DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XD655

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 Gulf of Mexico 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 April 3, 2015.

ADDRESSES: Comments on the application should be addressed to Jolie Harrison, 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.Guan@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 (4MP) 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: Shane Guan, 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.

An 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.''

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

On September 18, 2014, Shell submitted an application to NMFS for the taking of marine mammals incidental to exploration drilling activities in the Chukchi Sea, Alaska. After receiving comments and questions from NMFS, Shell revised its IHA application and 4MP on December 17, 2014. NMFS determined that the application was adequate and complete on January 5, 2015.

The proposed activity would occur between July and October 2015. The following specific aspects of the proposed activities are likely to result in the take of marine mammals: Exploration drilling, supply and drilling support vessels using dynamic positioning, mudline cellar construction, anchor handling, ice management activities, and zero-offset vertical seismic profiling (ZVSP) activities.

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 are: 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*).

In 2012, NMFS issued two IHAs to Shell to conducted two exploratory drilling activities at exploration wells in the Beaufort (77 FR 27284; May 9, 2012) and Chukchi (77 FR 27322; May 9, 2012) Seas, Alaska, during the 2012 Arctic open-water season (July through October). Shell's proposed 2015 exploration drilling program is similar to those conducted in 2012. In December 2012, Shell submitted two additional IHA applications to take marine mammals incidental to its proposed exploratory drilling in Beaufort and Chukchi Seas during the 2013 open-water season. However, Shell withdrew its application in February 2013.

Description of the Specified Activity

Overview

Shell proposes to conduct exploration drilling at up to four exploration drill sites at Shell's Burger Prospect on the OCS leases acquired from the U.S. Department of Interior, Bureau of Ocean Energy Management (BOEM). The exploration drilling planned for the

2015 season is a continuation of the Chukchi Sea exploration drilling program that began in 2012, and resulted in the completion of a partial well at the location known as Burger A. Exploration drilling will be done pursuant to Shell's Chukchi Sea Exploration Plan, Revision 2 (EP).

Shell plans to use two drilling units, the drillship *Noble Discoverer* (*Discoverer*) and semi-submersible *Transocean Polar Pioneer* (*Polar Pioneer*) to drill at up to four locations on the Burger Prospect. Both drilling units will be attended to by support vessels for the purposes of ice management, anchor handling, oil spill response (OSR), refueling, support to drilling units, and resupply. The drilling units will be accompanied by an expanded number of support vessels, aircraft, and oil spill response vessels (OSRV) greater than the number deployed during the 2012 drilling season.

Dates and Duration

Shell anticipates that its exploration drilling program will occur between July 1 and approximately October 31, 2015. The drilling units will move through the Bering Strait and into the Chukchi Sea on or after July 1, 2015, and then onto the Burger Prospect as soon as ice and weather conditions allow. Exploration drilling activities will continue until about October 31, 2015, the drilling units and support vessels will exit the Chukchi Sea at the conclusion of the exploration drilling season. Transit entirely out of the Chukchi Sea by all vessels associated with exploration drilling may take well into the month of November due to ice, weather, and sea states.

Specified Geographic Region

All drill sites at which exploration drilling would occur in 2015 will be at Shell's Burger Prospect (see Figure 1–1 on page 1–2 of Shell's IHA application). Shell has identified a total of six Chukchi Sea lease blocks on the Burger Prospect. All six drill sites are located more than 64 mi (103 km) off the Chukchi Sea coast. During 2015, the *Discoverer* and *Polar Pioneer* will be used to conduct exploration drilling activities at up to four exploration drill sites. As with any Arctic exploration program, weather and ice conditions will dictate actual operations.

Activities associated with the Chukchi Sea exploration drilling program and analyzed herein include operation of the *Discoverer, Polar Pioneer,* and associated support vessels. The drilling units 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.

Detailed Description of Activities

The specific activities that may result in incidental taking of marine mammals based on the IHA application are limited to Shell's exploration drilling program and related activities. Activities include exploration drilling sounds, MLC construction, anchor handling while mooring a drilling unit at a drill site, vessels on DP when tending to a drilling unit, ice management, and zero-offset vertical seismic profile (ZVSP) surveys.

(1) Exploration Drilling

In 2015 Shell plans to continue its exploration drilling program on BOEM Alaska OCS leases at drill sites greater than 64 mi (103 km) from the Chukchi Sea coast during the 2015 drilling season. Shell plans to conduct exploration drilling activities at up to four drill sites at the Burger Prospect utilizing two drilling units, the drillship *Discoverer* and the semi-submersible *Polar Pioneer.*

During 2012, Shell drilled a partial well at the Burger A drill site. Drilling at Burger A did not reach a depth at which a ZVSP survey would be conducted. Consequently one was not performed.

A mudline cellar (MLC) will be constructed at each drill site. The MLCs will be constructed in the seafloor using a large diameter bit operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer.*

(2) Support Vessels

During exploration drilling, the *Discoverer* and *Polar Pioneer* will be supported by the types of vessels listed in Table 1–1 of Shell's IHA application. These drilling units would be accompanied by greater number of support vessels and oil spill response vessels than were deployed by Shell during 2012 exploration drilling in the Chukchi Sea.

Two ice management vessels will support the drilling units. These vessels will enter and exit the Chukchi Sea with or ahead of the drilling units, and will generally remain in the vicinity of the drilling units during the drilling season. Ice management and ice scouting is expected to occur at distances of 20 mi (32 km) and 30 mi (48 km) respectively from drill site locations. However, these vessels may have to range beyond these distances depending on ice conditions.

Up to three anchor handlers will support the drilling units. These vessels will enter and exit the Chukchi Sea with or ahead of the drilling units, and will generally remain in the vicinity of the drilling units during the drilling season. When the vessels are not anchor handling, they will be available to provide other general support. Two of the three anchor handlers may be used to perform secondary ice management tasks if needed.

The planned exploration drilling activities will use three offshore supply vessels (OSVs) for resupply of the drilling units and support vessels. Drilling materials, food, fuel, and other supplies will be picked up in Dutch Harbor (with possible minor resupply coming out of Kotzebue) and transported to the drilling units and support vessels.

Shell plans to use up to two science vessels; one for each drilling unit, from which sampling of ocean water and sediments prior to and following drilling discharges would be conducted. The science vessel specifications are based on larger OSVs, but smaller vessels may be used.

Two tugs will tow the *Polar Pioneer* from Dutch Harbor to the Burger Prospect. After the *Polar Pioneer* is moored, the tugs will remain in the vicinity of the drilling units to help move either drilling unit in the event they need to be moved off of a drilling site due to ice or any other event.

Shell may deploy a MLC ROV system from an OSV type vessel that could be used to construct MLCs prior to a drilling units arriving. If used, this vessel would be located at a drill site on the Burger Prospect. When not in use, the vessel would be outside of the Chukchi Sea

(3) Oil Spill Response Vessels

The oil spill response (OSR) vessel types supporting the exploration drilling program are listed in Table 1.2 of Shell's IHA application.

One dedicated OSR barge and on-site oil spill response vessel (OSRV) will be staged in the vicinity of the drilling unit(s) when drilling into potential liquid hydrocarbon bearing zones. This will enable the OSRV to respond to a spill and provide containment, recovery, and storage for the initial response period in the unlikely event of a well control incident.

The OSR barge, associated tug, and OSRV possess sufficient storage capacity to provide containment, recovery, and storage for the initial response period. Shell plans to use two oil storage tankers (OSTs). An OST will be staged at the Burger Prospect. The OST will hold fuel for Shell's drilling units, support vessels, and have space for storage of recovered liquids in the unlikely event of a well control incident. A second OST will be stationed in the Chukchi Sea and sited such that it will be able to respond to a well control event before the first tanker reaches its recovered liquid capacity.

The tug and barge will be used for nearshore OSR. The nearshore tug and barge will be moored near Goodhope Bay, Kotzebue Sound. The nearshore tug and barge will also carry response equipment, including one 47 ft. (14 m) skimming vessel, 34 ft. (10 m) workboats, mini-barges, boom and duplex skimming units for nearshore recovery and possibly support nearshore protection. The nearshore tug and barge will also carry designated response personnel and will mobilize to recovery areas, deploy equipment, and begin response operations.

(4) Aircraft

Offshore operations will be serviced by up to three helicopters operated out of an onshore support base in Barrow. The helicopters are not yet contracted. Sikorsky S–92s (or similar) will be used to transport crews between the onshore support base, the drilling units and support vessels with helidecks. The helicopters will also be used to haul small amounts of food, materials, equipment, samples and waste between vessels and the shorebase. Approximately 40 Barrow to Burger Prospect round trip flights will occur each week to support the additional crew change necessities for an additional drilling unit, support vessels, and required sampling.

The route chosen will depend on weather conditions and whether subsistence users are active on land or at sea. These routes may be modified depending on weather and subsistence uses.

Shell will also have a dedicated helicopter for Search and Rescue (SAR). The SAR helicopter is expected to be a Sikorsky S–92 (or similar). This aircraft will stay grounded at the Barrow shore base location except during training drills, emergencies, and other non-routine events. The SAR helicopter and crew plan training flights for approximately 40 hr/month.

A fixed wing propeller or turboprop aircraft, such as the Saab 340–B, Beechcraft 1900, or De Havilland Dash 8, will be used to transport crews, materials, and equipment between Wainwright and hub airports such as Barrow or Fairbanks. It is anticipated that there will be one round trip flight every three weeks.

A fixed wing aircraft, Gulfstream Aero-Commander (or similar), will be used for photographic surveys of marine mammals. These flights will take place daily depending on weather conditions. Flight paths are located in the Marine Mammal Monitoring and Mitigation Plan (4MP).

An additional Gulfstream Aero Commander may be used to provide ice reconnaissance flights to monitor ice conditions around the Burger Prospect. Typically, the flights will focus on the ice conditions within 50 mi (80 km) of the drill sites, but more extensive ice reconnaissance may occur beyond 50 mi (80 km).

These flights will occur at an altitude of approximately 3,000 ft. (915 m).

(5) Vertical Seismic Profile

Shell may conduct a geophysical survey referred to as a vertical seismic profile (VSP) survey at each drill site where a well is drilled in 2015. During VSP surveys, an airgun array is deployed at a location near or adjacent to the drilling units, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically a string of them, 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 VSP is to gather geophysical information at various depths, which can then be used to tie-in or groundtruth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell will be conducting a particular form of VSP referred to as a zero-offset VSP (ZVSP), in which the sound source is maintained at a constant location near the wellbore (Figure 1–2 in IHA application). Shell may use one of two typical sound sources: (1) A three-airgun array consisting of three, 150 cubic inches (in^3) (2,458 cm^3) airguns, or (2) a two-airgun array consisting of two, 250 in^3 (4,097 cm^3) airguns. Typical receivers would consist of a standard wireline four-level vertical seismic imager (VSI) tool, which has four receivers 50 ft (15.2 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 would deploy the sound source (airgun array) over the side of the *Discoverer* or *Polar Pioneer* with a crane, the sound source will be 50–200 ft (15–61 m) from the wellhead depending on crane location, and reach a depth of approximately 10–23 ft (3–7 m) below the water surface. The VSI along with its four receivers will be temporarily anchored in the wellbore at depth.

The sound source will be pressured up to 3,000 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 re-anchored, after which the airgun array will again be activated 5–7 times. This process will be repeated until the entire wellbore is surveyed. The interval between anchor points for the VSI is usually 200–300 ft. (61–91 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.

(6) Ice Management and Forecasting

The exploration 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 will implement a Drilling Ice Management Plan (DIMP) to ensure real-time ice and weather forecasting that will identify conditions that could put operations at risk, allowing Shell to modify its activities accordingly.

Shell's ice management fleet will consist of four vessels: two ice management vessels and two anchor handler/icebreakers. Ice management that is necessary for safe operations during 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, thereby resulting in no threat to public safety or services that occur near to shore. Shell vessels will also communicate movements and activities through the 2015 North Slope Communications Centers (Com Centers). Management of ice will occur during the drilling season predominated by open water, thus it will not contribute to ice hazards, such as ridging, override, or pileup in an offshore or nearshore environment.

The ice-management/anchor handling vessels will manage the ice by deflecting any ice floes that could affect the *Discoverer* or *Polar Pioneer* when they are drilling or anchor mooring buoys even if the drilling units are not anchored at a drill site. When managing ice, the ice management vessels will generally operate upwind of the drilling units, since the wind and currents contribute to the direction of ice movement. Ice reconnaissance or ice scouting forays may occur out to 48.3km (30mi) from the drilling units and are conducted by the ice management vessels into ice that may move into the vicinity of exploration drilling activities. This will provide the vessel and shore-based ice advisors with the information required to decide whether or not active ice management is necessary. The actual distances from the drilling units and the patterns of ice management (distances between vessels, and width of the swath in which ice management occurs) will be determined by the ice floe speed, size, thickness, and character, and wind forecast.

Ice floe frequency and intensity is unpredictable and could range from no ice to ice densities that exceed ice-management capabilities, in which case drilling activities might be stopped and the drilling units disconnected from their moorings and moved off site. The *Discoverer* was disconnected from its moorings once during the 2012 season to avoid a potential encounter with multi-year ice flows of sufficient size to halt activities. Advance scouting of ice primarily north and east of the Burger A well by the ice management vessels did not detect ice of sufficient size or thickness to warrant disconnecting the *Discoverer* from its moorings during the remainder of the 2012 season. If ice is present, ice management activities may be necessary in early July, at discrete intervals at other times during the season, and towards the end of operations in late October. However, data regarding historic ice patterns in the area of activities indicate that it will not be required throughout the planned 2015 drilling season.

During the 2012 drilling season, a total of seven days of active ice management by vessels occurred in support of Shell's exploration drilling program in the Chukchi Sea.

When ice is present at a drill site, ice disturbance will be limited to the minimum amount needed to allow drilling to continue. First-year ice will be the type most likely to be encountered. The ice-management vessel will be tasked with managing the ice so that it flows easily around the drilling units and their anchor moorings without building up in front of either. 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 drilling units and making turns at both ends, or in circular patterns. During ice-management, the vessel's propeller is rotating at approximately 15 to 20% 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, and thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice features that would be managed at a much slower speed than that used to manage first-year ice.

As detailed in Shell's Drilling Ice Management Plan (DIMP), in 2012 Shell's ice management vessels conducted ice management to protect moorings for the *Discoverer* after the drilling unit was moved off of the Burger A well. This work consisted of re-directing flows as necessary to avoid potential impact with mooring buoys, without the necessity to break up multi-year ice flowbergs. Actual breaking of ice may need to occur in the event that ice conditions in the immediate vicinity of activities create a safety hazard for the drilling unit, or its moorings. In such a circumstance, operations personnel will follow the guidelines established in the DIMP 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. Despite Shell's experience in 2012, historical data relative to ice conditions in the Chukchi Sea in the vicinity of Shell's planned 2015 activities, establishes that there is a low probability for the type of hazardous ice conditions that might necessitate icebreaking (*e.g.,* records of the National Naval Ice Center archives; Shell/SIWAC). The probability could be greater at the beginning and/or the end of the drilling season (early July or late October). For the purposes of evaluating possible impacts of the planned activities, Shell has assumed icebreaking activities for a limited period of time, and estimated incidental exposures of marine mammals from such activities.

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. The ringed seal is listed as ''threatened'' under the ESA. 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. 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 are: 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 2013 SAR is available at: *http://www.nmfs.noaa.gov/pr/sars/pdf/ak2013_final.pdf.*

Table 1 lists the 12 marine mammal species or stocks under NMFS jurisdiction with confirmed or possible occurrence in the proposed project area.

TABLE 1—MARINE MAMMAL SPECIES AND STOCKS WITH CONFIRMED OR POSSIBLE OCCURRENCE IN THE PROPOSED EXPLORATION DRILLING AREA

Common name	Scientific name	Status	Occurrence	Seasonality	Range	Abundance
Odontocetes:						
Beluga whale (Eastern Chukchi Sea stock).	*Dephinapterus leucas*.	....	Common	Mostly spring and fall with some in summer.	Russia to Canada	3,710
Beluga whale (Beaufort Sea stock).	*Delphinapterus leucas*.	....	Common	Mostly spring and fall with some in summer.	Russia to Canada	39,258
Killer whale	*Orcinus orca*	....	Occasional/ Extralimital.	Mostly summer and early fall.	California to Alaska	2,084
Harbor porpoise	*Phocoena phocoena*.	....	Occasional/ Extralimital.	Mostly summer and early fall.	California to Alaska	48,215
Mysticetes:						
Bowhead whale	*Balaena mysticetus*	Endangered; Depleted.	Common	Mostly spring and fall with some in summer.	Russia to Canada	19,534
Gray whale	*Eschrichtius robustus*.	....	Somewhat common.	Mostly summer	Mexico to the U.S. Arctic Ocean.	19,126
Minke whale	*Balaenoptera acutorostrata*.	....	Rare	Summer	North Pacific	810–1,003
Fin whale (North Pacific stock).	*B. physalus*	Endangered; Depleted.	Rare	Summer	North Pacific	1,652
Humpback whale (Central North Pacific stock).	*Megaptera novaeangliae*.	Endangered; Depleted.	Rare	Summer	Central to North Pacific.	20,800
Pinnipeds:						
Bearded seal (Beringia distinct population segment).	*Erigathus barbatus*	Candidate	Common	Spring and summer.	Bering, Chukchi, and Beaufort Seas.	155,000
Ringed seal (Arctic stock).	*Phoca hispida*	Threatened; Depleted.	Common	Year round	Bering, Chukchi, and Beaufort Seas.	300,000
Spotted seal	*Phoca largha*	....	Common	Summer	Japan to U.S. Arctic Ocean.	141,479
Ribbon seal	*Histriophoca fasciata*.	Species of concern	Occasional	Summer	Russia to U.S. Arctic Ocean.	49,000

Potential Effects of the Specified Activity on Marine Mammals

This section includes a summary and discussion of the ways that the types of stressors associated with the specified activity (*e.g.,* drilling, seismic airgun, vessel movement) have been observed to or are thought to impact marine mammals. This section is intended as a background of potential effects and does not consider either the specific manner in which this activity will be carried out or the mitigation that will be implemented or how either of those will shape the anticipated impacts from this specific activity. The ''Estimated Take by Incidental Harassment'' section later in this document will include a quantitative analysis of the number of individuals that are expected to be taken by this activity. The ''Negligible Impact Analysis'' section will include the analysis of how this specific activity will impact marine mammals and will consider the content of this section, the ''Estimated Take by Incidental Harassment'' section, the ''Mitigation'' section, and the ''Anticipated Effects on Marine Mammal Habitat'' section to draw conclusions regarding the likely impacts of this activity on the reproductive success or survivorship of individuals and from that on the affected marine mammal populations or stocks.

