue and fin whale calls between seismic pulses in the Pacific. Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles *et al.,* 1994), a more recent study reported that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen *et al.,* 2002). Similar results were also reported during work in the Gulf of Mexico (Tyack *et al.,* 2003). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the numbers of calls detected may sometimes be reduced (Richardson *et al.,* 1986; Greene *et al.,* 1999; Blackwell *et al.,* 2009a). Bowhead whales in the Beaufort Sea may decrease their call rates in response to seismic operations, although movement out of the area might also have contributed to the lower call detection rate (Blackwell *et al.,* 2009a,b). Additionally, there is increasing evidence that, at times, there is enough reverberation between airgun pulses such that detection range of calls may be significantly reduced. In contrast, Di Iorio and Clark (2009) found evidence of increased calling by blue whales during operations by a lower-energy seismic source, a sparker.

There is little concern regarding masking due to the brief duration of these pulses and relatively longer silence between airgun shots (9–12 seconds) near the sound source. However, at long distances (over tens of kilometers away) in deep water, due to multipath propagation and reverberation, the durations of airgun pulses can be ''stretched'' to seconds with long decays (Madsen *et al.,* 2006; Clark and Gagnon, 2006). Therefore it could affect communication signals used by low frequency mysticetes when they occur near the noise band and thus reduce the communication space of animals (*e.g.,* Clark *et al.,* 2009a,b) and cause increased stress levels (*e.g.,* Foote *et al.,* 2004; Holt *et al.,* 2009). Nevertheless, the intensity of the noise is also greatly reduced at long distances. Therefore, masking effects are anticipated to be limited, especially in the case of odontocetes, given that they typically communicate at frequencies higher than those of the airguns.

(3) Behavioral Disturbance Reactions

As was described in more detail in the previous sub-section (''*Potential Effects of Exploratory Drilling Activities''*), behavioral responses to sound are highly variable and context-specific. Summaries of observed reactions and studies are provided next.

Baleen Whales—Baleen whale responses to pulsed sound (*e.g.,* seismic airguns) have been studied more thoroughly than responses to continuous sound (*e.g.,* drillships). 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 greater distances (Miller *et al.,* 2005). However, baleen whales exposed to strong noise pulses often react by deviating from their normal migration route (Richardson *et al.,* 1999). Migrating gray and bowhead whales were observed avoiding the sound source by displacing their migration route to varying degrees but within the natural boundaries of the migration corridors (Schick and Urban, 2000; Richardson *et al.,* 1999; Malme *et al.,* 1983). Baleen whale responses to pulsed sound however may depend on the type of activity in which the whales are engaged. Some evidence suggests that feeding bowhead whales may be more tolerant of underwater sound than migrating bowheads (Miller *et al.,* 2005; Lyons *et al.,* 2009; Christie *et al.,* 2010).

Results of studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 μPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 2.8–9 mi (4.5–14.5 km) from the source. For the much smaller airgun array used during the ZVSP survey (total discharge volume of 760 in^3), distances to received levels in the 170–160 dB re 1 μPa rms range are estimated to be 1.44–2.28 mi (2.31–3.67 km). Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and recent studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 μPa rms. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with avoidance occurring out to distances of 12.4–18.6 mi (20–30 km) from a medium-sized airgun source (Miller *et al.,* 1999; Richardson *et al.,* 1999). However, more recent research on bowhead whales (Miller *et al.,* 2005) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 μPa rms (Richardson *et al.,* 1986; Ljungblad *et al.,* 1988; Miller *et al.,* 2005).

Malme *et al.* (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 in^3 airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast and on observations of the distribution of feeding Western Pacific gray whales off Sakhalin Island, Russia, during a seismic survey (Yazvenko *et al.,* 2007).

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. While it is not certain whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years, certain species have continued to use areas ensonified by airguns and have continued to increase in number despite successive years of anthropogenic activity in the area. Gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades (Appendix A in Malme *et al.,* 1984). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson *et al.,* 1987). Populations of both gray whales and bowhead whales grew substantially during this time. Bowhead whales have increased by approximately 3.4% per year for the last 10 years in the Beaufort Sea (Allen and Angliss, 2011). In any event, the brief exposures to sound pulses from the proposed airgun source (the airguns will only be fired for a period of 10–14 hours for each of the three, possibly four, wells) are highly unlikely to result in prolonged effects.

Toothed Whales—Few systematic data are available describing reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized earlier in this document have been reported for toothed whales. However, systematic work on sperm whales is underway (Tyack *et al.,* 2003), and 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).

Seismic operators and marine mammal observers sometimes 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 seismic vessels operating large airgun systems. 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 arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away or maintain a somewhat greater distance from the vessel when a large array of airguns is operating than when it is silent (*e.g.,* Goold, 1996a,b,c; Calambokidis and Osmek, 1998; Stone, 2003). The beluga may be a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 6.2–12.4 mi (10–20 km) of an active seismic vessel. These results were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel, suggesting that some belugas might be avoiding the seismic operations at distances of 6.2–12.4 mi (10–20 km) (Miller *et al.,* 2005).

Captive bottlenose dolphins and (of more relevance in this project) beluga whales exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran *et al.,* 2002, 2005). However, the animals tolerated high received levels of sound (pk-pk level >200 dB re 1 μPa) before exhibiting aversive behaviors.

Reactions of toothed whales to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for mysticetes. However, based on the limited existing evidence, belugas should not be grouped with delphinids in the ''less responsive'' category.

Pinnipeds—Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources proposed for use. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. 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). Monitoring work in the Alaskan Beaufort Sea during 1996–2001 provided considerable information regarding the behavior of seals exposed to seismic pulses (Harris *et al.,* 2001; Moulton and Lawson, 2002). These seismic projects usually involved arrays of 6 to 16 airguns with total volumes of 560 to 1,500 in^3. The combined results suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal sightings tended to be farther away from the seismic vessel when the airguns were operating than when they were not (Moulton and Lawson, 2002). However, these avoidance movements were relatively small, on the order of 328 ft (100 m) to a few hundreds of meters, and many seals remained within 328–656 ft (100–200 m) of the trackline as the operating airgun array passed by. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey, 1987; Jefferson and Curry, 1994; Richardson *et al.,* 1995a). 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 pinniped 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. Additionally, the airguns are only proposed to be used for a short time during the exploration drilling program (approximately 10–14 hours for each well, for a total of 40–56 hours, and more likely to be 30–42 hours if the fourth well is not completed, over the entire open-water season, which lasts for approximately 4 months).

(4) Hearing Impairment and Other Physiological Effects

TTS—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, can be limited to a particular frequency range, and can be in varying degrees (*i.e.,* a loss of a certain number of dBs of sensitivity). 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.

Marine mammal hearing plays a critical role in communication with conspecifics and in interpretation of environmental cues for purposes such as predator avoidance and prey capture. Depending on the degree (elevation of threshold in dB), duration (*i.e.,* recovery time), and frequency range of TTS and the context in which it is experienced, TTS can have effects on marine mammals ranging from discountable to serious. For example, a marine mammal may be able to readily compensate for a brief, relatively small amount of TTS in a non-critical frequency range that takes place during a time when the animal is traveling through the open ocean, where ambient noise is lower and there are not as many competing sounds present. Alternatively, a larger amount and longer duration of TTS sustained during a time when communication is critical for successful mother/calf interactions could have more serious impacts if it were in the same frequency band as the necessary vocalizations and of a severity that it impeded communication. The fact that animals exposed to levels and durations of sound that would be expected to result in this physiological response would also be expected to have behavioral responses of a comparatively more severe or sustained nature is also notable and potentially of more importance than the simple existence of a TTS.

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

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are assumed to be lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison, 2004), meaning that baleen whales require sounds to be louder (*i.e.,* higher dB levels) than odontocetes in the frequency ranges at which each group hears the best. From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales (Southall *et al.,* 2007). Since current NMFS practice assumes the same thresholds for the onset of hearing impairment in both odontocetes and mysticetes, NMFS' onset of TTS threshold is likely conservative for mysticetes. For this proposed activity, Shell expects no cases of TTS given the strong likelihood that baleen whales would avoid the airguns before being exposed to levels high enough for TTS to occur. The source levels of the drillship are far lower than those of the airguns.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. However, systematic TTS studies on captive pinnipeds have been conducted (Bowles *et al.,* 1999; Kastak *et al.,* 1999, 2005, 2007; Schusterman *et al.,* 2000; Finneran *et al.,* 2003; Southall *et al.,* 2007). Initial evidence from more prolonged (non-pulse) exposures suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak *et al.,* 1999, 2005; Ketten *et al.,* 2001; cf. Au *et al.,* 2000). The TTS threshold for pulsed sounds has been indirectly estimated as being a sound exposure level (SEL) of approximately 171 dB re 1 $\mu Pa^2 \cdot s$ (Southall *et al.,* 2007) which would be equivalent to a single pulse with a received level of approximately 181 to 186 dB re 1 µPa (rms), or a series of pulses for which the highest rms values are a few dB lower. Corresponding values for California sea lions and northern elephant seals are likely to be higher (Kastak *et al.,* 2005). For harbor seal, which is closely related to the ringed seal, TTS onset apparently occurs at somewhat lower received energy levels than for odonotocetes. The sound level necessary to cause TTS in pinnipeds depends on exposure duration, as in other mammals; with longer exposure, the level necessary to elicit TTS is reduced (Schusterman *et al.,* 2000; Kastak *et al.,* 2005, 2007). For very short exposures (*e.g.,* to a single sound pulse), the level necessary to cause TTS is very high (Finneran *et al.,* 2003). For pinnipeds exposed to in-air sounds, auditory fatigue has been measured in response to single pulses and to non-pulse noise (Southall *et al.,* 2007), although high exposure levels were required to induce TTS-onset (SEL: 129 dB re: 20 $\mu Pa^2 \cdot s$; Bowles *et al.,* unpub. data).

NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur, which are 180 and 190 dB re 1 µPa (rms) for cetaceans and pinnipeds, respectively (NMFS 1995, 2000). The established 180– and 190–dB re 1 µPa (rms) criteria are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before additional TTS measurements for marine mammals became available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. TTS is considered by NMFS to be a type of Level B (non-injurious) harassment. The 180– and 190–dB levels are shutdown criteria applicable to cetaceans and pinnipeds, respectively, as specified by NMFS (2000) and are used to establish exclusion zones (EZs), as appropriate. Additionally, based on the summary provided here and the fact that modeling indicates the back-propagated source level for the *Discoverer* to be between 177 and 185 dB re 1 µPa at 1 m (Austin and Warner, 2010), TTS is not expected to occur in any marine mammal species that may occur in the proposed drilling area since the source level will not reach levels thought to induce even mild TTS. While the source level of the airgun is higher than the 190–dB threshold level, an animal would have to be in very close proximity to be exposed to such levels. Additionally, the 180– and 190–dB radii for the airgun are 0.8 mi (1.24 km) and 0.3 mi (524 m), respectively, from the source. Because of the short duration that the airguns will be used (no more than 30–56 hours throughout the entire open-water season) and mitigation and monitoring measures described later in this document, hearing impairment is not anticipated.

PTS—When PTS occurs, there is physical damage to the sound receptors in the ear. In some 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 underwater industrial sound associated with oil exploration can cause PTS in any marine mammal (see Southall *et al.,* 2007). However, given the possibility that mammals might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to such activities might incur PTS (*e.g.,* Richardson *et al.,* 1995, p. 372*ff;* Gedamke *et al.,* 2008). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. 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 (Southall *et al.,* 2007; Le Prell, in press). PTS might occur at a received sound level at least several decibels above that inducing mild TTS. 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).

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause PTS during the proposed exploratory drilling program. As mentioned previously in this document, the source levels of the drillship are not considered strong enough to cause even slight TTS. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, based on the modeled source levels for the drillship, the levels immediately adjacent to the drillship may not be sufficient to induce PTS, even if the animals remain in the immediate vicinity of the activity. The modeled source level from the *Discoverer* suggests that marine mammals located immediately adjacent to a drillship would likely not be exposed to received sound levels of a magnitude strong enough to induce PTS, even if the animals remain in the immediate vicinity of the proposed activity location for a prolonged period of time. Because the source levels do not reach the threshold of 190 dB currently used for pinnipeds and is at the 180 dB threshold currently used for cetaceans, it is highly unlikely that any type of hearing impairment, temporary or permanent, would occur as a result of the exploration drilling activities. Additionally, Southall *et al.* (2007) proposed that the thresholds for injury of marine mammals exposed to ''discrete'' noise events (either single or multiple exposures over a 24-hr period) are higher than the 180– and 190–dB re 1 µPa (rms) in-water threshold currently used by NMFS. Table 1 in this document summarizes the SPL and SEL levels thought to cause auditory injury to cetaceans and pinnipeds in-water. For more information, please refer to Southall *et al.* (2007).

TABLE 1—PROPOSED INJURY CRITERIA FOR CETACEANS AND PINNIPEDS EXPOSED TO "DISCRETE" NOISE EVENTS (EITHER SINGLE PULSES, MULTIPLE PULSES, OR NON-PULSES WITHIN A 24-HR PERIOD; SOUTHALL et al., 2007)

	Single pulses	Multiple pulses	Non pulses
Low-frequency cetaceans			
Sound pressure level	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat).
Sound exposure level	198 dB re 1 μPa²-s (M_{lf})	198 dB re 1 μPa²-s (M_{lf})	215 dB re 1 μPa²-s (M_{lf}).
Mid-frequency cetaceans			
Sound pressure level	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat).
Sound exposure level	198 dB re 1 μPa²-s (M_{lf})	198 dB re 1 μPa²-s (M_{lf})	215 dB re 1 μPa²-s (M_{lf}).
High-frequency cetaceans			
Sound pressure level	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat).
Sound exposure level	198 dB re 1 μPa²-s (M_{lf})	198 dB re 1 μPa²-s (M_{lf})	215 dB re 1 μPa²-s (M_{lf}).
Pinnipeds (in water)			
Sound pressure level	218 dB re 1 μPa (peak) (flat)	218 dB re 1 μPa (peak) (flat)	218 dB re 1 μPa (peak) (flat).
Sound exposure level	186 dB re 1 μPa²-s (M_{pw})	186 dB re 1 μPa²-s (M_{pw})	203 dB re 1 μPa²-s (M_{pw}).

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, and other types of organ or tissue damage (Cox *et al.,* 2006; Southall *et al.,* 2007). Studies examining any 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 sounds for sufficiently long that significant physiological stress would develop.

Classic stress responses begin when an animal's central nervous system perceives a potential threat to its homeostasis. That perception triggers stress responses regardless of whether a stimulus actually threatens the animal; the mere perception of a threat is sufficient to trigger a stress response (Moberg, 2000; Sapolsky *et al.,* 2005; Seyle, 1950). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses; autonomic nervous system responses; neuroendocrine responses; or immune responses.

In the case of many stressors, an animal's first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor. An animal's second line of defense to stressors involves the sympathetic part of the autonomic nervous system and the classical ''fight or flight'' response, which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with ''stress.'' These responses have a relatively short duration and may or may not have significant long-term effects on an animal's welfare.

An animal's third line of defense to stressors involves its neuroendocrine or sympathetic nervous systems; the system that has received the most study has been the hypothalmus-pituitary-adrenal system (also known as the HPA axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress—including immune competence, reproduction, metabolism, and behavior—are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Moberg, 1987; Rivier, 1995), altered metabolism (Elasser *et al.,* 2000), reduced immune competence (Blecha, 2000), and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals; see Romano *et al.,* 2004) have been equated with stress for many years.

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and distress is the biotic cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose a risk to the animal's welfare. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions, which impair those functions that experience the diversion. For example, when mounting a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. When mounting a stress response diverts energy from a fetus, an animal's reproductive success and fitness will suffer. In these cases, the animals will have entered a pre-pathological or pathological state which is called ''distress'' (sensu Seyle, 1950) or ''allostatic loading'' (sensu McEwen and Wingfield, 2003). This pathological state will last until the animal replenishes its biotic reserves sufficient to restore normal function. Note that these examples involved a long-term (days or weeks) stress response exposure to stimuli.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses have also been documented fairly well through controlled experiment; because this physiology exists in every vertebrate that has been studied, it is not surprising that stress responses and their costs have been documented in both laboratory and free-living animals (for examples see, Holberton *et al.,* 1996; Hood *et al.,* 1998; Jessop *et al.,* 2003; Krausman *et al.,* 2004; Lankford *et al.,* 2005; Reneerkens *et al.,* 2002; Thompson and Hamer, 2000). Although no information has been collected on the physiological responses of marine mammals to anthropogenic sound exposure, studies of other marine animals and terrestrial animals would lead us to expect some marine mammals to experience physiological stress responses and, perhaps, physiological responses that would be classified as ''distress'' upon exposure to anthropogenic sounds.

For example, Jansen (1998) reported on the relationship between acoustic exposures and physiological responses that are indicative of stress responses in humans (*e.g.,* elevated respiration and increased heart rates). Jones (1998) reported on reductions in human performance when faced with acute, repetitive exposures to acoustic disturbance. Trimper *et al.* (1998) reported on the physiological stress responses of osprey to low-level aircraft noise while Krausman *et al.* (2004) reported on the auditory and physiology stress responses of endangered Sonoran pronghorn to military overflights. Smith *et al.* (2004a, 2004b) identified noise-induced physiological transient stress responses in hearing-specialist fish (*i.e.,* goldfish) that accompanied short- and long-term hearing losses. Welch and Welch (1970) reported physiological and behavioral stress responses that accompanied damage to the inner ears of fish and several mammals.

Hearing is one of the primary senses marine mammals use to gather information about their environment and communicate with conspecifics. Although empirical information on the relationship between sensory impairment (TTS, PTS, and acoustic masking) on marine mammals remains limited, it seems reasonable to assume that reducing an animal's ability to gather information about its environment and to communicate with other members of its species would be stressful for animals that use hearing as their primary sensory mechanism. Therefore, we assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC, 2003). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses (Moberg, 2000), NMFS also assumes that stress responses could persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS. However, as stated previously in this document, the source levels of the drillships are not loud enough to induce PTS or likely even TTS.

Resonance effects (Gentry, 2002) and direct noise-induced bubble formations (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 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. Additionally, no beaked whale species occur in the proposed exploration drilling area.

In general, very little is known about the potential for strong, anthropogenic 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. The low levels of continuous sound that will be produced by the drillship are not expected to cause such effects. Additionally, marine mammals that show behavioral avoidance of the proposed activities, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects.

Stranding and Mortality

Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten *et al.,* 1993; Ketten, 1995). However, explosives are no longer used for marine waters for commercial seismic surveys; they have been replaced entirely by airguns or related non-explosive pulse generators. Underwater sound from drilling, support activities, and airgun arrays is less energetic and has 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 involving mid-frequency active sonar, and, in one case, a Lamont-Doherty Earth Observatory (L–DEO) seismic survey (Malakoff, 2002; Cox *et al.,* 2006), has raised the possibility that beaked whales exposed to strong pulsed sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding (*e.g.,* Hildebrand, 2005; Southall *et al.,* 2007).

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include:

(1) Swimming in avoidance of a sound into shallow water;

(2) A change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage or other forms of trauma;

(3) A physiological change, such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and

(4) Tissue damage directly from sound exposure, such as through acoustically-mediated bubble formation and growth or acoustic resonance of tissues.

Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are indications that gas-bubble disease (analogous to ''the bends''), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. However, the evidence for this remains circumstantial and is associated with exposure to naval mid-frequency sonar, not seismic surveys or exploratory drilling programs (Cox *et al.,* 2006; Southall *et al.,* 2007).

Both seismic pulses and continuous drillship sounds are quite different from mid-frequency sonar signals, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses or drillships. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz, and the low-energy continuous sounds produced by drillships have most of the energy between 20 and 1,000 Hz. Additionally, the non-impulsive, continuous sounds produced by the drillship proposed to be used by Shell do not have rapid rise times. Rise time is the fluctuation in sound levels of the source. The type of sound that would be produced during the proposed drilling program will be constant and will not exhibit any sudden fluctuations or changes. Typical military mid-frequency sonar emits non-impulse sounds at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time. A further difference between them is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and oil and gas industry operations on marine mammals. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (*e.g.,* Balcomb and Claridge, 2001; NOAA and USN, 2001; Jepson *et al.,* 2003; Fernández *et al.,* 2004, 2005; Hildebrand, 2005; Cox *et al.,* 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity ''pulsed'' sound.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel *et al.,* 2004) were not well founded (IAGC, 2004; IWC, 2007). In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the L–DEO vessel R/V *Maurice Ewing* was operating a 20 airgun (8,490 in^3) array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002). Nonetheless, the Gulf of California incident, plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar, suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand, 2005). No injuries of beaked whales are anticipated during the proposed exploratory drilling program because none occur in the proposed area.

Exploratory Drilling Program and Potential for Oil Spill

As noted above, the specified activity involves the drilling of exploratory wells and associated activities in the Chukchi Sea during the 2012 open-water season. The impacts to marine mammals that are reasonably expected to occur will be acoustic in nature. In response to previous IHA applications submitted by Shell, various entities have asserted that NMFS cannot authorize the take of marine mammals incidental to exploratory drilling under an IHA. Instead, they contend that incidental take can be allowed only with a letter of authorization (LOA) issued under five-year regulations because of the potential that an oil spill will cause serious injury or mortality.

There are two avenues for authorizing incidental take of marine mammals under the MMPA. NMFS may, depending on the nature of the anticipated take, authorize the take of marine mammals incidental to a specified activity through regulations and LOAs or annual IHAs. *See* 16 U.S.C. 1371(a)(5)(A) and (D). In general, regulations (accompanied by LOAs) may be issued for any type of take (*e.g.,* Level B harassment (behavioral disturbance), Level A harassment (injury), serious injury, or mortality), whereas IHAs are limited to activities that result only in harassment (*e.g.,* behavioral disturbance or injury). Following the 1994 MMPA Amendments, NMFS promulgated implementing regulations governing the issuance of IHAs in Arctic waters. See 60 FR 28379 (May 31, 1995) and 61 FR 15884 (April 10, 1996). NMFS stated in the preamble of the proposed rulemaking that the scope of IHAs would be limited to ''* * * those authorizations for harassment involving incidental harassment that may involve *non-serious injury.*'' See 60 FR 28380 (May 31, 1995; emphasis added); 50 CFR 216.107(a). (''[e]xcept for activities that have the potential to result in serious injury or mortality, which must be authorized under 216.105, incidental harassment authorizations may be issued, * * * to allowed activities that may result in only the incidental harassment of a small number of marine mammals.'') NMFS explained further that applications would be reviewed to determine whether the activity would result in more than harassment, and, if so, the agency would either (1) attempt to negate the potential for serious injury through mitigation requirements, or (2) deny the incidental harassment authorization and require the applicant to apply for incidental take regulations. See *id.* at 28380–81.

