

**DEPARTMENT OF COMMERCE****National Oceanic and Atmospheric Administration**

RIN 0648-XW14

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

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

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

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

**DATES:** Comments and information must be received no later than June 7, 2010.

**ADDRESSES:** Comments on the application should be addressed to Michael Payne, Chief, Permits, Conservation and Education Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910. The mailbox address for providing e-mail comments is [PR1.0648-XW14@noaa.gov](mailto:PR1.0648-XW14@noaa.gov). NMFS is not responsible for e-mail comments sent to addresses other than the one provided here. Comments sent via e-mail, including all attachments, must not exceed a 10-megabyte file size.

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 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](http://www.nmfs.noaa.gov/pr/permits/incidental.htm). The following associated documents are also available at the same Internet address: Shell's 2010 Exploration Drilling Communication Plan Chukchi Sea, Alaska, and Shell's 2010 Plan of Cooperation (POC) Camden Bay, Alaska. Documents cited in this notice may also be viewed, by appointment, during regular business hours, at the aforementioned address.

**FOR FURTHER INFORMATION CONTACT:** Candace Nachman, Office of Protected Resources, NMFS, (301) 713-2289, ext 156.

**SUPPLEMENTARY INFORMATION:****Background**

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

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

Section 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the U.S. can apply for an authorization to incidentally take small numbers of marine mammals by harassment. Section 101(a)(5)(D) establishes a 45-day time limit for NMFS review of an application followed by a 30-day public notice and comment period on any proposed authorizations for the incidental harassment of marine mammals. Within 45 days of the close of the comment period, NMFS must either issue or deny the authorization.

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

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

**Summary of Request**

NMFS received an application on May 26, 2009, from Shell for the taking, by harassment, of marine mammals incidental to offshore exploration drilling on OCS leases in the Chukchi Sea, Alaska. NMFS reviewed Shell's application and identified a number of issues requiring further clarification. After addressing comments from NMFS, Shell modified its application and submitted a revised application on December 11, 2009. However, after some additional discussions regarding certain activities, NMFS determined that a second revision to the application was warranted. The latest revised application was submitted to NMFS on April 14, 2010. NMFS carefully evaluated Shell's application, including their analyses, and determined that the application is complete and that it is appropriate to make the necessary preliminary determinations pursuant to the MMPA. The April 14, 2010, application is the one available for public comment (see **ADDRESSES**) and considered by NMFS for this proposed IHA.

Shell intends to drill up to three exploration wells at five possible drill sites on seven leases at the prospects known as Burger, Crackerjack, and Southwest (SW) Shoenbill on OCS leases offshore in the Chukchi Sea, Alaska, during the 2010 Arctic open-water season (July through October). Impacts to marine mammals may occur from noise produced by the drillship and supporting vessels and aircraft. Shell has requested an authorization to take 13 marine mammal species by Level B harassment. However, the narwhal (*Monodon monoceros*) is not expected to be found in the activity area. Therefore, NMFS is proposing to authorize take of 12 marine mammal species, by Level B harassment, incidental to Shell's offshore exploration drilling in the Chukchi Sea. These species include: beluga whale (*Delphinapterus leucas*); bowhead whale (*Balaena mysticetus*); gray whale (*Eschrichtius robustus*); killer whale (*Orcinus orca*); minke whale (*Balaenoptera acutorostrata*); fin whale (*Balaenoptera physalus*); humpback whale (*Megaptera novaeangliae*); harbor porpoise (*Phocoena phocoena*); bearded

seal (*Erignathus barbatus*); ringed seal (*Phoca hispida*); spotted seal (*P. largha*); and ribbon seal (*Histiophoca fasciata*).

#### Description of the Specified Activity

Shell plans to conduct an offshore exploration drilling program on U.S. Department of the Interior, Minerals Management Service (MMS) Alaska OCS leases located greater than 60 mi (97 km) from the Chukchi Sea coast during the 2010 open-water season. The leases were acquired during the Chukchi Sea Oil and Gas Lease Sale 193 held in February 2008. During the 2010 drilling program, Shell plans to drill up to three exploration wells at five possible drill sites on seven leases at the prospects known as Burger, Crackerjack, and SW Shoebill. See Figure 1–1 in Shell's application for the lease block and drill site locations (see ADDRESSES). All drilling is planned to be vertical.

All of the possible Chukchi Sea offshore drill sites are located between 64 and 124 mi (103 and 200 km) from the Chukchi coast in water depths between 142 and 149 ft (43.3 and 45.4 m). Table 2–1 in Shell's application provides the coordinates for the drill sites (see ADDRESSES). Shell plans to commence drilling at the Burger prospect as soon as ice, weather, and other conditions allow for safe drilling operations. In the event ice and weather conditions prevent the *Discoverer* from reaching the Burger prospect, Shell intends to mobilize its exploration operations to one of the alternative drill sites in the SW Shoebill or Crackerjack prospects.

The ice reinforced drillship *Discoverer* will be used to drill the wells. The *Discoverer* is 514 ft (156.7 m) long with a maximum height (above keel) of 274 ft (83.7 m). Additional rig specifications for the *Discoverer* can be found in Attachment A of Shell's application (see ADDRESSES). While on location at the drill sites, the *Discoverer* will be affixed to the seafloor using eight 7-ton Stevpris anchors arranged in a radial array.

During the 2010 drilling season, the *Discoverer* will be attended by a minimum of seven vessels that will be used for ice-management, anchor handling, oil spill response (OSR), refueling, resupply, and servicing of the drilling operations. The ice-management vessels will consist of an icebreaker and an anchor handler. Table 1–2 in Shell's application provides a list of the support vessels that will be used during the drilling program, as well as information about trip frequency and duration for each vessel.

Primary resupply between the drill sites and logistics facilities at Dutch

Harbor will use a coastwise qualified offshore supply vessel. Some minor resupply is also planned to be conducted between the drill sites and Wainwright with a shallow water landing craft. An ice-capable OSR vessel will be dedicated to Chukchi Sea operations and remain in the vicinity of the drillship when drilling into liquid hydrocarbon zones. An OSR barge, with an associated tug, will be staged in the nearshore zone, and an OSR tanker will be staged to respond to a discharge and provide storage capability for recovered liquids, if necessary.

Shell's base plan is for the ice-management vessel, the *M/V Vladimir Ignatjuk*, and the anchor handler, the *M/V Nordica*, or similar vessels, to accompany the *Discoverer* traveling north from Dutch Harbor through the Bering Strait, on or about July 1, 2010, then into the Chukchi Sea, before arriving on location approximately July 4. Exploration drilling is expected to be complete by October 31. At the completion of the drilling season, one or two ice-management vessels, along with various support vessels, such as the OSR fleet, will accompany the *Discoverer* as it travels south out of the Chukchi Sea and through the Bering Strait to Dutch Harbor. Subject to ice conditions, alternate exit routes may be considered.

Shell plans to cease drilling on or before October 31, after which the *Discoverer* will exit the Alaskan Chukchi Sea. Shell anticipates that the exploration drilling program will require approximately 37 days per well, including mudline cellar construction. Therefore, if Shell is able to drill three exploration wells during the 2010 open-water season, it would require a total of 111 days. These estimates do not include any downtime for weather or other operational delays. Shell also assumes approximately 10 additional days will be needed for transit, drillship mobilization and mooring, drillship moves between locations, and drillship demobilization.

Activities associated with the 2010 Chukchi Sea exploration drilling program include operation of the *Discoverer*, associated support vessels, crew change support, and resupply. The *Discoverer* will remain at the location of the designated exploration drill sites except when mobilizing and demobilizing to and from the Chukchi Sea, transiting between drill sites, and temporarily moving off location if it is determined ice conditions require such a move to ensure the safety of personnel and/or the environment in accordance with Shell's Ice-management Plan (IMP). The anchor handler and OSR

vessels will remain in close proximity to the drillship during drilling operations. The ice-management vessel will generally be working upwind of the drillship from 3–25 mi (4.8–40.2 km) away. Helicopters would be used to provide support for crew change, provision resupply, and any search-and-rescue operations during the drilling season.

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

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

The ice-management/anchor handling vessels would manage the ice by deflecting any ice floes that could affect the *Discoverer* when it is drilling and would also handle the *Discoverer's* anchors during connection to and separation from the seafloor. The ice floe frequency and intensity are unpredictable and could range from no

ice to ice sufficiently dense that the fleet has insufficient capacity to continue operating, and the *Discoverer* would need to disconnect from its anchors and move off site. If ice is present, ice-management activities may be necessary in early July and towards the end of operations in late October, but it is not expected to be needed throughout the proposed drilling season. Shell has indicated that when ice is present at the drill site, ice disturbance will be limited to the minimum needed to allow drilling to continue. First-year ice will be the type most likely to be encountered. The ice-management vessels will be tasked with managing the ice so that it will flow easily around and past the *Discoverer* without building up in front of it. This type of ice is managed by the ice-management vessel continually moving back and forth across the drift line, directly up-drift of the *Discoverer* and making turns at both ends. During ice-management, the vessel's propeller is rotating at approximately 15–20 percent of the vessel's propeller rotation capacity. Ice-management occurs with slow movements of the vessel using lower power and therefore slower propeller rotation speed (*i.e.*, lower cavitation), allowing for fewer repositions of the vessel, thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice ridges that would be managed at a much slower speed than that used to manage first-year ice. Shell has indicated that they do not have any intention of breaking ice with the ice-management vessels but, rather, intend to push it out of the area as described here. Should ice become so prevalent in the drilling area that it is difficult to continue operations without the breaking of ice, Shell has indicated that they would stop operations and move off site instead of breaking ice (S. Childs, Shell, 2010, pers. comm.). Shell has indicated that ice breaking would only be conducted if the ice poses an immediate safety hazard at the drill sites.

Potential impacts to marine mammals could occur from the noise produced by the drillship and its support vessels and aircraft. The drillship produces continuous noise into the marine environment. NMFS currently uses a threshold of 120 dB re 1  $\mu$ Pa (rms) for the onset of Level B harassment from continuous sound sources. Sound measurements from the *Discoverer* have not previously been conducted in the Arctic or elsewhere; however, sounds from a similar drillship, the *Northern Explorer II*, were measured at two different times and locations in the

Beaufort Sea (Miles *et al.*, 1987; Greene, 1987a,b). In both cases, a support vessel was present in the vicinity of the drillship, thus providing an aggregate source level for modeling the combined drilling activities. The underwater received sound pressure level (SPL) in the 20–1,000 Hz band for drilling activity by the *Northern Explorer II*, including a nearby support vessel, was 134 dB re 1  $\mu$ Pa (rms) at 0.1 mi (0.2 km; Greene, 1987b). The back-propagated source levels (175 dB re 1  $\mu$ Pa at 1 m) from these measurements were used as a proxy for modeling the sounds likely to be produced by drilling activities from the *Discoverer*. NMFS has determined that the sound measurements for the *Northern Explorer II* constitute a good proxy for estimating sound radii for the *Discoverer*. Sound propagation measurements will be performed on the *Discoverer* in 2010 once on location near the Chukchi Sea drill sites. The results of those measurements will be used during the drilling season to implement proposed mitigation measures described later in this document (*see* the “Proposed Mitigation” section).