Background on Sound

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water, and is generally characterized by several variables. Frequency describes the sound's pitch and is measured in hertz (Hz) or kilohertz (kHz), while sound level describes the sound's intensity and is measured in decibels (dB). Sound level increases or decreases exponentially with each dB of change. The logarithmic nature of the scale means that each 10-dB increase is a 10-fold increase in acoustic power (and a 20-dB increase is then a 100-fold increase in power). A 10-fold increase in acoustic power does not mean that the sound is perceived as being 10 times louder, however. Sound levels are compared to a reference sound pressure (micro-Pascal) to identify the medium. For air and water, these reference pressures are ''re 20 µPa'' and ''re 1 µPa,'' respectively. Root mean square (RMS) is the quadratic mean sound pressure over the duration of an impulse. RMS is calculated by squaring all of the sound amplitudes, averaging the squares, and then taking the square root of the average (Urick, 1983). RMS accounts for both positive and negative values; squaring the pressures makes all values positive so that they may be accounted for in the summation of pressure levels (Hastings and Popper, 2005). This measurement is often used in the context of discussing behavioral effects, in part, because behavioral effects, which often result from auditory cues, may be better expressed through averaged units rather than by peak pressures.

Exploration Drilling Program Sound Characteristics

(1) Drilling Sounds

Exploration drilling will be conducted from the drilling units *Discoverer* and *Polar Pioneer.* Underwater sound propagation during the activities results from the use of generators, drilling machinery, and the drilling units themselves. 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 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 0.17 km, the 20–1000 Hz band level was 122–125 dB re 1µPa rms for the drillship *Explorer I.* Underwater sound levels were slightly higher (134 db re 1µPa rms) during drilling activity from the *Explorer II* at a range of 0.20 km; although tones were only recorded below 600 Hz. Underwater sound measurements from the *Kulluk* in 1986 at 0.98 km were higher (143 dB re 1µPa rms) than from the other two vessels. Measurements of the *Discoverer* on the Burger prospect in 2012, without any support vessels operating nearby, showed received sound levels of 120 dB re 1 µPa rms at 1.5 km. The *Polar Pioneer,* a semi-submersible drilling unit, is expected to introduce less sound into the water than the *Discoverer* during drilling and related activities.

(2) Airgun Sounds

Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in^3 (2,458 cm^3) airguns for a total volume of 450 in^3 (7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4097 cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3). Typically, a single ZVSP survey will be performed when the well has reached PTD or final depth although, in some instances, a prior ZVSP will have been performed at a shallower depth. A typical survey, would last 10–14 hours, depending on the depth of the well and the number of anchoring points, and include firings of up to the full array, plus additional firing of the smallest airgun in the array to be used as a ''mitigation airgun'' while the geophones are relocated within the wellbore.

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. A typical high-energy airgun arrays emit most energy at 10–120 Hz. However, the pulses contain energy up to 500–1000 Hz and some energy at higher frequencies (Goold and Fish 1998; Potter *et al.* 2007).

(3) Aircraft Noise

Helicopters may be used for personnel and equipment transport to and from the drilling units and support vessels. 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 drilling units will generally maintain straight-line routes at altitudes of 1,500 ft. (457 m) above sea level, thereby limiting the received levels at and below the surface.

(4) Vessel Noise

In addition to the drilling units, various types of vessels will be used in support of the operations including ice management vessels, anchor handlers, OSVs, 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. For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB re 1 µPa rms at distances ranging from ~1.5 to 2.3 mi (~2.4 to 3.7 km) from various types of barges. MacDonnell *et al.* (2008) estimated higher underwater sound pressure levels from the seismic vessel *Gilavar* of 120 dB re 1 µPa rms at ~13 mi (~21 km) from the source, although the sound level was only 150 dB re 1 µPa rms at 85 ft (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies. During 2012, underwater sound from ten (10) vessels in transit, and in two instances towing or providing a tow-assist, were recorded by JASCO in the Chukchi Sea as a function of the sound source characterization (SSC) study required in the Shell 2012 Chukchi Sea drilling IHA. SSC transit and tow results from 2012 include ice management vessels, an anchor handler, OSR vessels, the OST, support tugs, and OSVs. The recorded sound pressure levels to 120 dB re 1 µPa rms for vessels in transit primarily range from ~0.8–4.3 mi (1.3–6.9 km), whereas the measured 120 dB re 1 µPa rms for the drilling unit *Kulluk* under tow by the *Aiviq* in the Chukchi Sea was approximately 11.8 mi (19 km) on its way to the Beaufort Sea (O'Neil and McCrodan 2012a, b). Measurements of vessel sounds from

Shell's 2012 exploration drilling program in the Chukchi Sea are presented in detail in the 2012 Comprehensive Monitoring Report (LGL 2013).

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 ice-breaking 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.

Acoustic Impacts

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 30 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;
- Phocid pinnipeds in Water: functional hearing is estimated to occur between approximately 75 Hz and 100 kHz; and
- Otariid pinnipeds in Water: functional hearing is estimated to occur between approximately 100 Hz and 40 kHz.

As mentioned previously in this document, 12 marine mammal species or stocks (nine cetaceans and four phocid pinnipeds) may occur in the proposed seismic survey area. Of the nine cetacean species or stocks likely to occur in the proposed project area and for which take is requested, two are classified as low-frequency cetaceans (*i.e.,* bowhead and gray whales), two are classified as mid-frequency cetaceans (*i.e.,* both beluga stocks and killer whales), and one is classified as a high-frequency cetacean (*i.e.,* harbor porpoise) (Southall *et al.,* 2007). A species functional hearing group is a consideration when we analyze the effects of exposure to sound on marine mammals.

(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 demonstrate 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 in the Arctic (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 in the Arctic. 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 Zero-Offset Vertical Seismic Profile Activities''*).

Potential Effects From Zero-Offset Vertical Seismic Profile 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 in³ or 3,147 in³ 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 related to seismic airgun activity 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 in³), 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 drilling units 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 criteria were established before additional TTS measurements for marine mammals became available, and represent the received levels above which one could not be certain 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 also typically used as shutdown criteria for mitigation 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 drilling units 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 drilling units, the levels immediately adjacent to the drilling units 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 drilling unit 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.

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 drilling units 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 drilling units 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.

(5) 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, coinciding with 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 drilling units 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.

Potential Impacts From Drilling Wastes

Shell will discharge drilling wastes to the Chukchi Sea. These discharges will be authorized under the EPA's National Pollutant Discharge Elimination System (NPDES) General Permit for Oil and Gas Exploration Activities on the Outer Continental Shelf in the Chukchi Sea (AKG–28–8100; ''NPDES exploration facilities GP''). This permit establishes various limits and conditions on the authorized discharges, and the EPA has determined that with these limits and conditions the discharges will not result in any unreasonable degradation of ocean waters.

Under the NPDES exploration facilities GP, drilling wastes to be discharged must have a 96-hr Lethal Concentration 50 percent (LC50) toxicity of 30,000 parts per million or greater at the point of discharge. Both modeling and field studies have shown that discharged drilling wastes are diluted rapidly in receiving waters (Ayers *et al.* 1980a, 1980b, Brandsma *et al.* 1980, NRC 1983, O'Reilly *et al.* 1989, Nedwed *et al.* 2004, Smith *et al.* 2004; Neff 2005). The dilution is strongly affected by the discharge rate. The NPDES exploration facilities GP limits the discharge of drilling wastes to 1,000 bbl/hr (159 m^3/hr). For example, TetraTech (2011) modeled hypothetical 1,000 bbl/hr (159 m^3/hr) discharges of drilling wastes in water depths of 131–164 ft (40–50 m) in the Beaufort and Chukchi Seas for the EPA and predicted dilution factors of 950–17,500 at a distance of 330 ft (100 m) from the discharge point.

The primary effect of the drilling waste discharges will be increases in total suspended solids (TSS) in the water column and localized increase in sedimentation on the sea floor. Shell conducted dispersion modeling of the drilling waste discharges using the Offshore Operators Committee Mud and Produced Water Discharge (OOC) model (Fluid Dynamix 2014). Simulations were performed for each of the six discrete drilling intervals with two discharge locations: Seafloor and sea surface. The Burger Prospect wells are all very similar in well design and site conditions so the simulation approximates the results for the all drill sites. The model results indicate that most of the increase in TSS will be ameliorated within 984 ft (300 m) of the discharge locations through settling and dispersion. Impacts to water quality will cease when the discharge is concluded.

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 (43 m^3) discharge of drilling wastes 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 waste would diminish to levels that would have no effect within about two minutes of discharge and within 16 ft (5 m) of the discharge location.

Discharges of drilling wastes could potentially displace marine mammals a short distance from a drilling location. However, it is likely that marine mammals will have already avoided the area due to sound energy generated by the drilling activities.

Baleen whales, such as bowheads, tend to avoid drilling units at distances up to 12 mi (20 km). Therefore, it is highly unlikely that the whales will swim or feed in close enough proximity of discharges to be affected. The levels of drilling waste discharges are regulated by the NPDES exploration facilities GP. The impact of drilling waste discharges would be localized and temporary. Drilling waste discharges could displace endangered whales (bowhead and humpback whales) a short distance from a drill site. Effects on the whales present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, endangered whales are not likely to have long-term exposures to drilling wastes because of the episodic nature of discharges (typically only a few hours in duration).

Like other baleen whales, gray whales will more than likely avoid drilling activities and therefore not come into close contact with drilling wastes. Gray whales are benthic feeders and the seafloor area covered by accumulations of discharged drilling wastes will be unavailable to the whales for foraging purposes, and represents an indirect impact on these animals. Such indirect impacts are negligible resulting in little effect on individual whales and no effect on the population, because such areas of disturbance will be few and in total will occur over a very small area representing an extremely small portion of available foraging habitat in the Chukchi Sea. Other baleen whales such as the minke whale, which could be found near the drill site, would not be expected to be affected.

Discharges of drilling wastes are not likely to affect beluga whales and other odontocetes such as harbor porpoises and killer whales. These marine mammals will likely avoid the immediate areas where drilling wastes will be discharged. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer* based on maximum prevailing current speeds of 9.84 in/s (25 cm/s), shows that sedimentation depth of drilling wastes at greater than 0.4 in (1 cm) thickness will occur within approximately 1,641 (500 m) of the drilling unit discharge point (Fluid Dynamix, 2014b). Concentrations of TSS, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 3,281 ft (1,000 m) from the drilling unit discharge point. Therefore, it is highly unlikely that beluga whales will come into contact with any drilling discharge and impacts are not expected.

Seals are also not expected to be impacted by the discharges of drilling wastes. It is highly unlikely that a seal would remain within 330 ft (100 m) of the discharge source for any extended period of time but if they were to remain within 330 ft (100 m) of the discharge source for an extended period of time, it is possible that physiological effects due to toxins could impact the animal.

Potential Impacts From Drilling Units' Presence

The length of the *Discoverer* at 514 ft (156.7 m) and *Polar Pioneer* at 279 ft (85m) are not large enough to cause large-scale diversions from the animals' normal swim and migratory paths. The drilling units' physical footprints are small relative to the size of the geographic region either would occupy, and will likely not cause marine mammals to deflect greatly from their typical migratory routes.

Any deflection of bowhead whales or other marine mammal species due to the physical presence of the drilling units or support vessels would be extremely small. Even if animals may deflect because of the presence of the drilling units, the Chukchi Sea's migratory corridor is much larger in size than the length of the drilling units, and animals would have other means of passage around the drilling units. In sum, the physical presence of the drilling units is not likely to cause a material deflection to migrating marine mammals. Moreover, any impacts would last only as long as the drilling units are actually present.

Seal species which may be encountered during ice management activities include ringed seals, bearded seals, spotted seals, and the much less common ribbon seal. Ringed seals are found in the activity area year-around. Bearded seals spend the winter season in the Bering Sea, and then follow the ice edge as it retreats in spring. Spotted seals are found in the Bering Sea in winter and spring where they breed, molt, and pup in large groups. Few spotted seals are expected to be encountered in the Chukchi Sea until July. Even then, they are rarely seen on pack ice but are commonly observed hauled out on land or swimming in open water.

Based on extensive analysis of digital imagery taken during aerial surveys in support of Shell's 2012 operations in the Chukchi and Beaufort Seas, ice seals are very infrequently observed hauled out on the ice in groups of greater than one individual. Tens of thousands of images from 17 flights that took place from July through October were reviewed in detail. Of 107 total observations of spotted or ringed seals on ice, only three of those sightings were of a group of two or more individuals. Since seals are found as individuals or in very small groups when they are in the activity area, the chance of a stampede event is very unlikely. Finally, ice seals are well adapted to move between ice and water without injury, including ''escape reactions'' to avoid predators.

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 2015 open-water season. The impacts to marine mammals that are reasonably expected to occur will be behavioral in nature. 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). 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.

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; DIMP; 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;
- Shell will conduct a function test of annular and ram BOPs every 7 days between pressure tests;
- 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 of marine mammals from the proposed 2015 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; 77 FR 27322, May 9, 2012; and 77 FR 27284, May 9, 2012).

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 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. Moreover, 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. 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 Exxon Valdez Oil Spill (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 likely 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 Exxon Valdez Oil Spill, 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 Exxon Valdez Oil Spill (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 Exxon Valdez Oil Spill Exxon Valdez Oil Spill, 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 Exxon Valdez Oil Spill 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

Exxon Valdez Oil Spill Exxon Valdez Oil Spill (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 Exxon Valdez Oil Spill 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 Exxon Valdez Oil Spill. The results from Hoover-Miller *et al.* (2001) indicate that the effects of Exxon Valdez Oil Spill 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 Exxon Valdez Oil Spill (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 drilling units 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.

Potential Impacts on Habitat From Seafloor Disturbance (Mooring and MLC Construction)

Mooring of the drilling units and construction of MLCs will result in some seafloor disturbance and temporary increases in water column turbidity.

The drilling units would be held in place during operations with systems of eight anchors for each unit. The embedment type anchors are designed to embed into the seafloor thereby providing the required resistance. The anchors will penetrate the seafloor on contact and may drag 2–3 or more times their length while being set. Both the anchor and anchor chain will disturb sediments in this process creating a trench or depression with surrounding berms where the displaced sediment is mounded. Some sediments will be suspended in the water column during the setting and subsequent removal of the anchors. The depression with associated berm, collectively known as an anchor scar, remains when the anchor is removed.

Dimensions of future anchor scars can be estimated based on the dimensions of the anchor. Shell estimates that each anchor may impact a seafloor area of up to about 2,510 ft^2 (233m^2). Impact estimates associated with mooring a drilling unit by its eight anchors is 20,078 ft^2 (1,865 m^2) of seafloor assuming that the 15 metric ton anchors are used and set only once. Shell plans to pre-set anchors and deploy mooring lines at each drill site prior to arrival of the drilling units. Unless moved by an outside force such as sea current, anchors should only need to be set once per drill site.

Once the drilling units end operation, the *Polar Pioneer* anchors will be retrieved and the *Discoverer* anchors may be left on site for wet storage. 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 five to ten years after retrieval. Scars typically do not form or persist in sandy mud or sand sediments but may last for nine years in hard clays (Centaur Associates, Inc 1984). 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 drilling units using a large diameter drill bit will displace about 589m³ of seafloor sediments and directly disturb approximately 1,075 ft² (100 m²) of seafloor. 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 pumped and discharged on the seafloor away from the MLC. These excavated materials will also have some indirect effects as they are suspended in the water and deposited on the seafloor in the vicinity of the MLCs. Direct and indirect effects would include slight changes in seafloor relief and sediment consistency, and smothering of benthic organisms.

Potential Impacts on Habitat From Sound Generation

Underwater noise generated from Shell's proposed exploration drilling activity may potentially affect marine mammal prey species, which are fish species and various invertebrates in the action area.

(1) Zooplankton

Zooplankton are food sources for several endangered species, including bowhead, fin, and humpback whales. The primary generators of sound energy associated with the exploration drilling program are the airgun array during the conduct of ZVSPs, the drilling units during drilling, and marine vessels, particularly during ice management and DP. Sound energy generated by these activities will not negatively impact the diversity and abundance of zooplankton, and will therefore have no direct effect on marine mammals.