NMFS' determination of whether the type of incidental take authorization requested is appropriate occurs shortly after the applicant submits an application for an incidental take authorization. The agency evaluates the proposed action and all information contained in the application to determine whether it is adequate and complete and whether the type of taking requested is appropriate. See 50 CFR 216.104; see also 60 FR 28380 (May 31, 1995). Among other things, NMFS considers the specific activity or class of activities that can reasonably be *expected* to result in incidental take; the *type* of incidental take authorization that is being requested; and the *anticipated* impact of the activity upon the species or stock and its habitat. See *id.* at 216.104(a) (emphasis added). Any application that is determined to be incomplete or inappropriate for the type of taking requested will be returned to the applicant with an explanation of why the application is being returned. See *id.* Finally, NMFS evaluates the best available science to determine whether a proposed activity is reasonably expected or likely to result in serious injury or mortality.

NMFS evaluated Shell's incidental take application for its proposed 2012 drilling activities in light of the foregoing criteria and has concluded that Shell's request for an IHA is warranted. Shell submitted information with its IHA Application indicating that an oil spill is a highly unlikely event that is not reasonably expected to occur during the course of exploration drilling or ZVSP surveys. *See* Chukchi Sea IHA Application, p. 3 and Attachment E—Analysis of the Probability of an ''Unspecified Activity'' and Its Impacts: Oil Spill. In addition, Shell's 2012 Exploration Plan indicates there is a ''very low likelihood of a large oil spill event.'' *See* Shell Offshore, Inc.'s Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (May 2011), at p. 8–1; *see also,* Appendix F to Shell's Revised Outer Continental Shelf Lease Exploration Plan, at p. 4–174.

The likelihood of a large or very large (*i.e.,* ≥1,000 barrels or ≥150,000 barrels, respectively) oil spill occurring during Shell's proposed program has been estimated to be low. A total of 35 exploration wells have been drilled between 1982 and 2003 in the Chukchi and Beaufort seas, and there have been no blowouts. In addition, no blowouts have occurred from the approximately 98 exploration wells drilled within the Alaskan OCS (MMS, 2007a). Attachment E in Shell's IHA Application contains information regarding the probability of an oil spill occurring during the proposed program and the potential impacts should one occur. Based on modeling conducted by Bercha (2008), the predicted frequency of an exploration well oil spill in waters similar to those in the Chukchi Sea, Alaska, is 0.000612 per well for a blowout sized between 10,000 barrels (bbl) to 149,000 bbl and 0.000354 per well for a blowout greater than 150,000 bbl. Please refer to Shell's application for additional information on the model and predicted frequencies (see **ADDRESSES**).

Shell has implemented several design standards and practices to reduce the already low probability of an oil spill occurring as part of its operations. The wells proposed to be drilled in the Arctic are exploratory and will not be converted to production wells; thus, production casing will not be installed, and the well will be permanently plugged and abandoned once exploration drilling is complete. Shell has also developed and will implement the following plans and protocols: Shell's Critical Operations Curtailment Plan; IMP; Well Control Plan; and Fuel Transfer Plan. Many of these safety measures are required by the Department of the Interior's interim final rule implementing certain measures to improve the safety of oil and gas exploration and development on the Outer Continental Shelf in light of the Deepwater Horizon event (*see* 75 FR 63346, October 14, 2010). Operationally, Shell has committed to the following to help prevent an oil spill from occurring in the Chukchi Sea:

- Shell's Blow Out Preventer (BOP) was inspected and tested by an independent third party specialist;
- Further inspection and testing of the BOP have been performed to ensure the reliability of the BOP and that all functions will be performed as necessary, including shearing the drill pipe;
- Subsea BOP hydrostatic tests will be increased from once every 14 days to once every 7 days;
- A second set of blind/shear rams will be installed in the BOP stack;
- Full string casings will typically not be installed through high pressure zones;
- Liners will be installed and cemented, which allows for installation of a liner top packer;
- Testing of liners prior to installing a tieback string of casing back to the wellhead;
- Utilizing a two-barrier policy; and
- Testing of all casing hangers to ensure that they have two independent, validated barriers at all times.

NMFS has considered Shell's proposed action and has concluded that there is no reasonable likelihood of serious injury or mortality from the 2012 Chukchi Sea exploration drilling program. NMFS has consistently interpreted the term ''potential,'' as used in 50 CFR 216.107(a), to only include impacts that have more than a discountable probability of occurring, that is, impacts must be reasonably expected to occur. Hence, NMFS has regularly issued IHAs in cases where it found that the potential for serious injury or mortality was ''highly unlikely'' (*See* 73 FR 40512, 40514, July 15, 2008; 73 FR 45969, 45971, August 7, 2008; 73 FR 46774, 46778, August 11, 2008; 73 FR 66106, 66109, November 6, 2008; 74 FR 55368, 55371, October 27, 2009).

Interpreting ''potential'' to include impacts with any probability of occurring (*i.e.,* speculative or extremely low probability events) would nearly preclude the issuance of IHAs in every instance. For example, NMFS would be unable to issue an IHA whenever vessels were involved in the marine activity since there is always some, albeit remote, possibility that a vessel could strike and seriously injure or kill a marine mammal. This would also be inconsistent with the dual-permitting scheme Congress created and undesirable from a policy perspective, as limited agency resources would be used to issue regulations that provide no additional benefit to marine mammals beyond what is proposed in this IHA.

Despite concluding that the risk of serious injury or mortality from an oil spill in this case is extremely remote, NMFS has nonetheless evaluated the potential effects of an oil spill on marine mammals. While an oil spill is not a component of Shell's specified activity, potential impacts on marine mammals from an oil spill are discussed in more detail below and will be addressed further in the Environmental Assessment.

Potential Effects of Oil on Cetaceans

The specific effects an oil spill would have on cetaceans are not well known. While mortality is unlikely, exposure to spilled oil could lead to skin irritation, baleen fouling (which might reduce feeding efficiency), respiratory distress from inhalation of hydrocarbon vapors, consumption of some contaminated prey items, and temporary displacement from contaminated feeding areas. Geraci and St. Aubin (1990) summarize effects of oil on marine mammals, and Bratton *et al.* (1993) provides a synthesis of knowledge of oil effects on bowhead whales. The number of cetaceans that might be contacted by a spill would depend on the size, timing, and duration of the spill and where the oil is in relation to the animals. Whales may not avoid oil spills, and some have been observed feeding within oil slicks (Goodale *et al.,* 1981). These topics are discussed in more detail next.

In the case of an oil spill occurring during migration periods, disturbance of the migrating cetaceans from cleanup activities may have more of an impact than the oil itself. Human activity associated with cleanup efforts could deflect whales away from the path of the oil. However, noise created from cleanup activities likely will be short term and localized. In fact, whale avoidance of clean-up activities may benefit whales by displacing them from the oil spill area.

There is no direct evidence that oil spills, including the much studied Santa Barbara Channel and Exxon Valdez spills, have caused any deaths of cetaceans (Geraci, 1990; Brownell, 1971; Harvey and Dahlheim, 1994). It is suspected that some individually identified killer whales that disappeared from Prince William Sound during the time of the Exxon Valdez spill were casualties of that spill. However, no clear cause and effect relationship between the spill and the disappearance could be established (Dahlheim and Matkin, 1994). The AT–1 pod of transient killer whales that sometimes inhabits Prince William Sound has continued to decline after the Exxon Valdez oil spill (EVOS). Matkin *et al.* (2008) tracked the AB resident pod and the AT–1 transient group of killer whales from 1984 to 2005. The results of their photographic surveillance indicate a much higher than usual mortality rate for both populations the year following the spill (33% for AB Pod and 41% for AT–1 Group) and lower than average rates of increase in the 16 years after the spill (annual increase of about 1.6% for AB Pod compared to an annual increase of about 3.2% for other Alaska killer whale pods). In killer whale pods, mortality rates are usually higher for non-reproductive animals and very low for reproductive animals and adolescents (Olesiuk *et al.,* 1990, 2005; Matkin *et al.,* 2005). No effects on humpback whales in Prince William Sound were evident after the EVOS (von Ziegesar *et al.,* 1994). There was some temporary displacement of humpback whales out of Prince William Sound, but this could have been caused by oil contamination, boat and aircraft disturbance, displacement of food sources, or other causes.

Migrating gray whales were apparently not greatly affected by the Santa Barbara spill of 1969. There appeared to be no relationship between the spill and mortality of marine mammals. The higher than usual counts of dead marine mammals recorded after the spill represented increased survey effort and therefore cannot be conclusively linked to the spill itself (Brownell, 1971; Geraci, 1990). The conclusion was that whales were either able to detect the oil and avoid it or were unaffected by it (Geraci, 1990).

(1) Oiling of External Surfaces

Whales rely on a layer of blubber for insulation, so oil would have little if any effect on thermoregulation by whales. Effects of oiling on cetacean skin appear to be minor and of little significance to the animal's health (Geraci, 1990). Histological data and ultrastructural studies by Geraci and St. Aubin (1990) showed that exposures of skin to crude oil for up to 45 minutes in four species of toothed whales had no effect. They switched to gasoline and applied the sponge up to 75 minutes. This produced transient damage to epidermal cells in whales. Subtle changes were evident only at the cell level. In each case, the skin damage healed within a week. They concluded that a cetacean's skin is an effective barrier to the noxious substances in petroleum. These substances normally damage skin by getting between cells and dissolving protective lipids. In cetacean skin, however, tight intercellular bridges, vital surface cells, and the extraordinary thickness of the epidermis impeded the damage. The authors could not detect a change in lipid concentration between and within cells after exposing skin from a white-sided dolphin to gasoline for 16 hours in vitro.

Bratton *et al.* (1993) synthesized studies on the potential effects of contaminants on bowhead whales. They concluded that no published data proved oil fouling of the skin of any free-living whales, and conclude that bowhead whales contacting fresh or weathered petroleum are unlikely to suffer harm. Although oil is unlikely to adhere to smooth skin, it may stick to rough areas on the surface (Henk and Mullan, 1997). Haldiman *et al.* (1985) found the epidermal layer to be as much as seven to eight times thicker than that found on most whales. They also found that little or no crude oil adhered to preserved bowhead skin that was dipped into oil up to three times, as long as a water film stayed on the skin's surface. Oil adhered in small patches to the surface and vibrissae (stiff, hairlike structures), once it made enough contact with the skin. The amount of oil sticking to the surrounding skin and epidermal depression appeared to be in proportion to the number of exposures and the roughness of the skin's surface. It can be assumed that if oil contacted the eyes, effects would be similar to those observed in ringed seals; continued exposure of the eyes to oil could cause permanent damage (St. Aubin, 1990).

(2) Ingestion

Whales could ingest oil if their food is contaminated, or oil could also be absorbed through the respiratory tract. Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Geraci, 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt, 1978, 1982). Oil ingestion can decrease food assimilation of prey eaten (St. Aubin, 1988). Cetaceans may swallow some oil-contaminated prey, but it likely would be only a small part of their food. It is not known if whales would leave a feeding area where prey was abundant following a spill. Some zooplankton eaten by bowheads and gray whales consume oil particles and bioaccumulation can result. Tissue studies by Geraci and St. Aubin (1990) revealed low levels of naphthalene in the livers and blubber of baleen whales. This result suggests that prey have low concentrations in their tissues, or that baleen whales may be able to metabolize and excrete certain petroleum hydrocarbons. Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin, 1980, 1982) and this kind of damage has not been reported (Geraci, 1990).

(3) Fouling of Baleen

Baleen itself is not damaged by exposure to oil and is resistant to effects of oil (St. Aubin *et al.,* 1984). Crude oil could coat the baleen and reduce filtration efficiency; however, effects may be temporary (Braithwaite, 1983; St. Aubin *et al.,* 1984). If baleen is coated in oil for long periods, it could cause the animal to be unable to feed, which could lead to malnutrition or even death. Most of the oil that would coat the baleen is removed after 30 min, and less than 5% would remain after 24 hr (Bratton *et al.,* 1993). Effects of oiling of the baleen on feeding efficiency appear to be minor (Geraci, 1990). However, a study conducted by Lambertsen *et al.* (2005) concluded that their results highlight the uncertainty about how rapidly oil would depurate at the near zero temperatures in arctic waters and whether baleen function would be restored after oiling.

(4) Avoidance

Some cetaceans can detect oil and sometimes avoid it, but others enter and swim through slicks without apparent effects (Geraci, 1990; Harvey and Dahlheim, 1994). Bottlenose dolphins in the Gulf of Mexico apparently could detect and avoid slicks and mousse but did not avoid light sheens on the surface (Smultea and Wursig, 1995). After the Regal Sword spill in 1979, various species of baleen and toothed whales were observed swimming and feeding in areas containing spilled oil southeast of Cape Cod, MA (Goodale *et al.,* 1981). For months following EVOS, there were numerous observations of gray whales, harbor porpoises, Dall's porpoises, and killer whales swimming through light-to-heavy crude-oil sheens (Harvey and Dalheim, 1994, cited in Matkin *et al.,* 2008). However, if some of the animals avoid the area because of the oil, then the effects of the oiling would be less severe on those individuals.

(5) Factors Affecting the Severity of Effects

Effects of oil on cetaceans in open water are likely to be minimal, but there could be effects on cetaceans where both the oil and the whales are at least partly confined in leads or at ice edges (Geraci, 1990). In spring, bowhead and beluga whales migrate through leads in the ice. At this time, the migration can be concentrated in narrow corridors defined by the leads, thereby creating a greater risk to animals caught in the spring lead system should oil enter the leads. This situation would only occur if there were an oil spill late in the season and Shell could not complete cleanup efforts prior to ice covering the area. The oil would likely then be trapped in the ice until it began to thaw in the spring.

In fall, the migration route of bowheads can be close to shore (Blackwell *et al.,* 2009c). If fall migrants were moving through leads in the pack ice or were concentrated in nearshore waters, some bowhead whales might not be able to avoid oil slicks and could be subject to prolonged contamination. However, the autumn migration through the Chukchi Sea extends over several weeks, and some of the whales travel along routes north or inland of the area, thereby reducing the number of whales that could approach patches of spilled oil. Additionally, vessel activity associated with spill cleanup efforts may deflect whales traveling near the Burger prospect in the Chukchi Sea, thereby reducing the likelihood of contact with spilled oil.

Bowhead and beluga whales overwinter in the Bering Sea (mainly from November to March). In the summer, the majority of the bowhead whales are found in the Canadian Beaufort Sea, although some have recently been observed in the U.S. Beaufort and Chukchi Seas during the summer months (June to August). Data from the Barrow-based boat surveys in

2009 (George and Sheffield, 2009) showed that bowheads were observed almost continuously in the waters near Barrow, including feeding groups in the Chukchi Sea at the beginning of July. The majority of belugas in the Beaufort stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham *et al.,* 1984; Ljungblad *et al.,* 1984; Richardson *et al.,* 1995a). Therefore, a spill in summer would not be expected to have major impacts on these species. Additionally, humpback and fin whales are only sighted in the Chukchi Sea in small numbers in the summer, as this is thought to be the extreme northern edge of their range. Therefore, impacts to these species from an oil spill would be extremely limited.

Potential Effects of Oil on Pinnipeds

Ice seals are present in open-water areas during summer and early autumn. Externally oiled phocid seals often survive and become clean, but heavily oiled seal pups and adults may die, depending on the extent of oiling and characteristics of the oil. Prolonged exposure could occur if fuel or crude oil was spilled in or reached nearshore waters, was spilled in a lead used by seals, or was spilled under the ice when seals have limited mobility (NMFS, 2000). Adult seals may suffer some temporary adverse effects, such as eye and skin irritation, with possible infection (MMS, 1996). Such effects may increase stress, which could contribute to the death of some individuals. Ringed seals may ingest oil-contaminated foods, but there is little evidence that oiled seals will ingest enough oil to cause lethal internal effects. There is a likelihood that newborn seal pups, if contacted by oil, would die from oiling through loss of insulation and resulting hypothermia. These potential effects are addressed in more detail in subsequent paragraphs.

Reports of the effects of oil spills have shown that some mortality of seals may have occurred as a result of oil fouling; however, large scale mortality had not been observed prior to the EVOS (St. Aubin, 1990). Effects of oil on marine mammals were not well studied at most spills because of lack of baseline data and/or the brevity of the post-spill surveys. The largest documented impact of a spill, prior to EVOS, was on young seals in January in the Gulf of St. Lawrence (St. Aubin, 1990). Brownell and Le Boeuf (1971) found no marked effects of oil from the Santa Barbara oil spill on California sea lions or on the mortality rates of newborn pups.

Intensive and long-term studies were conducted after the EVOS in Alaska. There may have been a long-term decline of 36% in numbers of molting harbor seals at oiled haul-out sites in Prince William Sound following EVOS (Frost *et al.,* 1994a). However, in a reanalysis of those data and additional years of surveys, along with an examination of assumptions and biases associated with the original data, Hoover-Miller *et al.* (2001) concluded that the EVOS effect had been overestimated. The decline in attendance at some oiled sites was more likely a continuation of the general decline in harbor seal abundance in Prince William Sound documented since 1984 (Frost *et al.,* 1999) rather than a result of EVOS. The results from Hoover-Miller *et al.* (2001) indicate that the effects of EVOS were largely indistinguishable from natural decline by 1992. However, while Frost *et al.* (2004) concluded that there was no evidence that seals were displaced from oiled sites, they did find that aerial counts indicated 26% fewer pups were produced at oiled locations in 1989 than would have been expected without the oil spill. Harbor seal pup mortality at oiled beaches was 23% to 26%, which may have been higher than natural mortality, although no baseline data for pup mortality existed prior to EVOS (Frost *et al.,* 1994a). There was no conclusive evidence of spill effects on Steller sea lions (Calkins *et al.,* 1994). Oil did not persist on sea lions themselves (as it did on harbor seals), nor did it persist on sea lion haul-out sites and rookeries (Calkins *et al.,* 1994). Sea lion rookeries and haul out sites, unlike those used by harbor seals, have steep sides and are subject to high wave energy (Calkins *et al.,* 1994).

(1) Oiling of External Surfaces

Adult seals rely on a layer of blubber for insulation, and oiling of the external surface does not appear to have adverse thermoregulatory effects (Kooyman *et al.,* 1976, 1977; St. Aubin, 1990). Contact with oil on the external surfaces can potentially cause increased stress and irritation of the eyes of ringed seals (Geraci and Smith, 1976; St. Aubin, 1990). These effects seemed to be temporary and reversible, but continued exposure of eyes to oil could cause permanent damage (St. Aubin, 1990). Corneal ulcers and abrasions, conjunctivitis, and swollen nictitating membranes were observed in captive ringed seals placed in crude oil-covered water (Geraci and Smith, 1976) and in seals in the Antarctic after an oil spill (Lillie, 1954).

Newborn seal pups rely on their fur for insulation. Newborn ringed seal pups in lairs on the ice could be contaminated through contact with oiled mothers. There is the potential that newborn ringed seal pups that were contaminated with oil could die from hypothermia.

(2) Ingestion

Marine mammals can ingest oil if their food is contaminated. Oil can also be absorbed through the respiratory tract (Geraci and Smith, 1976; Engelhardt *et al.,* 1977). Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Engelhardt, 1981). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt, 1978, 1982, 1985). In addition, seals exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin, 1980, 1982).

(3) Avoidance and Behavioral Effects

Although seals may have the capability to detect and avoid oil, they apparently do so only to a limited extent (St. Aubin, 1990). Seals may abandon the area of an oil spill because of human disturbance associated with cleanup efforts, but they are most likely to remain in the area of the spill. One notable behavioral reaction to oiling is that oiled seals are reluctant to enter the water, even when intense cleanup activities are conducted nearby (St. Aubin, 1990; Frost *et al.,* 1994b, 2004).

(4) Factors Affecting the Severity of Effects

Seals that are under natural stress, such as lack of food or a heavy infestation by parasites, could potentially die because of the additional stress of oiling (Geraci and Smith, 1976; St. Aubin, 1990; Spraker *et al.,* 1994). Female seals that are nursing young would be under natural stress, as would molting seals. In both cases, the seals would have reduced food stores and may be less resistant to effects of oil than seals that are not under some type of natural stress. Seals that are not under natural stress (*e.g.,* fasting, molting) would be more likely to survive oiling.

In general, seals do not exhibit large behavioral or physiological reactions to limited surface oiling or incidental exposure to contaminated food or vapors (St. Aubin, 1990; Williams *et al.,* 1994). Effects could be severe if seals surface in heavy oil slicks in leads or if oil accumulates near haul-out sites (St. Aubin, 1990). An oil spill in open-water is less likely to impact seals.

The potential effects to marine mammals described in this section of the document do not take into consideration the proposed monitoring and mitigation measures described later in this document (see the ''Proposed Mitigation'' and ''Proposed Monitoring and Reporting'' sections).

Anticipated Effects on Marine Mammal Habitat

The primary potential impacts to marine mammals and other marine species are associated with elevated sound levels produced by the exploratory drilling program (*i.e.* the drillship and the airguns). However, other potential impacts are also possible to the surrounding habitat from physical disturbance and an oil spill (should one occur). This section describes the potential impacts to marine mammal habitat from the specified activity. Because the marine mammals in the area feed on fish and/or invertebrates there is also information on the species typically preyed upon by the marine mammals in the area.

Common Marine Mammal Prey in the Area

All of the marine mammal species that may occur in the proposed project area prey on either marine fish or invertebrates. The ringed seal feeds on fish and a variety of benthic species, including crabs and shrimp. Bearded seals feed mainly on benthic organisms, primarily crabs, shrimp, and clams. Spotted seals feed on pelagic and demersal fish, as well as shrimp and cephalopods. They are known to feed on a variety of fish including herring, capelin, sand lance, Arctic cod, saffron cod, and sculpins. Ribbon seals feed primarily on pelagic fish and invertebrates, such as shrimp, crabs, squid, octopus, cod, sculpin, pollack, and capelin. Juveniles feed mostly on krill and shrimp.

Bowhead whales feed in the eastern Beaufort Sea during summer and early autumn but continue feeding to varying degrees while on their migration through the central and western Beaufort Sea in the late summer and fall (Richardson and Thomson [eds.], 2002). Aerial surveys in recent years have sighted bowhead whales feeding in Camden Bay on their westward migration through the Beaufort Sea. When feeding in relatively shallow areas, bowheads feed throughout the water column. However, feeding is concentrated at depths where zooplankton is concentrated (Wursig *et al.,* 1984, 1989; Richardson [ed.], 1987; Griffiths *et al.,* 2002). Lowry and Sheffield (2002) found that copepods and euphausiids were the most common prey found in stomach samples from bowhead whales harvested in the Kaktovik area from 1979 to 2000. Areas to the east of Barter Island in the Beaufort Sea appear to be used regularly for feeding as bowhead whales migrate slowly westward across the Beaufort Sea (Thomson and Richardson, 1987; Richardson and Thomson [eds.], 2002). However, in some years, sizable groups of bowhead whales have been seen feeding as far west as the waters just east of Point Barrow (which is more than 150 mi [241 km] east of Shell's proposed drill sites in the Chukchi Sea) near the Plover Islands (Braham *et al.,* 1984; Ljungblad *et al.,* 1985; Landino *et al.,* 1994). The situation in September–October 1997 was unusual in that bowheads fed widely across the Alaskan Beaufort Sea, including higher numbers in the area east of Barrow than reported in any previous year (S. Treacy and D. Hansen, MMS, pers. comm.). However, by the time most bowhead whales reach the Chukchi Sea (October), they will likely no longer be feeding, or if it occurs it will be very limited. The location near Point Barrow is currently under intensive study as part of the BOWFEST program (BOWFEST, 2011).