Although there will be several support vessels in the drilling operations area, NMFS considers the possibility of collisions with marine mammals highly unlikely. Once on location, the majority of the support vessels will remain in the area of the drillship throughout the 2010 drilling season and will not be making trips between the shorebase and the offshore vessels. Aircraft travel would be controlled by Federal Aviation Administration approved flight paths. Shell has agreed to a flight altitude of 1,500 ft (457 m; except during takeoffs and landings or during emergencies) to minimize impacts on marine mammals. As the crew change/resupply activities are considered part of normal vessel traffic and are not anticipated to impact marine mammals in a manner that would rise to the level of taking, those activities are not considered further in this document. Additionally, ice-management activities are not anticipated to impact marine mammals in a manner that would rise to the level of taking. This is based on the fact that the propeller rotation (*i.e.*, cavitation) will be similar to that of vessels under normal operations and will not be used at 100 percent power as is the case in other situations rising to the level of taking (*e.g.*, thruster use for dynamic positioning at terminals).

### 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 walrus (*Odobenus rosmarus divergens*; *see* Table 3–1 in Shell's application). The bowhead, humpback, and fin whales are listed as “endangered” under the Endangered Species Act (ESA) and as depleted under the MMPA. Certain stocks or populations of gray, beluga, and killer whales and spotted seals are listed as endangered or are proposed for listing under the ESA; however, none of those stocks or populations occur in the proposed activity area. Additionally, the ribbon seal is considered a “species of concern” under the ESA, and the bearded and ringed seals are “candidate species” under the ESA, meaning they are currently being considered for listing. Both the walrus and the polar bear are managed by the U.S. Fish and Wildlife Service (USFWS) and are not considered further in this proposed IHA notice.

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

document (see the “Estimated Take by Incidental Harassment” section).

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

Shell’s application contains information on the status, distribution, seasonal distribution, and abundance 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 2009 SAR is available at: <http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2009.pdf>.

### Brief Background on Marine Mammal Hearing

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

- *Low frequency cetaceans* (13 species of mysticetes): functional hearing is estimated to occur between approximately 7 Hz and 22 kHz;
- *Mid-frequency cetaceans* (32 species of dolphins, six species of larger toothed whales, and 19 species of beaked and bottlenose whales):

functional hearing is estimated to occur between approximately 150 Hz and 160 kHz;

- *High frequency cetaceans* (eight species of true porpoises, six species of river dolphins, *Kogia*, the franciscana, and four species of cephalorhynchids): functional hearing is estimated to occur between approximately 200 Hz and 180 kHz; and

- *Pinnipeds in Water*: functional hearing is estimated to occur between approximately 75 Hz and 75 kHz, with the greatest sensitivity between approximately 700 Hz and 20 kHz.

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

### Potential Effects of the Specified Activity on Marine Mammals

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

- (1) The noise may be too weak to be heard at the location of the animal (*i.e.*, lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both);
- (2) The noise may be audible but not strong enough to elicit any overt behavioral response;

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

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

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

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

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

### Drilling Sounds

Exploratory drilling will be conducted from a vessel specifically designed for such operations in the Arctic. Underwater sound propagation results from the use of generators, drilling machinery, and the rig itself. Received sound levels during vessel-based operations may fluctuate depending on the specific type of activity at a given

time and aspect from the vessel. Underwater sound levels may also depend on the specific equipment in operation. Lower sound levels have been reported during well logging than during drilling operations (Greene, 1987b), and underwater sound appeared to be lower at the bow and stern aspects than at the beam (Greene, 1987a).

Most drilling sounds generated from vessel-based operations occur at relatively low frequencies below 600 Hz although tones up to 1,850 Hz were recorded by Greene (1987a) during drilling operations in the Beaufort Sea. At a range of 558 ft (170 m) the 20–1000 Hz band level was 122–125 dB for the drillship *Explorer I*. Underwater sound levels were slightly higher (134 dB) during drilling activity from the *Northern Explorer II* at a range of 656 ft (200 m), although tones were only recorded below 600 Hz. Underwater sound measurements from the *Kulluk* at 0.62 mi (1 km) were higher (143 dB) than from the other two vessels. Shell used the measurements from the *Northern Explorer II* to model the various sound radii (which are discussed later in this document) for the *Discoverer*. Once on location at the drill sites in the Chukchi Sea, Shell plans to take measurements of the *Discoverer* to quantify the absolute sound levels produced by drilling and to monitor their variations with time, distance, and direction from the drillship. Based on the similarities of the two drillships, NMFS has preliminarily determined that the radii produced by the *Discoverer* would be similar to those recorded for the *Northern Explorer II*.

#### Vessel Sounds

In addition to the drillship, various types of vessels will be used in support of the operations, including ice-management vessels, anchor handlers, and oil-spill response vessels. Sounds from boats and vessels have been reported extensively (Greene and Moore, 1995; Blackwell and Greene, 2002, 2005, 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort seas. Results of these measurements were reported in various 90-day and comprehensive reports since 2007 (e.g., Aerts *et al.*, 2008; Hauser *et al.*, 2008; Brueggeman, 2009; Ireland *et al.*, 2009). For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB at distances ranging from approximately 1.5 to 2.3 mi (2.4 to 3.7 km) from various types of barges. MacDonald *et al.* (2008) estimated higher underwater SPLs from the seismic vessel *Gilavar* of

120 dB at approximately 13 mi (21 km) from the source, although the sound level was only 150 dB at 85 ft (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies.

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross, 1976). Propeller cavitation and singing are produced outside the hull, whereas propulsion or other machinery noise originates inside the hull. There are additional sounds produced by vessel activity, such as pumps, generators, flow noise from water passing over the hull, and bubbles breaking in the wake. Icebreakers contribute greater sound levels during 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.

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

#### Aircraft Sound

Helicopters may be used for personnel and equipment transport to and from the drillship, as well as any search-and-rescue operations that may be necessary. Under calm conditions, rotor and engine sounds are coupled into the water within a 26° cone beneath the aircraft. Some of the sound will transmit beyond

the immediate area, and some sound will enter the water outside the 26° area when the sea surface is rough. However, scattering and absorption will limit lateral propagation in the shallow water.

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

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

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drillship will generally maintain straight-line routes at altitudes of at least 1,000 ft (305 m), thereby limiting the received levels at and below the surface.

#### 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). 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).

#### Masking

The term “masking” refers to the obscuring of sounds of interest by interfering sounds, generally at similar frequencies. Masking effects of underwater sounds 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](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. For example, bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced (Richardson *et al.*, 1986; Greene *et al.*, 1999; Blackwell *et al.*, 2009). Additionally, 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 nearly 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 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).

Cummings *et al.* (1984) subjected breeding ringed seals to recordings of industrial sounds. The authors did not document any impacts to ringed seal vocalizations as a result of exposure to the recordings.

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. If, as described later in this document, certain species avoid the proposed drilling locations, impacts from masking will be low.

#### Behavioral Disturbance Reactions

Behavioral responses to sound are highly variable and context-specific. Many different variables can influence an animal’s perception of and response to (in both nature and magnitude) an acoustic event. An animal’s prior experience with a sound or sound source affects whether it is less likely (habituation) or more likely (sensitization) to respond to certain sounds in the future (animals can also be innately pre-disposed to respond to certain sounds in certain ways; Southall

*et al.*, 2007). Related to the sound itself, the perceived nearness of the sound, bearing of the sound (*approaching* vs. *retreating*), similarity of a sound to biologically relevant sounds in the animal’s environment (*i.e.*, calls of predators, prey, or conspecifics), and familiarity of the sound may affect the way an animal responds to the sound (Southall *et al.*, 2007). Individuals (of different age, gender, reproductive status, *etc.*) among most populations will have variable hearing capabilities and differing behavioral sensitivities to sounds that will be affected by prior conditioning, experience, and current activities of those individuals. Often, specific acoustic features of the sound and contextual variables (*i.e.*, proximity, duration, or recurrence of the sound or the current behavior that the marine mammal is engaged in or its prior experience), as well as entirely separate factors such as the physical presence of a nearby vessel, may be more relevant to the animal’s response than the received level alone.

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

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

mammal species to sound and the wide range of potential acoustic sources to which a marine mammal may be exposed.

**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).

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 ice breaking 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 other sightings were at much greater distances. Few bowheads were recorded near industrial activities by aerial observers, but observations by surface observers suggested that 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 whale reactions resulted from exposure to helicopter activity and little response to fixed-wing aircraft was observed. Most reactions occurred when the helicopter was at altitudes  $\leq 492$  ft (150 m) and lateral distances  $\leq 820$  ft (250 m; Nowacek *et al.*, 2007). Restriction 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  $\mu$ Pa (rms). Probability of avoidance and other behavioral effects increased when received levels were from 120–160 dB re 1  $\mu$ Pa (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 percent, 50 percent, and 90 percent 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 percent 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  $\mu$ Pa (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 Pt. Barrow in spring.

At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson *et al.*, 1995b). Received levels from the icebreaker playback were estimated at 78–84 dB in the  $\frac{1}{3}$ -

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. However, while the *Vladimir Ignatjuk* (an icebreaker) is anticipated to be one of the vessels attending the *Discoverer*, it will only be conducting ice-management activities (which were described in the "Description of the Specified Activity" section earlier in this document) and not physical breaking of ice. Thus, NMFS does not anticipate that marine mammals would exhibit the types of behavioral reactions as those noted in the aforementioned studies.

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  $\leq 820$  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 to 120 dB, while others failed to exhibit such responses for exposure to received levels from 120 to 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 ice-breaking ships. Beluga whales responded to oncoming vessels by (1) fleeing at speeds of up to 12.4 mi/hr (20 km/hr) from distances of 12.4–50 mi (20–80 km), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a "freeze" response, lying motionless or swimming slowly away (as far as 23 mi [37 km] down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

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

Observations during 1983 (LGL and Greeneridge, 1986) involved two ice-breaking 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 ice-breaking 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.

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 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").

Harbor porpoise off Vancouver Island, British Columbia, were found to be sensitive to the simulated sound of a 2-megawatt offshore wind turbine (Koschinski *et al.*, 2003). The porpoises remained significantly further away from the sound source when it was active, and this effect was seen out to a distance of 60 m (197 ft). The device used in that study produced sounds in the frequency range of 30 to 800 Hz, with peak source levels of 128 dB re 1  $\mu$ Pa at 1 m at the 80- and 160-Hz frequencies.

Kastelein *et al.* (2005) exposed two captive harbor porpoise (a high-frequency cetacean) to various non-pulse sounds in an approximately 111.5  $\times$  65.6 ft (34  $\times$  20 m) enclosure. The frequency range of the four test sounds fell into the  $\frac{1}{3}$ -octave bands 8, 10, 12.5, and 16 kHz, with a source level range of 116 to 130 [plus or minus 3] dB, depending on the sound source. Each session lasted for 30 minutes (15-min period of baseline [no sound emission] followed immediately by 15-min test period [sound emission]). The researchers measured the distance between the underwater transducer and the surfacing area of the porpoises to determine the deterrent effect and the number of respirations during the session to determine the level of agitation of the animals. Kastelein *et al.* (2005) found that one porpoise was displaced between 29.5 and 42.7 ft (9 and 13 m), and the other one was displaced between 16.4 and 32.8 ft (5 and 10 m). Additionally, the researchers found that both animals surfaced more during test periods than during baseline periods. The porpoises were not reinforced with food for remaining in the sound field. It should be noted, however, that the sounds used in this study produce frequencies much higher than those that will be produced by the drillship proposed to be used by Shell for this program.