Sound energy generated by the airgun arrays to be used for the ZVSPs will have no more than negligible effects on zooplankton. Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Chukchi Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Hartline *et al.* 1996, Wong 1996) respectively, and therefore have some sensitivity to sound; however any effects of airguns on zooplankton would be expected to be restricted to the area within a few feet or meters of the airgun array and would likely be sublethal. Studies on brown shrimp in the Wadden Sea (Webb and Kempf 1998) revealed no particular sensitivity to sounds generated by airguns at sound levels of 190 dB re 1 μPa rms at 3.3 ft. (1.0 m) in water depths of 6.6 ft. (2.0 m). Koshleva (1992) reported no detectable effects on the amphipod (*Gammarus locusta*) at distances as close as 0.5 m from an airgun with a source level of 223 dB re 1 μPa rms. A recent Canadian government review of the impacts of seismic sound on invertebrates and other organisms (CDFO 2004) included similar findings; this review noted "there are no documented cases of invertebrate mortality upon exposure to seismic sound under field operating conditions" (CDFO 2004). Some sublethal effects (*e.g.,* reduced growth, behavioral changes) were noted (CDFO 2004).

The energy from airguns has sometimes been shown to damage eggs and fry of some fish. Eggs and larvae of some fish may apparently sustain sublethal to lethal effects if they are within very close proximity to the seismic-energy-discharge point. These types of effects have been demonstrated by some laboratory experiments using single airguns (*e.g.,* Kosheleva 1992, Matishov 1992, Holliday *et al.* 1987), while other similar studies have found no material increases in mortality or morbidity due to airgun exposure (Dalen and Knutsen 1986, Kostyuvchenko 1973). The effects, where they do occur, are apparently limited to the area within 3–6 ft. (1–2 m) from the airgun-discharge ports. In their detailed review of studies on the effects of airguns on fish and fisheries, Dalen *et al.* (1996) concluded that airguns can have deleterious effects on fish eggs and larvae out to a distance of 16 ft (5.0 m), but that the most frequent and serious injuries are restricted to the area within 5.0 ft (1.5 m) of the airguns. Most investigators and reviewers (Gausland 2003, Thomson and Davis 2001, Dalen *et al.* 1996) have concluded that even seismic surveys with much larger airgun arrays than are used for shallow hazards and site clearance surveys, have no impact to fish eggs and larvae discernible at the population or fisheries level.

These studies indicate that some zooplankton within a distance of about 16 ft. (5.0 m) or less from the airgun array may sustain sublethal or lethal injuries but there would be no population effects even over small areas. Therefore there would be no indirect effect on marine mammals.

Ice management is likely to be the most intense sources of sound associated with the exploration drilling program Richardson *et al.* (1995a). Ice management vessels, during active ice management, may have to adjust course forward and astern while moving ice and thereby create greater variability in propeller cavitation than other vessels that maintain course with less adjustment. The drilling units maintain station during drilling without activation of propulsion propellers. Richardson (*et al.*1995a) reported that the noise generated by an icebreaker pushing ice was 10–15 dB re 1 μPa rms greater than the noise produced by the ship underway in open water. It is expected that the lower level of sound produced by the drilling units, ice management, or other vessels would have less impact on zooplankton than would 3D seismic (survey) sound.

No appreciable adverse impact on zooplankton populations will occur due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortality or impacts on zooplankton as a result of Shell's operations is immaterial as compared to the naturally occurring reproductive and mortality rates of these species. This is consistent with previous conclusions that crustaceans (such as zooplankton) are not particularly sensitive to sound produced by seismic sounds (Wiese 1996). Impact from sound energy generated by an ice breaker, other marine vessels, and drill ships would have less impact, as these activities produce lower sound energy levels (Burns 1993). Historical sound propagation studies performed on the *Kulluk* by Hall *et al.* (1994) also indicate the *Kulluk* and similar drilling units would have lower sound energy output than three-dimensional seismic sound sources (Burns *et al.* 1993). The drilling units *Discoverer* and *Polar Pioneer* would emit sounds at a lower level than the *Kulluk* and therefore the impacts due to drilling noise would be even lower than the *Kulluk.* Therefore, zooplankton organisms would not likely be affected by sound energy levels by the vessels to be used during Shell's exploration drilling activities in the Chukchi Sea.

(2) Benthos

There was no indication from post-drilling benthic biomass or density studies that previous drilling activities at the Hammerhead Prospect have had a measurable impact on the ecology of the immediate local area. To the contrary, the abundance of benthic communities in the Sivulliq area would suggest that the benthos were actually thriving there (Dunton *et al.* 2008).

Sound energy generated by exploration drilling and ice management activities will not appreciably affect diversity and abundance of plants or animals on the seafloor. The primary generators of sound energy are the drilling units and marine vessels. Ice management vessels are likely to be the loudest sources of sounds associated with the exploration drilling program (Richardson *et al.* 1995a). Ice management vessels, during active ice management, may have to adjust course forward and astern while moving ice and thereby create greater variability in propeller cavitation than other vessels that maintain course with less adjustment. The drilling units maintain station during drilling without activation of propulsion propellers. Richardson *et al.* (1995a) reported that the noise generated by an icebreaker pushing ice was 10–15 dB re 1 μPa rms greater than the noise produced by the ship underway in open water. The lower level of sound produced by the drilling units, ice management vessels, or other vessels will have less impact on bottom-dwelling organisms than would 3D seismic (survey) sound.

No appreciable adverse impacts on benthic populations would be expected due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortalities or impacts that might occur as a result of Shell's operations is immaterial compared to the naturally occurring high reproductive and mortality rates. This is consistent with previous BOEM conclusions that the effect of seismic exploration on benthic organisms probably would be immeasurable (USDI/MMS 2007). Impacts from sound energy generated by ice breakers, other marine vessels, and drilling units would have less impact, as these activities produce much lower sound energy levels (Burns *et al.* 1993).

(3) Fish

Fish react to sound and use sound to communicate (Tavolga *et al.* 1981). Experiments have shown that fish can sense both the intensity and direction of sound (Hawkins 1981). Whether or not fish can hear a particular sound depends upon its frequency and intensity. Wavelength and the natural background sound also play a role. The intensity of sound in water decreases with distance as a result of geometrical spreading and absorption. Therefore, the distance between the sound source and the fish is important. Physical conditions in the sea, such as temperature thermoclines and seabed topography, can influence transmission loss and thus the distance at which a sound can be heard.

The impact of sound energy from exploration drilling and ice management activities will be negligible and temporary. Fish typically move away from sound energy above a level that is at 120 dB re 1 μPa rms or higher (Ona 1988).

Drilling unit sound source levels during drilling can range from 90 dB re 1 μPa rms within 31 mi (50 km) of the drilling unit to 138 dB re 1 μPa rms within a distance of 0.06 mi (0.01 km) from the drilling unit (Greene 1985, 1987b). These are predicted sound levels at various distances based on modeled transmission loss equations in the literature (Greene 1987b). Ice management vessel sound source levels can range from 174–184 dB re 1 μPa rms. At these intensity levels, fish may avoid the drilling unit, ice management vessels, or other large support vessels. This avoidance behavior is temporary and limited to periods when a vessel is underway or drilling. There have been no studies of the direct effects of ice management vessel sounds on fish. However, it is known that the ice management vessels produce sounds generally 10–15 dB re 1 μPa rms higher when moving through ice rather than open water (Richardson *et al.* 1995b). In general, fish show greater reactions to a spike in sound energy levels, or impulse sounds, rather than a continuous high intensity signal (Blaxter *et al.* 1981).

Fish sensitivity to impulse sound such as that generated by ZVSPs varies depending on the species of fish. Cod, herring and other species of fish with swim bladders have been found to be relatively sensitive to sound, while mackerel, flatfish, and many other species that lack swim bladders have been found to have poor hearing (Hawkins 1981, Hastings and Popper 2005). An alarm response in these fish is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level (Blaxter *et al.* 1981). Any such effects on fish would be negligible and have no indirect effect on marine mammals.

Potential Impacts on Habitat From Drilling Wastes

Discharges of drilling wastes must be authorized by the NPDES exploration facilities GP, and this GP places numerous conditions and limitations on such discharges. The EPA (2012) has determined that with these limits and conditions in place, the discharges will not result in any unreasonable degradation of ocean waters. The primary impacts of the discharges are increases in TSS in the water column and the deposition of drilling wastes on the seafloor. These impacts would be localized to the drill sites and temporary.

(1) Zooplankton

Reviews by EPA (2006) and Neff (2005) indicate that though planktonic organisms are sensitive to environmental conditions (*e.g.,* temperature, light, availability of nutrients, and water quality), there is little or no evidence of effects from drilling waste discharges on plankton in the ocean. In the laboratory, high concentrations of drilling wastes have been shown to have lethal or sublethal effects on zooplankton due to toxicity and abrasion by suspended sediments. These effects are minimized at the drill site by limits and conditions placed on the discharges by the NPDES exploration facilities GP, which include discharge rate limits and toxicity limits.

Any impact by drilling waste discharges on zooplankton would be localized and temporary. Fine-grained particulates and other solids in drilling wastes could cause sublethal effects to organisms in the water column. Responses observed in the laboratory following exposure to drilling mud include alteration of respiration and filtration rates and altered behavior. Zooplankton in the immediate area of discharge from drilling operations could potentially be adversely impacted by sediments in the water column, which could clog respiratory and feeding structures, cause abrasions to gills and other sensitive tissues, or alter behavior or development. However, the planktonic organisms are not likely to have long-term exposures to the drilling waste because of the episodic nature of discharges (typically only a few hours in duration), the small area affected, and the movement of the organisms with the ocean currents. The discharged waste must have low toxicities to meet permit requirements and modeling studies indicate dilution factors of >1,000 within 328 ft (100 m). Modeling and monitoring studies have demonstrated that increased TSS in the water column from the discharges would largely be limited to the area within 984 ft (300 m) from the discharge. This impact would likely not have more than a short-term impact on zooplankton and no effect on zooplankton populations, and therefore no indirect effects on marine mammals.

(2) Benthos

Benthic organisms would primarily be affected by the discharges through the deposition of the discharged drilling waste on the seafloor resulting in the smothering of organisms, changes in the consistency of sediments on the seafloor, and possible elevation in heavy metal concentrations in the accumulations.

Drilling waste discharges are regulated by the EPA's NPDES exploration facilities GP. The impact of drilling waste discharges would be localized and temporary. Effects on benthic organisms present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, benthic animals are not likely to have long-term exposures to drilling wastes because of the episodic nature of discharges (typically only a few hours in duration).

Shell conducted dispersion modeling of the drilling waste discharges using the Offshore Operators Committee Mud and Produced Water Discharge (OOC) model (Fluid Dynamix 2014a, b). The modeling effort provided predictions of the area and thickness of accumulations of discharged drilling waste on the seafloor. The USA EPA has performed an evaluation of drilling waste in support of the issuance of NPDES GP AKG–28–8100 for exploration facilities (EPA, 2012b) (October 2012), and determined these accumulations will not result in any unreasonable degradation of the marine environment.

Heavy metal contamination of sediments and resulting effects on benthic organisms is not expected. The NPDES exploration facilities GP contains stringent limitations on the concentrations of mercury, cadmium, chromium, silver, and thallium allowed in discharged drilling waste. Additional limitations are placed on free oil, diesel oil, and total aromatic hydrocarbons allowed in discharged drilling waste. Discharge rates are also controlled by the permit. Baseline studies at the 1985 Hammerhead drill site (Trefry and Trocine 2009) detected background levels Al, Fe, Zn, Cd and Hg in all surface and subsurface sediment samples. Considering the relatively small area that drilling waste discharges will be deposited, no material impacts on sediment are expected to occur. The expected increased concentrations of Zn, Cd, and Cr in sediments near the drill site due to the discharge are in the range where no or low effects would result.

Studies in the 1980s, 1999, 2000, and 2002 (Brown *et al.* 2001 in USDI/MMS 2003) also found that benthic organism near drill sites in the Beaufort Sea 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.

Sediment samples taken in the Chukchi Sea Environmental Studies Program Burger Study Area were analyzed for metal and hydrocarbon concentrations (Neff *et al.* 2010). Concentrations of all measured hydrocarbon types were found to be well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies (Neff *et al.* 2010, Dunton *et al.* 2012). Metal concentrations were found to be quite variable. Average concentrations of all metals except for arsenic and barium were found to be lower than those reported for average marine sediment.

Trefry *et al.* (2012) confirmed findings by Neff *et al.* 2010 that concentrations of all measured hydrocarbon types were well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies.

Neff *et al.* (2010) assessed the concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells in the Chukchi Sea, which were drilled in 1989–1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2–3 times greater at the historic drill sites (mean = 1,410 μ/g and 1,300 μ/g) than in the surrounding areas (639 μ/g and 595 μ/g). Concentrations of copper, mercury, and lead, were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (below ERL or Effects Range Low of Long 1995) believed to have adverse ecological effects (Neff *et al.* 2010). Similar results were reported by Trefry and Trocine (2009) for the historic Hammerhead drill sites in the Beaufort Sea.

These data show that the potential accumulation of heavy metals in discharged drilling waste on the Chukchi seafloor associated with drilling exploration wells is very limited and does not pose a threat. Impacts to seafloor sediments from the discharge of drilling wastes will be minor, as they would be restricted to a very small portion of the activity area and will not result in contamination.

The drilling waste discharges will be conducted as authorized by the EPA's NPDES exploration facilities GP, which limits the metal content and flow rate for such discharges. The EPA (2012b) analyzed the effects of these types of discharges, including potential transport of pollutants such as metals by biological, physical, or chemical processes, and has concluded that these types of discharges do not result in unreasonable degradation of ocean waters. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor (15.7–33.2 ac in total for the exploration program) which represents less than 0.000011%–0.000024% of the seafloor of the Chukchi Sea. However, the predicted small increases in concentrations of metals will likely be evident for a number of years until gouged by ice, redistributed by currents, or buried under natural sedimentation.

There is relatively little information on the effects of various deposition depths on arctic biota (Hurley and Ellis 2004); most such studies have investigated the effects of deposition of dredged materials (Wilbur 1992). Burial depths as low as 1.0 in (2.54 cm) have been found to be lethal for some benthic organisms (Wilbur 1992, EPA 2006). Accumulations of drilling waste to depths > 1.0 in (>2.54 cm) will be restricted to very small areas of the seafloor around each drill site and in total represent an extremely small portion of the Chukchi Sea. These areas would be re-colonized by benthic organisms rather quickly. Impacts to benthic organisms are therefore considered to be negligible with no indirect effects on marine mammals. As required by the NPDES exploration facilities GP, Shell will implement an environmental monitoring program (EMP), to assess the recovery of the benthos from impacts drilling waste discharges.

(3) Fish

Drilling waste discharges are regulated by the NPDES exploration facilities GP. The impact of drilling waste discharges would be localized and temporary. Drilling waste discharges could displace fish a short distance from a drill site. Effects on fish and fish larvae present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, fish and fish larvae that live in the water column are not likely to have long-term exposures to drilling wastes because of the episodic nature of the discharges (typically only a few hours in duration).

Although unlikely at deeper offshore drilling locations, demersal fish eggs could be smothered if discharges occur in a spawning area during the period of egg production. No specific demersal fish spawning locations have been identified at the Burger drill site 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.

Habitat alteration concerns apply to special or relatively uncommon habitats, such as those important for spawning, nursery, or overwintering. Important fish overwintering habitats are located in coastal rivers and nearshore coastal waters, but are not found in the proposed exploration drilling areas. Important spawning areas have not been identified in the Chukchi Sea. Impacts on fish will be negligible, with no indirect effects on marine mammals.

Potential Impacts on Habitat From Ice Management/Icebreaking Activities

Ice management or icebreaking activities include the physical pushing or moving of ice in the proposed exploration drilling area and to prevent ice floes from striking the drilling unit. Ringed, bearded, spotted, and ribbon seals) 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. Shell does not expect to have to manage pack ice during the majority of the drilling season. The majority of the ice management or icebreaking should occur in the early and latter portions of the drilling season. Landfast ice would not be present during Shell's proposed operations.

The ringed seal is the most common pinniped species in the Chukchi Sea activity area. While ringed seals use ice year-round, they do not construct lairs for pupping until late winter/early spring on the landfast ice. Shell plans to conclude drilling on or before 31 October, therefore Shell's activities would not impact ringed seal lairs or habitat needed for breeding and pupping in the Chukchi Sea. Ringed seals can be found on the pack ice surface in the late spring and early summer in the Chukchi Sea, the latter part of which may overlap with the start of Shell's planned exploration drilling activities. Management of pack ice that contains hauled out seals may result in the animals becoming startled and entering the water, but such effects would be brief.

Ice management or icebreaking would occur during a time when ringed seal life functions such as breeding, pupping, and molting do not occur in the proposed project area. Additionally, these life functions occur more commonly on landfast ice, which will not be impacted by Shell's activity.

Bearded seals breed in the Bering and Chukchi Seas, but would not be plentiful in the area of the Chukchi Sea exploration drilling program. Spotted seals are even less common in the Chukchi Sea activity area. Ice is used by bearded and spotted seals for critical life functions such as breeding and molting, but it is unlikely these life functions would occur in the proposed project area, during the time in which drilling activities will take place. The availability of ice would not be impacted as a result of Shell's exploration drilling program.