Beluga whales feed on a variety of fish, shrimp, squid, and octopus (Burns and Seaman, 1985). Like several of the other species in the area, harbor porpoise feed on demersal and benthic species, mainly schooling fish and cephalopods. Killer whales from resident stocks primarily feed on salmon while killer whales from transient stocks feed on other marine mammals, such as harbor seals, harbor porpoises, gray whale calves and other pinniped and cetacean species.

Gray whales are primarily bottom feeders, and benthic amphipods and isopods form the majority of their summer diet, at least in the main summering areas west of Alaska (Oliver *et al.,* 1983; Oliver and Slattery, 1985). Farther south, gray whales have also been observed feeding around kelp beds, presumably on mysid crustaceans, and on pelagic prey such as small schooling fish and crab larvae (Hatler and Darling, 1974). The northeastern-most of the recurring feeding areas for gray whales is in the northeastern Chukchi Sea southwest of Barrow (Clarke *et al.,* 1989).

Three other baleen whale species may occur in the proposed project area, although likely in very small numbers: Minke, humpback, and fin whales. Minke whales opportunistically feed on crustaceans (*e.g.,* krill), plankton (*e.g.,* copepods), and small schooling fish (*e.g.,* anchovies, dogfish, capelin, coal fish, cod, eels, herring, mackerel, salmon, sand lance, saury, and wolfish) (Reeves *et al.,* 2002). Fin whales tend to feed in northern latitudes in the summer months on plankton and shoaling pelagic fish (Jonsgard, 1966a,b). Like many of the other species in the area, humpback whales primarily feed on euphausiids, copepods, and small schooling fish (*e.g.,* herring, capelin, and sand lance) (Reeves *et al.,* 2002). However, the primary feeding grounds for these species do not occur in the northern Chukchi Sea.

Two kinds of fish inhabit marine waters in the study area: (1) True marine fish that spend all of their lives in salt water, and (2) anadromous species that reproduce in fresh water and spend parts of their life cycles in salt water.

Most arctic marine fish species are small, benthic forms that do not feed high in the water column. The majority of these species are circumpolar and are found in habitats ranging from deep offshore water to water as shallow as 16.4–33 ft (5–10 m; Fechhelm *et al.,* 1995). The most important pelagic species, and the only abundant pelagic species, is the Arctic cod. The Arctic cod is a major vector for the transfer of energy from lower to higher trophic levels (Bradstreet *et al.,* 1986). In summer, Arctic cod can form very large schools in both nearshore and offshore waters (Craig *et al.,* 1982; Bradstreet *et al.,* 1986). Locations and areas frequented by large schools of Arctic cod cannot be predicted but can be almost anywhere. The Arctic cod is a major food source for beluga whales, ringed seals, and numerous species of seabirds (Frost and Lowry, 1984; Bradstreet *et al.,* 1986).

Anadromous Dolly Varden char and some species of whitefish winter in rivers and lakes, migrate to the sea in spring and summer, and return to fresh water in autumn. Anadromous fish form the basis of subsistence, commercial, and small regional sport fisheries. Dolly Varden char migrate to the sea from May through mid-June (Johnson, 1980) and spend about 1.5–2.5 months there (Craig, 1989). They return to rivers beginning in late July or early August with the peak return migration occurring between mid-August and early September (Johnson, 1980). At sea, most anadromous corregonids (whitefish) remain in nearshore waters within several kilometers of shore (Craig, 1984, 1989). They are often termed ''amphidromous'' fish in that they make repeated annual migrations into marine waters to feed, returning each fall to overwinter in fresh water.

Benthic organisms are defined as bottom dwelling creatures. Infaunal organisms are benthic organisms that live within the substrate and are often sedentary or sessile (bivalves, polychaetes). Epibenthic organisms live on or near the bottom surface sediments and are mobile (amphipods, isopods, mysids, and some polychaetes). The northeastern Chukchi Sea supports a higher biomass of benthic organisms than do surrounding areas (Grebmeier and Dunton, 2000). Some benthic-feeding marine mammals, such as walruses and gray whales, take advantage of the abundant food resources and congregate in these highly productive areas. Harold and Hanna Shoals are two known highly productive areas in the Chukchi Sea rich with benthic animals.

Many of the nearshore benthic marine invertebrates of the Arctic are circumpolar and are found over a wide range of water depths (Carey *et al.,* 1975). Species identified include polychaetes (*Spio filicornis, Chaetozone setosa, Eteone longa*), bivalves (*Cryrtodaria kurriana, Nucula tenuis, Liocyma fluctuosa*), an isopod (*Saduria entomon*), and amphipods (*Pontoporeia femorata, P. affinis*). Additionally, kelp beds occur in at least two areas in the nearshore areas of the Chukchi Sea (Mohr *et al.,* 1957; Phillips *et al.,* 1982; Phillips and Reiss, 1985), but they are located within about 15.5 mi (25 km) of the coast, which is much closer nearshore than Shell's proposed activities.

Potential Impacts From Seafloor Disturbance on Marine Mammal Habitat

There is a possibility of some seafloor disturbance or temporary increased turbidity in the seabed sediments during anchoring and excavation of the mudline cellars (MLCs). The amount and duration of disturbed or turbid conditions will depend on sediment material and consolidation of specific activity.

The *Discoverer* would be stabilized and held in place with a system of eight 15,400 lb (7,000 kg) Stevpris anchors during operations. The anchors from the *Discoverer* are designed to embed into the seafloor. Prior to setting, the anchors will penetrate the seafloor and drag two or three times their length. Both the anchor and anchor chain will disturb sediments and create an ''anchor scar,'' which is a depression in the seafloor caused by the anchor embedding. The anchor scar is a depression with ridges of displaced sediment, and the area of disturbance will often be greater than the size of the anchor itself because the anchor is dragged along the seafloor until it takes hold and sets.

Each Stevpris anchor may impact an area of 2,027 ft^2 (188 m^2) of the seafloor, including the scar made when the anchor chain is dragged across the seafloor. Minimum impact estimates from each well or mooring the *Discoverer* by its eight anchors is 16,216 ft^2 (1,507 m^2) of seafloor. This estimate assumes that the anchors are set only once. Shell plans to pre-set anchors at each drill site. Unless moved by an outside force such as sea current, anchors should only need to be set once per drill site. (Shell proposes to drill at three sites and potentially a fourth site in the Chukchi Sea during the 2012 open-water season.) Additionally, based on the vast size of the Chukchi Sea, the area of disturbance is not anticipated to adversely affect marine mammal use of the area.

Once the drillship ends operation, the anchors will be retrieved. Over time, the anchor scars will be filled through natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type. Anchor scars were visible under low energy conditions in the North Sea for 5–10 years after retrieval. Centaur Associates, Inc. (1984) reported that anchoring in sand or muddy sand sediments may not result in anchor scars or may result in scars that do not persist. Surficial sediments in Shell's Burger prospect consist of soft sandy mud (silt and clay) with lesser amounts of gravel (Battelle Memorial Institute, 2010; Blanchard *et al.,* 2010a,b). The energy regime, plus possible effects of ice gouge in the Chukchi Sea, suggests that anchor scars would be refilled faster than in the North Sea.

Excavation of each MLC by the *Discoverer* will displace about 17,128 ft^3 (485 m^3) of seafloor sediments and directly disturb approximately 314 ft^2 (29 m^2) of seafloor. Material will be excavated from the MLCs using a large diameter drillbit. Pressurized air and seawater (no drilling mud used) will be used to assist in the removal of the excavated materials from the MLC.

Some of the excavated sediments will be displaced to adjacent seafloor areas and some will be removed via the air lift system and discharged on the seafloor away from the MLC. These excavated materials will also have some indirect effects as they are deposited on the seafloor in the vicinity of the MLCs. Direct and indirect effects would include slight changes in seafloor relief and sediment consistency.

Vessel mooring and MLC construction would result in increased suspended sediment in the water column that could result in lethal effects on some zooplankton (food source for baleen whales). However, compared to the overall population of zooplankton and the localized nature of effects, any mortality that may occur would not be considered significant. Due to fast regeneration periods of zooplankton, populations are expected to recover quickly.

Impacts on fish resulting from suspended sediments would be dependent upon the life stage of the fish (*e.g.,* eggs, larvae, juveniles, or adults), the concentration of the suspended sediments, the type of sediment, and the duration of exposure (IMG Golder, 2004). Eggs and larvae have been found to exhibit greater sensitivity to suspended sediments (Wilber and Clarke, 2001) and other stresses, which is thought to be related to their relative lack of motility (Auld and Schubel, 1978). Sedimentation could affect fish by causing egg morbidity of demersal fish feeding near or on the ocean floor (Wilber and Clarke, 2001). Surficial membranes are especially susceptible to abrasion (Cairns and Scheier, 1968). Adhesive demersal eggs could be exposed to the sediments as long as the excavation activity continues, while exposure of pelagic eggs would be much shorter as they move with ocean currents (Wilber and Clarke, 2001). Most of the offshore demersal marine fish species in the northeastern Chukchi Sea (Shell's proposed project area) spawn under the ice during the winter and therefore would not be affected by redeposition of sediments on the seafloor due to MLC construction since Shell has not scheduled any exploration drilling activities during the winter months.

Most diadromous fish species expected to be present in the area of Shell's drilling operations lay their eggs in freshwater or coastal estuaries. Therefore, only those eggs carried into the marine environment by winds and current would be affected by these operations. Because Shell's proposed drill sites occur 65 and 78 mi (105 and 125.5 km) from the Chukchi coast, the statistical probability of diadromous fish eggs being present in the vicinity of Shell's proposed operations is infinitesimally small. Thus, impacts on diadromous fish eggs due to abrasion, puncture, burial, or other effects associated with anchoring or MLC construction would be slight. Further, since most diadromous fish species produce eggs prolifically, even if a small number of eggs were impacted by these activities, the total species population would not be expected to be impacted.

Suspended sediments, resulting from vessel mooring and MLC excavation, are not expected to result in permanent damage to habitats used by the marine mammal species in the proposed project area or on the food sources that they utilize. Rather, NMFS considers that such impacts will be temporary in nature and concentrated in the areas directly surrounding vessel mooring and MLC excavation activities—areas which are very small relative to the overall Chukchi Sea region. Less than 0.0000001 percent of the fish habitat in the LS 193 area would be directly affected by the mooring and excavation activity.

Potential Impacts From Sound Generation

With regard to fish as a prey source for odontocetes and seals, fish are known to hear and react to sounds and to use sound to communicate (Tavolga *et al.,* 1981) and possibly avoid predators (Wilson and Dill, 2002). Experiments have shown that fish can sense both the strength and direction of sound (Hawkins, 1981). Primary factors determining whether a fish can sense a sound signal, and potentially react to it, are the frequency of the signal and the strength of the signal in relation to the natural background noise level.

Fishes produce sounds that are associated with behaviors that include territoriality, mate search, courtship, and aggression. It has also been speculated that sound production may provide the means for long distance communication and communication under poor underwater visibility conditions (Zelick *et al.,* 1999), although the fact that fish communicate at low-frequency sound levels where the masking effects of ambient noise are naturally highest suggests that very long distance communication would rarely be possible. Fishes have evolved a diversity of sound generating organs and acoustic signals of various temporal and spectral contents. Fish sounds vary in structure, depending on the mechanism used to produce them (Hawkins, 1993). Generally, fish sounds are predominantly composed of low frequencies (less than 3 kHz).

Since objects in the water scatter sound, fish are able to detect these objects through monitoring the ambient noise. Therefore, fish are probably able to detect prey, predators, conspecifics, and physical features by listening to environmental sounds (Hawkins, 1981). There are two sensory systems that enable fish to monitor the vibration-based information of their surroundings. The two sensory systems, the inner ear and the lateral line, constitute the acoustico-lateralis system.

Although the hearing sensitivities of very few fish species have been studied to date, it is becoming obvious that the intra- and inter-specific variability is considerable (Coombs, 1981). Nedwell *et al.* (2004) compiled and published available fish audiogram information. A noninvasive electrophysiological recording method known as auditory brainstem response is now commonly used in the production of fish audiograms (Yan, 2004). Generally, most fish have their best hearing in the low-frequency range (*i.e.,* less than 1 kHz). Even though some fish are able to detect sounds in the ultrasonic frequency range, the thresholds at these higher frequencies tend to be considerably higher than those at the lower end of the auditory frequency range.

Literature relating to the impacts of sound on marine fish species can be divided into the following categories: (1) Pathological effects; (2) physiological effects; and (3) behavioral effects. Pathological effects include lethal and sub-lethal physical damage to fish; physiological effects include primary and secondary stress responses; and behavioral effects include changes in exhibited behaviors of fish. Behavioral changes might be a direct reaction to a detected sound or a result of the anthropogenic sound masking natural sounds that the fish normally detect and to which they respond. The three types of effects are often interrelated in complex ways. For example, some physiological and behavioral effects could potentially lead to the ultimate pathological effect of mortality. Hastings and Popper (2005) reviewed what is known about the effects of sound on fishes and identified studies needed to address areas of uncertainty relative to measurement of sound and the responses of fishes. Popper *et al.* (2003/2004) also published a paper that reviews the effects of anthropogenic sound on the behavior and physiology of fishes.

Potential effects of exposure to continuous sound on marine fish include TTS, physical damage to the ear region, physiological stress responses, and behavioral responses such as startle response, alarm response, avoidance, and perhaps lack of response due to masking of acoustic cues. Most of these effects appear to be either temporary or intermittent and therefore probably do not significantly impact the fish at a population level. The studies that resulted in physical damage to the fish ears used noise exposure levels and durations that were far more extreme than would be encountered under conditions similar to those expected during Shell's proposed exploratory drilling activities.

The level of sound at which a fish will react or alter its behavior is usually well above the detection level. Fish have been found to react to sounds when the sound level increased to about 20 dB above the detection level of 120 dB (Ona, 1988); however, the response threshold can depend on the time of year and the fish's physiological condition (Engas *et al.,* 1993). In general, fish react more strongly to pulses of sound rather than a continuous signal (Blaxter *et al.,* 1981), such as the type of sound that will be produced by the drillship, and a quicker alarm response is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level.

Investigations of fish behavior in relation to vessel noise (Olsen *et al.,* 1983; Ona, 1988; Ona and Godo, 1990) have shown that fish react when the sound from the engines and propeller exceeds a certain level. Avoidance reactions have been observed in fish such as cod and herring when vessels approached close enough that received sound levels are 110 dB to 130 dB (Nakken, 1992; Olsen, 1979; Ona and Godo, 1990; Ona and Toresen, 1988). However, other researchers have found that fish such as polar cod, herring, and capeline are often attracted to vessels (apparently by the noise) and swim toward the vessel (Rostad *et al.,* 2006). Typical sound source levels of vessel noise in the audible range for fish are 150 dB to 170 dB (Richardson *et al.,* 1995a). (Based on models, the 160 dB radius for the *Discoverer* would extend approximately 33 ft [10 m]; therefore, fish would need to be in close proximity to the drillship for the noise to be audible). In calm weather, ambient noise levels in audible parts of the spectrum lie between 60 dB to 100 dB.

Sound will also occur in the marine environment from the various support vessels. Reported source levels for vessels during ice-management have ranged from 175 dB to 185 dB (Brewer *et al.,* 1993, Hall *et al.,* 1994). However, ice management or icebreaking activities are not expected to be necessary throughout the entire drilling season, so impacts from that activity would occur less frequently than sound from the drillship. Sound pressures generated by drilling vessels during active drilling operations have been measured during past exploration in the Beaufort and Chukchi seas. Sounds generated by drilling and ice-management are generally low frequency and within the frequency range detectable by most fish.

Shell also proposes to conduct seismic surveys with an airgun array for a short period of time during the drilling season (a total of approximately 30–56 hours over the course of the entire proposed drilling program). Airguns produce impulsive sounds as opposed to continuous sounds at the source. Short, sharp sounds can cause overt or subtle changes in fish behavior. Chapman and Hawkins (1969) tested the reactions of whiting (hake) in the field to an airgun. When the airgun was fired, the fish dove from 82 to 180 ft (25 to 55 m) depth and formed a compact layer. The whiting dove when received sound levels were higher than 178 dB re 1 µPa (Pearson *et al.,* 1992).

Pearson *et al.* (1992) conducted a controlled experiment to determine effects of strong noise pulses on several species of rockfish off the California coast. They used an airgun with a source level of 223 dB re 1 µPa. They noted:

- Startle responses at received levels of 200–205 dB re 1 µPa and above for two sensitive species, but not for two other species exposed to levels up to 207 dB;
- Alarm responses at 177–180 dB for the two sensitive species, and at 186 to 199 dB for other species;
- An overall threshold for the above behavioral response at about 180 dB;
- An extrapolated threshold of about 161 dB for subtle changes in the behavior of rockfish; and
- A return to pre-exposure behaviors within the 20–60 minute exposure period.

In summary, fish often react to sounds, especially strong and/or intermittent sounds of low frequency. Sound pulses at received levels of 160 dB re 1 µPa may cause subtle changes in behavior. Pulses at levels of 180 dB may cause noticeable changes in behavior (Chapman and Hawkins, 1969; Pearson *et al.,* 1992; Skalski *et al.,* 1992). It also appears that fish often habituate to repeated strong sounds rather rapidly, on time scales of minutes to an hour. However, the habituation does not endure, and resumption of the strong sound source may again elicit disturbance responses from the same fish. Underwater sound levels from the drillship and other vessels produce sounds lower than the response threshold reported by Pearson *et al.* (1992), and are not likely to result in major effects to fish near the proposed drill sites.

Based on a sound level of approximately 140 dB, there may be some avoidance by fish of the area near the drillship while drilling, around ice management vessels in transit and during ice management, and around other support and supply vessels when underway. Any reactions by fish to these sounds will last only minutes (Mitson and Knudsen, 2003; Ona *et al.,* 2007) longer than the vessel is operating at that location or the drillship is drilling. Any potential reactions by fish would be limited to a relatively small area within about 0.21 mi (0.34 km) of the drillship during drilling (JASCO, 2007). Avoidance by some fish or fish species could occur within portions of this area. No important spawning habitats are known to occur at or near the drilling locations.

Some of the fish species found in the Arctic are prey sources for odontocetes and pinnipeds. A reaction by fish to sounds produced by Shell's proposed operations would only be relevant to marine mammals if it caused concentrations of fish to vacate the area. Pressure changes of sufficient magnitude to cause that type of reaction would probably occur only very close to the sound source, if any would occur at all due to the low energy sounds produced by the majority of equipment proposed for use. Impacts on fish behavior are predicted to be inconsequential. Thus, feeding odontocetes and pinnipeds would not be adversely affected by this minimal loss or scattering, if any, of reduced prey abundance.

Some mysticetes, including bowhead whales, feed on concentrations of zooplankton. Bowhead whales primarily feed off Point Barrow in September and October. Reactions of zooplankton to sound are, for the most part, not known. Their ability to move significant distances is limited or nil, depending on the type of zooplankton. A reaction by zooplankton to sounds produced by the exploratory drilling program 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 sound source, if any would occur at all due to the low energy sounds produced by the drillship. However, Barrow is located approximately 140 mi (225 km) east of Shell's Burger prospect. Impacts on zooplankton behavior are predicted to be inconsequential. Thus, bowhead whales feeding off Point Barrow would not be adversely affected.

Gray whales are bottom feeders and suck sediment and the benthic amphipods that are their prey from the seafloor. The species primary feeding habitats are in the northern Bering Sea and Chukchi Sea (Nerini, 1984; Moore *et al.,* 1986; Weller *et al.,* 1999). In the northeastern Chukchi Sea, gray whales can be found feeding in the shallow offshore water area known as Hanna Shoals, which is located approximately 25 mi (40 km) northeast from the proposed drill sites. This area lies outside of the 120-dB and 160-dB ensonified zones for Shell's proposed Chukchi Sea drill sites. Moore *et al.* (2000) reported that in the summer gray whales were clustered along the shore primarily between Cape Lisburne and Point Barrow. In 2006 and 2007, gray whales were noted to be most abundant along the coast south of Wainwright (2006) and nearshore from Wainwright to Barrow (2007) (Thomas *et al.,* 2007; Thomas *et al.,* 2009). While some gray whales may migrate past or through Shell's proposed drill sites, no impacts to gray whales feeding at Hanna Shoal are anticipated based on the distance from the proposed activity and the area of the ensonified zone. Additionally, Yazvenko *et al.* (2007) studied the impacts of seismic surveys off Sakhalin Island, Russia, on feeding gray whales and found that the seismic activity had no measurable effect on bottom feeding gray whales in the area.

Potential Impacts From Drill Cuttings

Discharging drill cuttings or other liquid waste streams generated by the drilling vessel could potentially affect marine mammal habitat. Toxins could persist in the water column, which could have an impact on marine mammal prey species. However, despite a considerable amount of investment in research on exposures of marine mammals to organochlorines or other toxins, there have been no marine mammal deaths in the wild that can be conclusively linked to the direct exposure to such substances (O'Shea, 1999).

The National Pollutant Discharge Elimination System (NPDES) General Permit (GP) establishes discharge limits for drilling fluids (at the end of a discharge pipe) to a minimum 96-hr LC_{50} of 30,000 parts per million. Both modeling and field studies have shown that discharged drilling fluids are diluted rapidly in receiving waters (Ayers *et al.,* 1980a,b; Brandsma *et al.,* 1980; NRC, 1983; O'Reilly *et al.,* 1989; Nedwed *et al.,* 2004; Smith *et al.,* 2004; Neff, 2005). The dilution rate is strongly affected by the discharge rate; the NPDES GP limits the discharge of cuttings and fluids to 750 bbl/hr. For example, the EPA modeled hypothetical 750 bbl/hr discharges of drilling fluids in water depths of 66 ft (20 m) in the Beaufort and Chukchi Seas and predicted a minimum dilution of 1,326:1 at 330 ft (100 m).