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).

Responses of pinnipeds to drilling noise have not been well studied. Richardson *et al.* (1995) summarizes the few available studies, which showed ringed and bearded seals in the Arctic to be rather tolerant of drilling noise. Seals were often seen near active drillships and approached, to within 50 m (164 ft), a sound projector broadcasting low-frequency drilling sound.

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 <1.9 mi (3 km) 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.

Reactions of harbor seals to the simulated noise of a 2-megawatt wind power generator were measured by Koschinski *et al.* (2003). Harbor seals surfaced significantly further away from the sound source when it was active and did not approach the sound source as closely. The device used in that study produced sounds in the frequency range of 30 to 800 Hz, with peak source levels of 128 dB re 1  $\mu$ Pa at 1 m at the 80- and 160-Hz frequencies.

#### *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. The following subsections discuss in somewhat more detail the possibilities of TTS, permanent threshold shift (PTS), and non-auditory 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. 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.

Human non-impulsive noise exposure guidelines are based on exposures of equal energy (the same sound exposure level [SEL]) producing equal amounts of hearing impairment regardless of how the sound energy is distributed in time (NIOSH, 1998). Until recently, previous marine mammal TTS studies have also generally supported this equal energy relationship (Southall *et al.*, 2007). Three newer studies, two by Mooney *et al.* (2009a,b) on a single bottlenose dolphin either exposed to playbacks of U.S. Navy mid-frequency active sonar or octave-band noise (4–8 kHz) and one by Kastak *et al.* (2007) on a single California sea lion exposed to airborne octave-band noise (centered at 2.5 kHz), concluded that for all noise exposure situations the equal energy relationship may not be the best indicator to predict TTS onset levels. Generally, with sound exposures of equal energy, those that were quieter (lower SPL) with longer duration were found to induce TTS onset more than those of louder (higher SPL) and shorter duration. Given the available data, the received level of a single seismic pulse (with no frequency weighting) might need to be approximately 186 dB re 1  $\mu$ Pa<sup>2</sup>-s (*i.e.*, 186 dB SEL) in order to produce brief, mild TTS. Exposure to several strong seismic pulses that each have received levels near 175–180 dB SEL might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. Given that the SPL is approximately 10–15 dB higher than the SEL value for the same pulse, an odontocete would need to be exposed to a sound level of 190 dB re 1  $\mu$ Pa (rms) in order to incur TTS.

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 lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. Marine mammals can hear sounds at varying frequency levels. However, sounds that are produced in the frequency range at which an animal hears the best do not need to be as loud as sounds in less functional frequencies to be detected by the animal. 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. Since current NMFS practice assumes the same thresholds for the onset of hearing impairment in both odontocetes and mysticetes, the threshold is likely conservative for mysticetes.

In free-ranging 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). Kastak *et al.* (1999) reported TTS of approximately 4–5 dB in three species of pinnipeds (harbor seal, Californian sea lion, and northern elephant seal) after underwater exposure for approximately 20 minutes to noise with frequencies ranging from 100 Hz to 2,000 Hz at received levels 60–75 dB above hearing threshold. This approach allowed similar effective exposure conditions to each of the subjects, but resulted in variable absolute exposure values depending on subject and test frequency. Recovery to near baseline levels was reported within 24 hours of noise exposure (Kastak *et al.*, 1999). Kastak *et al.* (2005) followed up on their previous work using higher sensitive levels and longer exposure times (up to 50-min) and corroborated their previous findings. The sound exposures necessary to cause slight threshold shifts were also determined for two California sea lions and a juvenile elephant seal exposed to underwater sound for similar duration. 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  $\mu\text{Pa}^2\text{-s}$ ; Bowles *et al.*, unpub. data).

NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1  $\mu\text{Pa}$  (rms). The established 180- and 190-dB re 1  $\mu\text{Pa}$

(rms) criteria are not considered to be the levels above which TTS might occur. Rather, they are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. Based on the summary provided here and the fact that modeling indicates the back-propagated source level for the drillship to be 175 dB re 1  $\mu\text{Pa}$  at 1 m, 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.

**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.

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. 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. PTS might occur at a received sound level at least several decibels above that inducing mild TTS.

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause PTS during the proposed exploratory drilling program. As mentioned previously in this document, the source levels of the drillship are not considered strong enough to cause even slight TTS. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, based on the modeled source levels for the drillship, the levels immediately adjacent to the drillship may not be sufficient to induce PTS, even if the animals remain in the immediate vicinity of the activity. The modeled source level from a similar drillship (*i.e.*, the *Northern Explorer II*) suggests that marine mammals located immediately adjacent to a drillship such as the *Discoverer* 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.

**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. 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.

Until recently, it was assumed that diving marine mammals are not subject to the bends or air embolism. This possibility was first explored at a workshop (Gentry [ed.], 2002) held to discuss whether the stranding of beaked whales in the Bahamas in 2000 (Balcomb and Claridge, 2001; NOAA and USN, 2001) might have been related to bubble formation in tissues caused by exposure to noise from naval sonar. However, the opinions were inconclusive. Jepson *et al.* (2003) first suggested a possible link between mid-frequency sonar activity and acute and chronic tissue damage that results from the formation in vivo of gas bubbles, based on the beaked whale stranding in the Canary Islands in 2002 during naval exercises. Fernandez *et al.* (2005a) showed those beaked whales did indeed have gas bubble-associated lesions as well as fat embolisms. Fernandez *et al.* (2005b) also found evidence of fat embolism in three beaked whales that stranded 62 mi (100 km) north of the Canaries in 2004 during naval exercises. Examinations of several other stranded species have also revealed evidence of gas and fat embolisms (Arbelo *et al.*, 2005; Jepson *et al.*, 2005a; Mendez *et al.*, 2005). Most of the afflicted species were deep divers. There is speculation that gas and fat embolisms may occur if cetaceans ascend unusually quickly when exposed to aversive sounds or if sound in the environment causes the destabilization of existing bubble nuclei (Potter, 2004; Arbelo *et al.*, 2005; Fernandez *et al.*, 2005a; Jepson *et al.*, 2005b). Even if gas and fat embolisms can occur during exposure to mid-frequency sonar, there is no evidence that that type of effect occurs in response to the types of sound produced during the proposed exploratory activities. Also, most evidence for such

effects has been in beaked whales, which do not occur in the proposed survey area.

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

#### *Stranding and Mortality*

Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten *et al.*, 1993; Ketten, 1995). Underwater sound from drilling and support activities is less energetic and has slower rise times, and there is no proof that they can cause serious injury, death, or stranding. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a Lamont-Doherty Earth Observatory seismic survey, 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. The potential for stranding to result from exposure to strong pulsed sound suggests that caution be used when exposing marine mammals to pulsed or other underwater sound. Most of the stranding events associated with exposure of marine mammals to pulsed sound however, have involved beaked whales which do not occur in the proposed area. Additionally, the sound produced from the proposed activities will be at much lower levels than those reported during stranding events, as the source levels of the drillship are much lower than those other sources. Pulsed sounds, such as those produced by seismic airgun arrays, are transient and have rapid rise times, whereas the non-impulsive, continuous sounds produced by the drillship to be used by Shell do not have a rapid rise time. 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.

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 Habitat*

The primary potential impacts to marine mammals and other marine species are associated with elevated sound levels produced by the exploratory drilling program. However, other potential impacts to the surrounding habitat from physical disturbance are also possible.

#### *Potential Impacts From Seafloor Disturbance*

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

Both the anchor and anchor chain will disturb sediments and create an “anchor scar,” which is a depression in the seafloor caused by the anchor embedding. The anchor scar is a depression with ridges of displaced sediment, and the area of disturbance will often be greater than the size of the anchor itself because the anchor is dragged along the seafloor until it takes hold and sets. The drilling units will be stabilized and held in place with a system of eight 15,432 lbs (7,000 kg) anchors during operations, which are designed to embed into the seafloor. The area of seafloor that would be impacted by the setting of an anchor varies, but, on average, each anchor may impact an area of 2,124 ft<sup>2</sup> (197 m<sup>2</sup>) of the seafloor, including the scar made when the anchor chain is dragged across the seafloor. Assuming eight anchors will be set for each well, mooring the *Discoverer* at three drill sites would disturb approximately 1.2 acres (4,736 m<sup>2</sup>) of seafloor. This estimate assumes that the anchors are set only once and not moved by outside forces such as sea current. However, based on the vast size of the Chukchi Sea, the area of disturbance is not anticipated to adversely affect marine mammal use of the area.

Once the drillship ends operation, the anchors will be retrieved. Over time, the anchor scars will be filled through natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type. Anchor scars were visible under low energy conditions in the North Sea for 5–10 years after retrieval. Centaur Associates, Inc. (1984) reported that anchoring in sand or muddy sand sediments may not

result in anchor scars or may result in scars that do not persist. Shallow hazards and geotechnical surveys conducted at the historic Burger, Crackerjack, and Tourmaline prospects indicate the surficial sediments in Shell’s Burger, Crackerjack, and SW Shoebill prospects consist of fine materials (clays and silts), which are reworked by currents, storms, and ice gouging. The physical effects of MLCs and anchor scars are expected to be obscured within 5–10 years.

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

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

Most diadromous fish species expected to be present in the area of Shell’s drilling operations lay their eggs in freshwater or coastal estuaries. Therefore, only those eggs carried into the marine environment by winds and current would be affected by these operations. Because Shell’s proposed

drill sites occur 64 and 124 mi (103 and 200 km) from the Chukchi coast, the statistical probability of diadromous fish eggs being present in the vicinity of Shell's proposed operations is infinitesimally small. Thus, impacts on diadromous fish eggs due to abrasion, puncture, burial, or other effects associated with anchoring or MLC construction would be slight. Further, since most diadromous fish species produce eggs prolifically, even if a small number of eggs were impacted by these activities, the total species population would not be expected to be impacted.

Suspended sediments, resulting from vessel mooring and MLC excavation, are not expected to result in permanent damage to habitats used by the marine mammal species in the proposed project area or on the food sources that they utilize. Rather, NMFS considers that such impacts will be temporary in nature and concentrated in the areas directly surrounding vessel mooring and MLC excavation activities—areas which are very small relative to the overall Chukchi Sea region. Less than 0.000001 percent of the fish habitat in the LS 193 area would be directly affected by the mooring and excavation activity.