Ice-management or icebreaking related to Shell's planned exploration drilling program in the Chukchi Sea is not expected to have any habitat-related effects that could cause material or long-term consequences for individual marine mammals or on the food sources that they utilize.

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.

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).

Shell submitted a 4MP as part of its application (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 4MP is a combination of active monitoring in the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. Monitoring will provide information on marine mammals potentially affected by exploration activities, in addition to facilitating real time mitigation to prevent injury of marine mammals by industrial sounds or activities.

Vessel Based Marine Mammal Monitoring for Mitigation

The objectives of the vessel based marine mammal monitoring are to ensure that disturbance to marine mammals and subsistence hunts is minimized, that effects on marine mammals are documented, and that data is collected on the occurrence and distribution of marine mammals in the project area.

The marine mammal monitoring will be implemented by a team of experienced protected species observers (PSOs). The PSOs will be experienced biologists and Alaska Native personnel trained as field observers. PSOs will be stationed on both drilling units, ice management vessels, anchor handlers and other drilling support vessels engaged in transit to and between drill sites to monitor for marine mammals. The duties of the PSOs will include; watching for and identifying marine mammals, recording their numbers, recording distances and reactions of marine mammals to exploration drilling activities, initiating mitigation measures when appropriate, and reporting results of the vessel based monitoring program, which will include the estimation of the number of marine mammal ''exposures'' as defined by the NMFS and stipulated in the IHA.

The vessel based work will provide:

- The basis for initiating real-time mitigation, if necessary, as required by the various permits that Shell receives;
- Information needed to estimate the number of ''exposures'' of marine mammals to sound levels that may result in harassment, which must be reported to NMFS;
- Data on the occurrence, distribution, and activities of marine mammals in the areas where drilling activity is conducted;
- Information to compare the distances, distributions, behavior, and movements of marine mammals relative to the drilling unit during times with and without drilling activity occurring;
- A communication channel to coastal communities including whalers; and
- Employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Alaska Native PSOs.

The vessel based monitoring will be operated and administered consistent with monitoring programs conducted during past exploration drilling activities, seismic and shallow hazards surveys, or alternative requirements stipulated in permits issued to Shell. Agreements between Shell and other agencies will also be fully incorporated. PSOs will be provided training through a program approved by the NMFS.

Mitigation Measures During the Exploration Drilling Program

Shell's planned exploration drilling activities incorporate design features and operational procedures aimed at minimizing potential impacts on marine mammals and subsistence hunts. Some of the mitigation design features include:

- Conducting pre-season acoustic modeling to establish the appropriate exclusion and disturbance zones;
- Vessel based PSO monitoring to implement appropriate mitigation if necessary, and to determine the effects of the drilling program on marine mammals;
- Passive acoustic monitoring of drilling and vessel sounds and marine mammal vocalizations; and
- Aerial surveys with photographic equipment over operations and in coastal and nearshore waters with photographic equipment to help determine the effects of project activities on marine mammals; and seismic activity mitigation measures during acquisition of the ZVSP surveys.

The potential disturbance of marine mammals during drilling activities will be mitigated through the implementation of several vessel based mitigation measures as necessary.

(1) Exclusion and Disturbance Zones

Mitigation for NMFS' incidental take authorizations typically includes ''safety radii'' or ''exclusion zones'' for marine mammals around airgun arrays and other impulsive industrial sound sources where received levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. These zones are based on a cautionary assumption that sound energy at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur from exposure to sound at distances greater than these zones (Richardson *et al.* 1995). The NMFS assumes that marine mammals exposed to pulsed airgun sounds with received levels ≥160 dB re 1 μPa (rms) or continuous sounds from vessel activities with received levels ≥120 dB re 1 μPa (rms) have the potential to be disturbed. These sound level thresholds are currently used by NMFS to define acoustic disturbance (harassment) criteria.

(A) Exploration Drilling Activities

The areas exposed to sounds produced by the drilling units *Discoverer* and *Polar Pioneer* were determined by measurements from drilling in 2012 or were modeled by JASCO Applied Sciences. The 2012 measurement of the distance to the 120 dB (rms) threshold for normal drilling activity by the *Discoverer* was 0.93 mi (1.5 km) while the distance of the ≥120 dB (rms) radius during MLC construction was 5.1 mi (8.2 km).

Measured sound levels for the *Polar Pioneer* were not available. Its sound footprint was estimated with JASCOs Marine Operations Noise Model (MONM) using an average source level derived from a number of reported acoustic measurements of comparable semi-submersible drill units, including the Ocean Bounty (Gales, 1982), SEDCO 708 (Greene, 1986), and Ocean General (McCauley, 1998). The model yielded a propagation range of 0.22 mi (0.35 km) for rms sound pressure levels of 120 dB for the *Polar Pioneer* while drilling at the Burger Prospect.

In addition to drilling and MLC construction, numerous activities in support of exploration drilling produce continuous sounds above 120 dB (rms). These activities in direct support of the moored drilling units include ice management, anchor handling, and supply/discharge sampling vessels using DP thrusters. Detailed sound characterizations for each of these activities are presented in the 2012 Comprehensive Report for NMFS' 2012 IHA (LGL *et al.* 2013).

The source levels for exploration drilling and related support activities are not high enough to cause temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals. Consequently, mitigation as described for seismic activities including ramp ups, power downs, and shut downs should not be necessary for exploration drilling activities. However, Shell plans to use PSOs onboard the drilling units, ice management, and anchor handling vessels to monitor marine mammals and their responses to industry activities, in addition to initiating mitigation measures should in-field measurements of the activities indicate conditions that may present a threat to the health and well-being of marine mammals.

(B) ZVSP Surveys

Two sound sources have been proposed by Shell for the ZVSP surveys. The first is a small airgun array that consists of three 150 in³ (2,458 cu cm³) airguns for a total volume of 450 in³

(7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4,097 cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3). Sound footprints of the ZVSP airgun array configurations were estimated using JASCO Applied Sciences' Marine Operations Noise Model (MONM). The model results were maximized over all water depths between 9.9 and 23 ft (3 and 7 m) to yield sound level isopleths as a function of range and direction from the source. The 450 in^3 airgun array at a source depth of 23 ft (7 m) yielded the maximum ranges to the ≥190, ≥180, and ≥160 dB (rms) isopleths. The estimated 95th percentile distances to these thresholds were: 190 dB = 558 ft (170 m), 180 dB = 3,018 ft (920 m), and 160 dB = 39,239 ft (11,960 m). These distances were multiplied by 1.5 as a conservative measure, and the resulting radii are shown in Table 1.

PSOs on the drilling units will initially use the radii in Table 1 for monitoring and mitigation purposes during ZVSP surveys. An acoustics contractor will perform direct measurements of the received levels of underwater sound versus distance and direction from the ZVSP array using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable and used to verify (and if necessary adjust) the threshold radii distances during later ZVSP surveys. The mitigation measures to be implemented will include pre-ramp up watches, ramp ups, power downs and shut downs as described below.

TABLE 1—ESTIMATED DISTANCES OF THE ≥190, 180, AND 160, dB (rms) ISOPLETHS TO BE USED FOR MITIGATION PURPOSES DURING ZVSP SURVEYS UNTIL SSV RESULTS ARE AVAILABLE

Threshold levels in dB re 1 μPa (rms)	Estimated distance (m)
≥190	255
≥180	1,380
≥160	11,960

(2) Ramp Ups

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 time for them to leave the area, thus avoiding any potential injury or impairment of their hearing abilities.

During the proposed ZVSP surveys, the operator 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 observation of the exclusion zone by PSOs for a minimum of 30 minutes to ensure that no marine mammals are present. The entire exclusion zones must be visible during the 30 minutes leading into to a full ramp up. If the entire exclusion zone is not visible, a ramp up from a cold start cannot begin. If a marine mammal is sighted within the relevant exclusion zone during the 30 minutes prior to ramp up, ramp up will be delayed until the marine mammal is sighted outside of the exclusion zone or is not sighted for at least 15–30 minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

(3) Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shut down 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 shut down (*i.e.,* no sources firing).

Mitigation Conclusions

NMFS has carefully evaluated the applicant'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.

Any mitigation measure(s) prescribed by NMFS should be able to accomplish, have a reasonable likelihood of accomplishing (based on current science), or contribute to the accomplishment of one or more of the general goals listed below:

1. Avoidance or minimization of injury or death of marine mammals wherever possible (goals 2, 3, and 4 may contribute to this goal).
2. A reduction in the numbers of marine mammals (total number or number at biologically important time or location) exposed to received levels of noises generated from exploration drilling and associated activities, or other activities expected to result in the take of marine mammals (this goal may contribute to 1, above, or to reducing harassment takes only).
3. A reduction in the number of times (total number or number at biologically important time or location) individuals would be exposed to received levels of noises generated from exploration drilling and associated activities, or other activities expected to result in the take of marine mammals (this goal may contribute to 1, above, or to reducing harassment takes only).
4. A reduction in the intensity of exposures (either total number or number at biologically important time or location) to received levels of noises generated from exploration drilling and associated activities, or other activities expected to result in the take of marine mammals (this goal may contribute to a, above, or to reducing the severity of harassment takes only).
5. Avoidance or minimization of adverse effects to marine mammal habitat, paying special attention to the food base, activities that block or limit passage to or from biologically important areas, permanent destruction of habitat, or temporary destruction/disturbance of habitat during a biologically important time.
6. For monitoring directly related to mitigation—an increase in the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation.

Based on our evaluation of the applicant's proposed measures, as well as other measures considered by NMFS, NMFS has preliminarily determined that the proposed mitigation measures provide the means of effecting the least practicable impact on marine mammals species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Proposed measures to ensure availability of such species or stock for taking for certain subsistence uses are 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 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. Shell submitted a marine mammal monitoring plan as part of the IHA application. It can be found in Appendix B of the Shell's IHA application. 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).

Monitoring measures prescribed by NMFS should accomplish one or more of the following general goals:

1. An increase in the probability of detecting marine mammals, both within the mitigation zone (thus allowing for more effective implementation of the mitigation) and in general to generate more data to contribute to the analyses mentioned below;

2. An increase in our understanding of how many marine mammals are likely to be exposed to levels of noises generated from exploration drilling and associated activities that we associate with specific adverse effects, such as behavioral harassment, TTS, or PTS;

3. An increase in our understanding of how marine mammals respond to stimuli expected to result in take and how anticipated adverse effects on individuals (in different ways and to varying degrees) may impact the population, species, or stock (specifically through effects on annual rates of recruitment or survival) through any of the following methods:

▪ Behavioral observations in the presence of stimuli compared to observations in the absence of stimuli (need to be able to accurately predict received level, distance from source, and other pertinent information);

▪ Physiological measurements in the presence of stimuli compared to observations in the absence of stimuli (need to be able to accurately predict received level, distance from source, and other pertinent information);

▪ Distribution and/or abundance comparisons in times or areas with concentrated stimuli versus times or areas without stimuli;

4. An increased knowledge of the affected species; and

5. An increase in our understanding of the effectiveness of certain mitigation and monitoring measures.

Proposed Monitoring Measures

1. Protected Species Observers

Vessel based monitoring for marine mammals will be done by trained PSOs on both drilling units and ice management and anchor handler vessels throughout the exploration drilling activities. The observers will monitor the occurrence and behavior of marine mammals near the drilling units, ice management and anchor handling vessels, during all daylight periods during the exploration drilling operation, and during most periods when exploration drilling is not being conducted. PSO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling activities; and documenting exposures to sound levels that may constitute harassment as defined by NMFS. PSOs will help ensure that the vessel communicates with the Communications and Call Centers (Com Centers) in Native villages along the Chukchi Sea coast.

(A) Number of Observers

A sufficient number of PSOs will be onboard to meet the following criteria:

• 100 percent monitoring coverage during all periods of exploration drilling operations in daylight;

• Maximum of four consecutive hours on watch per PSO; and

• Maximum of approximately 12 hours on watch per day per PSO.

PSO teams will consist of trained Alaska Natives and field biologist observers. An experienced field crew leader will be on every PSO team aboard the drilling units, ice management and anchor handling vessels, and other support vessels during the exploration drilling program. The total number of PSOs aboard may decrease later in the season as the duration of daylight decreases.

(B) Crew Rotation

Shell anticipates that there will be provisions for crew rotation at least every three to six weeks to avoid observer fatigue. During crew rotations detailed notes will be provided to the incoming crew leader. Other communications such as email, fax, and/or phone communication between the current and oncoming crew leaders during each rotation will also occur when necessary. In the event of an unexpected crew change Shell will facilitate such communications to insure monitoring consistency among shifts.

(C) Observer Qualifications and Training

Crew leaders serving as PSOs will have experience from one or more projects with operators in Alaska or the Canadian Beaufort.

Biologist-observers will have previous PSO experience, and crew leaders will be highly experienced with previous vessel based marine mammal monitoring projects. Resumes for those individuals will be provided to the NMFS for approval. All PSOs will be trained and familiar with the marine mammals of the area. A PSO handbook, adapted for the specifics of the planned Shell drilling program, will be prepared and distributed beforehand to all PSOs.

PSOs will also complete a two-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the drilling season. The training sessions will be conducted by marine mammalogists with extensive crew leader experience from previous vessel based seismic monitoring programs in the Arctic.

Primary objectives of the training include:

• Review of the 4MP for this project, including any amendments adopted or specified by NMFS in the final IHA or other agreements in which Shell may elect to participate;

• Review of marine mammal sighting, identification, (photographs and videos) and distance estimation methods, including any amendments specified by NMFS in the IHA (if issued);

• Review operation of specialized equipment (*e.g.,* reticle binoculars, big eye binoculars, night vision devices, GPS system); and

• Review of data recording and data entry systems, including procedures for recording data on mammal sightings, exploration drilling and monitoring activities, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer databases and laptop computers.

(D) PSO Handbook

A PSO Handbook will be prepared for Shell's monitoring program. The

Handbook will contain maps, illustrations, and photographs as well as copies of important documents and descriptive text and are intended to provide guidance and reference information to trained individuals who will participate as PSOs. The following topics will be covered in the PSO Handbook:

- Summary overview descriptions of the project, marine mammals and underwater sound energy, the 4MP (vessel-based, aerial, acoustic measurements, special studies), the IHA (if issued) and other regulations/ permits/agencies, the Marine Mammal Protection Act;
- Monitoring and mitigation objectives and procedures, including initial exclusion and disturbance zones;
- Responsibilities of staff and crew regarding the 4MP;
- Instructions for staff and crew regarding the 4MP;
- Data recording procedures: codes and coding instructions, common coding mistakes, electronic database; navigational, marine physical, and drilling data recording, field data sheet;
- Use of specialized field equipment (*e.g.,* reticle binoculars, Big-eye binoculars, NVDs, laser rangefinders);
- Reticle binocular distance scale;
- Table of wind speed, Beaufort wind force, and sea state codes;
- Data storage and backup procedures;
- List of species that might be encountered: identification, natural history;
- Safety precautions while onboard;
- Crew and/or personnel discord; conflict resolution among PSOs and crew;
- Drug and alcohol policy and testing;
- Scheduling of cruises and watches;
- Communications;
- List of field gear provided;
- Suggested list of personal items to pack;
- Suggested literature, or literature cited;
- Field reporting requirements and procedures;
- Copies of the IHA will be made available; and
- Areas where vessels need permission to operate such as the Ledyard Bay Critical Habitat Unit (LBCHU).

2. Vessel-Based Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the drilling units and support vessels. Ideally this vantage point is an elevated stable platform from which the PSO has an unobstructed 360o view of the water. The observer(s) will scan systematically with the naked 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 marine mammal observer(s) in watching for pinnipeds and cetaceans. 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 marine mammal observers will include the same types of information that were recorded during previous monitoring projects (*e.g.,* Moulton and Lawson 2002; Reiser *et al.* 2010, 2011; Bisson *et al.* 2013). When a mammal sighting is made, the following information about the sighting will be carefully and accurately recorded:

- Species, group size, age/size/sex categories (if determinable), physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals;
- Behavior when first sighted and after initial sighting;
- Heading (if consistent), bearing and distance from observer;
- Apparent reaction to activities (*e.g.,* none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;
- Time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare, on support vessels the distance and bearing to the drilling unit will also be recorded; and
- Positions of other vessel(s) in the vicinity of the observer location.

The vessel's position, speed, 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.

An electronic database will be used to record and collate data obtained from visual observations during the vessel-based study. The PSOs will enter the data into the custom data entry program installed on field laptops. The data entry program automates the data entry process and reduces data entry errors and maximizes PSO time spent looking at the water. PSOs also have voice recorders available to them. This is another tool that will allow PSOs to maximize time spent focused on the water.

PSO's are instructed to identify animals as unknown when appropriate rather than strive to identify an animal when there is significant uncertainty. PSOs should also provide any sightings cues they used and any distinguishable features of the animal even if they are not able to identify the animal and record it as unidentified. Emphasis will also be placed on recording what was not seen, such as dorsal features.

(A) Monitoring at Night and in Poor Visibility

Night-vision equipment ''Generation 3'' binocular image intensifiers or equivalent units will be available for use when needed. However, past experience with night-vision devices (NVDs) in the Beaufort Sea and elsewhere indicates that NVDs are not nearly as effective as visual observation during daylight hours (*e.g.,* Harris *et al.* 1997, 1998; Moulton and Lawson 2002; Hartin *et al.* 2013).