Modeling of similar discharges offshore of Sakhalin Island predicted a 1,000-fold dilution within 10 minutes and 330 ft (100 m) of the discharge. In a field study (O'Reilly *et al.,* 1989) of a drilling waste discharge offshore of California, a 270 bbl discharge of drilling fluids was found to be diluted 183-fold at 33 ft (10 m) and 1,049-fold at 330 ft (100 m). Neff (2005) concluded that concentrations of discharged drilling fluids drop to levels that would have no effect within about two minutes of discharge and within 16 ft (5 m) of the discharge location.

Studies by the EPA (2006) and Neff (2005) indicate that although planktonic organisms are extremely sensitive to environmental conditions (*e.g.,* temperature, light, availability of nutrients, and water quality), there is little or no evidence of effects from drilling mud and cuttings discharges on plankton. More than 30 OCS well sites have been drilled in the Beaufort Sea. The Warthog well was drilled in Camden Bay in 35 ft (11 m) of water (Thurston *et al.,* 1999). BOEMRE routinely monitored that well site for contaminants and found that it had no accumulated petroleum hydrocarbons or heavy metals (Brown *et al.,* 2001). Effects on zooplankton present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, zooplankton and benthic animals are not likely to have long-term exposures to drilling mud and cuttings because of the episodic nature of discharges (typically only a few hours in duration). Results of a recent study on a historical drill site in Camden Bay (HH–2) showed that movement of drilling mud and cuttings were restricted to within 330 ft (100 m) of the discharge site (Trefry and Trocine, 2009).

Fine-grained particulates and other solids in drilling mud and cuttings could cause sublethal effects to organisms in the water column. The responses observed following exposure to drilling mud include alteration of respiration and filtration rates and altered behavior. Zooplankton in the immediate area of discharge from exploration drilling operations could potentially be adversely impacted by sediments in the water column, which could clog respiratory and feeding structures, and they could suffer abrasions. However, because of the close proximity that is required to endure such effects, impacts are anticipated to be inconsequential.

Studies in the 1980s, 1999, 2000, and 2002 (Brown *et al.,* 2001 cited in MMS, 2003) also found that benthic organisms near drilling sites in the Beaufort have accumulated neither petroleum hydrocarbon nor heavy metals. In 2008, Shell investigated the benthic communities (Dunton *et al.,* 2008) and sediments (Trefry and Trocine, 2009) around the Sivulliq Prospect, including the location of the historical Hammerhead drill site that was drilled in 1985. Benthic communities at the historical Hammerhead drill site were found not to differ statistically in abundance, community structure, or diversity, from benthic communities elsewhere in this portion of the Beaufort Sea, indicating that there was no long term effect. Because discharges from drilling mud and cuttings are composed of seawater, impacts to benthic organisms are anticipated to be inconsequential and restricted to a very small area of the seafloor in the Chukchi Sea.

Discharges and drill cuttings could impact fish by displacing them from the affected area. Additionally, sedimentation could impact fish, as demersal fish eggs could be smothered if discharges occur in a spawning area during the period of egg production. However, this is unlikely in deeper offshore locations, and no specific demersal fish spawning locations have been identified at the Burger well locations. The most abundant and trophically important marine fish, the Arctic cod, spawns with planktonic eggs and larvae under the sea ice during winter and will therefore have little exposure to discharges. Based on this information, drilling muds and cutting wastes are not anticipated to have long-term impacts to marine mammals or their prey.

Potential Impacts From Drillship Presence

The *Discoverer* is 514 ft (156.7 m) long. If an animal's swim path is directly perpendicular to the drillship, the animal will need to swim around the ship in order to pass through the area. The length of the drillship (approximately one and a half football fields) is not significant enough to cause a large-scale diversion from the animals' normal swim and migratory paths. Additionally, the eastward spring bowhead whale migration will occur prior to the beginning of Shell's proposed exploratory drilling program. Moreover, any deflection of bowhead whales or other marine mammal species due to the physical presence of the drillship or its support vessels would be very minor. The drillship's physical footprint is small relative to the size of the geographic region it will occupy and will likely not cause marine mammals to deflect greatly from their typical migratory route. Also, even if animals may deflect because of the presence of the drillship, the Chukchi Sea is much larger in size than the length of the drillship (many dozens to hundreds of miles vs. less than two football fields), and animals would have other means of passage around the drillship. While there are other vessels that will be on location to support the drillship, most of those vessels will remain within a few kilometers of the drillship (with the exception of the ice management vessels which will remain approximately 25 mi [40 km] upwind of the drillship when not in use). In sum, the physical presence of the drillship is not likely to cause a significant deflection to migrating marine mammals.

Potential Impacts From an Oil Spill

Lower trophic organisms and fish species are primary food sources for Arctic marine mammals. However, as noted earlier in this document, the offshore areas of the Chukchi Sea are not primary feeding grounds for many of the marine mammals that may pass through the area. Therefore, impacts to lower trophic organisms (such as zooplankton) and marine fishes from an oil spill in the proposed drilling area would not be likely to have long-term or significant consequences to marine mammal prey. Impacts would be greater if the oil moves closer to shore, as many of the marine mammals in the area have been seen feeding at nearshore sites (such as bowhead whales). Gray whales do feed in more offshore locations in the Chukchi Sea; therefore, impacts to their prey from oil could have some impacts.

Due to their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate populations is expected to occur soon after the surface oil passes. Spill response activities are not likely to disturb the prey items of whales or seals sufficiently to cause more than minor effects. Spill response activities could cause marine mammals to avoid the disturbed habitat that is being cleaned. However, by causing avoidance, animals would avoid impacts from the oil itself. Additionally, the likelihood of an oil spill is expected to be very low, as discussed earlier in this document.

Potential Impacts From Ice Management/Icebreaking Activities

Ice management activities include the physical pushing or moving of ice to create more open-water in the proposed drilling area and to prevent ice floes from striking the drillship. Icebreaking activities include the physical breaking of ice. Shell does not intend to conduct icebreaking activities. However, should there be a need for icebreaking, it would only be performed in order to safely move the drillship and other vessels off location and to end operations for the season. Ringed, bearded, spotted, and ribbon seals (along with the walrus) are dependent on sea ice for at least part of their life history. Sea ice is important for life functions such as resting, breeding, and molting. These species are dependent on two different types of ice: Pack ice and landfast ice. Should ice management/icebreaking activities be necessary during the proposed drilling program, Shell would only manage pack ice in either early to mid-July or mid- to late October. Landfast ice would not be present during Shell's proposed operations.

The ringed seal is the most common pinniped species in the proposed project area. While ringed seals use ice year-round, they do not construct lairs for pupping until late winter/early spring on the landfast ice. Therefore, since Shell plans to conclude drilling by October 31, Shell's activities would not impact ringed seal lairs or habitat needed for breeding and pupping in the Chukchi Sea. Aerial surveys in the eastern Chukchi Sea conducted in late May-early June 1999–2000 found that ringed seals were four to ten times more abundant in nearshore fast and pack ice environments than in offshore pack ice (Bengtson *et al.,* 2005). Ringed seals can be found on the pack ice surface in the late spring and early summer in the northern Chukchi Sea, the latter part of which may overlap with the start of Shell's proposed drilling activities. If an ice floe is pushed into one that contains hauled out seals, the animals may become startled and enter the water when the two ice floes collide. Bearded seals breed in the Bering and Chukchi Seas from mid-March through early May (several months prior to the start of Shell's operations). Bearded seals require sea ice for molting during the late spring and summer period. Because this species feeds on benthic prey, bearded seals occur over the pack ice front over the Chukchi Sea shelf in summer (Burns and Frost, 1979) but were not associated with the ice front when it receded over deep water (Kingsley *et al.,* 1985). The spotted seal does not breed in the Chukchi Sea. Spotted seals molt most intensely during May and June and then move to the coast after the sea ice has melted. Ribbon seals are not known to breed in the Chukchi Sea. From July-October, when sea ice is absent, the ribbon seal is entirely pelagic, and its distribution is not well known (Burns, 1981; Popov, 1982). Therefore, ice used by bearded, spotted, and ribbon seals needed for life functions such as breeding and molting would not be impacted as a result of Shell's drilling program since these life functions do not occur in the proposed project area or at the same time as Shell's operations. For ringed seals, ice management/icebreaking activities would occur during a time when life functions such as breeding, pupping, and molting do not occur in the proposed activity area. Additionally, these life functions normally occur on landfast ice, which will not be impacted by Shell's activity.

Proposed Mitigation

In order to issue an incidental take authorization (ITA) under Sections 101(a)(5)(A) and (D) of the MMPA, NMFS must, where applicable, set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable 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 (where relevant). This section summarizes the contents of Shell's Marine Mammal Monitoring and Mitigation Plan (4MP). Later in this document in the ''Proposed Incidental Harassment Authorization'' section, NMFS lays out the proposed conditions for review, as they would appear in the final IHA (if issued).

Mitigation Measures Proposed by Shell

Shell submitted a 4MP as part of its application (Attachment C; see **ADDRESSES**). Shell's planned offshore drilling program incorporates both design features and operational procedures for minimizing potential impacts on marine mammals and on subsistence hunts. The design features and operational procedures have been described in the IHA and LOA applications submitted to NMFS and USFWS, respectively, and are summarized here. Survey design features include:

- Timing and locating drilling and support activities to avoid interference with the annual subsistence hunts by the peoples of the Chukchi villages;
- Identifying transit routes and timing to avoid other subsistence use areas and communicating with coastal communities before operating in or passing through these areas; and
- Conducting pre-season sound propagation modeling to establish the appropriate exclusion and behavioral radii.

Shell indicates that the potential disturbance of marine mammals during operations will be minimized further through the implementation of several ship-based mitigation measures, which include establishing and monitoring safety and disturbance zones.

Exclusion radii for marine mammals around sound sources are customarily defined as the distances within which received sound levels are greater than or equal to 180 dB re 1 μPa (rms) for cetaceans and greater than or equal to 190 dB re 1 μPa (rms) for pinnipeds. These exclusion criteria are based on an assumption that sounds at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels might have such effects. It should be understood that marine mammals inside these exclusion zones will not necessarily be injured, as the received sound thresholds which determine these zones were established prior to the current understanding that significantly higher levels of sound would be required before injury would likely occur (see Southall *et al.,* 2007). With respect to Level B harassment, NMFS' practice has been to apply the 120 dB re 1 μPa (rms) received level threshold for underwater continuous sound levels and the 160 dB re 1 μPa (rms) received level threshold for underwater impulsive sound levels.

Shell proposes to monitor the various radii in order to implement any mitigation measures that may be necessary. Initial radii for the sound levels produced by the *Discoverer,* the icebreaker, and the airguns have been modeled. Measurements taken by Austin and Warner (2010) indicated broadband source levels between 177 and 185 dB re 1 μPa rms for the *Discoverer.* Measurements of the icebreaking supply ship *Robert Lemeur* pushing and breaking ice during exploration drilling operations in the Beaufort Sea in 1986 resulted in an estimated broadband source level of 193 dB re 1 μPa rms (Greene, 1987a; Richardson *et al.,* 1995a). Based on a similar airgun array used in the shallow waters of the Beaufort Sea in 2008 by BP, the source level of the airgun is predicted to be 241.4 dB re 1 μPa rms. Once on location in the Chukchi Sea, Shell will conduct sound source verification (SSV) tests to establish safety zones for the previously mentioned sound level criteria. The objectives of the SSV tests are: (1) To quantify the absolute sound levels produced by drilling and to monitor their variations with time, distance, and direction from the drillship; and (2) to measure the sound levels produced by vessels operating in support of drilling operations, which include crew change vessels, tugs, ice management vessels, and spill response vessels. The methodology for conducting the SSV tests is fully described in Shell's 4MP (see **ADDRESSES**). Please refer to that document for further details. Upon completion of the SSV tests, the new radii will be established and monitored, and mitigation measures will be implemented in accordance with Shell's 4MP.

Based on the best available scientific literature, the source levels noted above for exploration drilling are not high enough to cause a temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals. Consequently, Shell believes that mitigation as described for seismic activities including ramp ups, power downs, and shutdowns should not be necessary for drilling activities. NMFS has also determined that these types of mitigation measures, traditionally required for seismic survey operations, are not practical or necessary for this proposed drilling activity. Seismic airgun arrays can be turned on slowly (*i.e.,* only turning on one or some guns at a time) and powered down quickly. The types of sound sources used for exploratory drilling have different properties and are unable to be ''powered down'' like airgun arrays or shutdown instantaneously without posing other risks to operational and human safety. However, Shell plans to use Protected Species Observers (PSOs, formerly referred to as marine mammal observers) onboard the drillship and the various support vessels to monitor marine mammals and their responses to industry activities and to initiate mitigation measures (for ZVSP activities) should in-field measurements of the operations indicate that such measures are necessary. Additional details on the PSO program are described in the ''Proposed Monitoring and Reporting'' section found later in this document. Also, for the ZVSP activities, Shell proposes to implement standard mitigation procedures, such as ramp ups, power downs, and shutdowns.

A ramp up of an airgun array provides a gradual increase in sound levels and involves a step-wise increase in the number and total volume of airguns firing until the full volume is achieved. The purpose of a ramp up (or ''soft start'') is to ''warn'' cetaceans and pinnipeds in the vicinity of the airguns and to provide the time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the proposed ZVSP surveys, Shell will ramp up the airgun arrays slowly. Full ramp ups (*i.e.,* from a cold start when no airguns have been firing) will begin by firing a single airgun in the array. A full ramp up will not begin until there has been a minimum of 30 minutes of observation of the 180-dB and 190-dB exclusion zones for cetaceans and pinnipeds, respectively, by PSOs to assure that no marine mammals are present. The entire exclusion zone must be visible during the 30-minute lead-in to a full ramp up. If the entire exclusion zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the exclusion zone during the 30-minute watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the applicable exclusion zone or the animal(s) is not sighted for at least 15 minutes for small odontocetes and pinnipeds or 30 minutes for baleen whales.

A power down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shutdown is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable exclusion zone of the full arrays but is outside the applicable exclusion zone of the single source. If a marine mammal is sighted within the applicable exclusion zone of the single energy source, the entire array will be shutdown (*i.e.,* no sources firing). The same 15 and 30 minute sighting times described for ramp up also apply to starting the airguns again after either a power down or shutdown.

Additional mitigation measures proposed by Shell include: (1) Reducing speed and/or changing course if a marine mammal is sighted from a vessel in transit (NMFS has proposed a specific distance in the next subsection); (2) resuming full activity (*e.g.,* full support vessel speed) only after marine mammals are confirmed to be outside the safety zone; (3) implementing flight restrictions prohibiting aircraft from flying below 1,500 ft (457 m) altitude (except during takeoffs and landings or in emergency situations); and (4) keeping vessels anchored when approached by marine mammals to avoid the potential for avoidance reactions by such animals.

Shell has also proposed additional mitigation measures to ensure no unmitigable adverse impact on the availability of affected species or stocks for taking for subsistence uses. Those measures are described in the ''Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses'' section found later in this document.

Additional Mitigation Measures Proposed by NMFS

In addition to the mitigation measures proposed by Shell, NMFS proposes the following measures (which apply to vessel operations) be included in the IHA, if issued, in order to ensure the least practicable impact on the affected species or stocks. NMFS proposes to require Shell to avoid multiple changes in direction or speed when within 300 yards (274 m) of whales. Additionally, NMFS proposes to require Shell to reduce speed in inclement weather.

Oil Spill Contingency Plan

In accordance with BOEM regulations, Shell has developed an Oil Discharge Prevention and Contingency Plan (ODPCP) for its Chukchi Sea exploration drilling program. A copy of this document can be found on the Internet at: *http://www.alaska.boemre.gov/fo/ODPCPs/2010_Chukchi_rev1.pdf.* Additionally, in its Plan of Cooperation (POC), Shell has agreed to several mitigation measures in order to reduce impacts during the response efforts in the unlikely event of an oil spill. Those measures are detailed in the ''*Plan of Cooperation (POC)*'' section found later in this document. The ODPCP is currently under review by the Department of the Interior and other agencies. A final decision on the adequacy of the ODPCP is expected prior to the start of Shell's 2012 Chukchi Sea drilling program.

NMFS has carefully evaluated Shell's proposed mitigation measures and considered a range of other measures in the context of ensuring that NMFS prescribes the means of effecting the least practicable impact on the affected marine mammal species and stocks and their habitat. Our evaluation of potential measures included consideration of the following factors in relation to one another:

- The manner in which, and the degree to which, the successful implementation of the measure is expected to minimize adverse impacts to marine mammals;
- The proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and
- The practicability of the measure for applicant implementation.

Proposed measures to ensure availability of such species or stock for taking for certain subsistence uses is discussed later in this document (see

''Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses'' section).

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, where applicable, set forth ''requirements pertaining to the monitoring and reporting of such taking''. The MMPA implementing regulations at 50 CFR 216.104(a)(13) indicate that requests for ITAs 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 in the proposed action area.

Monitoring Measures Proposed by Shell

The monitoring plan proposed by Shell can be found in the 4MP (Attachment C of Shell's application; see **ADDRESSES**). The plan may be modified or supplemented based on comments or new information received from the public during the public comment period or from the peer review panel (see the ''Monitoring Plan Peer Review'' section later in this document). A summary of the primary components of the plan follows. Later in this document in the ''Proposed Incidental Harassment Authorization'' section, NMFS lays out the proposed monitoring and reporting conditions, as well as the mitigation conditions, for review, as they would appear in the final IHA (if issued).

(1) Vessel-Based PSOs

Vessel-based monitoring for marine mammals will be done by trained PSOs throughout the period of drilling operations on all vessels. PSOs will monitor the occurrence and behavior of marine mammals near the drillship during all daylight periods during operation and during most daylight periods when drilling operations are not occurring. PSO duties will include watching for and identifying marine mammals, recording their numbers, distances, and reactions to the drilling operations. A sufficient number of PSOs will be required onboard each vessel to meet the following criteria: (1) 100% monitoring coverage during all periods of drilling operations in daylight; (2) maximum of 4 consecutive hours on watch per PSO; and (3) maximum of 12 hours of watch time per day per PSO. Shell anticipates that there will be provision for crew rotation at least every 3–6 weeks to avoid observer fatigue.

Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring projects. Resumes for those individuals will be provided to NMFS so that NMFS can review and accept their qualifications. Inupiat observers will be experienced in the region, familiar with the marine mammals of the area, and complete a NMFS approved observer training course designed to familiarize individuals with monitoring and data collection procedures. A handbook, adapted for the specifics of the planned Shell drilling program, will be prepared and distributed beforehand to all PSOs.

PSOs will watch for marine mammals from the best available vantage point on the drillship and support vessels. PSOs will scan systematically with the unaided eye and 7 x 50 reticle binoculars, supplemented with ''Big-eye'' binoculars and night-vision equipment when needed. Personnel on the bridge will assist the PSOs in watching for marine mammals. New or inexperienced PSOs will be paired with an experienced PSO or experienced field biologist so that the quality of marine mammal observations and data recording is kept consistent.

Information to be recorded by PSOs will include the same types of information that were recorded during recent monitoring programs associated with industry activity in the Arctic (*e.g.,* Ireland *et al.,* 2009). The recording will include information about the animal sighted, environmental and operational information, and the position of other vessels in the vicinity of the sighting. The ship's position, speed of support vessels, and water temperature, water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7 x 50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. PSOs may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience showed that a Class 1 eye-safe device was not able to measure distances to seals more than about 230 ft (70 m) away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 1968 ft (600 m)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. Humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20% when given immediate feedback about actual distances during training.

(2) Aerial Survey Program

Recent aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 mi (37 km) offshore in 2006–2008 and 2010 in support of Shell's summer seismic exploration activities. These surveys were designed to provide data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell proposes to conduct an aerial survey program in the Chukchi Sea in 2012 that would be similar to the previous programs.

The current aerial survey program will be designed to collect data on cetaceans but will be limited in its ability to collect similar data on pinnipeds. Shell's objectives for this program include:

- To collect data on the distribution and abundance of marine mammals in coastal areas of the eastern Chukchi Sea; and
- To collect and report data on the distribution, numbers, orientation and behavior of marine mammals, particularly beluga whales, near traditional hunting areas in the eastern Chukchi Sea.

With agreement from hunters in the coastal villages, aerial surveys of coastal areas to approximately 23 mi (37 km) offshore between Point Hope and Point Barrow will begin in early to mid-July and will continue until drilling operations in the Chukchi Sea are completed. Weather and equipment permitting, surveys will be conducted twice per week during this time period. In addition, during the 2012 drilling season, aerial surveys will be coordinated in cooperation with the aerial surveys funded by BOEMRE and conducted by NMFS and any other groups conducting surveys in the region. A full description of Shell's survey procedures can be found in the 4MP of Shell's application (see **ADDRESSES**). A summary follows next.

Transects will be flown in a saw-toothed pattern between the shore and 23 mi (37 km) offshore, as well as along the coast from Point Barrow to Point Hope (see Figure 6 of Shell's 4MP). This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore region. The surveyed area will include waters where belugas are normally available to subsistence hunters. Survey altitude will be at least 1,000 ft (305 m) with an average survey speed of 110–120 knots. As with past surveys of the Chukchi Sea coast, coordination with coastal villages to avoid disturbance of the beluga whale subsistence hunt will be extremely important. ''No-fly'' zones around coastal villages or other hunting areas established during communications with village representatives will be in place until the end of the hunting season.

Aerial surveys at an altitude of 1,000 ft (305 m) do not provide much information about seals but are suitable for bowhead, beluga, and gray whales. The need for a 1,000+ ft (305+ m) cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher altitude for surveys would result in a significant reduction in the number of days during which surveys would be possible, impairing the ability of the aerial program to meet its objectives. If large concentrations of belugas are encountered during the survey, the survey may be interrupted to photograph the groups to obtain better counts of the number of animals present. If whales are photographed in lagoons or other shallow-water concentration areas, the aircraft will climb to approximately 10,000 ft (3,050 m) altitude to avoid disturbing the whales and causing them to leave the area. If whales are in offshore areas, the aircraft will climb high enough to include all whales within a single photograph; typically about 3,000 ft (914 m) altitude.

Three PSOs will be aboard the aircraft during surveys. Two primary observers will be looking for marine mammals; one each at bubble windows on either side of the aircraft. The third person will record data. For each marine mammal sighting, the observer will dictate the species, number, size/age/sex class when determinable, activity, heading, swimming speed category (if traveling), sighting cue, ice conditions (type and percentage), and inclinometer reading to the marine mammal into a digital recorder. The inclinometer reading will be taken when the animal's location is 90° to the side of the aircraft track, allowing calculation of lateral distance from the aircraft trackline.

Transect information, sighting data and environmental data will be entered into a GPS-linked computer by the third observer and simultaneously recorded on digital voice recorders for backup and validation. At the start of each transect, the observer recording data will record the transect start time and position, ceiling height (ft), cloud cover (in 10ths), wind speed (knots), wind direction (°T) and outside air temperature (°C). In addition, each observer will record the time, visibility (subjectively classified as excellent, good, moderately impaired, seriously impaired or impossible), sea state (Beaufort wind force), ice cover (in 10ths) and sun glare (none, moderate, severe) at the start and end of each transect, and at 2 min intervals along the transect. The data logger will automatically record time and aircraft position (latitude and longitude) for sightings and transect waypoints, and at pre-selected intervals along the transects.