#### *Potential Impacts From Sound Generation*

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

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

Investigations of fish behavior in relation to vessel noise (Olsen *et al.*, 1983; Ona, 1988; Ona and Godo, 1990) have shown that fish react when the sound from the engines and propeller exceeds a certain level. Avoidance reactions have been observed in fish such as cod and herring when vessels approached close enough that received sound levels are 110 dB to 130 dB (Nakken, 1992; Olsen, 1979; Ona and Godo, 1990; Ona and Toresen, 1988). However, other researchers have found that fish such as polar cod, herring, and capeline are often attracted to vessels (apparently by the noise) and swim toward the vessel (Rostad *et al.*, 2006). Typical sound source levels of vessel noise in the audible range for fish are 150 dB to 170 dB (Richardson *et al.*, 1995a). (Based on measurements from the *Northern Explorer II*, the 160 dB radius for the *Discoverer* was modeled by JASCO to be approximately 115 ft [35 m]; therefore, fish would need to be in close proximity to the drillship for the noise to be audible). In calm weather, ambient noise levels in audible parts of the spectrum lie between 60 dB to 100 dB.

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

Based on a sound level of approximately 140 dB, there may be some avoidance by fish of the area near the drillship while drilling, around ice-management vessels in transit and during ice-management, and around other support and supply vessels when underway. Any reactions by fish to these sounds will last only minutes (Mitson and Knudsen, 2003; Ona *et al.*, 2007) longer than the vessel is operating at that location or the drillship is drilling. Any potential reactions by fish would be limited to a relatively small area within about 0.9 mi (1.4 km) of the drillship during drilling based on the modeled 120-dB isopleth. Avoidance by some fish or fish species could occur within portions of this area. No important spawning habitats are known to occur at or near the drilling locations.

Additionally, impacts to fish as a prey species for odontocetes and seals are expected to be minor.

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

Gray whales are bottom feeders and suck sediment and the benthic amphipods that are their prey from the seafloor. The species primary feeding habitats are in the northern Bering Sea and Chukchi Sea (Nerini, 1984; Moore *et al.*, 1986; Weller *et al.*, 1999). In the northeastern Chukchi Sea, gray whales can be found feeding in the shallow offshore water area known as Hanna Shoals, which is located approximately 25 mi (40 km) northeast from the proposed drill sites. This area lies outside of the 120-dB ensounded zone for all of Shell's proposed Chukchi Sea drill sites. While some gray whales may migrate past or through Shell's proposed drill sites, no impacts to gray whales feeding at Hanna Shoal are anticipated based on the distance from the proposed activity and the area of the ensounded zone. Additionally, Yazvenko *et al.* (2007) studied the impacts of seismic surveys off Sakhalin Island, Russia, on feeding gray whales and found that the seismic activity had no measurable effect on bottom feeding gray whales in the area.

#### *Potential Impacts From Drillship Presence*

The *Discoverer* is 514 ft (156.7 m) long. If an animal's swim path is directly perpendicular to the drillship, the animal will need to swim around the ship in order to pass through the area. The length of the drillship (approximately one and a half football fields) is not significant enough to cause a large-scale diversion from the animals' normal swim and migratory paths.

Additionally, the eastward spring bowhead whale migration will occur prior to the beginning of Shell's proposed exploratory drilling program. Moreover, any deflection of bowhead whales or other marine mammal species due to the physical presence of the drillship or its support vessels would be very minor. The drillship's physical footprint is small relative to the size of the geographic region it will occupy and will likely not cause marine mammals to deflect greatly from their typical migratory route. Also, even if animals may deflect because of the presence of the drillship, the Chukchi Sea is much larger in size than the length of the drillship (many dozens to hundreds of miles vs. less than two football fields), and animals would have other means of passage around the drillship. In sum, the physical presence of the drillship is not likely to cause a significant deflection to migrating marine mammals.

#### *Potential Impacts From Ice-management*

Ice-management activities include the physical pushing or moving of ice to create more open-water in the proposed drilling area and to prevent ice floes from striking the drillship. Ringed, bearded, spotted, and ribbon seals (along with the walrus) are dependent on sea ice for at least part of their life history. Sea ice is important for life functions such as resting, breeding, and molting. These species are dependent on two different types of ice: Pack ice and landfast ice. Should ice-management activities be necessary during the proposed drilling program, Shell would only manage pack ice in either early to mid-July or mid- to late October. Landfast ice would not be present during Shell's proposed operations.

The ringed seal is the most common pinniped species in the proposed project area. While ringed seals use ice year-round, they do not construct lairs for pupping until late winter/early spring on the landfast ice. Therefore, since Shell plans to conclude drilling on October 31, Shell's activities would not impact ringed seal lairs or habitat needed for breeding and pupping in the Chukchi Sea. Aerial surveys in the eastern Chukchi Sea conducted in late May–early June 1999–2000 found that ringed seals were four to ten times more abundant in nearshore fast and pack ice environments than in offshore pack ice (Bengtson *et al.*, 2005). Ringed seals can be found on the pack ice surface in the late spring and early summer in the northern Chukchi Sea, the latter part of which may overlap with the start of Shell's proposed drilling activities. If an

ice floe is pushed into one that contains hauled out seals, the animals may become startled and enter the water when the two ice floes collide. Bearded seals breed in the Bering and Chukchi Seas from mid-March through early May (several months prior to the start of Shell's operations). Bearded seals require sea ice for molting during the late spring and summer period. Because this species feeds on benthic prey, bearded seals occur over the pack ice front over the Chukchi Sea shelf in summer (Burns and Frost, 1979) but were not associated with the ice front when it receded over deep water (Kingsley *et al.*, 1985). The spotted seal does not breed in the Chukchi Sea. Spotted seals molt most intensely during May and June and then move to the coast after the sea ice has melted. Ribbon seals are not known to breed in the Chukchi Sea. From July–October, when sea ice is absent, the ribbon seal is entirely pelagic, and its distribution is not well known (Burns, 1981; Popov, 1982). Therefore, ice used by bearded, spotted, and ribbon seals needed for life functions such as breeding and molting would not be impacted as a result of Shell's drilling program since these life functions do not occur in the proposed project area or occur prior to the start of Shell's operations. For ringed seals, ice-management would occur during a time when life functions such as breeding, pupping, and molting do not occur in the proposed activity area. Additionally, these life functions normally occur on landfast ice, which will not be impacted by Shell's activity.

In conclusion, NMFS has preliminarily determined that Shell's proposed exploration drilling program in the Chukchi Sea, Alaska, is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or on the food sources that they utilize.

#### **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).

#### *Mitigation Measures Proposed in Shell's IHA Application*

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

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

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

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

Initial safety and behavioral radii for the sound levels produced by the drilling activities have been modeled. These radii will be used for mitigation purposes, should they be necessary,

until direct measurements are available early during the exploration activities. However, it is not anticipated that source levels from the *Discoverer* will reach the 180- or 190-dB (rms) levels.

Sounds from the *Discoverer* have not previously been measured in the Arctic or elsewhere, but sounds from a similar drillship, *Explorer II*, were measured in the Beaufort Sea (Greene, 1987; Miles *et al.*, 1987). The underwater received SPL in the 20 to 1,000 Hz band for drilling activity by the *Explorer II*, including a nearby support vessel, was 134 dB re 1  $\mu$ Pa (rms) at 0.1 mi (0.2 km; Greene 1987). The back-propagated source levels (175 dB re 1  $\mu$ Pa at 1 m) from these measurements were used as a proxy for modeling the sounds likely to be produced by drilling activities from the *Discoverer*. Based on the models, source levels from drilling are not expected to reach the 180-dB (rms) level and are expected to fall below 160 dB rms at 328 ft (100 m) from the drillship. The 120-dB (rms) radius is expected to be 0.85 mi (1.36 km) from the drillship at the Burger prospect, 0.35 mi (0.57 km) at the SW Shoebill prospect, and 0.37 mi (0.59 km) at the Crackerjack prospect. These estimated source measurements were used to model the expected sounds produced at the exploratory well sites by the *Discoverer*.

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

are described in the “Proposed Monitoring and Reporting” section found later in this document.

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 drillship. Once on location in the Chukchi Sea, Shell will conduct sound source verification (SSV) tests to establish safety zones for the previously mentioned sound level criteria. The objectives of the SSV tests are: (1) To quantify the absolute sound levels produced by drilling and to monitor their variations with time, distance, and direction from the drillship; and (2) to measure the sound levels produced by vessels operating in support of drilling operations, which include crew change vessels, tugs, ice-management vessels, and spill response vessels. The methodology for conducting the SSV tests is fully described in Shell’s 4MP (*see ADDRESSES*). Please refer to that document for further details. Upon completion of the SSV tests, the new radii will be established and monitored, and mitigation measures will be implemented in accordance with Shell’s 4MP.

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

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

#### *Additional Mitigation Measures Proposed by NMFS*

In addition to the mitigation measures proposed in Shell’s IHA application, NMFS proposes the following measures to be included in the IHA, if issued, in order to ensure the least practicable impact on the affected species or stocks:

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

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

(3) 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.

#### *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.

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 mammal species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

#### **Proposed Monitoring and Reporting**

In order to issue an ITA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must, where applicable, set forth “requirements pertaining to the monitoring and reporting of such taking”. The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for ITAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on



populations of marine mammals that are expected to be present in the proposed action area.

#### *Monitoring Measures Proposed in Shell's IHA Application*

The monitoring plan proposed by Shell can be found in the 4MP (Attachment B of Shell's application; see **ADDRESSES**). The plan may be modified or supplemented based on comments or new information received from the public during the public comment period or from the peer review panel (see the "Monitoring Plan Peer Review" section later in this document). A summary of the primary components of the plan follows.

##### (1) Vessel-Based MMOs

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

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

MMOs will watch for marine mammals from the best available vantage point on the drillship and support vessels. MMOs will scan systematically with the unaided eye and

7 x 50 reticle binoculars, supplemented with "Big-eye" binoculars and night-vision equipment when needed. Personnel on the bridge will assist the MMOs in watching for marine mammals.

Information to be recorded by MMOs will include the same types of information that were recorded during recent monitoring programs associated with industry activity in the Arctic (e.g., Ireland *et al.*, 2009). When a mammal sighting is made, the following information about the sighting will be recorded:

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

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

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

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

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7 x 50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. MMOs may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water.

However, previous experience showed that a Class 1 eye-safe device was not able to measure distances to seals more than about 230 ft (70 m) away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 1,968 ft (600 m)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. Humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about  $\pm 20$  percent when given immediate feedback about actual distances during training.

##### (2) Aerial Survey Program

Recent aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 mi (37 km) offshore in

2006–2008 in support of Shell's summer seismic exploration activities. These surveys were designed to provide data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell proposes to conduct an aerial survey program in the Chukchi Sea in 2010 that would be similar to the 2006–2008 program.

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. Shell's objectives for this program include:

(A) To address data deficiencies in the distribution and abundance of marine mammals in coastal areas of the eastern Chukchi Sea; and

(B) To collect and report data on the distribution, numbers, orientation and behavior of marine mammals, particularly beluga whales, near traditional hunting areas in the eastern Chukchi Sea.

With agreement from hunters in the coastal villages, aerial surveys of coastal areas to approximately 23 mi (37 km) offshore between Point Hope and Point Barrow will begin in early to mid-July and will continue until drilling operations in the Chukchi Sea are completed. Weather and equipment permitting, surveys will be conducted twice per week during this time period. In addition, during the 2010 drilling season, aerial surveys will be coordinated in cooperation with the aerial surveys funded by MMS and conducted by NMFS and any other groups conducting surveys in the region. A full description of Shell's survey procedures can be found in the 4MP of Shell's application (see **ADDRESSES**). A summary follows next.