(B) Specialized Field Equipment

Shell will provide the following specialized field equipment for use by the onboard PSOs: reticle binoculars, Big-eye binoculars, GPS unit, laptop computers, night vision binoculars, and possibly digital still and digital video cameras. Big eye binoculars will be mounted and used on key monitoring vessels including the drilling units, ice management vessels and the anchor handler.

(C) Field Data-Recording, Verification, Handling, and Security

The observers on the drilling units and support vessels will record their observations directly into computers using a custom software package. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing. Quality control of the data will be facilitated by (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season.

The data will be sent off of the vessel to Anchorage on a daily basis and backed up regularly onto storage devices on the vessel, and stored at separate locations on the vessel. If practicable, hand-written data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data devices carried back to the Anchorage office during crew rotations.

In addition to routine PSO duties, observers will be encouraged to record comments about their observations into the ''comment'' field in the database. Copies of these records will be available to the observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and comprehensive reports documenting the monitoring work.

PSOs will be able to plot sightings in near real-time for their vessel. Significant sightings from key vessels including drilling units, ice management, anchor handlers and aircraft will be relayed between platforms to keep observers aware of animals that may be in or near the area but may not be visible to the observer at any one time. Emphasis will be placed on relaying sightings with the greatest potential to involve mitigation or reconsideration of a vessel's course (*e.g.,* large group of bowheads).

Observer training will emphasize the use of ''comments'' for sightings that may be considered unique or not fully captured by standard data codes. In addition to the standard marine mammal sightings forms, a specialized form was developed for recording traditional knowledge and natural history observations. PSOs will be encouraged to use this form to capture observations related to any aspect of the arctic environment and the marine mammals found within it. Examples might include relationships between ice and marine mammal sightings, marine mammal behaviors, comparisons of observations among different years/seasons, etc. Voice recorders will also be available for observers to use during periods when large numbers of animals may be present and it is difficult to capture all of the sightings on written or digital forms. These recorders can also be used to capture traditional knowledge and natural history observations should individuals feel more comfortable using the recorders rather than writing down their comments. Copies of these records will be available to all observers for reference if they wish to prepare a statement about their observations for reporting purposes. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

3. Acoustic Monitoring Plan

Exploration Drilling, ZVSP, and Vessel Noise Measurements

Exploration 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 drilling units. The goals of these measurements are:

- To quantify the absolute sound levels produced by exploration drilling and to monitor their variations with time, distance and direction from the drilling unit;
- To measure the sound levels produced by vessels while operating in direct support of exploration drilling operations. These vessels will include crew change vessels, tugs, ice-management vessels, and spill response vessels not measured in 2012; and
- To measure the sound levels produced by an end-of-hole zero-offset vertical seismic profile (ZVSP) survey using a stationary sound source.

Sound characterization and measurements of all exploration drilling activities will be performed using five Autonomous Multichannel Acoustic Recorders (AMAR) deployed on the seabed along the same radial at distances of 0.31, 0.62, 1.2, 2.5 and 5 mi (0.5,1, 2, 4 and 8 km) from each drilling unit. All five recording stations will sample at least at 32 kHz, providing calibrated acoustic measurements in the 5 Hz to 16 kHz frequency band. The logarithmic spacing of the recorders is designed to sample the attenuation of drilling unit sounds with distance. The autonomous recorders will sample through completion of the first well, to provide a detailed record of sounds emitted from all activities. These recorders will be retrieved and their data analyzed and reported in the project's 90-day report.

The deployment of drilling sound monitoring equipment will occur before, or as soon as possible after the *Discoverer* and the *Polar Pioneer* are on site. Activity logs of exploration drilling operations and nearby vessel activities will be maintained to correlate with these acoustic measurements. All results, including back-propagated source levels for each operation, will be reported in the 90-day report.

(A) Vessel Sound Characterization

Vessel sound characterizations will be performed using dedicated recorders deployed at sufficient distances from exploration drilling operations so that sound produced by those activities does not interfere. Three AMAR acoustic recorders will be deployed on and perpendicular to a sail track on which all Shell contracted vessels will transit. This geometry is designed to obtain sound level measurements as a function of distance and direction. The fore and aft directions are sampled continuously over longer distances to 3 and 6 miles (5 and 10 km) respectively, while broadside and other directions are sampled as the vessels pass closer to the recorders.

Vessel sound measurements will be processed and reported in a manner similar to that used by Shell and other operators in the Beaufort and Chukchi Seas during seismic survey operations. The measurements will further be analyzed to calculate source levels. Source directivity effects will be examined and reported. Preliminary vessel characterization measurements will be reported in a field report to be delivered 120 hours after the recorders are retrieved and data downloaded. Those results will include sound level data but not source level calculations. All vessel characterization results, including source levels, will be reported in 1/3-octave bands in the project 90-day report.

(B) Zero-Offset Vertical Seismic Profiling Sound Monitoring

Shell states that it may conduct a geophysical survey referred to as a zero-offset vertical seismic profile, or ZVSP, at two drill sites in 2015. During ZVSP surveys, an airgun array, which is much smaller than those used for routine seismic surveys, is deployed at a location near or adjacent to the drilling unit, 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 a string of them, 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 survey is to gather geophysical information at various depths in the wellbore, which can then be used to tie-in or ground truth geophysical information from the previously collected 2D and 3D seismic surveys with geological data collected within the wellbore.

Shell will conduct a ZVSP surveys in which the sound source is maintained at a constant location near the wellbore. Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in^3 (2,458 cu cm^3) airguns for a total volume of 450 in^3 (7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4,097 cu cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3).

A ZVSP survey is typically conducted at each well after total depth is reached but may be conducted at a shallower depth. For each survey, the sound source (airgun array) would be deployed over the side of the *Discoverer* or the *Polar Pioneer* with a crane. The sound source will be positioned 50–200ft (15–61 m) from the wellhead (depending on crane location), at a depth of ~10–23ft (3–7 m) below the water surface. Receivers will be temporarily anchored in the wellbore at depth. The sound source will be pressured up to 3,000 pounds per square inch (psi), and activated 5–7 times at approximately 20-second intervals. The receivers will then be moved to the next interval of the wellbore and re-anchored, after which the airgun array will again be activated 5–7 times. This process will be repeated until the entire wellbore has been surveyed in this manner. The interval between anchor points for the receiver array is usually 200–300ft (61–91 m). A typical ZVSP survey takes about 10–14 hours to complete per well (depending on the depth of the well and the number of anchoring points in each well).

ZVSP sound verification measurements will be performed using either the AMARs that are deployed for drilling unit sound characterizations, or by JASCO Ocean Bottom Hydrophone (OBH) recorders. The use of AMARS or OBHs depends on the specific timing these measurements will be required by NMFS; the AMARs will not be retrieved until several days after the ZVSP as they are intended to monitor during retrievals of drilling unit anchors and related support activities. If the ZVSP acoustic measurements are required sooner, four OBH recorders would be deployed at the same locations and those could be retrieved immediately following the ZVSP measurement. The ZVSP measurements can be delivered within 120 hours of retrieval and download of the data from either instrument type.

(C) Acoustic Data Analyses

Exploration drilling sound data will be analyzed to extract a record of the frequency-dependent sound levels as a function of time. These results are useful for correlating measured sound energy events with specific survey operations. The analysis provides absolute sound levels in finite frequency bands that can be tailored to match the highest-sensitivity hearing ranges for species of interest. The analyses will also consider sound level integrated through 1-hour durations (referred to as sound energy equivalent level Leq (1-hour). Similar graphs for long time periods will be generated as part of the data analysis performed for indicating drilling sound variation with time in selected frequency bands.

(D) Reporting of Results

Acoustic sound level results will be reported in the 90-day and comprehensive reports for this program. The results reported will include:

- Sound source levels for the drilling units and all drilling support vessels;
- Spectrogram and band level versus time plots computed from the continuous recordings obtained from the hydrophone systems;
- Hourly Leq levels at the hydrophone locations; and
- Correlation of exploration drilling source levels with the type of exploration drilling operation being performed. These results will be obtained by observing differences in drilling sound associated with differences in drilling unit activities as indicated in detailed drilling unit logs.

Acoustic ''Net'' Array in Chukchi Sea

This section describes acoustic studies that were undertaken from 2006 through 2013 in the Chukchi Sea as part of the Joint Monitoring Program and that will be continued by Shell during exploration drilling activities. The acoustic ''net'' array used during the 2006–2013 field seasons in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of marine mammals (including beluga whale, bowhead whale, and other species) that may be available to subsistence hunters near villages along the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns. The second objective was to measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

A net array configuration similar to that deployed in 2007–2013 is again proposed. The basic components of this effort consist of autonomous acoustic recorders deployed widely across the U.S. Chukchi Sea during the open water season and then more limited arrays during the winter season. These calibrated systems sample at 16 kHz with 24-bit resolution, and are capable of recording marine mammal sounds and making anthropogenic noise measurements. The net array configuration will include a regional array of 23 AMAR recorders deployed July–October off the four main transect locations: Cape Lisburne, Point Lay, Wainwright and Barrow. All of these offshore systems will capture sounds associated with exploration drilling, where present, over large distances to help characterize the sound transmission properties in the Chukchi Sea. Six additional summer AMAR recorders will be deployed around the Burger drill sites to monitor directional variations and longer-range propagation of drilling-related sounds. These recorders will also be used to examine marine mammal vocalization patterns in vicinity of exploration drilling activities. The regional recorders will be retrieved in early October 2015; acoustic monitoring will continue through the winter with 8 AMAR recorders deployed October 2015–August 2016. The winter recorders will sample at 16 kHz on a 17% duty cycle (40 minutes every 4 hours). The winter recorders deployed in previous years have provided important information about fall and spring migrations of bowhead, beluga, walrus and several seal species.

The Chukchi acoustic net array will produce an extremely large dataset comprising several Terabytes of acoustic data. The analyses of these data require identification of marine mammal vocalizations. Because of the very large amount of data to be processed, the analysis methods will incorporate automated vocalization detection algorithms that have been developed over several years. While the hydrophones used in the net array are not directional, and therefore not capable of accurate localization of detections, the number of vocalizations detected on each of the sensors provides a measure of the relative spatial distribution of some marine mammal species, assuming that vocalization patterns are consistent within a species across the spatial and geographic distribution of the hydrophone array. These results therefore provide information such as timing of migrations and routes of migration for belugas and bowheads.

A second purpose of the Chukchi net array is to monitor the amplitude of exploration drilling sound propagation over a very large area. It is expected that sounds from exploratory drilling activities will be detectable on hydrophone systems within approximately 30 km of the drilling units when ambient sound energy conditions are low. The drilling sound levels at recorder locations will be quantified and reported.

Analysis of all acoustic data will be prioritized to address the primary questions. The primary data analysis questions are to (a) determine when, where, and what species of animals are acoustically detected on each recorder (b) analyze data as a whole to determine offshore distributions as a function of time, (c) quantify spatial and temporal variability in the ambient sound energy, and (d) measure received levels of exploration drilling survey events and drilling unit activities. The detection data will be used to develop spatial and temporal animal detection 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, season, environmental conditions, ambient sound energy, and drilling or vessel sound levels).

4. Chukchi Offshore Aerial Photographic Monitoring Program

Shell has been reticent to conduct manned aerial surveys in the offshore Chukchi Sea because conducting those surveys puts people at risk. There is a strong desire, however, to obtain data on marine mammal distribution in the offshore Chukchi Sea and Shell will conduct a photographic aerial survey that would put fewer people at risk as an alternative to the fully-manned aerial survey. The photographic survey would reduce the number of people on board the aircraft from six persons to two persons (the pilot and copilot) and would serve as a pilot study for future surveys that would use an Unmanned Aerial System (UAS) to capture the imagery.

Aerial photographic surveys have been used to monitor distribution and estimate densities of marine mammals in offshore areas since the mid-1980s, and before that, were used to estimate numbers of animals in large concentration areas. Digital photographs provide many advantages over observations made by people if the imagery has sufficient resolution (Koski *et al.* 2013). With photographs there is constant detectability across the imagery, whereas observations by people decline with distance from the center line of the survey area. Observations at the outer limits of the transect can decline to 5–10% of the animals present for real-time observations by people during an aerial survey. The distance from the trackline of sightings is more accurately determined from photographs; group size can be more accurately determined; and sizes of animals can be measured, and hence much more accurately determined, in photographs. As a result of the latter capability, the presence or absence of a calf can be more accurately determined from a photograph than by in-the-moment visual observations. Another benefit of photographs over visual observations is that photographs can be reviewed by more than one independent observer allowing quantification of detection, identification and group size biases.

The proposed photographic survey will provide imagery that can be used to evaluate the ability of future studies to use the same image capturing systems in an UAS where people would not be put at risk. Although the two platforms are not the same, the slower airspeed and potentially lower flight altitude of the UAS would mean that the data quality would be better from the UAS. Initial comparisons have been made between data collected by human observers on board both the Chukchi and Beaufort aerial survey aircraft and the digital imagery collected in 2012. Overall, the imagery provided better estimates of the number of large cetaceans and pinnipeds present but fewer sightings were identified to species in the imagery than by PSOs, because the PSOs had sightings in view for a longer period of time and could use behavior to differentiate species. The comparisons indicated that some cetaceans that were not seen by PSOs were detected in the imagery; errors in identification were made by the PSOs during the survey that could be resolved from examination of the imagery; cetaceans seen by PSOs were visible in the imagery; and during periods with large numbers of sightings, the imagery provided much better estimates of numbers of sightings and group size than the PSO data.

Photographic surveys would start as soon as the ice management, anchor handler and drilling units are at or near the first drill site and would continue throughout the drilling period and until the drilling related vessels have left the exploration drilling area. Since the current plans are for vessels to enter the Chukchi Sea on or about 1 July, surveys would be initiated on or about 3 July. This start date differs from past practices of beginning five days prior to initiation of an activity and continuing until five days after cessation of the activity because the presence of vessels with helidecks in the area where overflights will occur is one of the main mitigations that will allow for safe operation of the overflight program this far offshore. The surveys will be based out of Barrow and the same aircraft will conduct the offshore surveys around the drilling units and the coastal saw-tooth pattern. The surveys of offshore areas around the drilling units will take precedence over the sawtooth survey, but if weather does not permit surveying offshore, the nearshore survey will be conducted if weather permits.

The aerial survey grids are designed to maximize coverage of the sound level fields of the drilling units during the different exploratory drilling activities. The survey grids can be modified as necessary based on weather and whether a noisy activity or quiet activity is taking place. The intensive survey design maximizes the effort over the area where sound levels are highest. The outer survey grid covers an elliptical area with a 45 km radius near the center of the ellipse. The spacing of the outer survey lines is 10 km, and the spacing between the intensive and outer lines is 5 km. The expanded survey grid covers a larger survey area, and the design is based on an elliptical area with a 50 km radius centered on the well sties. For both survey designs the main transects will be spaced 10 km apart which will allow even coverage of the survey area during a single flight if weather conditions permit completion of a survey. A random starting point will be selected for each survey and the evenly spaced lines will be shifted NE or SW along the perimeter of the elliptical survey area based on the start point. The total length of survey lines will be about 1,000 km and the exact length will depend on the location of the randomly selected start point.

Following each survey, the imagery will be downloaded from the memory card to a portable hard drive and then backed up on a second hard drive and stored at accommodations in Barrow until the second hard drive can be transferred to Anchorage. In Anchorage, the imagery will be processed through a computer-assisted analysis program to identify where marine mammal sightings might be located among the many images obtained. A team of trained photo analysts will review the photographs identified as having potential sightings and record the appropriate data on each sighting. If time permits, a second review of some of the images will be conducted while in the field, but the sightings recorded during the second pass will be identified in the database as secondary sightings, so that biases associated with the detection in the imagery can be quantified. If time does not permit that review to be conducted while in the field, the review will be conducted by personnel in the office during or after the field season. A sample of images that are not identified by the computer-assisted analysis program will be examined in detail by the image analysts to determine if the program has missed marine mammal sightings. If the analysis program has missed mammal sightings, these data will be to develop correction factors to account for these missed sightings among the images that were not examined.

5. Chukchi Sea Coastal Aerial Survey

Nearshore aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 miles (mi) [37 kilometers (km)] offshore in 2006–2008 and in 2010 in support of Shell's summer seismic exploration activities. In 2012 these surveys were flown when it was not possible to fly the photographic transects out over the Burger well site due to weather or rescue craft availability. These surveys provided data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell plans to conduct these nearshore aerial surveys in the Chukchi Sea as opportunities unfold and surveys will be similar to those conducted during previous years except that no PSOs will be onboard the aircraft. As noted above, the first priority will be to conduct photographic surveys around the offshore exploration drilling activities, but nearshore surveys will be conducted whenever weather does not permit flying offshore. As in past years, surveys in the southern part of the nearshore survey area will depend on the end of the beluga hunt near Point Lay. In past years, Point Lay has requested that aerial surveys not be conducted until after the beluga hunt has ended and so the start of surveys has been delayed until mid-July.