(3) Acoustic Monitoring

As discussed earlier in this document, Shell will conduct SSV tests to establish the isopleths for the applicable exclusion radii, mostly to be employed during the ZVSP surveys. In addition, Shell proposes to use an acoustic ''net'' array.

Drilling Sound Measurements—Drilling sounds are expected to vary significantly with time due to variations in the level of operations and the different types of equipment used at different times onboard the *Discoverer.* The objectives of these measurements are:

(1) To quantify the absolute sound levels produced by drilling and to monitor their variations with time, distance, and direction from the drilling vessel;

(2) To measure the sound levels produced by vessels operating in support of exploration drilling operations. These vessels will include crew change vessels, tugs, icebreakers, and OSRVs; and

(3) To measure the sound levels produced by an end-of-hole ZVSP survey, using a stationary sound source.

The *Discoverer,* support vessels, and ZVSP sound measurements will be performed using one of two methods, both of which involve real-time monitoring. The first method would involve use of bottom-founded hydrophones cabled back to the *Discoverer* (see Figure 1 in Shell's 4MP). These hydrophones would be positioned between 1,640 ft (500 m) and 3,281 ft (1,000 m) from the *Discoverer,* depending on the final positions of the anchors used to hold the *Discoverer* in place. Hydrophone cables would be fed to real-time digitization systems onboard. In addition to the cabled system, a separate set of bottom-founded hydrophones (see Figure 2 in Shell's 4MP) may be deployed at various distances from the exploration drilling operation for storage of acoustic data to be retrieved and processed at a later date.

As an alternative to the cabled hydrophone system (and possible inclusion of separate bottom-founded hydrophones), the second (or alternative) monitoring method would involve a radio buoy approach deploying four sparbuoys 4–5 mi (6–8 km) from the *Discoverer.* Additional hydrophones may be deployed closer to the *Discoverer,* if necessary, to better determine sound source levels. Monitoring personnel and recording/receiving equipment would be onboard one of the support vessels with 24-hr monitoring capacity. The system would allow for collection and processing of real-time data similar to that provided by the cabled system but from a wider range of locations.

Sound level monitoring with either method will occur on a continuous basis throughout all exploration drilling activities. Both types of systems will be set to record digital acoustic data at a sample rate of 32 kHz, providing useful acoustic bandwidth to at least 15 kHz. These systems are capable of measuring absolute broadband sound levels between 90 and 180 dB re 1 μPa. The long duration recordings will capture many different operations performed from the drillship. Retrieval of these systems will occur following completion of the exploration drilling activities.

These recorders will provide a capability to examine sound levels produced by different drilling activities and practices. This system will not have the capability to locate calling marine mammals and will indicate only relative proximity. The system will be evaluated during operations for its potential to improve PSO observations through notification of PSOs on vessel and aircraft of high levels of call detections and their general locations.

The deployment of drilling sound monitoring equipment will occur as soon as possible once the drillship is on site. Activity logs of exploration drilling operations and nearby vessel activities will be maintained to correlate with these acoustic measurements. This equipment will also be used to take measurements of the support vessels and airguns. Additional details can be found in Shell's 4MP.

Acoustic ''Net'' Array—The acoustic ''net'' array used by Shell during the 2006–2010 field seasons is proposed for 2011 and 2012. The array was designed to accomplish two main objectives:

• To collect information on the occurrence and distribution of marine mammals that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns; and

- To measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sound from industry and other activities further offshore in the Chukchi Sea.

The net array configuration used in 2007–2010 is again proposed for 2011 and 2012. The basic components of this effort consist of 30 hydrophone systems placed widely across the U.S. Chukchi Sea and a prospect specific array of 12 hydrophones capable of localization of marine mammal calls. The net array configuration will include hydrophone systems distributed at each of the four primary transect locations: Cape Lisburne; Point Hope; Wainwright; and Barrow. The systems comprising the regional array will be placed at locations shown in Figure 7 of the 4MP in Shell's application (see **ADDRESSES**). These offshore systems will capture exploration drilling sounds, if present, over large distances to help characterize the sound transmission properties in the Chukchi Sea and will also provide a large amount of information related to marine mammals in the Chukchi Sea.

The regional acoustic monitoring program will be augmented in 2012 by an array of additional acoustic recorders to be deployed on a grid pattern over a 7.2 mi (12 km) by 10.8 mi (18 km) area extending over several of Shell's lease blocks near locations of highest interest for exploration drilling in 2012. The cluster array will operate at a sampling frequency of 16 kHz, which is sufficient to capture vocalizations from bowhead, beluga, gray, fin, humpback, and killer whales, and most other marine mammals known to be present in the Chukchi Sea. The cluster deployment configuration was defined to allow tracking of vocalizing animals that pass through the immediate area of these lease blocks. Maximum separation between adjacent recorders is 3.6 mi (5.8 km). At this spacing, Shell expects that individual whale calls will be detected on at least three different recorders when the calling animals are within the boundary of the deployment pattern. Bowhead and other mysticete calls should be detectable simultaneously on more than three recorders due to their relatively higher sound source levels compared to other marine mammals. In calm weather conditions, when ambient underwater sound levels are low, Shell expects to detect most other marine mammal calls on more than three recorders. The goal of simultaneous detection on multiple recorders is to allow for triangulation of the call positions, which also requires accurate time synchronization of the recorders. When small numbers of whales are vocalizing, Shell hopes to be able to identify and track the movements of specific individuals within the deployment area. It will not be possible to track individual whales if many whales are calling due to abundant overlapping calls. In this case, analyses will show the general distribution of calls in the vicinity of the recorders.

Additional details on data analysis for the types of monitoring described here (*i.e.,* vessel-based, aerial, and acoustic) can be found in the 4MP in Shell's application (see **ADDRESSES**).

Monitoring Plan Peer Review

The MMPA requires that monitoring plans be independently peer reviewed ''where the proposed activity may affect the availability of a species or stock for taking for subsistence uses'' (16 U.S.C. 1371(a)(5)(D)(ii)(III)). Regarding this requirement, NMFS' implementing regulations state, ''Upon receipt of a complete monitoring plan, and at its discretion, [NMFS] will either submit the plan to members of a peer review panel for review or within 60 days of receipt of the proposed monitoring plan, schedule a workshop to review the plan'' (50 CFR 216.108(d)).

NMFS has established an independent peer review panel to review Shell's 4MP for Exploration Drilling of Selected Lease Areas in the Alaskan Chukchi Sea in 2012. The panel is scheduled to meet in early January 2012, and will provide comments to NMFS shortly after they meet. After completion of the peer review, NMFS will consider all recommendations made by the panel, incorporate appropriate changes into the monitoring requirements of the IHA (if issued), and publish the panel's findings and recommendations in the final IHA notice of issuance or denial document.

Reporting Measures

(1) SSV Report

A report on the preliminary results of the acoustic verification measurements, including as a minimum the measured 190- , 180- , 160- , and 120-dB (rms) radii of the drillship, support vessels, and airgun array will be submitted within 120 hr after collection and analysis of those measurements at the start of the field season or in the case of the airgun once that part of the program is implemented. This report will specify the distances of the exclusion zones that were adopted for the exploratory drilling program. Prior to completion of these measurements, Shell will use the radii outlined in their application and elsewhere in this document.

(2) Technical Reports

The results of Shell's 2012 Chukchi Sea exploratory drilling monitoring program (*i.e.,* vessel-based, aerial, and acoustic) will be presented in the ''90-day'' and Final Technical reports, as required by NMFS under the proposed IHA. Shell proposes that the Technical Reports will include: (1) Summaries of monitoring effort (*e.g.,* total hours, total distances, and marine mammal distribution through study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals); (2) analyses of the effects of various factors influencing detectability of marine mammals (*e.g.,* sea state, number of observers, and fog/glare); (3) species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover; (4) sighting rates of marine mammals during periods with and without drilling activities (and other variables that could affect detectability); (5) initial sighting distances versus drilling state; (6) closest point of approach versus drilling state; (7) observed behaviors and types of movements versus drilling state; (8) numbers of sightings/individuals seen versus drilling state; (9) distribution around the drillship and support vessels versus drilling state; and (10) estimates of take by harassment. This information will be reported for both the vessel-based and aerial monitoring.

Analysis of all acoustic data will be prioritized to address the primary questions, which are to: (a) Determine when, where, and what species of animals are acoustically detected on each Directional Autonomous Seafloor Acoustic Recorder; (b) analyze data as a whole to determine offshore bowhead distributions as a function of time; (c) quantify spatial and temporal variability in the ambient noise; and (d) measure received levels of drillship activities. The bowhead detection data will be used to develop spatial and temporal animal distributions. Statistical analyses will be used to test for changes in animal detections and distributions as a function of different variables (*e.g.,* time of day, time of season, environmental conditions, ambient noise, vessel type, operation conditions).

The initial technical report is due to NMFS within 90 days of the completion of Shell's Beaufort Sea exploratory drilling program. The ''90-day'' report will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final report prior to acceptance by NMFS.

(3) Comprehensive Report

Following the 2012 drilling season, a comprehensive report describing the vessel-based, aerial, and acoustic monitoring programs will be prepared. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad-based assessment of industry activities, and other activities that occur in the Beaufort and/or Chukchi seas, and their impacts on marine mammals during 2012. The report will help to establish long-term data sets that can assist with the evaluation of changes in the Chukchi and Beaufort Sea ecosystems. The report will attempt to provide a regional synthesis of available data on industry activity in offshore areas of northern Alaska that may influence marine mammal density, distribution and behavior.

(4) Notification of Injured or Dead Marine Mammals

Shell will be required to notify NMFS' Office of Protected Resources and NMFS' Stranding Network of any sighting of an injured or dead marine mammal. Based on different circumstances, Shell may or may not be required to stop operations upon such a sighting. Shell will provide NMFS with the species or description of the animal(s), the condition of the animal(s) (including carcass condition if the animal is dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). The specific language describing what Shell must do upon sighting a dead or injured marine mammal can be found in the ''Proposed Incidental Harassment Authorization'' section of this document.

Estimated Take by Incidental 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]. Only take by Level B behavioral harassment is anticipated as a result of the proposed drilling program. Noise propagation from the drillship, associated support vessels (including during icebreaking if needed), and the airgun array are expected to harass, through behavioral disturbance, affected marine mammal species or stocks. Additional disturbance to marine mammals may result from aircraft overflights and visual disturbance of the drillship or support vessels. However, based on the flight paths and altitude, impacts from aircraft operations are anticipated to be localized and minimal in nature.

The full suite of potential impacts to marine mammals from various industrial activities was described in detail in the ''Potential Effects of the Specified Activity on Marine Mammals'' section found earlier in this document. The potential effects of sound from the proposed exploratory drilling program might include one or more of the following: Tolerance; masking of natural sounds; behavioral disturbance; non-auditory physical effects; and, at least in theory, temporary or permanent hearing impairment (Richardson *et al.,* 1995a). As discussed earlier in this document, NMFS estimates that Shell's activities will most likely result in behavioral disturbance, including avoidance of the ensonified area or changes in speed, direction, and/or diving profile of one or more marine mammals. For reasons discussed previously in this document, hearing impairment (TTS and PTS) is highly unlikely to occur based on the fact that most of the equipment to be used during Shell's proposed drilling program does not have source levels high enough to elicit even mild TTS and/or the fact that certain species are expected to avoid the ensonified areas close to the operations. Additionally, non-auditory physiological effects are anticipated to be minor, if any would occur at all. Finally, based on the proposed mitigation and monitoring measures described earlier in this document and the fact that the back-propagated source level for the drillship is estimated to be between 177 and 185 dB re 1 μPa (rms), no injury or mortality of marine mammals is anticipated as a result of Shell's proposed exploratory drilling program.

For continuous sounds, such as those produced by drilling operations and during icebreaking activities, NMFS uses a received level of 120-dB (rms) to indicate the onset of Level B harassment. For impulsive sounds, such as those produced by the airgun array during the ZVSP surveys, NMFS uses a received level of 160-dB (rms) to indicate the onset of Level B harassment. Shell provided calculations for the 120-dB isopleths produced by the *Discoverer* and by the icebreaker during icebreaking activities and then used those isopleths to estimate takes by harassment. Additionally, Shell provided calculations for the 160-dB isopleth produced by the airgun array and then used that isopleth to estimate takes by harassment. Shell provides a full description of the methodology used to estimate takes by harassment in its IHA application (see **ADDRESSES**), which is also provided in the following sections.

Shell has requested authorization to take bowhead, gray, fin, humpback, minke, killer, and beluga whales, harbor porpoise, and ringed, spotted, bearded, and ribbon seals incidental to exploration drilling, ice management/icebreaking, and ZVSP activities. Additionally, Shell provided exposure estimates and requested takes of narwhal. However, as stated previously in this document, sightings of this species are rare, and the likelihood of occurrence of narwhals in the proposed drilling area is minimal. Therefore, NMFS is not proposing to authorize take of this species.

Basis for Estimating ''Take by Harassment''

''Take by Harassment'' is described in this section and was calculated in Shell's application by multiplying the expected densities of marine mammals that may occur near the exploratory drilling operations by the area of water likely to be exposed to continuous, non-pulse sounds ≥120 dB re 1 μPa (rms) during drillship operations or icebreaking activities and impulse sounds ≥160 dB re 1 μPa (rms) created by seismic airguns during ZVSP activities. NMFS evaluated and critiqued the methods provided in Shell's application and determined that they were appropriate to conduct the requisite MMPA analyses. This section describes the estimated densities of marine mammals that may occur in the project area. The area of water that may be ensonified to the above sound levels is described further in the ''*Estimated Area Exposed to Sounds* >*120 dB or* >*160 dB re 1 μPa rms*'' subsection.

Marine mammal densities near the operation are likely to vary by season and habitat, mostly related to the presence or absence of sea ice. Marine mammal density estimates in the Chukchi Sea have been derived for two time periods, the summer period covering July and August, and the fall period including September and October. Animal densities encountered in the Chukchi Sea during both of these time periods will further depend on the habitat zone within which the operations are occurring: Open water or ice margin. More ice is likely to be present in the area of operations during the summer period, so summer ice-margin densities have been applied to 50 percent of the area that may be exposed to sounds from exploration drilling and ZVSP activities in those months. Open water densities in the summer were applied to the remaining 50 percent of the area. Less ice is likely to be present during the fall season, so fall ice-margin densities have been applied to only 20 percent of the area that may be exposed to sounds from exploration drilling and ZVSP activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since icebreaking activities would only occur within ice-margin habitat, the entire area potentially ensonified by icebreaking activities has been multiplied by the ice-margin densities in both seasons.

Shell notes that there is some uncertainty about the representativeness of the data and assumptions used in the calculations. To provide some allowance for the uncertainties, ''maximum estimates'' as well as ''average estimates'' of the numbers of marine mammals potentially affected have been derived. For a few marine mammal species, several density estimates were available, and in those cases the mean and maximum estimates were determined from the survey data. In other cases, no applicable estimate (or perhaps a single estimate) was available, so correction factors were used to arrive at ''average'' and ''maximum'' estimates. These are described in detail in the following subsections. Table 6–7 in Shell's application indicates that the ''average estimate'' for killer, fin, humpback, and minke whales, harbor porpoise, and ribbon seal is either zero or one. Therefore, to account for the fact that these species listed as being potentially taken by harassment in this document may occur in Shell's proposed drilling sites during active operations, NMFS either used the ''maximum estimates'' or made an estimate based on typical group size for a particular species.

Detectability bias, quantified in part by $f(0)$, is associated with diminishing sightability with increasing lateral distance from the trackline. Availability bias [$g(0)$] refers to the fact that there is <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 (*e.g.,* ringed seals in Bengtson *et al.,* 2005). In other cases the best available correction factors were applied to reported results when they had not been included in the reported data (*e.g.,* Moore *et al.,* 2000).

Estimated densities of marine mammals in the Chukchi Sea project area during the summer period (July–August) are presented in Table 6–1 in Shell's application and Table 2 here, and estimated fall densities (September–October) are presented in Table 6–2 in Shell's application and Table 3 here. Descriptions of the individual density estimates shown in the tables are presented next.

(1) Cetaceans

Beluga Whales—Summer densities of belugas in offshore waters are expected to be low, with somewhat higher densities in ice-margin and nearshore areas. Aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore *et al.,* 2000). Aerial surveys of the Chukchi Sea in 2008–2009 flown by NMFS' National Marine Mammal Laboratory (NMML) as part of the Chukchi Offshore Monitoring in Drilling Area project (COMIDA) have only reported five beluga sightings during more than 8,700 mi (14,001 km) of on-transect effort, only two of which were offshore (COMIDA, 2009). One of the three nearshore sightings was of a large group (approximately 275 individuals on July 12, 2009) of migrating belugas along the coastline just north of Peard Bay. Additionally, only one beluga sighting was recorded during more than 37,900 mi (60,994 km) of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September–October of 2006–2008 (Haley *et al.,* 2010). If belugas are present during the summer, they are more likely to occur in or near the ice edge or close to shore during their northward migration. Expected densities have previously been calculated from data in Moore *et al.* (2000). However, more recent data from COMIDA aerial surveys during 2008–2010 are now available (Clarke and Ferguson, in prep.). Effort and sightings reported by Clarke and Ferguson (in prep.) were used to calculate the average open-water density estimate. Clarke and Ferguson (in prep.) reported two on-transect beluga sightings (5 individuals) during 11,985 km of on-transect effort in waters 118–164 ft (36–50 m) deep in the Chukchi Sea during July and August. The mean group size of these two sightings is 2.5. A $f(0)$ value of 2.841 and $g(0)$ value of 0.58 from Harwood *et al.* (1996) were also used in the density calculation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in both open-water and ice-margin habitats. Specific data on the relative abundance of beluga in open-water versus ice-margin habitat during the summer in the Chukchi Sea is not available. However, belugas are commonly associated with ice, so an inflation factor of 4 was used to estimate the average ice-margin density from the open-water density. Very low densities observed from vessels operating in the Chukchi Sea during non-seismic periods and locations in July-August of 2006–2008 (0.0–0.0003/mi², 0.0–0.0001/km²; Haley *et al.,* 2010), also suggest the number of beluga whales likely to be present near the planned activities will not be large.

In the fall, beluga whale densities in the Chukchi Sea are expected to be somewhat higher than in the summer because individuals of the eastern Chukchi Sea stock and the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Allen and Angliss, 2010). However, there were no beluga sightings reported during more than 11,200 mi (18,025 km) of vessel based effort in good visibility conditions during 2006–2008 industry operations in the Chukchi Sea (Haley *et al.,* 2010). Densities derived from survey results in the northern Chukchi Sea in Clarke and Ferguson (in prep) were used as the average density for open-water fall season estimates (see Table 6–2 in Shell's application and Table 3 here). Clarke and Ferguson (in prep) reported 3 beluga sightings (6 individuals) during 6,236 mi (10,036 km) of on-transect effort in water depths 118–164 ft (36–50 m). The mean group size of those three sightings is 2. A $f(0)$ value of 2.841 and $g(0)$ value of 0.58 from Harwood *et al.* (1996) were used in the calculation. The same inflation factor of 2 used for summer densities was used to estimate the maximum density that may occur in both open-water and ice-margin habitats in the fall. Moore *et al.* (2000) reported lower than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas, so an inflation value of 4 was used to estimate the average ice-margin density from the open-water density. Based on the lack of any beluga sightings from vessels operating in the Chukchi Sea during non-seismic periods and locations in September–October of 2006–2008 (Haley *et al.,* 2010), the relatively low densities shown in Table 6–2 in Shell's application and Table 3 here are consistent with what is likely to be observed from vessels during the planned operations.

Table 2. Expected Densities of Marine Mammals in Areas of the Chukchi Sea, Alaska, for the Planned Summer (July-August) Period. Species listed as endangered under the ESA are in italics.

	Open Water		Ice Margin	
Species	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**
Odontocetes				
Monodontidae				
Beluga	0.0010	0.0020	0.0040	0.0080
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0011	0.0015	0.0011	0.0015
Mysticetes				
Bowhead whale	0.0013	0.0026	0.0013	0.0026
Fin whale	0.0001	0.0004	0.0001	0.0004
Gray whale	0.0258	0.0516	0.0258	0.0516
Humpback whale	0.0001	0.0004	0.0001	0.0004
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ribbon seal	0.0005	0.0020	0.0005	0.0020
Ringed seal	0.3668	0.6075	0.4891	0.8100
Spotted seal	0.0073	0.0122	0.0098	0.0162

Table 3. Expected Densities of Marine Mammals in Areas of the Chukchi Sea, Alaska, for the Planned Fall (September-October) Period. Species listed as endangered under the ESA are in italics.

	Open Water		Ice Margin	
Species	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**
Odontocetes				
Monodontidae				
Beluga	0.0015	0.0030	0.0060	0.0120
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0007	0.0011	0.0007	0.0011
Mysticetes				
Bowhead whale	0.0219	0.0438	0.0438	0.0876
Fin whale	0.0001	0.0004	0.0001	0.0004
Gray whale	0.0080	0.0160	0.0080	0.0160
Humpback whale	0.0001	0.0004	0.0001	0.0004
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ribbon seal	0.0005	0.0020	0.0005	0.0020
Ringed seal	0.2458	0.4070	0.3277	0.5427
Spotted seal	0.0049	0.0081	0.0065	0.0108

Bowhead Whales—By July, most bowhead whales are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea. No bowheads were reported during 6,640 mi (10,686 km) of on-transect effort in the Chukchi Sea by Moore *et al.* (2000). Aerial surveys in 2008–2010 by NMML as part of the COMIDA project reported only six sightings during more than 16,020 mi (25,781 km) of on-transect effort (Clarke and Ferguson, in prep.). Two of the six sightings were in waters less than 115 ft (35 m) deep, and the remaining four sightings were in waters 167–656 ft (51–200 m) deep. Bowhead whales were also rarely sighted in July–August of 2006–2008 during aerial surveys of the Chukchi Sea coast (Thomas *et al.,* 2010). This is consistent with movements of tagged whales (see ADFG, 2010), all of which moved through the Chukchi Sea by early May 2009, and tended to travel relatively close to shore, especially in the northern Chukchi Sea. The estimate of bowhead whale density in the Chukchi Sea was calculated by assuming there was one bowhead sighting during the 7,447 mi (11,985 km) of survey effort in waters 118–164 ft (36–50 m) deep in the Chukchi Sea during July–August reported in Clarke and Ferguson (in prep.) although no bowheads were actually observed during those surveys. The mean group size from September–October sightings reported in Clarke and Ferguson (in prep.) is 1.1, and this was also used in the calculation of summer densities. The group size value, along with a $f(0)$ value of 2 and a $g(0)$ value of 0.07, both from Thomas *et al.* (2002) were used to estimate a summer density of bowhead whales (see Table 6–1 in Shell's application and Table 2 here). The CV of group size and standard errors reported in Thomas *et al.* (2002) for $f(0)$ and $g(0)$ correction factors suggest that an inflation factor of 2 is appropriate for estimating the maximum density from the average density. Bowheads are not expected to be encountered in higher densities near ice in the summer (Moore *et al.,* 2000), so the same density estimates are used for open-water and ice-margin habitats. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.,* 2010) ranged from 0.0003–0.0018/mi² (0.0001–0.0007/km²) with a maximum 95% confidence interval (CI) of 0.0075/mi² (0.0029 km²).