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

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

Three MMOs will be aboard the aircraft during surveys. Two observers will be looking for marine mammals within 1.6 mi (2.5 km) of the survey track line; one each at bubble windows on either side of the aircraft. The third person will record data. When sightings are made, observers will notify the data recorder of the species or species class of the animal(s) sighted, the number of animals present, and the lateral distance (inclination angle) of the animals from the flight path of the aircraft. Data on location and conditions will also be recorded.

### (3) Acoustic Monitoring

As discussed earlier in this document, Shell will conduct SSV tests to establish the isopleths for the applicable safety radii. In addition, Shell proposes to use an acoustic "net" array to accomplish two main objectives:

(A) To collect information on the occurrence and distribution of marine mammals that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns; and  
(B) To measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sound from industry and other activities further offshore in the Chukchi Sea.

The net array configuration used in 2007–2009 is again proposed for 2010. The basic components of this effort consist of 30 hydrophone systems placed widely across the U.S. Chukchi

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

The regional acoustic monitoring program will be augmented in 2010 by an array of 12 additional acoustic recorders to be deployed on a grid pattern over a 7.2 mi (12 km) by 10.8 mi (18 km) area extending over several of Shell's lease blocks near locations of highest interest for drilling in 2010. The cluster array will operate at a sampling frequency of 16 kHz, which is sufficient to capture vocalizations from bowhead, beluga, gray, fin, humpback, and killer whales, walrus, and most other marine mammals known to be present in the Chukchi Sea. The cluster deployment configuration was defined to allow tracking of vocalizing animals that pass through the immediate area of these lease blocks. Maximum separation between adjacent recorders is 3.6 mi (5.8 km). At this spacing, Shell expects that individual whale calls will be detected on at least three different recorders when the calling animals are within the boundary of the deployment pattern. Bowhead and other mysticete calls should be detectable simultaneously on more than three recorders due to their relatively higher sound source levels compared to other marine mammals. In calm weather conditions, when ambient underwater sound levels are low, Shell expects to detect most other marine mammal calls on more than three recorders. The goal of simultaneous detection on multiple recorders is to allow for triangulation of the call positions, which also requires accurate time synchronization of the recorders. When small numbers of whales are vocalizing, Shell hopes to be able to identify and track the movements of specific individuals within the deployment area. It will not be possible to track individual whales if many whales are calling due to abundant overlapping calls. In this case, analyses will show the general distribution of calls in the vicinity of the recorders.

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

### Monitoring Plan Peer Review

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

NMFS convened an independent peer review panel to review Shell's 4MP for Exploration Drilling of Selected Lease Areas in the Alaskan Chukchi Sea in 2010. The panel met in late March 2010, and provided comments to NMFS in late April 2010. NMFS will consider all recommendations made by the panel, incorporate appropriate changes into the monitoring requirements of the IHA (if issued), and publish the panel's findings and recommendations in the final IHA notice of issuance or denial document.

### Reporting Measures

#### (1) SSV Report

A report on the preliminary results of the acoustic verification measurements, including as a minimum the measured 190-, 180-, 160-, and 120-dB (rms) radii, if source levels are high enough for all of these radii to be reached, of the drillship and the support vessels, will be submitted within 120 hr after collection and analysis of those measurements at the start of the field season. This report will specify the distances of the safety zones that were adopted for the exploratory drilling program.

#### (2) Technical Reports

The results of Shell's 2010 offshore Chukchi Sea exploratory drilling monitoring program (*i.e.*, vessel-based, aerial, and acoustic) will be presented in the "90-day" and Final Technical reports, as required by NMFS under IHAs. Shell proposes that the Technical Reports will include: (1) Summaries of monitoring effort (*e.g.*, total hours, total distances, and marine mammal distribution through study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals); (2)

analyses of the effects of various factors influencing detectability of marine mammals (e.g., sea state, number of observers, and fog/glare); (3) species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover; (4) sighting rates of marine mammals during periods with and without drilling activities (and other variables that could affect detectability); (5) initial sighting distances versus drilling state; (6) closest point of approach versus drilling state; (7) observed behaviors and types of movements versus drilling state; (8) numbers of sightings/individuals seen versus drilling state; (9) distribution around the drillship and support vessels versus drilling state; and (10) estimates of take by harassment. This information will be reported for both the vessel-based and aerial monitoring.

Analysis of all acoustic data will be prioritized to address the primary questions, which are to: (a) Determine when, where, and what species of animals are acoustically detected on each 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 noise; and (d) measure received levels of drillship 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 exploratory drilling program. The "90-day" report will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final report prior to acceptance by NMFS.

### (3) Comprehensive Report

In November, 2007, Shell (in coordination and cooperation with other Arctic seismic IHA holders) released a final, peer-reviewed edition of the 2006 Joint Monitoring Program in the Chukchi and Beaufort Seas, July–November 2006 (LGL, 2007). This report is available on the NMFS Protected Resources Web site (see ADDRESSES). In March, 2009, Shell released a final, peer-reviewed edition of the Joint Monitoring Program in the Chukchi and Beaufort Seas, Open Water Seasons, 2006–2007 (Ireland *et al.*, 2009). This

report is also available on the NMFS Protected Resources Web site (see ADDRESSES). A draft of the final comprehensive report for 2008 (Funk *et al.*, 2009), which incorporated comments from several agencies, was provided to NMFS and other government agencies in March 2010. The 2008 report provides data and analyses from a number of industry monitoring and research studies carried out in the Chukchi and Beaufort Seas during the 2008 open-water season with comparison to data collected in 2006 and 2007. Once Shell is able to incorporate reviewer comments, the final 2008 report will be made available to the public. The 2009 draft comprehensive report is due to NMFS by mid-April 2010. NMFS will make this report available to the public upon receipt.

Following the 2010 drilling season a comprehensive report describing the vessel-based, aerial, and acoustic monitoring programs will be prepared. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of industry activities, and other activities that occur in the Beaufort and/or Chukchi seas, and their impacts on marine mammals during 2010. The report will help to establish long-term data sets that can assist with the evaluation of changes in the Chukchi and Beaufort Sea ecosystems. The report will attempt to provide a regional synthesis of available data on industry activity in offshore areas of northern Alaska that may influence marine mammal density, distribution and behavior. The comprehensive report will be due to NMFS within 240 days of the date of issuance of the IHA (if issued).

### (4) Notification of Injured or Dead Marine Mammals

Shell will notify NMFS' Office of Protected Resources and NMFS' Stranding Network within 48 hours of sighting an injured or dead marine mammal in the vicinity of drilling operations. 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).

In the event that an injured or dead marine mammal is found by Shell that is not in the vicinity of the proposed drilling program, Shell will report the

same information listed above to NMFS as soon as operationally feasible.

### 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. Anticipated impacts to marine mammals are associated with noise propagation from the drillship and associated support vessels. Additional disturbance to marine mammals may result from aircraft overflights and visual disturbance of the drillship or support vessels. However, based on the flight paths and altitude, impacts from aircraft operations are anticipated to be localized and minimal in nature.

The full suite of potential impacts to marine mammals from various industrial activities was described in detail in the "Potential Effects of the Specified Activity on Marine Mammals" section found earlier in this document. The potential effects of sound from the proposed exploratory drilling program might include one or more of the following: tolerance; masking of natural sounds; behavioral disturbance; non-auditory physical effects; and, at least in theory, temporary or permanent hearing impairment (Richardson *et al.*, 1995a). As discussed earlier in this document, the most common impact will likely be from behavioral disturbance, including avoidance of the ensonified area or changes in speed, direction, and/or diving profile of the animal. For reasons discussed previously in this document, hearing impairment (TTS and PTS) are 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. Additionally, non-auditory physiological effects are anticipated to be minor, if any would occur at all. Finally, based on the proposed mitigation and monitoring measures described earlier in this document and the fact that the back-propagated source level for the drillship is estimated to be 175 dB re 1  $\mu$ Pa (rms), no injury or mortality of marine mammals is

anticipated as a result of Shell’s proposed exploratory drilling program.

For continuous sounds, such as those produced by drilling operations, NMFS uses a received level of 120-dB (rms) to indicate the onset of Level B harassment. Shell provided calculations for the 120-dB isopleths produced by the *Discoverer* and then used those isopleths to estimate takes by harassment. Shell also included modeling results of the 160-dB isopleths for the *Discoverer* and associated estimated takes by harassment. However, NMFS has used the 120-dB calculations to make the necessary MMPA preliminary findings. 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. However, this document only discusses the take estimates at the 120 dB level. Please refer to Shell’s application for the full explanation and estimates at the 160 dB level.

Shell has requested authorization for bowhead, gray, fin, humpback, minke, killer, and beluga whales, harbor porpoise, and ringed, spotted, bearded, and ribbon seals. 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

sound levels of ≥120 dB. NMFS evaluated and critiqued the methods provided in Shell’s application and determined that they were appropriate in order to make the necessary preliminary MMPA findings. This section describes the estimated densities of marine mammals that may occur in the project area. The area of water that may be ensounded to the above sound levels is described further in the “Potential Number of Takes by Harassment” subsection.

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

Shell notes that there is some uncertainty about the representativeness of the data and assumptions used in the calculations. To provide some allowance for the uncertainties, “maximum estimates” as well as “average estimates” of the numbers of marine mammals potentially affected

have been derived. For a few marine mammal species, several density estimates were available, and in those cases the mean and maximum estimates were determined from the survey data. In other cases, no applicable estimate (or perhaps a single estimate) was available, so correction factors were used to arrive at “average” and “maximum” estimates. These are described in detail in the following subsections. Table 6–6 in Shell’s application indicates that the “average estimate” for every species but one, the ringed seal, is zero. Therefore, to account for the fact that the 12 species listed as being potentially taken by harassment in this document may occur in Shell’s proposed drilling sites during active operations, NMFS either used the “maximum estimates” or made an estimate based on typical group size for a particular species.