Alaskan Natives from villages along the east coast of the Chukchi Sea hunt marine mammals during the summer and Native communities are concerned that offshore oil and gas exploration activities may negatively impact their ability to harvest marine mammals. Of particular concern are potential impacts on the beluga harvest at Point Lay and on future bowhead harvests at Point Hope, Point Lay, Wainwright and Barrow. Other species of concern in the Chukchi Sea include the gray whale; bearded, ringed, and spotted seals. Gray whale and harbor porpoise are expected to be the most numerous cetacean species encountered during the proposed aerial survey; although harbor porpoise are abundant they are difficult to detect from aircraft because of their small size and brief surfacing. Beluga whales may occur in high numbers early in the season. The ringed seal is likely to be the most abundant pinniped species. The current aerial survey program will be designed to collect distribution data on cetaceans but will be limited in its ability to collect similar data on pinnipeds and harbor porpoises because they are not reliably detectable during review of the collected images unless a third camera with a 50 mm or similar lens is deployed.

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. This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore region. Sawtooth transects were designed by placing transect start/end points every 34 mi (55 km) along the offshore boundary of this 23 mi (37 km) wide nearshore zone, and at midpoints between those points along the coast. The transect line start/end points will be shifted along both the coast and the offshore boundary for each survey based upon a randomized starting location, but overall survey distance will not vary substantially. The coastline transect will simply follow the coastline or barrier islands. 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.

Standard aerial survey procedures used in previous marine mammal projects (by Shell as well as by others) will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize controversy about the chosen survey procedures. The aircraft will be flown at 110–120 knots ground speed and usually at an altitude of 1,000 ft (305 m). 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) or 1,500+ ft (454+ 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.

The surveyed area will include waters where belugas are usually available to subsistence hunters. If large concentrations of belugas are encountered during the survey, the aircraft will climb to ~10,000 ft (3,050 m) altitude to avoid disturbing the cetaceans. If cetaceans are in offshore areas, the aircraft will climb high enough to include all cetaceans within a single photograph; typically about 3,000 ft (914 m) altitude. When in shallow water, belugas and other marine mammals are more sensitive to aircraft over flights and other forms of disturbance than when they are offshore (see Richardson *et al.* 1995 for a review). They frequently leave shallow estuaries when over flown at altitudes of 2,000–3,000 ft (610–904 m); whereas they rarely react to aircraft at 1,500 ft (457 m) when offshore in deeper water.

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 2015. The panel is scheduled to meet in early March 2015, 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 results of the acoustic verification measurements, including at a minimum the measured 190-, 180-, 160-, and 120-dB (rms) radii of the drilling units, and support vessels, will be reported in the 90-day report. A report of the acoustic verification measurements of the ZVSP airgun array will be submitted within 120 hr after collection and analysis of those measurements once that part of the program is implemented. The ZVSP acoustic array report will specify the distances of the exclusion zones that were adopted for the ZVSP program. Prior to completion of these measurements, Shell will use the radii outlined in their application and proposed in Tables 2 and 3 of this document.

(2) Field Reports

Throughout the exploration drilling program, the biologists will prepare a report each day or at such other interval as required summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS as required.

(3) Technical Reports

The results of Shell's 2015 Chukchi Sea exploratory drilling monitoring program (*i.e.*, vessel-based, aerial, and acoustic) will be presented in the ''90-day'' and Final Technical reports 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 drilling units 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 AMAR ; (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 drilling unit activities. The 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 Chukchi Sea exploration 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.

(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 later in 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 drilling units, 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 drilling units 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 without any mitigation 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.

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 aggregate sources 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 drilling unit 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 Density Estimates

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 activities are occurring: open water or ice margin. More ice is likely to be present in the area of activities during the July–August period, so summer ice-margin densities have been applied to 50% of the area that may be ensonified from 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% of the area that may be ensonified from drilling and ZVSP activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since ice management activities would only occur within ice-margin habitat, the entire area potentially ensonified by ice management activities has been multiplied by the ice-margin densities in both seasons.

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. In those cases, the mean and maximum estimates were determined from the reported densities or survey data. In other cases only one or no applicable estimate was available, so correction factors were used to arrive at ''average'' and ''maximum'' estimates. These are described in detail in the following subsections.

Detectability bias, quantified in part by f(0), is associated with diminishing sightability with increasing lateral distance from the survey trackline. Availability bias, g(0), refers to the fact that there is <100% probability of sighting an animal that is present along the survey trackline. Some sources below included these correction factors in the reported densities (*e.g.* ringed seals in Bengtson *et al.* 2005) and the best available correction factors were applied to reported results when they had not already been included (*e.g.* Moore *et al.* 2000).

(1) Cetaceans

Eight species of cetaceans are known to occur in the activity area. Three of the nine species, bowhead, fin, and humpback whales, are listed as ''endangered'' under the ESA.

(a) Beluga Whales

Summer densities of beluga whales in offshore waters are expected to be low, with somewhat higher densities in ice-margin and nearshore areas. Past aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore *et al.* 2000). More recent aerial surveys of the Chukchi Sea from 2008–2012 flown by the NMML as part of the COMIDA project, now part of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, reported 10 beluga sightings (22 individuals) in offshore waters during 22,154 km of on-transect effort. Larger groups of beluga whales were recorded in nearshore areas, especially in June and July during the spring migration (Clarke *et al.* 2012, 2013). Additionally, only one beluga sighting was recorded during >80,000 km of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September–October of 2006–2010 (Hartin *et al.* 2013). 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. Effort and sightings reported by Clarke *et al.* (2012, 2013) were used to calculate the average open-water density estimate. The mean group size of the sightings was 2.2. 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 resulting in an average open-water density of 0.0024 belugas/km^2 (Table 6–1 of Shell's IHA application). The highest density from the reported survey periods (0.0049 belugas/km^2, in 2012) has been used as the maximum density that may occur in open-water habitat (Table 6–1 in Shell's IHA application). 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 four was used to estimate the ice-margin densities from the open-water densities. Very low densities observed from vessels operating in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2010 (0.0–0.0003/mi^2, 0.0–0.0001/km^2; Hartin *et al.* 2013), 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 offshore 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 2012). Densities derived from survey results in the northern Chukchi Sea in Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013) were used as the average density for open-water season estimates (Table 6–2 in Shell's IHA application). Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013) reported 17 beluga sightings (28 individuals) during 22,255 km of on-transect effort in water depths 36–50 m during the months of July through September. The mean group size of those three sightings was 1.6. A f(0) value of 2.841 and a g(0) value of 0.58 from Harwood *et al.* (1996) were used to calculate the average open-water density of 0.0031 belugas/km^2 (Table 6–2 in Shell IHA application). The highest density from the reported periods (0.0053 belugas/km^2, in 2012) was again used as the maximum density that may occur in open-water habitat. 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 four was used to estimate the ice-margin densities from the open-water densities. Based on the few beluga sightings from vessels operating in the Chukchi Sea during non-seismic periods and locations in September–November of 2006–2010 (Hartin *et al.* 2013), the relatively low densities shown in Table 6–2 in Shell's IHA application are consistent with what is likely to be observed form vessels during the planned exploration drilling activities.

(b) 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 10,686 km of on-transect effort in the Chukchi Sea by Moore *et al.* (2000). Bowhead whales were also rarely sighted in July-August of 2006–2010 during aerial surveys of the Chukchi Sea coast (Thomas *et al.* 2011). This is consistent with movements of tagged whales (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 the July–August open-water bowhead whale density in the Chukchi Sea was calculated from the three bowhead sightings (3 individuals) and 22,154 km of survey effort in waters 36–50 m deep in the Chukchi Sea during July–August reported in Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013). The mean group size from those sightings was 1. 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 0.0019 bowheads/km² (Table 6–1 in Shell's IHA application). The two sightings recorded during 4,209 km of survey effort in 2011 (Clarke *et al.* 2012) produced the highest annual bowhead density during July–August (0.0068 bowheads/km²) which was used as the maximum open-water density (Table 6–1 in Shell's IHA application). Bowheads are not expected to be encountered in higher densities near ice in the summer (Moore *et al.* 2000), so the same density estimates have been 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 2006–2010 (Hartin *et al.* 2013) ranged from 0.0002–0.0008/km² with a maximum 95% CI of 0.0085/km². This suggests the densities used in the calculations and shown in Table 6–1 in Shell's IHA application are similar to what are likely to be observed from vessels near the area of planned exploration drilling activities.

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 those bowheads will be encountered in the Chukchi Sea at this time of year. Moore *et al.* (2000) reported 34 bowhead sightings during 44,354 km of on-transect survey effort in the Chukchi Sea during September–October. Thomas *et al.* (2011) also reported increased sightings on coastal surveys of the Chukchi Sea during October and November of 2006–2010. 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 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). However, tagged whales did spend a considerable amount of time in the north-central Chukchi Sea in 2012, despite ongoing industrial activities in the region (ADFG 2012). Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013) reported 72 sightings (86 individuals) during 22,255 km of on-transect aerial survey effort in waters 36–50 m deep in 2008–2012, the majority of which (53 sightings) were recorded in 2012. The mean group size of the 72 sightings was 1.2. The same f(0) and g(0) values that were used for the summer estimates above were used for the fall estimates resulting in an average September–October estimate of 0.0552 bowheads/km² (Table 6–2 in Shell's IHA application). The highest density form the survey periods (0.1320 bowheads/km²; in 2012) was used as the maximum open-water density during the fall period. 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 the ice-margin densities that are used are twice the open-water densities. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in September–November of 2006–2010 (Hartin *et al.* 2013) ranged from 0.0003 to 0.0052/km² with a maximum 95 percent CI of 0.051/km². This suggests the densities used in the calculations and shown in Table 6–2 in Shell's IHA application are somewhat higher than are likely to be observed from vessels near the area of planned exploration drilling activities.

(c) 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 35 m deep. Thomas *et al.* (2011) also reported substantial declines in the sighting rates of gray whales in the fall. The average open-water summer density (Table 6–1 in Shell's IHA application) was calculated from 2008–2012 aerial survey effort and sightings in Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013) for water depths 36–50 m including 98 sightings (137 individuals) during 22,154 km of on-transect effort. The average group size of those sightings was 1.4. Correction factors f(0) = 2.49 (Forney and Barlow 1998) and g(0) = 0.30 (Forney and Barlow 1998, Mallonee 1991) were used to calculate and average open-water density of 0.0253 gray whales/km2 (Table 6–1 in Shell's IHA application). The highest density from the survey periods reported in Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013) was 0.0268 gray whales/km² in 2012 and this was used as the maximum open-water density. 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 2006–2010 (Hartin *et al.* 2013) ranged from 0.0008/km² to 0.0085/km² with a maximum 95 percent CI of 0.0353 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 (46 sightings [64 individuals] during 22,255 km of on-transect effort) in water 36–50 m deep during September–October reported by Clarke and Ferguson (in prep, cited in Shell 2014) and Clarke *et al.* (2012, 2013) was used as the average estimate for the Chukchi Sea during the fall period (0.0118 gray whales/km²; Table 6–2 in Shell's IHA application). The corresponding group size value of 1.39, along with the same f(0) and g(0) values described above were used in the calculation. The maximum density from the survey periods (0.0248 gray whales/km²) was reported in 2011 (Clarke *et al.*

2012) and used as the maximum fall open-water density (Table 6–2 in Shell's IHA application). Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in September–November of 2006–2010 (Hartin *et al.* 2013) ranged from 0.0/km² to 0.0044/km² with a maximum 95% CI of 0.0335 km².

(d) Harbor Porpoises

Harbor Porpoise densities were estimated from industry data collected during 2006–2010 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 2006–2010, however, recorded sightings throughout the Chukchi Sea during the summer and early fall months. Density estimates from 2006–2010 observations during non-seismic periods and locations in July-August ranged from 0.0013/km² to 0.0029/km² with a maximum 95% CI of 0.0137/km² (Hartin *et al.* 2013). The average density from the summer season of those three years (0.0022/km²) was used as the average open-water density estimate while the high value (0.0029/km²) was used as the maximum estimate (Table 6–1 in Shell's IHA application). 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 2006–2010 were slightly lower and ranged from 0.0/km² to 0.0044/km² with a maximum 95% CI of 0.0275/km². The average of those years (0.0021/km²) was again used as the average density estimate and the high value (0.0044/km²) was used as the maximum estimate (Table 6–2 in Shell's IHA application).

(e) Other Whales

The remaining five cetacean species that could be encountered in the Chukchi Sea during Shell's planned exploration drilling program include the humpback whale, killer whale, minke whale, and fin whale. Although there is evidence of the occasional occurrence of these five cetacean species in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned exploration drilling program and therefore minimum densities have been assigned to these species (Tables 6–1 and 6–2 in Shell's IHA application). Clarke *et al.* (2011, 2013) and Hartin *et al.* (2013) reported humpback whale sightings; George and Suydam (1998) reported killer whales; Brueggeman *et al.* (1990), Hartin *et al.* (2013), Clarke *et al.* (2012, 2013), and Reider *et al.* (2013) reported minke whales; and Clarke *et al.* (2011, 2013) and Hartin *et al.* (2013) reported fin whales. With regard to humpback and fin whales, NMFS (2013) recently concluded these whales occur in very low numbers in the project area, but may be regular visitors.

Of these uncommon cetacean species, minke whale has the potential to be the most common based on recent industry surveys. Reider *et al.* (2013) reported 13 minke whale sightings in the Chukchi Sea in 2013 during Shell's marine survey program. All but one minke whale sighting in 2013, however, were observed in nearshore areas despite only minimal monitoring effort in nearshore areas compared to more offshore locations near the Burger prospect (Reider *et al.* 2013).

(2) Pinnipeds

Three species of pinnipeds under NMFS jurisdiction are likely to be encountered in the Chukchi Sea during Shell's planned exploration drilling program: Ringed seal, bearded seal, and spotted seal. Ringed and bearded seals are associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) for ringed and bearded seals 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 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, Hartin *et al.* 2013).

(a) Ringed and Bearded Seals

Ringed seal and bearded seals ''average'' and ''maximum'' summer ice-margin densities 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 haulout 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 3/4 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 2/3 the summer densities because ringed seals begin to reoccupy nearshore fast ice areas as it 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 2006–2010 industry operations ranged from 0.0138/km² to 0.0464/km² with a maximum 95 percent CI of 0.1581/km² (Hartin *et al.* 2013).

(b) 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 2012), and that the population of ringed seals in the Alaskan Chukchi Sea is ~208,000 animals (Bengtson *et al.* 2005). In the fall, spotted seals show increased use of coastal haulouts so densities were estimated to be 2/3 of the summer densities.

(c) Ribbon Seals

Four ribbon seal sightings were reported during industry vessel operations in the Chukchi Sea in 2006–2010 (Hartin *et al.* 2013). The resulting density estimate of 0.0007/km² was used as the average density and 4 times that was used as the maximum for both seasons and habitat zones.

Individual Sound Sources and Level B Radii

The assumed start date of Shell's exploration drilling program in the Chukchi Sea using the drilling units *Discoverer* and *Polar Pioneer* with associated support vessels is 4 July. Shell may conduct exploration drilling activities at up to four drill sites at the prospect known as Burger. Drilling activities are expected to be conducted through approximately 31 October 2015.

Previous IHA applications for offshore Arctic exploration programs estimated areas potentially ensonified to ≥120 or ≥160 dB re 1 μPa rms independently for each continuous or pulsed sound source, respectively (*e.g.,* drilling, ZVSP, etc.). The primary method used in this IHA application for estimating areas ensonified to continuous sound levels ≥120 dB re 1 μPa rms by drilling-related activities involved sound propagation modeling of a variety of scenarios consisting of multiple, concurrently-operating sound sources. These ''activity scenarios'' consider additive acoustic effects from multiple sound sources at nearby locations, and more closely capture the nature of a dynamic acoustic environment where numerous activities are taking place simultaneously. The area ensonified to ≥160 dB re 1 μPa rms from ZVSP, a pulsed sound source, was treated independently from the activity scenarios for continuous sound sources.

The continuous sound sources used for sound propagation modeling of activity scenarios included (1) drilling unit and drilling sounds, (2) supply and drilling support vessels using DP when tending to a drilling unit, (3) MLC construction, (4) anchor handling in support of mooring a drilling unit, and (5) ice management activities. The information used to generate sound level characteristics for each continuous sound source is summarized below to provide background on the model inputs. A ''safety factor'' of 1.3 dB re 1 μPa rms was added to the source level for each sound source prior to modeling activity scenarios to account for variability across the project area associated with received levels at different depths, geoacoustical properties, and sound-speed profiles. The addition of the 1.3 dB re 1 μPa rms safety factor to source levels resulted in an approximate 20 percent increase in the distance to the 120 dB re 1 μPa rms threshold for each continuous source.

Table 2 summarizes the 120 dB re 1 μPa rms radii for individual sound sources, both the ''original'' radii as measured in the field, and the ''adjusted'' values that were calculated by adding the ''safety factor'' of 1.3 dB re 1 μPa rms to each source. The adjusted source levels were then used in sound propagation modeling of activity scenarios to estimate ensonified areas and associated marine mammal exposure estimates. Additional details for each of the continuous sound sources presented in Table 2 are discussed below.

The pulsed sound sources used for sound propagation modeling of activity scenarios consisted of two small airgun arrays proposed for ZVSP activities. All possible array configurations and operating depths were modeled to identify the arrangement with the greatest sound propagation characteristics. The resulting ≥160 dB re 1 μPa rms radius was multiplied by 1.5 as a conservative measure prior to estimating exposed areas, which is discussed in greater detail below.