During the fall, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf migrate west and south to their wintering grounds in the Bering Sea, making it more likely that bowheads will be encountered in the Chukchi Sea at this time of year. Moore *et al.* (2002; Table 8) reported 34 bowhead sightings during 27,560 mi (44,354 km) of on-transect survey effort in the Chukchi Sea during September–October. Thomas *et al.* (2010) also reported increased sightings on coastal surveys of the Chukchi Sea during September and October of 2006–2008. GPS tagging of bowheads appear to show that migration routes through the Chukchi Sea are more variable than through the Beaufort Sea (Quakenbush *et al.,* 2010). Some of the routes taken by bowheads remain well north of the planned exploration drilling activities while others have passed near to or through the area. Kernel densities estimated from GPS locations of whales suggest that bowheads do not spend much time (*e.g.,* feeding or resting) in the north-central Chukchi Sea near the area of planned activities (Quakenbush *et al.,* 2010). Clarke and Ferguson (in prep) reported 14 sightings (15 individuals) during 6,236 mi (10,036) km of on transect aerial survey effort in 2008–2010. The mean group size of those sightings is 1.1. The same $f(0)$ and $g(0)$ values that were used for the summer estimates above were used for the fall estimates. As with the summer estimates, an inflation factor of 2 was used to estimate the maximum density from the average density in both habitat types. Moore *et al.* (2000) found that bowheads were detected more often than expected in association with ice in the Chukchi Sea in September–October, so a density of twice the average open-water density was used as the average ice-margin density. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.,* 2010) ranged from 0.0008 to 0.0114/mi² (0.0003–0.0044/km²) with a maximum 95% CI of 0.1089/mi² (0.0419 km²).

Gray Whales—Gray whale densities are expected to be much higher in the summer months than during the fall. Moore *et al.* (2000) found the distribution of gray whales in the planned operational area was scattered and limited to nearshore areas where most whales were observed in water less than 115 ft (35 m) deep. Thomas *et al.* (2010) also reported substantial declines in the sighting rates of gray whales in the fall. The average open-water summer density (see Table 6–1 in Shell's application and Table 2 here) was calculated from 2008–2010 aerial survey effort and sightings in Clarke and Ferguson (in prep.) for water depths 118–164 ft (36–50 m) including 54 sightings (73 individuals) during 7,447 mi (11,985 km) of on-transect effort. The average group size of those sightings is 1.35. Correction factors $f(0) = 2.49$ (Forney and Barlow, 1998) and $g(0) = 0.3$ (Forney and Barlow, 1998; Mallonee, 1991) were also used in the density calculation. Similar to beluga and bowhead whales, an inflation factor of 2 was used to estimate the maximum densities from average densities in both habitat types and seasons. Gray whales are not commonly associated with sea ice but may be present near it, so the same densities were used for ice-margin habitat as were derived for open-water habitat during both seasons. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.,* 2010) ranged from 0.0055mi² to 0.0208/mi² (0.0021/km² to 0.008/km²) with a maximum 95% CI of 0.0874 mi² (0.0336 km²).

In the fall, gray whales may be dispersed more widely through the northern Chukchi Sea (Moore *et al.,* 2000), but overall densities are likely to be decreasing as the whales begin migrating south. A density calculated from effort and sightings (15 sightings [19 individuals] during 6,236 mi [10,036 km] of on-transect effort) in water 118–164 ft (36–50 m) deep during September–October reported by Clarke and Ferguson (in prep.) was used as the average estimate for the Chukchi Sea during the fall period. The corresponding group size value of 1.26, along with the same $f(0)$ and $g(0)$ values described above were used in the calculation. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.,* 2010) ranged from 0.0068/mi² to 0.0109/mi² (0.0026/km² to 0.0042/km²) with a maximum 95% CI of 0.072 mi² (0.0277 km²).

Harbor Porpoise—Harbor porpoise densities were estimated from industry data collected during 2006–2008 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea, and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006–2008, however, recorded sightings throughout the Chukchi Sea during the summer and early fall months. Density estimates from 2006–2008 observations during non-seismic periods and locations in July–August ranged from 0.0021/mi² to 0.0039/mi² (0.0008/km² to 0.0015/km²) with a maximum 95% CI of 0.0205/mi² (0.0079/km²) (Haley *et al.,* 2010). The average density from the summer season of those three years (0.0029/mi² [0.0011/km²]) was used as the average open-water density estimate while the high value (0.0039/mi² [0.0015/km²]) was used as the maximum estimate (see Table 6–1 in Shell's application and Table 2 here). Harbor porpoise are not expected to be present in higher numbers near ice, so the open-water densities were used for ice-margin habitat in both seasons. Harbor porpoise densities recorded during industry operations in the fall months of 2006–2008 ranged from 0.0005 mi² to 0.0029/mi² (0.0002/km² to 0.0011/km²) with a maximum 95% CI of 0.0242/mi² (0.0093/km²). The average of those years of 0.0018/mi² (0.0007/km²) was again used as the average density estimate, and the high value of 0.0029/mi² (0.0011/km²) was used as the maximum estimate (see Table 6–2 in Shell's application and Table 3 here).

Other Cetaceans—The remaining four cetacean species that could be encountered in the Chukchi Sea during Shell's planned exploration drilling program include the humpback, killer, minke, and fin whales. Although there is evidence of the occasional occurrence of these animals in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned drilling program. Clarke *et al.* (2011) and Haley *et al.* (2010) reported humpback whale sightings; George and Suydam (1998) reported killer whales; Brueggeman *et al.* (1990), Haley *et al.* (2010), and COMIDA (2011) reported minke whales; and Clarke *et al.* (2011) and Haley *et al.* (2010) reported fin whales.

(2) Pinnipeds

Four species of pinnipeds may be encountered in the Chukchi Sea area of Shell's proposed drilling program: ringed, bearded, spotted, and ribbon seals. Each of these species, except the spotted seal, is associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be found in the southern margin of the retreating sea ice. However, satellite tagging has shown that they sometimes undertake long excursions into offshore waters, as far as 74.6 mi (120 km) off the Alaskan coast in the eastern Chukchi Sea, during summer (Lowry *et al.,* 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Patterson *et al.,* 2007; Haley *et al.,* 2010).

Ringed and Bearded Seals—Ringed and bearded seals ''average'' and ''maximum'' summer ice-margin densities (see Table 6–1 in Shell's application and Table 2 here) were available in Bengtson *et al.* (2005) from spring surveys in the offshore pack ice zone (zone 12P) of the northern Chukchi Sea. However, corrections for bearded seal availability, *g*(0), based on haul-out and diving patterns were not available. Densities of ringed and bearded seals in open-water are expected to be somewhat lower in the summer when preferred pack ice habitat may still be present in the Chukchi Sea. Average and maximum open-water densities have been estimated as ¾ of the ice margin densities during both seasons for both species. The fall density of ringed seals in the offshore Chukchi Sea has been estimated as ⅔ the summer densities because ringed seals begin to reoccupy nearshore fast ice areas as the ice forms in the fall. Bearded seals may also begin to leave the Chukchi Sea in the fall, but less is known about their movement patterns, so fall densities were left unchanged from summer densities. For comparison, the ringed seal density estimates calculated from data collected during summer 2006–2008 industry operations ranged from 0.0411/mi² to 0.1786/mi² (0.0158/km² to 0.0687/km²) with a maximum 95% CI of 0.3936/mi² (0.1514/km²) (Haley *et al.,* 2010). These estimates are lower than those made by Bengtson *et al.* (2005), which is not surprising given the different survey methods and timing.

Spotted Seals— Little information on spotted seal densities in offshore areas of the Chukchi Sea is available. Spotted seal densities in the summer were estimated by multiplying the ringed seal densities by 0.02. This was based on the ratio of the estimated Chukchi populations of the two species. Chukchi Sea spotted seal abundance was estimated by assuming that 8% of the Alaskan population of spotted seals is present in the Chukchi Sea during the summer and fall (Rugh *et al.,* 1997), the Alaskan population of spotted seals is 59,214 (Allen and Angliss, 2010), and that the population of ringed seals in the Alaskan Chukchi Sea is approximately 208,000 animals (Bengtson *et al.,* 2005). In the fall, spotted seals show increased use of coastal haul-outs so densities were estimated to be ⅔ of the summer densities.

Ribbon Seals—Two ribbon seal sightings were reported during industry vessel operations in the Chukchi Sea in 2006–2008 (Haley *et al.* 2010). The resulting density estimate of 0.0013/mi² (0.0005/km²) was used as the average density and 4 times that was used as the maximum for both seasons and habitat zones.

Estimated Area Exposed to Sounds ≥120 dB or ≥160 dB re 1 μPa rms

(1) Estimated Area Exposed to Continuous Sounds ≥ 120 dB rms From the Drillship

Sounds from the *Discoverer* have not previously been measured in the Arctic. However, measurements of sounds produced by the *Discoverer* were made in the South China Sea in 2009 (Austin and Warner, 2010). The results of those measurements were used to model the sound propagation from the *Discoverer* (including a nearby support vessel) at planned exploration drilling locations in the Chukchi and Beaufort seas (Warner and Hannay, 2011). Broadband source levels of sounds produced by the *Discoverer* varied by activity and direction from the ship but were generally between 177 and 185 dB re 1 μPa · m rms (Austin and Warner, 2010). Propagation modeling at the Burger Prospect resulted in an estimated distance of 0.81 mi (1.31 km) to the point at which exploration drilling sounds would likely fall below 120 dB. The estimated 0.81 mi (1.31 km) distance was multiplied by 1.5 (= 1.22 mi [1.97 km]) as a further precautionary measure before calculating the total area that may be exposed to continuous sounds ≥120 dB re 1 μPa rms by the *Discoverer* at each drill site on the Burger Prospect (Table 6–3 in Shell's application and Table 4 here). Given this distance or radius, the total area of water ensonified to ≥120 dB rms during exploration drilling at each drill site was estimated to be 4.6 mi² (12 km²). The 160-dB radius for the *Discoverer* was estimated to be approximately 33 ft (10 m). Again, because the source level for the drillship was measured to be between 177 and 185 dB, the 180 and 190-dB radii were not needed.

The acoustic propagation model used to estimate the sound propagation from the *Discoverer* in the Chukchi Sea is JASCO Research's Marine Operations Noise Model (MONM). MONM computes received sound levels in rms units when source levels are specified also in those units. MONM treats sound propagation in range-varying acoustic environments through a wide-angled parabolic equation solution to the acoustic wave equation. The specific parabolic equation code in MONM is based on the Naval Research Laboratory's Range-dependent Acoustic Model. This code has been extensively benchmarked for accuracy and is widely employed in the underwater acoustics community (Collins, 1993).

Changes in the water column of the Chukchi Sea through the course of the exploration drilling season will likely affect the propagation of sounds produced by exploration drilling activities, so the modeling of exploration drilling sounds was run using expected oceanographic conditions in October which are expected to support greater sound propagation (Warner and Hannay, 2011). Results of sound propagation modeling that were used in the calculations of areas exposed to various levels of received sounds are summarized in Table 6–3 in Shell's application and Table 4 here.

Distances shown in Table 6–3 in Shell's application and Table 4 here were used to estimate the area ensonified to ≥120 dB rms around the drillship. As noted above, all exploration drilling activities will occur at the Burger Prospect. The exploration drill sites assumed for the summer of 2012 at the Burger Prospect (Burger A, F, J, and V) are 3.4 to 13 mi (5.5 km to 21 km) from each other, and wells will not be drilled simultaneously. Therefore, the area exposed to continuous sounds ≥120 dB at each drill site is not expected to overlap with any other drill site. The total area of water potentially exposed to received sound levels ≥120 dB rms by exploration drilling operations during July–August at two locations is therefore estimated to be 9.42 mi² (24.4 km²). Activities at two additional locations in September–October may expose an additional 9.42 mi² (24.4 km²) to continuous sounds ≥120 dB rms.

Table 4. Sound Propagation Modeling Results of Exploration Drilling, Icebreaking, and ZVSP Activities at the Burger Prospect in the Alaskan Chukchi Sea

Source	Received Level (dB re 1 μPa)	Modeling Results (km)	Used in Calculations (km)
Discoverer	120	1.31	1.97
Icebreaking	120	7.63	9.50
ZVSP	160	3.67	5.51

(2) Estimated Area Exposed to Continuous Sounds ≥120 dB rms from Ice Management/Icebreaking Activities

Measurements of the icebreaking supply ship *Robert Lemeur* pushing and breaking ice during exploration drilling operations in the Beaufort Sea in 1986 resulted in an estimated broadband source level of 193 dB re 1 μPa · m (Greene, 1987a; Richardson *et al.,* 1995a). Measurements of the icebreaking sounds were made at five different distances and those were used to generate a propagation loss equation [RL = 141.4 − 1.65R − 10Log(R) where R is range in kilometers (Greene, 1987a); converting R to meters results in the following equation: R = 171.4 − 10log(R) − 0.00165R]. Using that equation, the estimated distance to the 120 dB threshold for continuous sounds from icebreaking is 4.74 mi (7.63 km). Since the measurements of the *Robert Lemeur* were taken in the Beaufort Sea under presumably similar conditions as would be encountered in the Chukchi Sea in 2012, an inflation factor of 1.25 was selected to arrive at a precautionary 120 dB distance of 5.9 mi (9.5 km) for icebreaking sounds (see Table 6–3 in Shell's application and Table 4 here). Additionally, measurements of identical sound sources at the Burger and Camden Bay prospects in 2008 yielded similar results, suggesting that sound propagation at the two locations is likely to be similar (Hannay and Warner, 2009).

If ice is present, ice management/icebreaking activities may be necessary in early July and towards the end of operations in late October, but it is not expected to be needed throughout the proposed exploration drilling season. Icebreaking activities would likely occur in a 40° arc up to 3.1 mi (5 km) upwind of the *Discoverer* (see Figure 1–3 and Attachment B in Shell's application for additional details). This activity area plus a 5.9 mi (9.5 km) buffer around it results in an estimated total area of 162 mi² (420 km²) that may be exposed to sounds ≥120 dB from ice management/icebreaking activities in each season.

(3) Estimated Area Exposed to Impulsive Sounds ≥ 160 dB rms From Airguns

Shell proposes to use the ITAGA eight-airgun array for the ZVSP surveys in 2012, which consists of four 150-in³ airguns and four 40-in³ airguns for a total discharge volume of 760 in³. The ≥160 dB re 1 μPa rms radius for this source was estimated from measurements of a similar seismic source used during the 2008 BP Liberty seismic survey (Aerts *et al.,* 2008). The BP liberty source was also an eight-airgun array but had a slightly larger total volume of 880 in³. Because the number of airguns is the same, and the difference in total volume only results in an estimated 0.4 dB decrease in the source level of the ZVSP source, the 100th percentile propagation model from the measurements of the BP Liberty source is almost directly applicable. However, the BP Liberty source was towed at a depth of 5.9 ft (1.8 m), while Shell's ZVSP source would be lowered to a target depth of 13 ft (4 m) (from 10–23 ft [3–7 m]). The deeper depth of the ZVSP source has the potential to increase the source strength by as much as 6 dB. Thus, the constant term in the propagation equation from the BP Liberty source was increased from 235.4 to 241.4 while the remainder of the equation (−18*LogR—0.0047*R) was left unchanged. NMFS reviewed the use of this equation and the similarities between the 2008 BP Liberty project and Shell's proposed drilling sites and determined that it is appropriate to base the sound isopleths on those results. This equation results in the following estimated distances to maximum received levels: 190 dB = 0.33 mi (524 m); 180 dB = 0.77 mi (1,240 m); 160 dB = 2.28 mi (3,670 m); 120 dB = 6.52 mi (10,500 m). The ≥160 dB distance was multiplied by 1.5 (see Table 6–3 in Shell's application and Table 4 here) for use in estimating the area ensonified to ≥160 dB rms around the drilling vessel during ZVSP activities. Therefore, the total area of water potentially exposed to received sound levels ≥160 dB rms by ZVSP operations at two exploration well sites during each season is estimated to be 73.7 mi² (190.8 km²).

Shell intends to conduct sound propagation measurements on the

Discoverer and the airgun source in 2012 once they are on location in the Chukchi Sea. The results of those measurements would then be used during the season to implement mitigation measures.

Potential Number of Takes by Harassment

Although a marine mammal may be exposed to drilling or icebreaking sounds ≥ 120 dB (rms) or airgun sounds ≥ 160 dB (rms), this does not mean that it will *actually* exhibit a disruption of behavioral patterns in response to the sound source. Rather, the estimates provided here are simply the best estimates of the number of animals that potentially could have a behavioral modification due to the noise. However, not all animals react to sounds at this low level, and many will not show strong reactions (and in some cases any reaction) until sounds are much stronger. There are several variables that determine whether or not an individual animal will exhibit a response to the sound, such as the age of the animal, previous exposure to this type of anthropogenic sound, habituation, *etc.*

Numbers of marine mammals that might be present and potentially disturbed (*i.e.,* Level B harassment) are estimated below based on available data about mammal distribution and densities at different locations and times of the year as described previously. Exposure estimates are based on a single drillship (*Discoverer*) drilling up to four wells in the Chukchi Sea from July 4–October 31, 2012. Shell assumes an average of 32 days at each drill site (including the partial well drill site, including 7.5 days of MLC excavation at all four drill sites). Shell also assumes that ZVSP activities may occur at each well drilled. Additionally, Shell assumed that more ice is likely to be present in the area of operations during the July–August period, so summer ice-margin densities have been applied to 50 percent of the area that may be exposed to sounds from exploration drilling and ZVSP activities in those months. Open-water densities in the summer were applied to the remaining 50 percent of the area. Less ice is likely to be present during the September–October period, so fall ice-margin densities have been applied to only 20 percent of the area that may be exposed to sounds from exploration drilling and ZVSP activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since ice management/icebreaking activities would only occur within ice-margin habitat, the entire area potentially ensonified by ice management/icebreaking activities has been multiplied by the ice-margin densities in both seasons.

The number of different individuals of each species potentially exposed to received levels of continuous drilling-related sounds ≥ 120 dB re 1 μPa or to pulsed airgun sounds ≥ 120 dB re 1 μPa within each season and habitat zone was estimated by multiplying:

- The anticipated area to be ensonified to the specified level in the time period and habitat zone to which a density applies, by
- The expected species density.

The numbers of exposures were then summed for each species across the seasons and habitat zones.

(1) Drillship Activities

Estimates of the average and maximum number of individual marine mammals that may be exposed to continuous sound levels ≥120 dB by exploration drilling activities are shown by season and habitat in Table 6–4 in Shell's application and Table 5 here. Due to the relatively small estimated ≥120 dB radius around the exploration drilling activities, only a few individuals of any species are estimated to be exposed based on average densities. However, chance encounters with individuals of any species are possible as all of the species are known to occur in the Chukchi Sea (except for the narwhal for reasons stated previously in this document). Minimal estimates have therefore been included in the Total (Max) column to account for chance encounters or where greater numbers may be encountered than calculations suggested.

(2) Ice Management/Icebreaking Activities

Estimates of the average and maximum number of individual marine mammals that may be exposed to continuous sound levels ≥120 dB by ice management/icebreaking activities are shown by season and habitat in Table 6–5 in Shell's application and Table 6 here. Should ice management/icebreaking be necessary, it would ensonify a larger area of water to ≥120 dB than the exploration drilling activities or to ≥160 dB by ZVSP surveys, and, therefore, results in the highest number of potential estimated individual exposed to such sounds.

The average and maximum estimates of the number of individual bowhead whales exposed to received sound levels ≥120 dB are 19 and 38, respectively. The average estimates for beluga and gray whales are 4 and 14, respectively. Few other cetaceans are likely to be exposed to icebreaking sounds ≥120 dB, but maximum estimates have been included to account for chance encounters.

Ringed seals are expected to be the most abundant animal in the Chukchi Sea, and the average and maximum estimates of the number exposed to ≥120 dB by potential ice management/icebreaking activities are 343 and 568, respectively. Estimated exposures of other seal species are substantially less than those for ringed seals (see Table 6–5 in Shell's application and Table 6 here).

(3) ZVSP Activities

Estimates of the average and maximum number of individual marine mammals that may be exposed to pulsed airgun sounds at received levels ≥160 dB during ZVSP activities are shown by season and habitat in Table 6–6 in Shell's application and Table 7 here. The estimates are somewhat greater than for exploration drilling activities because of the larger ≥160 dB radius around the airguns compared to the estimated ≥120 dB radius around exploration drilling activities (see Table 6–3 in Shell's application and Table 4 here).

The average and maximum estimates of the number of individual bowhead whales potentially exposed to received sound levels ≥160 dB are 5 and 11, respectively. The average estimates for beluga and gray whales are 1 and 6, respectively (see Table 6–6 in Shell's application and Table 7 here). Few other cetaceans are likely to be exposed to airgun sounds ≥160 dB, but maximum estimates have been included to account for chance encounters.

The average and maximum estimated number of ringed seals potentially exposed to ≥160 dB by ZVSP activities are 132 and 218, respectively. Estimated exposures of other seal species are substantially below those for ringed seals (Table 6–6 in Shell's application and Table 7 here).

Estimated Take Conclusions

As stated previously, NMFS' practice has been to apply the 120 dB re 1 μPa (rms) received level threshold for underwater continuous sound levels and the 160 dB re 1 μPa (rms) received level threshold for underwater impulsive sound levels to determine whether take by Level B harassment occurs. However, not all animals react to sounds at these low levels, and many will not show strong reactions (and in some cases any reaction) until sounds are much stronger. Southall *et al.* (2007) provide a severity scale for ranking observed behavioral responses of both free-ranging marine mammals and laboratory subjects to various types of anthropogenic sound (see Table 4 in Southall *et al.* (2007)). Tables 15, 17, and 21 in Southall *et al.* (2007) outline the numbers of low-frequency and mid-frequency cetaceans and pinnipeds in water, respectively, reported as having behavioral responses to non-pulsed sounds in 10-dB received level increments. These tables illustrate, especially for low- and mid-frequency cetaceans, that more intense observed behavioral responses did not occur until sounds were higher than 120 dB (rms). Many of the animals had no observable response at all when exposed to anthropogenic continuous sound at levels of 120 dB (rms) or even higher.