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

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

TABLE 1—EXPECTED DENSITIES OF CETACEANS AND SEALS IN AREAS OF THE CHUKCHI SEA, ALASKA, FOR THE PLANNED SUMMER (JULY–AUGUST) PERIOD. SPECIES LISTED UNDER THE ESA ARE IN ITALICS

Species	Open water		Ice margin	
	Average density (#/km <sup>2</sup> )	Maximum density (#/km <sup>2</sup> )	Average density (#/km <sup>2</sup> )	Maximum density (#/km <sup>2</sup> )
Odontocetes:				
<i>Monodontidae:</i>				
Beluga .....	0.0033	0.0066	0.0162	0.0324
Narwhal .....	0.0000	0.0000	0.0000	0.0001
<i>Delphinidae:</i>				
Killer whale .....	0.0001	0.0004	0.0001	0.0004
<i>Phocoenidae:</i>				
Harbor porpoise .....	0.0011	0.0016	0.0011	0.0016
Mysticetes:				
<i>Bowhead whale .....</i>	<i>0.0018</i>	<i>0.0036</i>	<i>0.0018</i>	<i>0.0036</i>
<i>Fin whale .....</i>	<i>0.0001</i>	<i>0.0004</i>	<i>0.0001</i>	<i>0.0004</i>

TABLE 1—EXPECTED DENSITIES OF CETACEANS AND SEALS IN AREAS OF THE CHUKCHI SEA, ALASKA, FOR THE PLANNED SUMMER (JULY–AUGUST) PERIOD. SPECIES LISTED UNDER THE ESA ARE IN ITALICS—Continued

Species	Open water		Ice margin	
	Average density (#/km <sup>2</sup> )	Maximum density (#/km <sup>2</sup> )	Average density (#/km <sup>2</sup> )	Maximum density (#/km <sup>2</sup> )
Gray whale .....	0.0081	0.0162	0.0081	0.0162
<i>Humpback whale</i> .....	<i>0.0001</i>	<i>0.0004</i>	<i>0.0001</i>	<i>0.0004</i>
Minke whale .....	0.0001	0.0004	0.0001	0.0004
Pinnipeds:				
Bearded seal .....	0.0107	0.0203	0.0142	0.0270
Ribbon seal .....	0.0003	0.0012	0.0003	0.0012
Ringed seal .....	0.3668	0.6075	0.4891	0.8100
Spotted seal .....	0.0073	0.0122	0.0098	0.0162

TABLE 2—EXPECTED DENSITIES OF CETACEANS AND SEALS IN AREAS OF THE CHUKCHI SEA, ALASKA, FOR THE PLANNED FALL (SEPTEMBER–OCTOBER) PERIOD. SPECIES LISTED UNDER THE ESA ARE IN ITALICS

Species	Open water		Ice margin	
	Average density (#/km <sup>2</sup> )	Maximum density (#/km <sup>2</sup> )	Average density (#/km <sup>2</sup> )	Maximum density (#/km <sup>2</sup> )
Odontocetes:				
<i>Monodontidae:</i>				
Beluga .....	0.0162	0.0324	0.0324	0.0648
Narwhal .....	0.0000	0.0000	0.0000	0.0001
<i>Delphinidae:</i>				
Killer whale .....	0.0001	0.0004	0.0001	0.0004
<i>Phocoenidae:</i>				
Harbor porpoise .....	0.0010	0.0013	0.0010	0.0013
Mysticetes:				
<i>Bowhead whale</i> .....	<i>0.0174</i>	<i>0.0348</i>	<i>0.0348</i>	<i>0.0696</i>
<i>Fin whale</i> .....	<i>0.0001</i>	<i>0.0004</i>	<i>0.0001</i>	<i>0.0004</i>
Gray whale .....	0.0062	0.0124	0.0062	0.0124
<i>Humpback whale</i> .....	<i>0.0001</i>	<i>0.0004</i>	<i>0.0001</i>	<i>0.0004</i>
Minke whale .....	0.0001	0.0004	0.0001	0.0004
Pinnipeds:				
Bearded seal .....	0.0107	0.0203	0.0142	0.0270
Ribbon seal .....	0.0003	0.0012	0.0003	0.0012
Ringed seal .....	0.2458	0.4070	0.3277	0.5427
Spotted seal .....	0.0049	0.0081	0.0065	0.0108

## (1) Cetaceans

*Beluga Whales*—Summer densities of belugas in offshore waters are expected to be low. Aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore *et al.*, 2000). Aerial surveys of the Chukchi Sea in 2008–2009 flown by NMFS' National Marine Mammal Laboratory (NMML) as part of the Chukchi Offshore Monitoring in Drilling Area project (COMIDA) have only reported five beluga sightings during more than 8,700 mi (14,001 km) of on-transect effort, only two of which were offshore (NMML, 2009). Additionally, only one beluga sighting was recorded during more than 37,900 mi (60,994 km) of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September–October of 2006–2008 (Haley *et al.*, 2009b). If belugas are present

during the summer, they are more likely to occur in or near the ice edge or close to shore during their northward migration. Expected densities were calculated from data in Moore *et al.* (2000). Data from Moore *et al.* (2000; Figure 6 and Table 6) used in the average open-water density estimate included two on-transect beluga sightings during 6,640 mi (10,686 km) of on-transect effort in the Chukchi Sea during summer. A mean group size of 7.1 (Coefficient of Variation [CV]=1.7) was calculated from 10 Chukchi Sea summer sightings present in the Bowhead Whale Aerial Survey Program (BWASP) database. A  $f(0)$  value of 2.841 and  $g(0)$  value of 0.58 from Harwood *et al.* (1996) were also used in the calculation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in both open-water and ice-margin

habitats. Specific data on the relative abundance of beluga in open-water versus ice-margin habitat during the summer in the Chukchi Sea is not available. However, Moore *et al.* (2000) reported higher than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas. This would suggest that densities near ice may actually be lower than open water, but belugas are commonly associated with ice, so an inflation factor of only 2 (instead of 4) was used to estimate the average ice-margin density from the open-water density.

In the fall, beluga whale densities in the Chukchi Sea are expected to be somewhat higher than in the summer because individuals of the eastern Chukchi Sea stock and the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Angliss and Allen, 2009). Consistent with this, the number of on-effort beluga

sightings reported during COMIDA flights in September–October of 2008–2009 was over three times more ( $n=17$ ) than during July–August with a very similar amount of on-transect effort (NMML, 2009). However, there were no beluga sightings reported during more than 11,200 mi (18,025 km) of vessel based effort in good visibility conditions during 2006–2008 industry operations in the Chukchi Sea. Densities derived from survey results in the northern Chukchi Sea in Moore *et al.* (2000) were used as the average density for open-water and ice-margin fall season estimates (see Table 6–2 in Shell's application and Table 2 here). Data from Moore *et al.* (2000; Table 8) used in the average open-water density estimate included 123 beluga sightings and 27,560 mi (44,354 km) of on-transect effort in water depths 118–164 ft (36–50 m). A mean group size of 2.39 (CV=0.92) came from the average group size of 82 Chukchi Sea fall sightings in waters 115–164 ft (35–50 m) deep present in the BWASP database. A  $f(0)$  value of 2.841 and  $g(0)$  value of 0.58 from Harwood *et al.* (1996) were used in the calculation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in both open-water and ice-margin habitats. Moore *et al.* (2000) reported higher than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas, so an inflation value of only 2 was used to estimate the average ice-margin density from the open-water density.

**Bowhead Whales**—By July, most bowhead whales are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea. No bowheads were reported during 6,640 mi (10,686 km) of on-transect effort in the Chukchi Sea by Moore *et al.* (2000). Aerial surveys in 2008–2009 by NMML as part of the COMIDA project reported only four sightings during more than 8,700 mi (14,001 km) of on-transect effort. Two of the four sightings were offshore, both of which occurred near the end of August. Bowhead whales were also rarely reported in July–August of 2006–2008 during aerial surveys of the Chukchi Sea coast (Thomas *et al.*, 2009). This is consistent with movements of tagged whales (see ADFG, 2009; Quakenbush *et al.*, 2009), all of which moved through the Chukchi Sea by early May 2009, and tended to travel relatively close to shore, especially in the northern Chukchi Sea. The estimate of bowhead whale density in the Chukchi Sea was calculated by

assuming there was one bowhead sighting during the 6,640 mi (10,686 km) of survey effort in the Chukchi Sea during the summer months reported in Moore *et al.* (2000) although no bowheads were actually observed during those surveys. The more recent COMIDA data were not used as NMML has not released a report summarizing the data so they are not considered final. Only two sightings are present in the BWASP database during July and August in the Chukchi Sea, both of which were of individual whales. The mean group size from combined July–August sightings in the BWASP, COMIDA, and 2006–2008 industry database is 1.33 (CV=0.58). This value, along with a  $f(0)$  value of 2 and a  $g(0)$  value of 0.07, both from Thomas *et al.* (2002) were used to estimate a summer density of bowhead whales. The CV of group size and standard errors reported in Thomas *et al.* (2002) for  $f(0)$  and  $g(0)$  correction factors suggest that an inflation factor of 2 is appropriate for estimating the maximum density from the average density. Bowheads are not expected to be encountered in higher densities near ice in the summer (Moore *et al.*, 2000), so the same density estimates are used for open-water and ice-margin habitats. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.*, 2009b) ranged from 0.0003–0.0013/mi<sup>2</sup> (0.0001–0.0005/km<sup>2</sup>) with a maximum 95 percent confidence interval (CI) of 0.0049/mi<sup>2</sup> (0.0019 km<sup>2</sup>).

During the fall, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf migrate west and south to their wintering grounds in the Bering Sea, making it more likely that bowheads will be encountered in the Chukchi Sea at this time of year. Moore *et al.* (2002; Table 8) reported 34 bowhead sightings during 27,560 mi (44,354 km) of on-transect survey effort in the Chukchi Sea during September–October. Thomas *et al.* (2009) also reported increased sightings on coastal surveys of the Chukchi Sea during September and October of 2006–2008. Aerial surveys in 2008–2009 (NMML, 2009) reported 20 bowhead sightings during 8,803 mi (14,167 km) of on-transect effort, eight of which were offshore. GPS tagging of bowheads appear to show that migration routes through the Chukchi Sea are more variable than through the Beaufort Sea (ADFG, 2009; Quakenbush *et al.*, 2009). 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.*, 2009). Most spent no more than 1 week in the general LS 193 area. The mean group size from September–October Chukchi Sea bowhead sightings in the BWASP database is 1.59 (CV=1.08). This is slightly below the mean group size of 1.85 from all the preliminary COMIDA sightings during the same months, but above the value of 1.13 from only on-effort COMIDA sightings (NMML, 2009). The same  $f(0)$  and  $g(0)$  values that were used for the summer estimates above were used for the fall estimates. As with the summer estimates, an inflation factor of 2 was used to estimate the maximum density from the average density in both habitat types. Moore *et al.* (2000) found that bowheads were detected more often than expected in association with ice in the Chukchi Sea in September–October, so a density of twice the average open-water density was used as the average ice-margin density. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.*, 2009b) ranged from 0.0003 to 0.0129/mi<sup>2</sup> (0.0001–0.0050/km<sup>2</sup>) with a maximum 95 percent CI of 0.1243/mi<sup>2</sup> (0.0480 km<sup>2</sup>).