TABLE 2—MEASURED AND ADJUSTED 120 dB re 1 μPa RADII FOR INDIVIDUAL, CONTINUOUS SOUND SOURCES

Activity/continuous sound source	Radii of 120 dB re 1 μPa (rms) isopleth (meters)	
	Original measurement	With 1.3 dB correction factor
Drilling at 1 site	1,500	1,800
Vessel in DP	4,500	5,500
Mudline cellar construction at 1 site	8,200	9,300
Anchor handling at 1 site (assumed to be 2 vessels)	19,000	22,000
Single vessel ice management	9,600	11,000

Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in3 (2,458 cm^3) airguns for a total volume of 450 in^3 (7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4,097 cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3). Sound footprints for each of the two proposed ZVSP airgun array configurations were estimated using JASCO Applied Sciences' MONM. The model results were maximized over all water depths from 9.8 to 23 ft (3 to 7 m) to yield precautionary sound level isopleths as a function of range and direction from the source. The 450 in^3 airgun array at a source depth of 7 m yielded the maximum ranges to the ≥190, ≥180, and ≥160 dB re 1 μPa rms isopleths.

There are two reasons that the radii for the 450 in^3 airgun array are larger than those for the 500 in^3 array. First, the sound energy does not scale linearly with the airgun volume, rather it is proportional to the cube root of the volume. Thus, the total sound energy from three airguns is larger than the total energy from two airguns, even though the total volume is smaller. Second, larger volume airguns emit more low-frequency sound energy than smaller volume airguns, and low-frequency airgun sound energy is strongly attenuated by interaction with the surface reflection. Thus, the sound energy for the larger-volume array experiences more reduction and results in shorter sound threshold radii.

The estimated 95th percentile distances to the following thresholds for the 450 in^3 airgun array were: ≥190 dB re 1 μPa rms = 170 m, ≥180 dB re 1 μPa rms = 920 m, and ≥160 dB re 1 μPa rms = 7,970 m. The ≥160 dB re 1 μPa rms distance was multiplied by 1.5 for a distance of 11,960 m. This radius was used for estimating areas ensonified by pulsed sounds to ≥160 dB re 1 μPa rms during a single ZVSP survey. ZVSP surveys may occur at up to two different drill sites during Shell's planned 2015 exploration drilling program in the Chukchi Sea.

As noted above, previous IHA applications for Arctic offshore exploration programs estimated areas potentially ensonified to continuous sound levels ≥120 dB re 1 μPa rms independently for each sound source. This method was appropriate for assessing a small number of continuous sound sources that did not consistently overlap in time and space. However, many of the continuous sound sources described above will operate concurrently at one or more nearby locations in 2015 during Shell's planned exploration drilling program in the Chukchi Sea. It is therefore appropriate to consider the concurrent operation of numerous sound sources and the additive acoustic effects from combined sound fields when estimating areas potentially exposed to levels ≥120 dB re 1 μPa rms.

A range of potential ''activity scenarios'' was derived from a realistic operational timeline by considering the various combinations of different continuous sound sources that may operate at the same time at one or more locations. The total number of possible activity combinations from all sources at up to four different drill sites would not be practical to assess or present in a meaningful way. Additionally, combinations such as concurrent drilling and anchor handling in close proximity do not add meaning to the analysis given the negligible contribution of drilling sounds to the total area ensonified by such a scenario. For these reasons, various combinations of similar activities were grouped into representative activity scenarios shown in Table 3. Ensonified areas for these representative activity scenarios were estimated through sound propagation modeling. Activity scenarios were modeled for different drill site combinations and, as a conservative measure, the locations corresponding to the largest ensonified area were chosen to represent the given activity scenario. In other words, by binning all potential scenarios into the most conservative representative scenario, the largest possible ensonified areas for all activities were identified for analysis. A total of nine representative activity scenarios were modeled to estimate areas exposed to continuous sounds ≥120 dB re 1 µPa rms for Shell's planned 2015 exploration drilling program in the Chukchi Sea (Table 3). A tenth scenario was included for the ZVSP activities.

TABLE 3—SOUND PROPAGATION MODELING RESULTS OF REPRESENTATIVE DRILLING RELATED ACTIVITY SCENARIOS AND ESTIMATES OF THE TOTAL AREA POTENTIALLY ENSONIFIED ABOVE THRESHOLD LEVELS AT THE BURGER PROSPECT IN THE CHUKCHI SEA, ALASKA, DURING SHELL'S PROPOSED 2015 EXPLORATION DRILLING PROGRAM

Activity scenario description	Threshold level (dB re 1 µPa rms)	Area potentially ensonified (km^2)	
		Summer	Fall
Drilling at 1 site	120	10.2	10.2
Drilling and DP vessel at 1 site	120	111.8	111.8
Drilling and DP vessel (1 site) + drilling and DP vessel (2nd site)	120	295.5	295.5
Mudline cellar construction at 2 different sites	120	575.5	575.5
Anchor handling at 1 site	120	1,534.9	1,534.9
Drilling and DP vessel at 1 site + anchor handling at 2nd site	120	1,759.2	1,759.2
Mudline cellar construction at 2 different sites + anchor handling at 3rd site	120	2,046.3	2,046.3
Two-vessel ice management	120	937.4	937.4
Four-vessel ice management	120	1,926.0	1,926.0
ZVSP at 2 different sites	160	0.0	898.0

Potential Number of "Takes by Harassment"

This section provides estimates of the number of individuals potentially exposed to continuous sound levels ≥120 dB re 1 µPa rms from exploration drilling related activities and pulsed sound levels ≥160 dB re 1 µPa rms by ZVSP activities. The estimates are based on a consideration of the number of marine mammals that might be affected by operations in the Chukchi Sea during 2015 and the anticipated area exposed to those sound levels.

To account for different densities in different habitats, Shell has assumed that more ice is likely to be present in the area of operations during the July–August period than in the September–October period, so summer ice-margin densities have been applied to 50% of the area that may be exposed to sounds from exploration drilling activities in those months. Open water densities in the summer were applied to the remaining 50% of the area.

Less ice is likely to be present during the September–October period than in the July–August period, so fall ice-margin densities have been applied to only 20% of the area that may be exposed to sounds from exploration drilling activities in those months. Fall open-water densities were applied to the remaining 80% 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.

Estimates of the numbers of marine mammals potentially exposed to continuous sounds ≥120 dB re 1 µPa rms or pulsed sounds ≥160 dB re 1 µPa rms are based on assumptions that include upward scaling of source levels for all sound sources, no avoidance of activities/sounds by individual marine mammals, and 100% turnover of individuals in ensonified areas every 24 hours (except for bowhead whales, as discussed below). NMFS considers that these assumptions are overly conservative, especially for non-migratory species/periods and for cetaceans in particular, which are known to avoid anthropogenic activities and associated sounds at varying distances depending on the context in which activities and sounds are encountered (Koski and Miller 2009; Moore 2000; Moore *et al.* 2000; Treacy *et al.* 2006). Although we recognize these assumptions may be overly conservative, it is difficult to scale variables in a more precise fashion until recent evidence can be incorporated into newer estimation methods.

The following sections present a range of exposure estimates for bowhead whales and ringed seals. Estimates were generated based on an evaluation of the best available science and a consideration of the assumptions surrounding avoidance behavior and the frequency of turnover. In addition to demonstrating the sensitivity of exposure estimates to variable assumptions, the wide range of estimates is more informative for assessing negligible impact compared to a single estimated value with a high degree of uncertainty.

It is difficult to determine an appropriate, precise average turnover time for a population of animals in a particular area of the Chukchi Sea. Reasons for this include differences in residency time for migratory and non-migratory species, changes in distribution of food and other factors such as behavior that influence animal movement, variation among individuals of the same species, etc. Complete turnover of individual bowhead whales in the project area each 24-hour period may occur during fall migration when bowheads are traveling through the area. Even during this fall period, bowheads often move in pulses with one to several days between major pulses of whales (Miller *et al.* 2002). Gaps between groups of whales can probably be accounted for partially by bowhead whales stopping to feed opportunistically when food is encountered. The extent of feeding by bowhead whales during fall migration across the Beaufort and Chukchi Seas varies greatly from year to year based on the location and abundance of prey (Shelden and Mocklin 2013). For example, if a turnover rate of 48 hours to account for intermittent periods of migrating and feeding individuals is assumed, then the number of bowhead whale being exposed would be reduced accordingly by 50%. Due to changes in the turnover rate across time, a conservative turnover rate of 24 hours has been selected to estimate the number of bowhead whales exposed.

During the summer, relatively few bowhead or beluga whales are present in the Chukchi Sea and in most cases, given that the operations area is not known to be a critical feeding area (Citta *et al.* 2014; Allen and Angliss 2014), whales would be likely to simply avoid the area of operations (Schick and Urban 2000; Richardson *et al.* 1995a). Similarly, during migration many whales would likely travel around the area (*i.e.,* avoid it) as it is not known to be important habitat for either bowheads or belugas during any portion of the year (Citta *et al.* 2014; Allen and Angliss 2014). There is a large body of evidence indicating that bowhead whales avoid anthropogenic activities and associated underwater sounds depending on the context in which these activities are encountered (LGL *et al.* 2014; Koski and Miller 2009; Moore 2000; Moore *et al.* 2000; Treacy *et al.* 2006). Increasing evidence suggests that proximity to an activity or sound source, coupled with an individual's behavioral state (*e.g.,* feeding vs traveling) among other contextual variables, as opposed to received sound level alone, strongly influences the degree to which an individual whale demonstrates aversion or other behaviors (reviewed in Richardson *et al.* 1995b; Gordon *et al.* 2004; Koski and Miller 2009).

Several historical studies provide valuable information on the distribution and behavior of bowhead whales relative to drilling activities in the Alaskan Arctic offshore. One is a 1986 study by Shell at Hammerhead and Corona prospects (Davis 1987) and another is an analysis by Schick and Urban (2000) of 1993 aerial survey data collected by Coastal Offshore and Pacific Corporation. Both studies suggest that few whales approached within ~18 km of an offshore drilling operation in the Beaufort Sea. Davis (1987) reported that the surfacing and respiration variables that are often used as indicators of behavioral disturbance seemed normal when whales were >18.5 km from the active drill site and as they circumnavigated the drilling operation. The Schick and Urban (2000) study found whales as close as 18.5–20.3 km in all directions around the active operation, suggesting that whales that had diverted returned to their normal migration routes shortly after passing the operation.

If bowhead whales avoid drilling and related support activities at distances of approximately 20 km in 2015, as was noted consistently by Davis (1987) and Schick and Urban (2002), this would preclude exposure of the vast majority of individuals to continuous sounds ≥120 dB re 1 μPa rms or pulsed sounds ≥160 dB re 1 μPa rms. The largest ensonified areas during Shell's 2012 exploration drilling program were produced by mudline cellar construction, ice management, and anchor handling (JASCO Applied Sciences and Greeneridge Sciences 2014). Only anchor handling is expected to result in the lateral propagation of continuous sound levels ≥120 dB re 1 μPa rms to distances of 20 km or greater from the source.

By assuming half of the individual bowhead whales would avoid areas with sounds at or above Level B thresholds, the exposure estimate would be reduced accordingly by 50% even if 100% turnover of migrating whales was still assumed to take place every 24 hours. Taking into consideration what is known from studies documenting temporary diversion around drilling activities, and conservative assumptions with regards to turnover rates, NMFS considers the conservative estimate associated with a 24 hour turnover and 50% avoidance to be the most reasonable estimate of individual exposures.

Table 4 presents the exposure estimates for Shell's proposed 2015 exploration drilling program in the Chukchi Sea. The table also summarizes abundance estimates for each species and the corresponding percent of each population that may be exposed to continuous sounds ≥120 dB re 1 μPa rms or pulsed sounds ≥160 dB re 1 μPa rms. With the exception of the exposure estimate for bowhead whales described above, estimates for all other species assumed 100% daily turnover and no avoidance of activities or ensonified areas.

TABLE 4—THE TOTAL NUMBER OF POTENTIAL EXPOSURES OF MARINE MAMMALS TO SOUND LEVELS ≥120 dB re 1 μPa rms OR ≥160 dB re 1 μPa rms DURING THE SHELL'S PROPOSED DRILLING ACTIVITIES IN THE CHUKCHI SEA, ALASKA, 2015

[Estimates are also shown as a percent of each population]

Species	Abundance	Number potential exposure	Percent estimated population
Beluga	42,968	974	2.3
Killer whale	2,084	14	0.8
Harbor porpoise	48,215	294	0.6
Bowhead whale	19,534	2,582	13.2
Fin whale	1,652	14	0.8
Gray whale	19,126	2,581	13.5
Humpback whale	20,800	14	0.1
Minke whale	810	41	5.1
Bearded seal	155,000	1,722	1.1
Ribbon seal	49,000	96	0.2
Ringed seal	300,000	50,433	16.8
Spotted seal	141,479	1,007	0.7

In summary, several precautionary methods were applied when calculating exposure estimates. These conservative methods and related considerations include:

- Application of a 1.3 dB re 1 μPa rms safety factor to the source level of each continuous sound source prior to sound propagation modeling of areas exposed to Level B thresholds;
- Binning of similar activity scenarios into a representative scenario, each of which reflected the largest exposed area for a related group of activities;
- Modeling numerous iterations of each activity scenario at different drill site locations to identify the spatial arrangement with the largest exposed area for each;
- Assuming 100 percent daily turnover of populations, which likely overestimates the number of different individuals that would be exposed, especially during non-migratory periods;
- Expected marine mammal densities assume no avoidance of areas exposed to Level B thresholds (with the exception of bowhead whale, for which 50% of individuals were assumed to demonstrate avoidance behavior); and
- Density estimates for some cetaceans include nearshore areas where more individuals would be expected to occur than in the offshore Burger Prospect area (*e.g.,* gray whales).

Additionally, post-season estimates of the number of marine mammals exposed to Level B thresholds per Shell 90-Day Reports from the 2012 IHA consistently support the methods used in Shell's IHA applications as precautionary. Most recently, exposure estimates reported by Reider *et al.* (2013) from Shell's 2012 exploration activities in the Chukchi Sea were considerably lower than those requested in Shell's 2012 IHA application. The following summary of the numbers of cetaceans and pinnipeds that may be exposed to sounds above Level B thresholds is best interpreted as conservatively high, particularly the larger value for each species that assumes a new population of individuals each day.

Analysis and Preliminary Determinations

Negligible Impact

Negligible impact is ''an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival'' (50 CFR 216.103). A negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (*i.e.,* population-level effects). An estimate of the number of Level B harassment takes, alone, is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be ''taken'' through behavioral harassment, NMFS must consider other factors, such as the likely nature of any responses (their intensity, duration, etc.), the context of any responses (critical reproductive time or location, migration, etc.), as well as the number and nature of estimated Level A harassment takes, the number of estimated mortalities, effects on habitat, and the status of the species.

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 drilling units or icebreaker above 120 dB or to impulsive sounds from the airguns above 160 dB, as those sound levels only propagate 1.8 km, 11 km, and 11.9 km, respectively, which includes the inflation factor. 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.,* drilling units, 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 or stocks likely to occur in the proposed drilling area, four are listed as endangered under the ESA: the bowhead, humpback, fin whales, and ringed seal. All four 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. Ringed seals were recently listed under the ESA as threatened species, and are considered depleted under the MMPA. On July 25, 2014, the U.S. District Court for the District of Alaska vacated NMFS' rule listing the Beringia bearded seal DPS as threatened and remanded the rule to NMFS to correct the deficiencies identified in the opinion. None of the other species that may occur in the project area is 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.

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the proposed monitoring and mitigation measures, NMFS preliminarily finds that the total marine mammal take from Shell's proposed 2015 open-water exploration drilling program in the Chukchi Sea will have a negligible impact on the affected marine mammal species or stocks.

Small Numbers

The estimated takes proposed to be authorized represent less than 1% of the affected population or stock for 6 of the species and less than 5.5% for three additional species. The estimated takes for bowhead and gray whales and for ringed seals are 13.2%, 13.5%, and 16.8%, respectively. 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, an application of a 1.3 dB safety factor to the source level of each continuous sound source prior to sound propagation modeling of areas exposed to Level B thresholds, which make the effective zones for take calculation larger than they likely would be. In addition, Shell applied binning of similar activity scenarios into a representative scenario, each of which reflected the largest exposed area for a related group of activities. Further, the take estimates assume 100% daily turnover of populations, which likely overestimates the number of different individuals that would be exposed, especially during non-migratory periods. In addition, the take estimates assume no avoidance of marine mammals in areas exposed to Level B thresholds (with the exception of bowhead whale, for which 50% of individuals were assumed to demonstrate avoidance behavior). Finally, density estimates for some cetaceans include nearshore areas where more individuals would be expected to occur than in the offshore Burger Prospect area (*e.g.,* gray whales).

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the mitigation and monitoring measures, NMFS preliminarily finds that small numbers of marine mammals will be taken relative to the populations of the affected species or stocks.

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. 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).

(1) Bowhead Whales

Sound energy and general activity associated with drilling and operation of vessels and aircraft have the potential to temporarily affect the behavior of bowhead whales. Monitoring studies (Davis 1987, Brewer *et al.* 1993, Hall *et al.* 1994) have documented temporary diversions in the swim path of migrating bowheads near drill sites; however, the whales have generally been observed to resume their initial migratory route within a distance of 6–20 mi (10–32 km). Drilling noise has not been shown to block or impede migration even in narrow ice leads (Davis 1987, Richardson *et al.* 1991).