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Table 5. The number of potential exposures of marine mammals to received sound levels in the water of ≥120 dB rms during planned exploration drilling activities in summer (July-August) and fall (September-October) in the Chukchi Sea, Alaska, 2012.

	Number of Individuals Potentially Exposed to Drilling Sounds ≥ 120 dB													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phocoenidae														
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Mysticetes														
Bowhead whale	0	0	0	0	0	0	0	1	0	0	1	1	1	5
Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Gray whale	0	1	0	1	1	1	0	0	0	0	0	0	1	5
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinnipeds														
Bearded seal	0	0	0	0	0	1	0	0	0	0	0	1	1	5
Ribbon seal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ringed seal	4	7	6	10	10	17	5	8	2	3	6	11	17	28
Spotted seal	0	0	0	0	0	0	0	0	0	0	0	0	0	5

Table 6. The number of potential exposures of marine mammals to received sound levels in the water of ≥120 dB rms during potential ice management/icebreaking activities in summer (July-August) and fall (September-October) in the Chukchi Sea, Alaska, 2012.

	Number of Individuals Potentially Exposed to Icebreaking Sounds ≥120 dB													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	0	0	2	3	2	3	0	0	3	5	3	5	4	5
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phocoenidae														
Harbor porpoise	0	0	0	1	0	1	0	0	0	0	0	0	1	5
Mysticetes														
Bowhead whale	0	0	1	1	1	1	0	0	18	37	18	37	19	38
Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Gray whale	0	0	11	22	11	22	0	0	3	7	3	7	14	28
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinnipeds														
Bearded seal	0	0	6	11	6	11	0	0	6	11	6	11	12	23
Ribbon seal	0	0	0	1	0	1	0	0	0	1	0	1	0	5
Ringed seal	0	0	205	340	205	340	0	0	138	228	138	228	343	568
Spotted seal	0	0	4	7	4	7	0	0	3	5	3	5	7	11

Table 7. The number of potential exposures of marine mammals to received sound levels in the water of ≥160 dB rms during planned ZVSP activities in summer (July-August) and fall (September-October) in the Chukchi Sea, Alaska, 2012.

	Number of Individuals Potentially Exposed to VSP Sounds ≥160 dB													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	0	0	0	1	0	1	0	0	0	0	0	1	1	5
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phocoenidae														
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Mysticetes														
Bowhead whale	0	0	0	0	0	0	3	7	2	3	5	10	5	11
Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Gray whale	2	5	2	5	5	10	1	2	0	1	2	3	6	13
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinnipeds														
Bearded seal	1	2	1	3	2	5	2	3	1	1	2	4	5	9
Ribbon seal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ringed seal	35	58	47	77	82	135	38	62	13	21	50	83	132	218
Spotted seal	1	1	1	2	2	3	1	1	0	0	1	2	3	5

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Although the 120-dB isopleth for the drillship may seem slightly expansive (*i.e.,* 1.22 mi [1.97 km], which includes the 50% inflation factor), the zone of ensonification begins to shrink dramatically with each 10-dB increase in received sound level to where the 160-dB isopleth is only about 33 ft (10 m) from the drillship. As stated previously, source levels are expected to be between 177 and 185 dB (rms). For an animal to be exposed to received levels between 177 and 185 dB, it would have to be within several meters of the vessel, which is unlikely, especially given the fact that certain species are likely to avoid the area (as described earlier in this document).

For impulsive sounds, such as those produced by the airguns, studies reveal that baleen whales show avoidance responses, which would reduce the likelihood of them being exposed to higher received sound levels. The 180-dB zone (0.77 mi [1.24 km]) is one-third the size of the 160-dB zone (2.28 mi [3.67 km], which is the modeled distance before the 1.5 inflation factor is included). In the limited studies that have been conducted on pinniped responses to pulsed sound sources, they seem to be more tolerant and do not exhibit strong behavioral reactions (see Southall *et al.,* 2007).

NMFS is proposing to authorize the maximum take estimates provided in Table 6–7 of Shell's application. Table 8 in this document outlines the abundance, proposed take, and percentage of each stock or population for the 12 species that may be exposed to sounds ≥ 120 dB from the drillship and ice management/ice breaking activities and to sounds ≥ 160 dB from ZVSP activities in Shell's proposed Chukchi Sea drilling area. With the exception of killer and minke whales (which are still less than 2.5%), less than 1% of each species or stock would potentially be exposed to sounds above the Level B harassment thresholds. The take estimates presented here do not take any of the mitigation measures presented earlier in this document into consideration. These take numbers also do not consider how many of the exposed animals may actually respond or react to the proposed exploration drilling program. Instead, the take estimates are based on the presence of animals, regardless of whether or not they react or respond to the activities.

Table 8. Population abundance estimates, total proposed Level B take estimates (when combining takes from drillship operations, ice management/icebreaking, and ZVSP surveys), and percentage of stock or population that may be taken for the potentially affected species that may occur in Shell's proposed Chukchi Sea drilling area.

Species	Abundance[1]	Total Proposed Take	Percentage of Stock or Population
Beluga Whale	39,258	15	0.04
Killer Whale	656	15	2.3
Harbor Porpoise	48,215	15	0.03
Bowhead Whale	15,232[2]	53	0.35
Fin Whale	5,700	15	0.26
Gray Whale	18,017	46	0.26
Humpback Whale	2,845	15	0.53
Minke Whale	810-1,233	15	1.22-1.85
Bearded Seal	155,000[3]	36	0.02
Ribbon Seal	49,000	15	0.03
Ringed Seal	208,000-252,000	814	0.32-0.39
Spotted Seal	59,214	21	0.04

1 Unless stated otherwise, abundance estimates are taken from Allen and Angliss (2011)

2 Estimate from George et al. (2004) with an annual growth rate of 3.4%

3Beringia Distinct Population Segment (NMFS, 2010)

Negligible Impact Analysis

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.'' In making a negligible impact determination, NMFS considers a variety of factors, including but not limited to: (1) The number of anticipated mortalities; (2) the number and nature of anticipated injuries; (3) the number, nature, intensity, and duration of Level B harassment; and (4) the context in which the takes occur.

No injuries or mortalities are anticipated to occur as a result of Shell's proposed Chukchi Sea exploratory drilling program, and none are proposed to be authorized. Injury, serious injury, or mortality could occur if there were a large or very large oil spill. However, as discussed previously in this document, the likelihood of a spill is extremely remote. Shell has implemented many design and operational standards to mitigate the potential for an oil spill of any size. NMFS does not propose to authorize take from an oil spill, as it is not part of the specified activity. Additionally, animals in the area are not expected to incur hearing impairment (*i.e.,* TTS or PTS) or non-auditory physiological effects. Instead, any impact that could result from Shell's activities is most likely to be behavioral harassment and is expected to be of limited duration. Although it is possible that some individuals may be exposed to sounds from drilling operations more than once, during the migratory periods it is less likely that this will occur since animals will continue to move across the Chukchi Sea towards their wintering grounds.

Bowhead and beluga whales are less likely to occur in the proposed project area in July and August, as they are found mostly in the Canadian Beaufort Sea at this time. The animals are more likely to occur later in the season (mid-September through October), as they head west towards Russia or south towards the Bering Sea. Additionally, while bowhead whale tagging studies revealed that animals occurred in the LS 193 area, a higher percentage of animals were found outside of the LS 193 area in the fall (Quakenbush *et al.,* 2010). Bowhead whales are not known to feed in areas near Shell's leases in the Chukchi Sea. The closest primary feeding ground is near Point Barrow, which is more than 150 mi (241 km) east of Shell's Burger prospect. Therefore, if bowhead whales stop to feed near Point Barrow during Shell's proposed operations, the animals would not be exposed to continuous sounds from the drillship or icebreaker above 120 dB or to impulsive sounds from the airguns above 160 dB, as those sound levels only propagate 1.22 mi (1.97 km), 5.9 mi (9.5 km), and 3.42 mi (5.51 km), respectively, which includes the inflation factor. Additionally, the 120-dB radius for the airgun array has been modeled to propagate 6.5 mi (10.5 km) from the source (and would still be less than 10 mi [16.1 km] if an inflation factor of 1.5 were applied). Therefore, sounds from the operations would not reach the feeding grounds near Point Barrow. Gray whales occur in the northeastern Chukchi Sea during the summer and early fall to feed. Hanna Shoals, an area northeast of Shell's proposed drill sites, is a common gray whale feeding ground. This feeding ground lies outside of the 120-dB and 160-dB ensonified areas from Shell's activities. While some individuals may swim through the area of active drilling, it is not anticipated to interfere with their feeding at Hanna Shoals or other Chukchi Sea feeding grounds. Other cetacean species are much rarer in the proposed project area. The exposure of cetaceans to sounds produced by exploratory drilling operations (*i.e.,* drillship, ice management/icebreaking, and airgun operations) is not expected to result in more than Level B harassment.

Few seals are expected to occur in the proposed project area, as several of the species prefer more nearshore waters. Additionally, as stated previously in this document, pinnipeds appear to be more tolerant of anthropogenic sound, especially at lower received levels, than other marine mammals, such as mysticetes. Shell's proposed activities would occur at a time of year when the ice seal species found in the region are not molting, breeding, or pupping. Therefore, these important life functions would not be impacted by Shell's proposed activities. The exposure of pinnipeds to sounds produced by Shell's proposed exploratory drilling operations in the Chukchi Sea is not expected to result in more than Level B harassment of the affected species or stock.

Of the 12 marine mammal species likely to occur in the proposed drilling area, three are listed as endangered under the ESA: The bowhead, humpback, and fin whales. All three species are also designated as ''depleted'' under the MMPA. Despite these designations, the Bering-Chukchi-Beaufort stock of bowheads has been increasing at a rate of 3.4% annually for nearly a decade (Allen and Angliss, 2011), even in the face of ongoing industrial activity. Additionally, during the 2001 census, 121 calves were counted, which was the highest yet recorded. The calf count provides corroborating evidence for a healthy and increasing population (Allen and Angliss, 2011). An annual increase of 4.8% was estimated for the period 1987–2003 for North Pacific fin whales. While this estimate is consistent with growth estimates for other large whale populations, it should be used with caution due to uncertainties in the initial population estimate and about population stock structure in the area (Allen and Angliss, 2011). Zeribini *et al.* (2006, cited in Allen and Angliss, 2011) noted an increase of 6.6% for the Central North Pacific stock of humpback whales in Alaska waters. Certain stocks or populations of gray and beluga whales and spotted seals are listed as endangered or are proposed for listing under the ESA; however, none of those stocks or populations occur in the proposed activity area. On December 10, 2010, NMFS published a notice of proposed threatened status for subspecies of the ringed seal (75 FR 77476) and a notice of proposed threatened and not warranted status for subspecies and distinct population segments of the bearded seal (75 FR 77496) in the **Federal Register**. Neither of these two ice seal species is currently considered depleted under the MMPA. The ribbon seal is a ''species of concern.'' None of the other species that may occur in the project area are listed as threatened or endangered under the ESA or designated as depleted under the MMPA. There is currently no established critical habitat in the proposed project area for any of these 12 species.

Potential impacts to marine mammal habitat were discussed previously in this document (see the ''Anticipated Effects on Habitat'' section). Although some disturbance is possible to food sources of marine mammals, the impacts are anticipated to be minor. Based on the vast size of the Arctic Ocean where feeding by marine mammals occurs versus the localized area of the drilling program, any missed feeding opportunities in the direct project area would be of little consequence, as marine mammals would have access to other feeding grounds.

The estimated takes proposed to be authorized represent less than 1% of the affected population or stock for 10 of the species and less than 2.5% for two of the species. These estimates represent the percentage of each species or stock that could be taken by Level B behavioral harassment if each animal is taken only once.

The estimated take numbers are likely somewhat of an overestimate for several reasons. First, these take numbers were calculated using a 50% inflation factor of the 120-dB radius from the drillship and of the 160-dB radius for the airguns and using a 25% inflation factor of the 120-dB radius from the icebreaker during active ice management/icebreaking activities, which is a conservative approach recommended by some acousticians when modeling a new sound source in a new location. This is fairly conservative given the fact that the radii were based on results from measurements of the *Discoverer* in another location and of the icebreaker and airguns in the Arctic Ocean. SSV tests may reveal that the Level B harassment zone is either smaller or larger than that used to estimate take. If the SSV tests reveal that the Level B harassment zone is slightly larger than those modeled or measured elsewhere, the inflation factors should cover the discrepancy, however, based on recent SSV tests of seismic airguns (which showed that the measured 160-dB isopleths was in the area of the modeled value), the 50% correction factor likely results in an overestimate of takes. Moreover, the mitigation and monitoring measures (described previously in this document) proposed for inclusion in the IHA (if issued) are expected to reduce even further any potential disturbance to marine mammals. Last, some marine mammal individuals, including mysticetes, have been shown to avoid the ensonified area around airguns at certain distances (Richardson *et al.,* 1999), and, therefore, some individuals would not likely enter into the Level B harassment zones for the various types of activities.

Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses

Relevant Subsistence Uses

The disturbance and potential displacement of marine mammals by sounds from drilling activities are the principal concerns related to subsistence use of the area. Subsistence remains the basis for Alaska Native culture and community. Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives. 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. Additionally, the animals taken for subsistence provide a significant portion of the food that will last the community throughout the year. The main species that are hunted include bowhead and beluga whales, ringed, spotted, and bearded seals, walruses, and polar bears. (As mentioned previously in this document, both the walrus and the polar bear are under the USFWS' jurisdiction.) The importance of each of these species varies among the communities and is largely based on availability.

The subsistence communities in the Chukchi Sea that have the potential to be impacted by Shell's offshore drilling program include Point Hope, Point Lay, Wainwright, Barrow, and possibly Kotzebue and Kivalina (however, these two communities are much farther to the south of the proposed project area). Wainwright is the coastal village closest to the proposed drill site and is located approximately 78 mi (125.5 km) from Shell's Burger prospect. Point Lay, Barrow, and Point Hope are all approximately 92, 140, and 180 mi (148, 225.3, and 290 km), respectively, from Shell's Burger prospect.

(1) Bowhead Whales

Bowhead whale hunting is a key activity in the subsistence economies of northwest Arctic communities. 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 (IWC) in 1977. The quota is now regulated through an agreement between NMFS and the Alaska Eskimo Whaling Commission (AEWC). The AEWC allots the number of bowhead whales that each whaling community may harvest annually (USDOI/BLM, 2005). The annual take of bowhead whales has varied due to (a) changes in the allowable quota level and (b) year-to-year variability in ice and weather conditions, which strongly influence the success of the hunt.

Bowhead whales migrate around northern Alaska twice each year, during the spring and autumn, and are hunted in both seasons. Bowhead whales are hunted from Barrow during the spring and the fall migration. The spring hunt along Chukchi villages and 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. From 1984–2009, bowhead harvests by the villages of Wainwright, Point Hope, and Point Lay occurred only between April 14 and June 24 and only between April 23 and June 15 in Barrow (George and Tarpley, 1986; George *et al.,* 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo *et al.,* 1994; Suydam *et al.,* 1995b, 1996, 1997, 2001b, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010). Shell will not mobilize and move into the Chukchi Sea prior to July 1.

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. 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 50 mi (80 km). The autumn bowhead hunt usually begins in Barrow in mid-September and mainly occurs in the waters east and northeast of Point Barrow. Fall bowhead whaling has not typically occurred in the villages of Wainwright, Point Hope, and Point Lay in recent years. However, a Wainwright whaling crew harvested the first fall bowhead whale in 90 years or more on October 8, 2010. Because of changing ice conditions, there is the potential for these villages to resume a fall bowhead harvest.

Barrow participates in a fall hunt each year. From 1984–2009, Barrow whalers harvested bowhead whales between August 31 and October 29. While this time period overlaps with that of Shell's proposed operations, the drill sites are located more than 140 mi (225 km) west of Barrow, so the whales would reach the Barrow hunting grounds before entering the sound field of Shell's operations. Shell will be flying helicopters out to the drillship for resupply missions. In the past 35 years, however, Barrow whaling crews have harvested almost all whales in the Beaufort Sea to the east of Point Barrow (Suydam *et al.,* 2008), indicating that relatively little fall hunting occurs to the west where the flight corridor is located.

(2) Beluga Whales

Beluga whales are available to subsistence hunters along the coast of Alaska in the spring when pack-ice conditions deteriorate and leads open up. Belugas may remain in coastal areas or lagoons through June and sometimes into July and August. The community of Point Lay is heavily dependent on the hunting of belugas in Kasegaluk Lagoon for subsistence meat. From 1983–1992 the average annual harvest was approximately 40 whales (Fuller and George, 1997). Point Hope residents hunt beluga primarily in the lead system during the spring (late March to early June) bowhead hunt but also in open-water along the coastline in July and August. Belugas are harvested in coastal waters near these villages, generally within a few miles from shore.

In Wainwright and Barrow, 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 1962–1982 was five (MMS, 1996). The Alaska Beluga Whale Committee (ABWC) recorded that 23 beluga whales had been harvested by Barrow hunters from 1987 to 2002, ranging from 0 in 1987, 1988 and 1995 to the high of 8 in 1997 (Fuller and George, 1997; ABWC, 2002 cited in USDOI/BLM, 2005). Barrow residents typically hunt for belugas between Point Barrow and Skull Cliffs in the Chukchi Sea (primarily April-June) and later in the summer (July-August) on both sides of the barrier island in Elson Lagoon/Beaufort Sea (MMS, 2008). Harvest rates indicate that the hunts are not frequent. Wainwright residents hunt beluga in April-June in the spring lead system, but this hunt typically occurs only if there are no bowheads in the area. Communal hunts for beluga are conducted along the coastal lagoon system later in July-August.

Shell's proposed exploration drilling activities take place well offshore, far away from areas that are used for beluga hunting by the Chukchi Sea communities.

(3) Ringed Seals

Ringed seals are hunted mainly from October through June. Hunting for these smaller mammals is concentrated during winter (November through March) 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 the barrier islands are used for hunting ringed seals. The average annual ringed seal harvest was 49 seals in Point Lay, 86 in Wainwright, and 394 in Barrow (Braund *et al.,* 1993; USDOI/BLM, 2003, 2005). Although ringed seals are available year-round, the planned activities will not occur during the primary period when these seals are typically harvested (November-March). Also, the activities will be largely in offshore waters where they will not influence ringed seals in the nearshore areas where they are hunted.

(4) Spotted Seals

The spotted seal subsistence hunt peaks in July and August along the shore where the seals haul out, but usually involves relatively few animals. Available maps of recent and past subsistence use areas for spotted seals indicate harvest of this species within 30–40 mi (48–64 km) of the coastline. Spotted seals typically migrate south by October to overwinter in the Bering Sea. During the fall migration, spotted seals are hunted by the Wainwright and Point Lay communities as the seals move south along the coast (USDOI/BLM, 2003). Spotted seals are also occasionally hunted in the area off Point Barrow and along the barrier islands of Elson Lagoon to the east (USDOI/BLM, 2005). The planned activities will remain offshore of the coastal harvest area of these seals and should not conflict with harvest activities.

(5) Bearded Seals

Bearded seals, although generally not favored for their meat, are important to subsistence activities in Barrow and Wainwright 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 spring and summer months in the Chukchi Sea (USDOI/BLM, 2003, 2005). The animals inhabit the environment around the ice floes in the drifting nearshore ice pack, so hunting usually occurs from boats in the drift ice. Most bearded seals are harvested in coastal areas inshore of the proposed exploration drilling area, so no conflicts with the harvest of bearded seals are expected.

Potential Impacts to Subsistence Uses

NMFS has defined ''unmitigable adverse impact'' in 50 CFR 216.103 as an impact resulting from the specified activity that is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by causing the marine mammals to abandon or avoid hunting areas; directly displacing subsistence users; or placing physical barriers between the marine mammals and the subsistence hunters; and that cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

Noise and general activity during Shell's proposed drilling program have the potential to impact marine mammals hunted by Native Alaskans. In the case of cetaceans, the most common reaction to anthropogenic sounds (as noted previously in this document) is avoidance of the ensonified area. In the case of bowhead whales, this often means that the animals divert from their normal migratory path by several kilometers. Helicopter activity also has the potential to disturb cetaceans and pinnipeds by causing them to vacate the area. Additionally, general vessel presence in the vicinity of traditional hunting areas could negatively impact a hunt. Native knowledge indicates that bowhead whales become increasingly ''skittish'' in the presence of seismic noise. Whales are more wary around the hunters and tend to expose a much smaller portion of their back when surfacing (which makes harvesting more difficult). Additionally, natives report that bowheads exhibit angry behaviors in the presence of seismic activity, such as tail-slapping, which translate to danger for nearby subsistence harvesters.

Plan of Cooperation (POC)

Regulations at 50 CFR 216.104(a)(12) require IHA applicants for activities that take place in Arctic waters to provide a POC or information that identifies what measures have been taken and/or will be taken to minimize adverse effects on the availability of marine mammals for subsistence purposes. Shell has developed a Draft POC for its 2012 Chukchi Sea, Alaska, exploration drilling program to minimize any adverse impacts on the availability of marine mammals for subsistence uses. A copy of the Draft POC was provided to NMFS with the IHA Application as Attachment D (see **ADDRESSES** for availability). Meetings with potentially affected subsistence users began in 2009 and continued into 2010 and 2011 (see Table 4.2–1 in Shell's POC for a list of all meetings conducted through April 2011). During these meetings, Shell focused on lessons learned from prior years' activities and presented mitigation measures for avoiding potential conflicts, which are outlined in the 2012 POC and this document. Shell's POC addresses vessel transit, drilling, and associated activities. Communities that were consulted regarding Shell's 2012 Arctic Ocean operations include: Barrow, Kaktovik, Wainwright, Kotzebue, Kivalina, Point Lay, Point Hope, Kiana, Gambell, Savoonga, and Shishmaref.

Beginning in early January 2009 and continuing into 2011, Shell held one-on-one meetings with representatives from the North Slope Borough (NSB) and Northwest Arctic Borough (NWAB), subsistence-user group leadership, and Village Whaling Captain Association representatives. Shell's primary purpose in holding individual meetings was to inform and prepare key leaders, prior to the public meetings, so that they would be prepared to give appropriate feedback on planned activities.

Shell presented the proposed project to the NWAB Assembly on January 27, 2009, to the NSB Assembly on February 2, 2009, and to the NSB and NWAB Planning Commissions in a joint meeting on March 25, 2009. Meetings were also scheduled with representatives from the AEWC, and presentations on proposed activities were given to the Inupiat Community of the Arctic Slope, and the Native Village of Barrow. On December 8, 2009, Shell held consultation meetings with representatives from the various marine mammal commissions. Prior to drilling in 2012, Shell will also hold additional consultation meetings with the affected communities and subsistence user groups, NSB, and NWAB to discuss the mitigation measures included in the POC. Shell also attended the 2011 Conflict Avoidance Agreement (CAA) negotiation meetings in support of a limited program of marine environmental baseline activities in 2011 taking place in the Beaufort and Chukchi seas. Shell has stated that it is committed to a CAA process and will demonstrate this by making a good-faith effort to negotiate a CAA every year it has planned activities.