**Gray Whales**—Gray whales densities are expected to be much higher in the summer months than during the fall. Moore *et al.* (2000) found the distribution of gray whales in the planned operational area was scattered and limited to nearshore areas where most whales were observed in water less than 115 ft (35 m) deep. With similar amounts of on-transect effort between the two seasons in the preliminary COMIDA data from aerial surveys in 2008–2009, there were 3 times as many gray whale sightings in July–August than September–October, five times as many if you consider all effort and sightings. Thomas *et al.* (2009) also reported substantial declines in the sighting rates of gray whales in the fall. The average open-water summer density was calculated from effort and sightings in Moore *et al.* (2000; Table 6) for water depths 118–164 ft (36–50 m), including 4 sightings during 3,901 mi (6,278 km) of on-transect effort. An average group size of 3.11 (CV=0.97) was calculated from all July–August Chukchi Sea gray whale sightings in the BWASP database and used in the summer density estimate. This value was higher than the average group size in the preliminary

COMIDA data (1.71; NMML, 2009) and from coastal aerial surveys in 2006–2008 (1.27; Thomas *et al.*, 2009). Correction factors  $f(0) = 2.49$  (Forney and Barlow, 1998) and  $g(0) = 0.30$  (Forney and Barlow, 1998; Mallonee, 1991) were also used in the density calculation because the group size used in the average density estimate was relatively high compared to other data sources and the CV near one, an inflation factor of 2 was used to estimate the maximum densities from average densities in both habitat types. Gray whales are not commonly associated with sea ice, but may be present near it, so the same densities were used for ice-margin habitat as were derived for open-water habitat during both seasons. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.*, 2009b) ranged from 0.0023/mi<sup>2</sup> to 0.0088/mi<sup>2</sup> (0.0009/km<sup>2</sup> to 0.0034/km<sup>2</sup>) with a maximum 95 percent CI of 0.0378 mi<sup>2</sup> (0.0146 km<sup>2</sup>).

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 (27 sightings during 27,559 mi [44,352 km] of on-transect effort) in water 118–164 ft (36–50 m) deep during autumn in Moore *et al.* (2000; Table 12) was used as the average estimate for the Chukchi Sea during the fall period. A group size value of 2.49 (CV=1.37) calculated from the BWASP database was used in the density calculation, along with the same  $f(0)$  and  $g(0)$  values described above. The group size value of 2.49 was again higher than the average group size calculated from preliminary COMIDA data (1.24; NMML, 2009) and reported from coastal aerial surveys in 2006–2008 (1.12; Thomas *et al.*, 2009). Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July–August of 2006–2008 (Haley *et al.*, 2009b) ranged from 0.0028/mi<sup>2</sup> to 0.0062/mi<sup>2</sup> (0.0011/km<sup>2</sup> to 0.0024/km<sup>2</sup>) with a maximum 95 percent CI of 0.0474 mi<sup>2</sup> (0.0183 km<sup>2</sup>).

**Harbor Porpoise**—Harbor porpoise densities were estimated from industry data collected during 2006–2008 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea, and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006–2008, however, recorded sightings throughout the Chukchi Sea during the summer and early fall months. Density estimates from 2006–

2008 observations during non-seismic periods and locations in July–August ranged from 0.0023/mi<sup>2</sup> to 0.0041/mi<sup>2</sup> (0.0009/km<sup>2</sup> to 0.0016/km<sup>2</sup>) with a maximum 95 percent CI of 0.0016/mi<sup>2</sup> (0.0041/km<sup>2</sup>) (Haley *et al.*, 2009b). The median value from the summer season of those three years (0.0028/mi<sup>2</sup>/0.0011/km<sup>2</sup>) was used as the average open-water density estimate while the high value (0.0041/mi<sup>2</sup>/0.0016/km<sup>2</sup>) was used as the maximum estimate (see Table 6–1 in Shell's application and Table 1 here). Harbor porpoise are not expected to be present in higher numbers near ice, so the open-water densities were used for ice-margin habitat in both seasons. Harbor porpoise densities recorded during industry operations in the fall months of 2006–2008 were slightly lower and ranged from 0.0005/mi<sup>2</sup> to 0.0034/km<sup>2</sup> (0.0002/km<sup>2</sup> to 0.0013/km<sup>2</sup>) with a maximum 95 percent CI of 0.0114/mi<sup>2</sup> (0.0044/km<sup>2</sup>). The median value 0.0026/mi<sup>2</sup> (0.0010/km<sup>2</sup>) was again used as the average density estimate and the high value 0.0034/mi<sup>2</sup> (0.0013/km<sup>2</sup>) was used as the maximum estimate (see Table 6–2 in Shell's application and Table 2 here).

**Other Cetaceans**—The remaining four cetacean species that could be encountered in the Chukchi Sea during Shell's planned exploration drilling program include the humpback, killer, minke, and fin whales. Although there is evidence of the occasional occurrence of these animals in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned drilling program. George and Suydam (1998) reported killer whales, Brueggeman *et al.* (1990) and Haley *et al.* (2009b) reported minke whale, Suydam and George (1992) and Haley *et al.* (2009b) reported harbor porpoise, and NMML (2009) and Haley *et al.* (2009b) reported fin whales off of Ledyard Bay in the Chukchi Sea.

## (2) Pinnipeds

Four species of pinnipeds may be encountered in the Chukchi Sea area of Shell's proposed drilling program: Ringed, bearded, spotted, and ribbon seals. Each of these species, except the spotted seal, is associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be found in the southern margin of the retreating sea ice, before they move to shore. However, satellite tagging has shown that they sometimes undertake long excursions into offshore waters, as far as

74.6 mi (120 km) off the Alaskan coast in the eastern Chukchi Sea, during summer (Lowry *et al.*, 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Patterson *et al.*, 2007; Haley *et al.*, 2009b).

**Ringed and Bearded Seals**—Ringed and bearded seals “average” and “maximum” summer ice-margin densities (see Table 6–1 in Shell's application and Table 1 here) were available in Bengtson *et al.* (2005) from spring surveys in the offshore pack ice zone of the northern Chukchi Sea. However, corrections for bearded seal availability,  $g(0)$ , based on haul-out and diving patterns were not available. Densities of ringed and bearded seals in open-water are expected to be somewhat lower in the summer when preferred pack ice habitat may still be present in the Chukchi Sea. Average and maximum open-water densities have been estimated as  $\frac{3}{4}$  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  $\frac{2}{3}$  the summer densities because ringed seals begin to reoccupy nearshore fast ice areas as the ice forms in the fall. Bearded seals may also begin to leave the Chukchi Sea in the fall, but less is known about their movement patterns, so fall densities were left unchanged from summer densities. For comparison, the ringed seal density estimates calculated from data collected during summer 2006–2008 industry operations ranged from 0.0212/mi<sup>2</sup> to 0.0572/mi<sup>2</sup> (0.0082/km<sup>2</sup> to 0.0221/km<sup>2</sup>) with a maximum 95 percent CI of 0.1494/mi<sup>2</sup> (0.0577/km<sup>2</sup>) (Haley *et al.*, 2009b). These estimates are lower than those made by Bengtson *et al.* (2005), which is not surprising given the different survey methods and timing. Little information on spotted seal densities in offshore areas of the Chukchi Sea is available.

**Spotted Seals**—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 percent of the Alaskan population of spotted seals is present in the Chukchi Sea during the summer and fall (Rugh *et al.*, 1997), the Alaskan population of spotted seals is 59,214 (Allen and Angliss, 2010), and that the population of ringed seals in the Alaskan Chukchi Sea is greater than 208,000 animals (Bengtson *et al.*, 2005). In the fall, spotted seals show increased use of coastal haul-outs so densities



were estimated to be 2/3 of the summer densities.

**Ribbon Seals**—Two ribbon seal sightings were reported during industry vessel operations in the Chukchi Sea in 2006–2008 (Haley *et al.* 2009b). The resulting density estimate of 0.0008/mi<sup>2</sup> (0.0003/km<sup>2</sup>) was used as the average density and 4 times that was used as the maximum for both seasons and habitat zones.

As described earlier in this document, Shell’s proposed start date for the exploration drilling program in the Chukchi Sea is July 4. Up to three wells may be drilled, with an average of 37 days at each drill site, including five days of MLC excavation. Shell’s

preferred order in which the wells will be drilled, ice permitting, will likely be Burger, SW Shoebill, and Crackerjack. Drilling operations are expected to be completed on or before October 31.

Expected sound propagation from the drillship *Discoverer* was modeled at the three possible drill sites. Changes in the water column of the Chukchi Sea through the course of the drilling season will likely affect the propagation of sounds produced by drilling activities, so models were run for expected oceanographic conditions in July and October to bracket the seasonal variability. As stated previously in this document, sounds from the *Discoverer*

have not previously been measured in the Arctic or elsewhere, but sounds from a similar drillship, *Explorer II*, were measured twice in the Beaufort Sea (Greene, 1987a,b; Miles *et al.*, 1987). The back-propagated source levels from these measurements (175 dB re 1 μPa rms), which included sounds from a support vessel operating nearby, were used as a proxy for modeling the sounds likely to be produced by drilling activities from the *Discoverer*. Results of sound propagation modeling that were used in the calculations of areas exposed to various levels of received sounds are summarized in Table 6–3 of Shell’s application and Table 3 here.

TABLE 3—THE 120 dB re 1 μPA (rms) SOUND PROPAGATION MODELING RESULTS OF DRILLING ACTIVITIES AT THREE LOCATIONS IN THE CHUKCHI SEA. THE VALUES USED IN CALCULATIONS INCLUDE A 50 PERCENT INFLATION FACTOR.

Location	Modeling results (km)	Used in calculations (km)
Burger (Summer) .....	1.36	2.04
SW Shoebill (Summer) .....	0.51	0.77
SW Shoebill (Fall) .....	0.57	0.86
Crackerjack (Fall) .....	0.59	0.89

*Potential Number of Takes by Harassment*

(1) Estimates of the Number of Individuals That may be Exposed to Sounds ≥120 dB

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

Numbers of marine mammals that might be present and potentially disturbed (*i.e.*, Level B harassment) are estimated below based on available data about mammal distribution and densities at different locations and times of the year as described previously. Exposure estimates are based on a single drillship (*Discoverer*) drilling up to three wells in the Chukchi Sea from July 4–October 31. Actual drilling may occur

on approximately 11 days while the *Discoverer* is in the Chukchi Sea.

The number of different individuals of each species potentially exposed to received levels ≥120 dB re 1 μPa within each season and habitat zone was estimated by multiplying:

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

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

(2) Estimated Area Exposed to Sounds ≥120 dB

Distances shown in Table 6–3 in Shell’s application and Table 3 here were used to estimate the area ensonified to ≥120 dB (rms) around the drillship in summer and fall seasons. As noted earlier in this document, drilling activities at the SW Shoebill location may occur in both seasons, so the entire area that may be exposed to sounds by operations at the SW Shoebill location have been included in calculations for both seasons. The area of water potentially exposed to received sound levels ≥120 dB (rms) by exploration drilling operations was estimated to be 5.8 mi<sup>2</sup> (14.9 km<sup>2</sup>) in the summer for the Burger and SW Shoebill prospects combined and 1.9 mi<sup>2</sup> (4.8 km<sup>2</sup>) in the fall at the SW Shoebill and Crackerjack prospects combined.

**Cetaceans**—Cetacean species estimates of the average and maximum number of individual cetaceans that would be exposed to received sound levels ≥120 dB are shown in Table 6–6 in Shell’s application. Based on the calculations, all species have an estimated average number of individuals exposed to ≥120 dB of less than one. However, chance encounters with individuals of any species are possible. To account for chance encounters with the cetacean species that possibly may occur in the proposed drilling area (*i.e.*, beluga, killer, bowhead, fin, gray, humpback, and minke whales and harbor porpoise), Shell provided minimal estimates for the number of each marine mammal species or stock that may experience Level B harassment (*see* Table 6–6 in Shell’s application). Shell proposed five exposures to sounds ≥120 dB for each of the cetacean species. The estimates show that three endangered cetacean species (the bowhead, fin, and humpback whales) are expected to be exposed to sounds ≥120 dB unless they avoid the area around the drill sites. Migrating bowheads are likely to do so to some extent, though many of the bowheads engaged in other activities, particularly feeding and socializing, probably will not (Richardson, 2004). Some of the other cetacean species are likely to avoid the immediate area around the drilling vessel due to the

vessel traffic; however, not all cetaceans will change their behavior when exposed to these sound levels.