Behavioral effects on bowhead whales from sound energy produced by drilling, such as avoidance, deflection, and changes in surface/dive ratios, have generally been found to be limited to areas around the drill site that are ensonified to >160 dB re 1 μPa rms, although effects have infrequently been observed out as far as areas ensonified to 120 dB re 1 μPa rms. Ensonification by drilling to levels >120 dB re 1 μPa rms will be limited to areas within about 0.93 mi (1.5 km) of either drilling units during Shell's exploration drilling program. Shell's proposed drill sites are located more than 64 mi (103 km) from the Chukchi Sea coastline, whereas mapping of subsistence use areas indicates bowhead hunts are conducted within about 30 mi (48 km) of shore; there is therefore little or no opportunity for the proposed exploration drilling activities to affect bowhead hunts.

Vessel traffic along planned travel corridors between the drill sites and marine support facilities in Barrow and Wainwright would traverse some areas used during bowhead harvests by

Chukchi villages. Bowhead hunts by residents of Wainwright, Point Hope and Point Lay take place almost exclusively in the spring prior to the date on which Shell would commence the proposed exploration drilling program. From 1984 through 2009, all bowhead harvests by these Chukchi Sea villages occurred only between April 14 and June 24 (George and Tarpley 1986; George *et al.* 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo *et al.* 1994; Suydam *et al.* 1995, 1996, 1997, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010), while Shell will not enter the Chukchi Sea prior to July 1. However, fall whaling by some of these Chukchi Sea villages has occurred since 2010 and is likely to occur in the future, particularly if bowhead quotas are not completely filled during the spring hunt, and fall weather is accommodating. A Wainwright whaling crew harvested the first fall bowhead for these villages in 90 years or more on October 7, 2010, and another in October of 2011 (Suydam *et al.* 2011, 2012, 2013). No bowhead whales were harvested during fall in 2012, but 3 were harvested by Wainwright in fall 2013.

Barrow crews have traditionally hunted bowheads during both spring and fall; however spring whaling by Barrow crews is normally finished before the date on which Shell operations would commence. From 1984 through 2011 whales were harvested in the spring by Barrow crews only between April 23 and June 15 (George and Tarpley 1986; George *et al.* 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo *et al.* 1994; Suydam *et al.* 1995, 1996, 1997, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2103). Fall whaling by Barrow crews does take place during the time period when vessels associated with Shell's exploration drilling program would be in the Chukchi Sea. From 1984 through 2011, whales were harvested in the fall by Barrow crews between August 31 and October 30, indicating that there is potential for vessel traffic to affect these hunts. Most fall whaling by Barrow crews, however, takes place east of Barrow along the Beaufort Sea coast, therefore providing little opportunity for vessel traffic associated with Shell's exploration drilling program to affect them. For example, Suydam *et al.* (2008) reported that in the previous 35 years, Barrow whaling crews harvested almost all their whales in the Beaufort Sea to the east of Point Barrow. Shell's mitigation measures, which include a system of Subsistence Advisors (SAs), Community Liaisons, and Com Centers, will be implemented to avoid any effects from vessel traffic on fall whaling in the Chukchi Sea by Barrow and Wainwright.

Aircraft traffic (helicopters and small fixed wing airplanes) between the drill sites and facilities in Wainwright and Barrow would also traverse these subsistence areas. Flights between the drill sites and Wainwright or other shoreline locations would take place after the date on which spring bowhead whaling out of Point Hope, Point Lay, and Wainwright is typically finished for the year; however, Wainwright has harvested bowheads in the fall since 2010 and aircraft may traverse areas sometimes utilized for these fall hunts. Aircraft overflights between the drill sites and Barrow or other shoreline locations could also occur over areas used by Barrow crews during fall whaling, but again, most fall whaling by Barrow crews takes place to the east of Barrow in the Beaufort Sea. The most commonly observed reactions of bowheads to aircraft traffic are hasty dives, but changes in orientation, dispersal, and changes in activity are sometimes noted. Such reactions could potentially affect subsistence hunts if the flights occurred near and at the same time as the hunt, but Shell has developed and proposes to implement a number of mitigation measures to avoid such impacts. These mitigation measures include minimum flight altitudes, employment of SAs, and Com Centers. Twice-daily calls are held during the exploration drilling program and are attended by operations staff, logistics staff, and SAs. Vessel movements and aircraft flights are adjusted as needed and planned in a manner that avoids potential impacts to bowhead whale hunts and other subsistence activities.

(2) Beluga Whale

Beluga whales typically do not represent a large proportion of the subsistence harvests by weight in the communities of Wainwright and Barrow, the nearest communities to Shell's planned exploration drilling program. Barrow residents hunt beluga in the spring (normally after the bowhead hunt) in leads between Point Barrow and Skull Cliffs in the Chukchi Sea, primarily in April–June and later in the summer (July–August) on both sides of the barrier island in Elson Lagoon/ Beaufort Sea (Minerals Management Service [MMS] 2008), but harvest rates indicate 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.

Belugas typically represent a much greater proportion of the subsistence harvest in Point Lay and Point Hope. Point Lay's primary beluga hunt occurs from mid-June through mid-July, but can sometimes continue into August if early success is not sufficient. 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. Shell's proposed drill sites are located more than 60 mi (97 km) offshore, therefore proposed exploration drilling in the Burger Prospect would have no or minimal impacts on beluga hunts. 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. However, all of the beluga hunt by Barrow residents in the Chukchi Sea, and much of the hunt by Wainwright residents, would likely be completed before Shell activities would commence. Additionally, vessel and aircraft traffic associated with Shell's planned exploration 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 vessel and aircraft traffic corridors do not traverse areas indicated in recent mapping as utilized by Point Lay or Point Hope for beluga hunts, and avoids important beluga hunting areas in Kasegaluk Lagoon that are used by Wainwright. Shell has developed and proposes to implement a number of mitigation measures, *e.g.,* PSOs on board vessels, minimum flight altitudes, and the SA and Com Center programs, to ensure that there is no impact on the availability of the beluga whale as a subsistence resource.

(3) Pinnipeds

Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell's exploration drilling program would commence, but some harvest continues during open water and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer. Most seals are harvested in coastal waters, with available maps of recent and past subsistence use areas indicating seal harvests have occurred only within 30–40 mi (48–64 km) of the coastline. Shell's planned drill sites are located more than 64 statute mi (103 km) offshore, so activities within the Burger Prospect, such as drilling, would have no impact on subsistence hunting for seals. Helicopter traffic between land and the offshore exploration drilling operations could potentially disturb seals and, therefore, subsistence hunts for seals, but any such effects would be minor and temporary lasting only minutes after the flight has passed due to the small number of flights and the altitude at which they typically fly, and the fact that most seal hunting is done during the winter and spring when the exploration drilling program is not operational. Mitigation measures to be implemented by Shell include minimum flight altitudes, employment of subsistence advisors in the villages, and operation of Com Centers.

Potential Impacts to Subsistence Uses

NMFS has defined ''unmitigable adverse impact'' in 50 CFR 216.103 as: ''an impact resulting from the specified activity: (1) That is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by: (i) Causing the marine mammals to abandon or avoid hunting areas; (ii) Directly displacing subsistence users; or (iii) Placing physical barriers between the marine mammals and the subsistence hunters; and (2) 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. Only limited seismic activity is planned in the vicinity of the drill units in 2015.

Plan of Cooperation or Measures To Minimize Impacts to Subsistence Hunts

Regulations at 50 CFR 216.104(a)(12) require IHA applicants for activities that take place in Arctic waters to provide a Plan of Cooperation (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 prepared and will implement a POC pursuant to BOEM Lease Sale Stipulation No. 5, which requires that all exploration operations be conducted in a manner that prevents unreasonable conflicts between oil and gas activities and the subsistence activities and resources of residents of the North Slope. This stipulation also requires adherence to USFWS and NMFS regulations, which require an operator to implement a POC to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR 18.124(c)(4) and 50 CFR 216.104(a)(12)). A POC was prepared and submitted with the initial Chukchi Sea EP that was submitted to BOEM in May 2009, and approved on 7 December 2009. Subsequent POC Addendums were submitted in May 2011 with a revised Chukchi Sea EP and the IHA application for the 2012 exploration drilling program. For this IHA application, Shell has again updated the POC Addendum. The POC Addendum has been updated to include documentation of meetings undertaken to specifically gather feedback from stakeholder communities on Shell's implementation of the Chukchi Sea exploration drilling program during 2012, plus inform and obtain their input regarding the continuation of the program with the addition of a second drilling unit, additional vessels and aircraft.

The POC Addendum identifies the measures that Shell has developed in consultation with North Slope subsistence communities to minimize any adverse effects on the availability of marine mammals for subsistence uses and will implement during its planned Chukchi Sea exploration drilling program for the summer of 2015. In addition, the POC Addendum details Shell's communications and consultations with local subsistence communities concerning its planned exploration drilling program, potential conflicts with subsistence activities, and means of resolving any such conflicts (50 CFR 18.128(d) and 50 CFR 216.104(a) (12) (i), (ii), (iv)). Shell has documented its contacts with the North Slope subsistence communities, as well as the substance of its communications with subsistence stakeholder groups.

The POC Addendum report (Attachment C of the IHA application) provides a list of public meetings attended by Shell since 2012 to develop the POC and the POC Addendum. The POC Addendum is updated through July 2015, and includes sign-in sheets and presentation materials used at the POC meetings held in 2014 to present the 2015 Chukchi Sea exploration drilling information. Comment analysis tables for numerous meetings held during 2014 summarize feedback from the communities on Shell's 2015 exploration drilling and planned activities beginning in the summer of 2015.

The following mitigation measures, plans and programs, are integral to this POC and were developed during Shell's consultation with potentially affected subsistence groups and communities. These measures, plans, and programs to monitor and mitigate potential impacts to subsistence users and resources will be implemented by Shell during its exploration drilling operations in the Chukchi Sea. The mitigation measures Shell has adopted and will implement during its Chukchi Sea exploration drilling operations are listed and discussed below. These mitigation measures reflect Shell's experience conducting exploration activities in the Alaska Arctic OCS since the 1980s and its ongoing efforts to engage with local subsistence communities to better understand their concerns and develop appropriate and effective mitigation measures to address those concerns. This most recent version of Shell's planned mitigation measures was presented to community leaders and subsistence user groups starting in January 2009 and has evolved since in response to information learned during the consultation process.

To minimize any cultural or resource impacts from its exploration operations, Shell will continue to 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 hunt:

(1) Communications

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

• Shell will employ local SAs from the Chukchi Sea villages that are potentially impacted by Shell's exploration drilling activities. The SAs will provide consultation and guidance regarding the whale migration and subsistence activities. There will be one per village, working approximately 8-hr per day and 40-hr per week during each drilling season. The subsistence advisor will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and provide advice on ways to minimize and mitigate potential negative impacts to subsistence resources during each drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; coordinating with the Com and Call Center personnel; and advising how to avoid subsistence conflicts.

(2) Aircraft Travel

• Aircraft over land or sea shall not operate below 1,500 ft. (457 m) altitude unless engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation.

• Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft. (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers.

(3) Vessel Travel

• The drilling unit(s) and support vessels will enter the Chukchi Sea through the Bering Strait on or after 1 July, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.

• The transit route for the drilling unit(s) and drilling support fleets will avoid known fragile ecosystems and the Ledyard Bay Critical Habitat Unit (LBCHU), and will include coordination through Com Centers.

• PSOs will be aboard the drilling unit(s) and transiting support vessels.

• When within 900 ft (274 m) of whales, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.

• Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals.

• Shell will communicate and coordinate with the Com Centers regarding all vessel transit.

(4) ZVSP

• Airgun arrays will be ramped up slowly during ZVSPs to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB radius for cetaceans and 190 dB re 1 μPa rms for pinnipeds. The entire safety zone must be visible during the 30-min lead-into an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15–30 min: 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.

(5) Ice Management

• Real time ice and weather forecasting will be from SIWAC.

(6) Oil Spill Response

• Pre-booming is required for all fuel transfers between vessels.

The potentially affected subsistence communities, identified in BOEM Lease Sale, that were consulted regarding Shell's exploration drilling activities include: Barrow, Wainwright, Point Lay, Point Hope, Kotzebue, and Deering. Additionally, Shell has met with subsistence groups including the Alaska Eskimo Whaling Commission (AEWC), Inupiat Community of the Arctic Slope (ICAS), and the Native Village of Barrow, and presented information regarding the proposed activities to the North Slope Borough (NSB) and Northwest Arctic Borough (NWAB) Assemblies, and NSB and NWAB Planning Commissions during 2014. In July 2014, Shell conducted POC meetings in Chukchi villages to present information on the proposed 2015 drilling season. Shell has supplemented the IHA application with a POC addendum to incorporate these POC visits. Throughout 2014 and 2015 Shell anticipates continued engagement with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research.

Shell continues to meet each year with the commissioners and committee heads of AEWC, Alaska Beluga Whale Committee, the Nanuuq Commission, Eskimo Walrus Commission, and Ice Seal Committee jointly in co-management meetings. Shell held individual consultation meetings with representatives from the various marine mammal commissions to discuss the planned Chukchi exploration drilling program. Following the drilling season, Shell will have a post-season co-management meeting with the commissioners and committee heads to discuss results of mitigation measures and outcomes of the preceding season. The goal of the post-season meeting is to build upon the knowledge base, discuss successful or unsuccessful outcomes of mitigation measures, and possibly refine plans or mitigation measures if necessary.

Shell attended the 2012–2014 Conflict Avoidance Agreement (CAA) negotiation meetings in support of exploration drilling, offshore surveys, and future drilling plans. Shell will do the same for the upcoming 2015 exploration drilling program. Shell states that it is committed to a CAA process and will make a good-faith effort to negotiate an agreement every year it has planned activities.

Unmitigable Adverse Impact Analysis and Preliminary Determination

NMFS considers that these mitigation measures including measures to reduce overall impacts to marine mammals in the vicinity of the proposed exploration drilling area and measures to mitigate any potential adverse effects on subsistence use of marine mammals are adequate to ensure subsistence use of marine mammals in the vicinity of Shell's proposed exploration drilling program in the Chukchi Sea.

Based on the description of the specified activity, the measures described to minimize adverse effects on the availability of marine mammals for subsistence purposes, and the proposed mitigation and monitoring measures, NMFS has preliminarily determined that there will not be an unmitigable adverse impact on subsistence uses from Shell's proposed activities.

Endangered Species Act (ESA)

There are four 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, and ringed seals. 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 preparing an Environmental Assessment (EA), pursuant to NEPA, to determine whether the issuance of an IHA to Shell for its 2015 drilling activities may have a significant impact on the human environment. NMFS has released a draft of the EA for public comment along with this proposed IHA.

Proposed Authorization

As a result of these preliminary determinations, NMFS proposes to issue an IHA to Shell for conducting an exploration drilling program in the Chukchi Sea during the 2015 Arctic open-water season, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. The proposed IHA language is provided next.

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 1, 2015, through October 31, 2015.

(2) This Authorization is valid only for activities associated with Shell's 2015 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) a three-airgun array consisting of three 150 in^3 airguns, or a two-airgun array consisting of two 250 in^3 airguns;

(b) continuous drilling unit and associated dynamic positioning sounds during active drilling operations;

(c) vessel sounds generated during active ice management or icebreaking;

(d) mudline cellar construction during the exploration drilling program;

(e) anchor handling during the exploration drilling program, and

(f) aircraft associated with marine mammal monitoring and support operations,

(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 her 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 a maximum of 5 knots when within 900 ft (300 yards/274 m) of 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 900 ft (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-approved, 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 drilling units 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 (7x50 Fujinon), big-eye binoculars (25x150), and night vision devices. PSO shifts shall last no longer than 4 consecutive hours 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 PSO, 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 PSO 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 Alaska Native 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 2015 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) 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 may 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 airgun array is in operation. Before the field verification tests, described in condition 10(c)(i) below, the 180 dB radius is temporarily designated to be 1.28 km and the 190 dB radius is temporarily designated to be 255 m;

(d) Implement a ''ramp-up'' procedure when starting up at the beginning of seismic operations. 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 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:

(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 2015 bowhead whale hunt;

(e) Employ local Subsistence Advisors (SAs) from the 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;

(10) Monitoring Measures:

(a) Vessel-based Monitoring: The Holder of this Authorization shall designate biologically-trained PSOs to be aboard the drilling units and all transiting 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 units, support vessels, and the airgun array not measured in previous seasons. 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 for the airgun array shall be reported to NMFS within 5 days of completing the test.

A report of the acoustic verification measurements of the ZVSP airgun array will be submitted within 120 hr after collection and analysis of those measurements once that part of the program is implemented. The ZVSP acoustic array report will specify the distances of the exclusion zones that were adopted for the ZVSP program. Prior to completion of these measurements, Shell will use the radii in condition 8(c).

(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 airguns, the Holder shall submit a preliminary report of the results to NMFS. A report on the results of the acoustic verification measurements of the drilling units and support vessels, not recorded in previous seasons, will be reported in the 90-day report. 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) Sound source verification results for drilling units and vessels recorded in 2015;

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

(iv) 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;

(v) 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 will 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, changes are made to the monitoring program after the independent monitoring plan peer review, 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 2015.

(e) The draft comprehensive report will be subject to review and comment by NMFS, the Alaska Eskimo Whaling Commission, and the North Slope Borough 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.

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 2015 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: February 26, 2015.

Donna S. Wieting,

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

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