The following mitigation measures, plans and programs, are integral to the POC and were developed during consultation with potentially affected subsistence groups and communities. These measures, plans, and programs will be implemented by Shell during its 2012 exploration drilling operations in both the Beaufort and Chukchi Seas to monitor and mitigate potential impacts to subsistence users and resources. The mitigation measures Shell has adopted and will implement during its 2012 Chukchi Sea offshore exploration drilling operations are listed and discussed below. This most recent version of Shell's planned mitigation measures was presented to community leaders and subsistence user groups starting in January of 2009 and has evolved since in response to information learned during the consultation process.

To minimize any cultural or resource impacts to subsistence activities from its exploration operations, Shell will implement the following additional measures to ensure coordination of its activities with local subsistence users to minimize further the risk of impacting marine mammals and interfering with the subsistence hunts for marine mammals:

(1) The drillship and support vessels will not enter the Chukchi Sea before July 1;

(2) To minimize impacts on marine mammals and subsistence hunting activities, vessels that can safely travel outside of the polynya zone will do so. In the event the transit outside of the polynya zone results in Shell having to break ice (as opposed to managing ice by pushing it out of the way), the drillship and support vessels will enter into the polynya zone far enough so that ice breaking is not necessary. If it is necessary to move into the polynya zone, Shell will notify the local communities of the change in the transit route through the Communication Centers (Com Centers);

(3) Shell has developed a Communication Plan and will implement the plan before initiating exploration drilling operations to coordinate activities with local subsistence users as well as Village Whaling Associations in order to minimize the risk of interfering with subsistence hunting activities and keep current as to the timing and status of the bowhead whale migration, as well as the timing and status of other subsistence hunts. The Communication Plan includes procedures for coordination with Com and Call Centers to be located in coastal villages along the Chukchi and Beaufort Seas during Shell's proposed activities in 2012;

(4) Shell will employ local Subsistence Advisors from the Beaufort and Chukchi Sea villages to provide consultation and guidance regarding the whale migration and subsistence hunt. There will be a total of nine subsistence advisor-liaison positions (one per village), to work approximately 8 hours per day and 40-hour weeks through Shell's 2012 exploration project. The subsistence advisor will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and advise on

ways to minimize and mitigate potential impacts to subsistence resources during the drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; and advising how to avoid subsistence conflicts. A subsistence advisor handbook will be developed prior to the operational season to specify position work tasks in more detail;

(5) Shell will recycle drilling muds (*e.g.,* use those muds on multiple wells), to the extent practicable based on operational considerations (*e.g.,* whether mud properties have deteriorated to the point where they cannot be used further), to reduce discharges from its operations. At the end of the season excess water base fluid will be pre-diluted to a 30:1 ratio with seawater and then discharged;

(6) Shell will implement flight restrictions prohibiting aircraft from flying within 1,000 ft (305 m) of marine mammals or below 1,500 ft (457 m) altitude (except during takeoffs and landings or in emergency situations) while over land or sea;

(7) Vessels within 900 ft (274 m) of marine mammals will reduce speed, avoid separating members from a group, and avoid multiple changes in direction;

(8) Vessels underway will alter course to avoid impacts to marine mammals, including collisions;

(9) The drilling support fleet will avoid known fragile ecosystems, including the Ledyard Bay Critical Habitat Unit and will include coordination through the Com Centers; and

(10) Vessel speeds will be reduced during inclement weather conditions in order to reduce the potential for collisions with marine mammals.

Aircraft and vessel traffic between the drill sites and support facilities in Wainwright, and aircraft traffic between the drill sites and air support facilities in Barrow would traverse areas that are sometimes used for subsistence hunting of belugas. Disturbance associated with vessel and aircraft traffic could therefore potentially affect beluga hunts. Vessel and aircraft traffic associated with Shell's proposed drilling program will be restricted under normal conditions to designated corridors that remain onshore or proceed directly offshore thereby minimizing the amount of traffic in coastal waters where beluga hunts take place. The designated traffic corridors do not traverse areas indicated in recent mapping as utilized by Barrow, Point Lay, or Point Hope for beluga hunts. The corridor avoids important beluga hunting areas in Kasegaluk Lagoon.

The POC also contains measures regarding ice management procedures, critical operations procedures, the blowout prevention program, and oil spill response. Some of the oil spill response measures to reduce impacts to subsistence hunts include: having the primary OSRV on standby at all times so that it is available within 1 hour if needed; the remainder of the OSR fleet will be available within 72 hours if needed and will be capable of collecting oil on the water up to the calculated Worst Case Discharge; oil spill containment equipment will be available in the unlikely event of a blowout; capping stack equipment will be stored aboard one of the ice management vessels and will be available for immediate deployment in the unlikely event of a blowout; and pre-booming will be required for all fuel transfers between vessels.

Unmitigable Adverse Impact Analysis

Shell has adopted a spatial and temporal strategy for its Chukchi Sea operations that should minimize impacts to subsistence hunters. Shell will enter the Chukchi Sea far offshore, so as to not interfere with July hunts in the Chukchi Sea villages and will communicate with the Com Centers to notify local communities of any changes in the transit route. After the close of the July beluga whale hunts in the Chukchi Sea villages, very little whaling occurs in Wainwright, Point Hope, and Point Lay. Although the fall bowhead whale hunt in Barrow will occur while Shell is still operating (mid- to late September to October), Barrow is located 140 mi (225 km) east of the proposed drill sites. Based on these factors, Shell's Chukchi Sea survey is not expected to interfere with the fall bowhead harvest in Barrow. In recent years, bowhead whales have occasionally been taken in the fall by coastal villages along the Chukchi coast, but the total number of these animals has been small. Wainwright landed its first fall whale in more than 90 years in October 2010. Hunters from the northwest Arctic villages prefer to harvest whales within 50 mi (80 km) so as to avoid long tows back to shore.

Adverse impacts are not anticipated on sealing activities since the majority of hunts for seals occur in the winter and spring, when Shell will not be operating. Additionally, most sealing activities occur much closer to shore than Shell's proposed drill sites.

Shell will also support the village Com Centers in the Arctic communities and employ local Subsistence Advisors from the Beaufort and Chukchi Sea villages to provide consultation and guidance regarding the whale migration and subsistence hunt. The Subsistence Advisors will provide advice to Shell on ways to minimize and mitigate potential impacts to subsistence resources during the drilling season. Support activities, such as helicopter flights, could impact nearshore subsistence hunts. However, Shell will use flight paths and agreed upon flight altitudes to avoid adverse impacts to hunts and will communicate regularly with the Com Centers.

In the unlikely event of a major oil spill in the Chukchi Sea, there could be major impacts on the availability of marine mammals for subsistence uses. As discussed earlier in this document, the probability of a major oil spill occurring over the life of the project is low (Bercha, 2008). Additionally, Shell developed an ODPCP, which is currently under review by the Department of the Interior and several Federal agencies and the public. Shell has also incorporated several mitigation measures into its operational design to reduce further the risk of an oil spill. Copies of Shell's 2012 Chukchi Sea Exploration Plan and ODPCP can be found on the Internet at: *http://alaska.boemre.gov/ref/ProjectHistory/2012_Shell_CK/revisedEP/EP.pdf* and *http://www.alaska.boemre.gov/fo/ODPCPs/2010_Chukchi_rev1.pdf,* respectively.

Proposed Incidental Harassment Authorization

This section contains a draft of the IHA itself. The wording contained in this section is proposed for inclusion in the IHA (if issued).

(1) This Authorization is valid from July 4, 2012, through October 31, 2012.

(2) This Authorization is valid only for activities associated with Shell's 2012 Chukchi Sea exploration drilling program. The specific areas where Shell's exploration drilling program will be conducted are within Shell lease holdings in the Outer Continental Shelf Lease Sale 193 area in the Chukchi Sea.

(3)(a) The incidental taking of marine mammals, by Level B harassment only, is limited to the following species: bowhead whale; gray whale; beluga whale; minke whale; fin whale; humpback whale; killer whale; harbor porpoise; ringed seal; bearded seal; spotted seal; and ribbon seal.

(3)(b) The taking by injury (Level A harassment), serious injury, or death of any of the species listed in Condition 3(a) or the taking of any kind of any other species of marine mammal is prohibited and may result in the modification, suspension or revocation of this Authorization.

(4) The authorization for taking by harassment is limited to the following acoustic sources (or sources with comparable frequency and intensity) and from the following activities:

(a) 8-Airgun array with a total discharge volume of 760 in^3;

(b) Continuous drillship sounds during active drilling operations; and

(c) Vessel sounds generated during active ice management or icebreaking.

(5) The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS or his designee.

(6) The holder of this Authorization must notify the Chief of the Permits and Conservation Division, Office of Protected Resources, at least 48 hours prior to the start of exploration drilling activities (unless constrained by the date of issuance of this Authorization in which case notification shall be made as soon as possible).

(7) General Mitigation and Monitoring Requirements: The Holder of this Authorization is required to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable impact on affected marine mammal species or stocks:

(a) All vessels shall reduce speed to at least 9 knots when within 300 yards (274 m) of whales. The reduction in speed will vary based on the situation but must be sufficient to avoid interfering with the whales. Those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group;

(b) Avoid multiple changes in direction and speed when within 300 yards (274 m) of whales;

(c) When weather conditions require, such as when visibility drops, support vessels must reduce speed and change direction, as necessary (and as operationally practicable), to avoid the likelihood of injury to whales;

(d) Aircraft shall not fly within 1,000 ft (305 m) of marine mammals or below 1,500 ft (457 m) altitude (except during takeoffs, landings, or in emergency situations) while over land or sea;

(e) Utilize two, NMFS-qualified, vessel-based Protected Species Observers (PSOs) (except during meal times and restroom breaks, when at least one PSO shall be on watch) to visually watch for and monitor marine mammals near the drillship or support vessel during active drilling or airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night. The vessels' crew shall also assist in detecting marine mammals, when practicable. PSOs shall have access to reticle binoculars (7 × 50 Fujinon), big-eye binoculars (25 × 150), and night vision devices. PSO shifts shall last no longer than 4 hours at a time and shall not be on watch more than 12 hours in a 24-hour period. PSOs shall also make observations during daytime periods when active operations are not being conducted for comparison of animal abundance and behavior, when feasible;

(f) When a mammal sighting is made, the following information about the sighting will be recorded by the PSOs:

(i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from the MMO, apparent reaction to activities (*e.g.,* none, avoidance, approach, paralleling, *etc.*), closest point of approach, and behavioral pace;

(ii) Time, location, speed, activity of the vessel, sea state, ice cover, visibility, and sun glare; and

(iii) The positions of other vessel(s) in the vicinity of the MMO location.

(iv) The ship's position, speed of support vessels, and water temperature, water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

(g) PSO teams shall consist of Inupiat observers and experienced field biologists. An experienced field crew leader will supervise the PSO team onboard the survey vessel. New observers shall be paired with experienced observers to avoid situations where lack of experience impairs the quality of observations;

(h) PSOs will complete a two or three-day training session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2012 open-water season. The training session(s) will be conducted by qualified marine mammalogists with extensive crew-leader experience during previous vessel-based monitoring programs. A marine mammal observers' handbook, adapted for the specifics of the planned program, will be reviewed as part of the training;

(i) If there are Alaska Native PSOs, the PSO training that is conducted prior to the start of the survey activities shall be conducted with both Alaska Native PSOs and biologist PSOs being trained at the same time in the same room. There shall not be separate training courses for the different PSOs; and

(j) PSOs shall be trained using visual aids (*e.g.,* videos, photos), to help them identify the species that they are likely to encounter in the conditions under which the animals will likely be seen.

(8) ZVSP Mitigation and Monitoring Measures: The Holder of this Authorization is required to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable impact on affected marine mammal species or stocks:

(a) PSOs shall conduct monitoring while the airgun array is being deployed or recovered from the water;

(b) PSOs shall visually observe the entire extent of the exclusion zone (EZ) (180 dB re 1 μPa [rms] for cetaceans and 190 dB re 1 μPa [rms] for pinnipeds) using NMFS-qualified PSOs, for at least 30 minutes (min) prior to starting the airgun array (day or night). If the PSO finds a marine mammal within the EZ, Shell must delay the seismic survey until the marine mammal(s) has left the area. If the PSO sees a marine mammal that surfaces then dives below the surface, the PSO shall continue the watch for 30 min. If the PSO sees no marine mammals during that time, they should assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 min period (*i.e.,* rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), the Holder of this Authorization may start the second airgun without observing the entire EZ for 30 min prior, provided no marine mammals are known to be near the EZ;

(c) Establish and monitor a 180 dB re 1 μPa (rms) and a 190 dB re 1 μPa (rms) EZ for marine mammals before the 8-airgun array (760 in^3) is in operation; and a 180 dB re 1 μPa (rms) and a 190 dB re 1 μPa (rms) EZ before a single airgun (40 in^3) is in operation, respectively. For purposes of the field verification tests, described in condition 10(c)(i) below, the 180 dB radius is predicted to be 0.77 mi (1.24 km) and the 190 dB radius is predicted to be 0.33 mi (524 m);

(d) Implement a ''ramp-up'' procedure when starting up at the beginning of seismic operations, which means start the smallest gun first and add airguns in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSOs shall monitor the EZ, and if marine mammals are sighted, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from shut-down requires that the PSOs be able to view the full EZ;

(e) Power-down or shutdown the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant EZ. A shutdown means all operating airguns are shutdown (*i.e.,* turned off). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun, which reduces the EZ to the degree that the animal(s) is no longer in or about to enter it;

(f) Following a power-down, if the marine mammal approaches the smaller designated EZ, the airguns must then be completely shutdown. Airgun activity shall not resume until the PSO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 min for species with shorter dive durations (small odontocetes and pinnipeds) or 30 min for species with longer dive durations (mysticetes);

(g) Following a power-down or shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described in Condition 8(d) above;

(h) ZVSP surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant EZs are visible and can be effectively monitored; and

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

(9) Subsistence Mitigation Measures: To ensure no unmitigable adverse impact on subsistence uses of marine mammals, the Holder of this Authorization shall:

(a) Traverse north through the Bering Strait through the Chukchi Sea along a route that lies offshore of the polynya zone. In the event the transit outside of the polynya zone results in Shell having to break ice, the drilling vessel and support vessels will enter into the polynya zone far enough so that icebreaking is not necessary. If it is necessary to move into the polynya zone, Shell shall notify the local communities of the change in transit route through the Communication and Call Centers (Com Centers). As soon as the fleet transits past the ice, it will exit the polynya zone and continue a path in the open sea toward the Camden Bay drill sites;

(b) Not enter the Bering Strait prior to July 1 to minimize effects on spring and early summer whaling;

(c) Implement the Communication Plan before initiating exploration drilling operations to coordinate activities with local subsistence users and Village Whaling Associations in order to minimize the risk of interfering with subsistence hunting activities;

(d) Participate in the Com Center Program. The Com Centers shall operate 24 hours/day during the 2012 bowhead whale hunt;

(e) Employ local Subsistence Advisors (SAs) from the Beaufort and Chukchi Sea villages to provide consultation and guidance regarding the whale migration and subsistence hunt;

(f) Not operate aircraft below 1,500 ft (457 m) unless engaged in marine mammal monitoring, approaching, landing or taking off, or unless engaged in providing assistance to a whaler or in poor weather (low ceilings) or any other emergency situations;

(g) Cool all drilling mud to mitigate any potential permafrost thawing or thermal dissociation of any methane hydrates encountered during exploration drilling if such materials are present at the drill site; and

(h) Recycle all drilling mud to the extent practicable based on operational considerations (*e.g.,* whether mud properties have deteriorated to the point where they cannot be used further) so that the volume of the mud disposed of at the end of the drilling season is reduced.

(10) Monitoring Measures:

(a) Vessel-based Monitoring: The Holder of this Authorization shall designate biologically-trained PSOs to be aboard the drillship and all support vessels. The PSOs are required to monitor for marine mammals in order to implement the mitigation measures described in conditions 7 and 8 above;

(b) Aerial Survey Monitoring: The Holder of this Authorization must implement the aerial survey monitoring program detailed in its Marine Mammal Mitigation and Monitoring Plan (4MP); and

(c) Acoustic Monitoring:

(i) Field Source Verification: the Holder of this Authorization is required to conduct sound source verification tests for the drilling vessel, support vessels, and the airgun array. Sound source verification shall consist of distances where broadside and endfire directions at which broadband received levels reach 190, 180, 170, 160, and 120 dB re 1 μPa (rms) for all active acoustic sources that may be used during the activities. For the airgun array, the configurations shall include at least the full array and the operation of a single source that will be used during power downs. The test results shall be reported to NMFS within 5 days of completing the test.

(ii) Acoustic ''Net'' Array: Deploy acoustic recorders widely across the U.S. Chukchi Sea and on the prospect in order to gain information on the distribution of marine mammals in the region. This program must be implemented as detailed in the 4MP.

(11) Reporting Requirements: The Holder of this Authorization is required to:

(a) Within 5 days of completing the sound source verification tests for the drillship, support vessels, and the airguns, the Holder shall submit a preliminary report of the results to NMFS. The report should report down to the 120-dB radius in 10-dB increments;

(b) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the exploration drilling program. This report must contain and summarize the following information:

(i) summaries of monitoring effort (*e.g.,* total hours, total distances, and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals);

(ii) analyses of the effects of various factors influencing detectability of marine mammals (*e.g.,* sea state, number of observers, and fog/glare);

(iii) species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover;

(iv) sighting rates of marine mammals during periods with and without exploration drilling activities (and other variables that could affect detectability), such as: (A) initial sighting distances versus drilling state; (B) closest point of approach versus drilling state; (C) observed behaviors and types of movements versus drilling state; (D) numbers of sightings/individuals seen versus drilling state; (E) distribution around the survey vessel versus drilling state; and (F) estimates of take by harassment;

(v) Reported results from all hypothesis tests should include estimates of the associated statistical power when practicable;

(vi) Estimate and report uncertainty in all take estimates. Uncertainty could be expressed by the presentation of confidence limits, a minimum-maximum, posterior probability distribution, *etc.;* the exact approach would be selected based on the sampling method and data available;

(vii) The report should clearly compare authorized takes to the level of actual estimated takes.

(viii) If, after the independent monitoring plan peer review changes are made to the monitoring program, those changes must be detailed in the report.

(c) The draft report will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final report prior to acceptance by NMFS. The draft report will be considered the final report for this activity under this Authorization if NMFS has not provided comments and recommendations within 90 days of receipt of the draft report.

(d) A draft comprehensive report describing the aerial, acoustic, and vessel-based monitoring programs will be prepared and submitted within 240 days of the date of this Authorization. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of all industry activities and their impacts on marine mammals in the Arctic Ocean during 2012.

(e) The draft comprehensive report will be subject to review and comment by NMFS, the AEWC, and the NSB Department of Wildlife Management. The draft comprehensive report will be accepted by NMFS as the final comprehensive report upon incorporation of comments and recommendations.

(12)(a) In the unanticipated event that the drilling program operation clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (*e.g.,* ship-strike, gear interaction, and/or entanglement), Shell shall immediately cease operations and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, by phone or email and the Alaska Regional Stranding Coordinators. The report must include the following information: (i) Time, date, and location (latitude/longitude) of the incident; (ii) the name and type of vessel involved; (iii) the vessel's speed during and leading up to the incident; (iv) description of the incident; (v) status of all sound source use in the 24 hours preceding the incident; (vi) water depth; (vii) environmental conditions (*e.g.,* wind speed and direction, Beaufort sea state, cloud cover, and visibility); (viii) description of marine mammal observations in the 24 hours preceding the incident; (ix) species identification or description of the animal(s) involved; (x) the fate of the animal(s); (xi) and photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with Shell to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. Shell may not resume their activities until notified by NMFS via letter, email, or telephone.

(b) In the event that Shell discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (*i.e.,* in less than a moderate state of decomposition as described in the next paragraph), Shell will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, by phone or email and the NMFS Alaska Stranding Hotline and/or by email to the Alaska Regional Stranding Coordinators. The report must include the same information identified in Condition 12(a) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with Shell to determine whether modifications in the activities are appropriate.

(c) In the event that Shell discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (*e.g.,* previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Shell shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, by phone or email and the NMFS Alaska Stranding Hotline and/or by email to the Alaska Regional Stranding Coordinators, within 24 hours of the discovery. Shell shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

(13) Activities related to the monitoring described in this Authorization do not require a separate scientific research permit issued under section 104 of the Marine Mammal Protection Act.

(14) The Plan of Cooperation outlining the steps that will be taken to cooperate and communicate with the native communities to ensure the availability of marine mammals for subsistence uses must be implemented.

(15) Shell is required to comply with the Terms and Conditions of the Incidental Take Statement (ITS) corresponding to NMFS's Biological Opinion issued to NMFS's Office of Protected Resources.

(16) A copy of this Authorization and the ITS must be in the possession of all contractors and PSOs operating under the authority of this Incidental Harassment Authorization.

(17) Penalties and Permit Sanctions: Any person who violates any provision of this Incidental Harassment Authorization is subject to civil and criminal penalties, permit sanctions, and forfeiture as authorized under the MMPA.

(18) This Authorization may be modified, suspended or withdrawn if the Holder fails to abide by the conditions prescribed herein or if the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals, or if there is an unmitigable adverse impact on the availability of such species or stocks for subsistence uses.

Endangered Species Act (ESA)

There are three marine mammal species listed as endangered under the ESA with confirmed or possible occurrence in the proposed project area: the bowhead, humpback, and fin whales. NMFS' Permits and Conservation Division will initiate consultation with NMFS' Endangered Species Division under section 7 of the ESA on the issuance of an IHA to Shell under section 101(a)(5)(D) of the MMPA for this activity. Consultation will be concluded prior to a determination on the issuance of an IHA.

National Environmental Policy Act (NEPA)

NMFS is currently preparing an Environmental Assessment (EA), pursuant to NEPA, to determine whether the issuance of an IHA to Shell for its 2012 drilling activities may have a significant impact on the human environment. NMFS expects to release a draft of the EA for public comment and will inform the public through the **Federal Register** and posting on our Web site once a draft is available (see **ADDRESSES**).

Request for Public Comment

As noted above, NMFS requests comment on our analysis, the draft authorization, and any other aspect of the Notice of Proposed IHA for Shell's 2012 Chukchi Sea exploratory drilling program. Please include, with your comments, any supporting data or literature citations to help inform our final decision on Shell's request for an MMPA authorization.

Dated: November 2, 2011.

James H. Lecky,

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

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