**Pinnipeds**—The ringed seal is the most widespread and abundant pinniped in ice-covered arctic waters, and there appears to be a great deal of year-to-year variation in abundance and distribution of these marine mammals. Ringed seals account for a large number of marine mammals expected to be encountered during the exploration drilling program, and hence exposed to sounds with received levels  $\geq 120$  dB. The average (and maximum) estimate is that 8 (13) ringed seals might be exposed to sounds with received levels  $\geq 120$  dB from the exploration drilling program.

Two additional seal species are expected to be encountered: Bearded and spotted seals. Additionally, there is a slight possibility that ribbon seals may occur in the project area. Based on the calculations, all species have an estimated average number of individuals exposed to  $\geq 120$  dB of less than one. However, chance encounters with individuals of any species are possible. To account for chance encounters with these three pinniped species, Shell provided minimal estimates for the number of each marine mammal species or stock that may experience Level B harassment (see Table 6–6 in Shell’s application). Shell proposed five exposures each to sounds

$\geq 120$  dB for bearded, spotted, and ribbon seals.

**Estimated Take Conclusions**

As stated previously, NMFS’ practice has been to apply the 120 dB re 1  $\mu$ Pa (rms) received level threshold for underwater continuous sound levels to determine whether take by Level B harassment occurs. However, not all animals react to sounds at this low level, and many will not show strong reactions (and in some cases any reaction) until sounds are much stronger. Southall *et al.* (2007) provide a severity scale for ranking observed behavioral responses of both free-ranging marine mammals and laboratory subjects to various types of anthropogenic sound (see Table 4 in Southall *et al.* (2007)). Tables 15, 17, 19 and 21 in Southall *et al.* (2007) outline the numbers of low-frequency, mid-frequency, and high-frequency cetaceans and pinnipeds in water, respectively, reported as having behavioral responses to non-pulses in 10-dB received level increments. These tables illustrate, especially for low- and mid-frequency cetaceans, that more intense observed behavioral responses did not occur until sounds were higher than 120 dB (rms). Many of the animals had no observable response at all when exposed to anthropogenic sound at levels of 120 dB (rms) or even higher.

Although the 120-dB isopleth for the drillship may seem slightly expansive

(*i.e.*, 1.27 mi [2.04 km], which includes the 50 percent inflation factor), the zone of ensonification begins to shrink dramatically with each 10–dB increase in received sound level to where the 160-dB isopleth is only about 328 ft (100 m) from the drillship. As stated previously, source levels are expected to be 175 dB (rms). For an animal to receive a sound at this level, it would have to be within several meters of the vessel, which is unlikely, especially given the fact that certain species are likely to avoid the area (as described earlier in this document).

NMFS is proposing to authorize the maximum take estimates provided in Table 6–6 of Shell’s application. The only exception to this is for the beluga whale to account for group size, as belugas typically occur in groups of 10 to several hundred individuals. Therefore, NMFS proposes to authorize the take of 20 beluga whales, 13 ringed seals, and 5 individuals each of killer, bowhead, fin, gray, humpback, and minke whales, harbor porpoise, and bearded, ribbon, and spotted seals. Table 4 outlines the abundance, proposed take, and percentage of each stock or population for the 12 species that may be exposed to sounds  $\geq 120$  dB in Shell’s proposed Chukchi Sea drilling area. Less than 1 percent of each species or stock would potentially be exposed to sounds above the Level B harassment threshold.

**TABLE 4—ABUNDANCE ESTIMATES, TOTAL PROPOSED TAKE ESTIMATES, AND PERCENTAGE OF STOCK OR POPULATION THAT MAY BE TAKEN FOR SPECIES THAT MAY OCCUR IN SHELL’S PROPOSED CHUKCHI SEA DRILLING AREA**

Species	Abundance <sup>1</sup>	Total proposed take	Percentage of stock or population
Beluga Whale .....	39,258	20	0.05
Killer Whale .....	656	5	0.76
Harbor Porpoise .....	48,215	5	0.01
Bowhead Whale .....	<sup>2</sup> 14,247	5	0.04
Fin Whale .....	5,700	5	0.09
Gray Whale .....	17,752	5	0.03
Humpback Whale .....	2,256	5	0.22
Minke Whale .....	810–1,003	5	0.62
Bearded Seal .....	<sup>3</sup> 4,863	5	0.1
Ribbon Seal .....	49,000	5	0.01
Ringed Seal .....	208,000–252,000	13	0.01
Spotted Seal .....	59,214	5	0.01

<sup>1</sup> Unless stated otherwise, abundance estimates are taken from the 2009 Alaska SAR.

<sup>2</sup> Assumes 3.4 percent annual growth from the 2001 estimate of 10,545 individuals (Zeh and Punt, 2005).

<sup>3</sup> Eastern Chukchi Sea population (NMML, unpublished data).

Lastly, even though Shell has indicated that the Chukchi Sea drilling program will occur for approximately 111 days between July 4 and October 31, 2010, Shell has requested that the IHA (if issued) be valid for a full year. NMFS is proposing to grant this request in the event that Shell is unable to conduct

active operations for the full 111 days. Therefore, depending on the expiration date of the IHA (if issued), Shell could potentially work early in the 2011 open-water season. The take numbers presented here (and in Shell’s application) are based on 111 days of active operations. Therefore, these

numbers account for this situation. In fact, these numbers may then be an overestimate, as fewer animals, especially bowhead and beluga whales, would be expected at the drill sites in early July 2011.

### Negligible Impact and Small Numbers Analysis and Preliminary Determination

NMFS has defined “negligible impact” in 50 CFR 216.103 as “\* \* \* an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.” In making a negligible impact determination, NMFS considers a variety of factors, including but not limited to: (1) The number of anticipated mortalities; (2) the number and nature of anticipated injuries; (3) the number, nature, intensity, and duration of Level B harassment; and (4) the context in which the takes occur.

No injuries or mortalities are anticipated to occur as a result of Shell’s proposed Chukchi Sea exploratory drilling program, and none are proposed to be authorized. Additionally, animals in the area are not expected to incur hearing impairment (*i.e.*, TTS or PTS) or non-auditory physiological effects. Takes will be limited to Level B behavioral harassment. 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 (ADF&G, 2009). 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 ensonified area 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 is not expected to result in more than Level B harassment and is anticipated to have

no more than a negligible impact on the affected species or stock.

Few seals are expected to occur in the proposed project area, as several of the species prefer more nearshore waters. NMFS has preliminarily determined that the exposure of pinnipeds to sounds produced by exploratory drilling operations is not expected to result in more than Level B harassment and is anticipated to have no more than a negligible impact on the animals.

Of the 12 marine mammal species likely to occur in the proposed drilling area, three are listed as endangered under the ESA: the bowhead, humpback, and fin whales. All three species are also designated as “depleted” under the MMPA. Despite these designations, the Bering-Chukchi-Beaufort stock of bowheads has been increasing at a rate of 3.4 percent annually for nearly a decade (Allen and Angliss, 2010). 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, 2010). An annual increase of 4.8 percent 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, 2010). Zeribini *et al.* (2006, cited in Allen and Angliss, 2010) noted an increase of 6.6 percent for the Central North Pacific stock of humpback whales in Alaska waters. There is no critical habitat designated in the U.S. Arctic for any of these three whale species. The ribbon seal is a “species of concern,” and bearded and ringed seals are “candidate species” under the ESA, meaning they are currently being considered for listing but are not designated as depleted under the MMPA. None of the other three species that may occur in the project area are listed as threatened or endangered under the ESA or designated as depleted under the MMPA.

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 enough as to not affect rates of recruitment or survival of marine mammals in the area. 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 minor based on the fact that other feeding grounds exist elsewhere.

The estimated takes proposed to be authorized represent less than 1 percent of the affected population or stock for all 12 species. These estimates represent the percentage of each species or stock that could be taken by Level B behavioral harassment if each animal is taken only once. Additionally, these numbers are likely an overestimate, as these take numbers were calculated using a 50 percent inflation factor of the 120-dB radius, which is a conservative approach recommended by some acousticians when modeling a new sound source in a new location. This is fairly conservative given the fact that the radii were based on results from a similar drillship (*i.e.*, the *Northern Explorer II*). SSV tests may reveal that the Level B harassment zone may in fact be smaller than that used to estimate take. If the SSV tests reveal that the Level B harassment zone is slightly larger than that of the *Northern Explorer II*, the 50 percent inflation factor should cover the discrepancy. Moreover, the mitigation and monitoring measures (described previously in this document) proposed for inclusion in the IHA (if issued) are expected to reduce even further any potential disturbance to marine mammals.

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 Shell’s proposed Chukchi Sea exploratory drilling program may result in the incidental take of small numbers of marine mammals, by Level B harassment only, and that the total taking from the exploratory drilling program will have a negligible impact on 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, walrus, and polar bears. (As mentioned previously in this document, both the walrus and the polar bear are under the USFWS' jurisdiction.) The importance of each of these species varies among the communities and is largely based on availability.

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

Point Hope residents subsistence hunt for bowhead and beluga whales, polar bears, and walrus. Bowhead and beluga whales are hunted in the spring and early summer along the ice edge. Beluga whales may also be hunted later in the summer along the shore. Walrus are harvested in late spring and early summer, and polar bears are hunted from October to April (MMS, 2007). Seals are available from October through June, but are harvested primarily during the winter months, from November through March, due to the availability of other resources during the other periods of the year (MMS, 2007).

With Point Lay situated near Kasegaluk Lagoon, the community's main subsistence focus is on beluga whales. Each year, hunters from Point Lay drive belugas into the lagoon to a traditional hunting location. The belugas have been predictably sighted near the lagoon from late June through mid- to late July (Suydam *et al.*, 2001). Seals are available year-round, and polar bears and walrus are normally hunted in the winter. Hunters typically travel to Barrow, Wainwright, or Point Hope to participate in bowhead whale harvest, but there is interest in reestablishing a local Point Lay harvest.

Wainwright residents subsist on both beluga and bowhead whales in the spring and early summer. During these two seasons the chances of landing a whale are higher than during other seasons. Seals are hunted by this

community year-round, and polar bears are hunted in the winter.

Barrow residents' main subsistence focus is concentrated on biannual bowhead whale hunts. They hunt these whales during the spring and fall. Westbound bowheads typically reach the Barrow area in mid-September and are in that area until late October (Brower, 1996). Autumn bowhead whaling near Barrow normally begins in mid-September to early October but may begin as early as late-August if whales are observed and ice conditions are favorable (USDI/BLM, 2005). Whaling near Barrow can continue into October, depending on the quota and conditions. Other animals, such as seals, walrus, and polar bears are hunted outside of the whaling season, but they are not the primary source of the subsistence harvest (URS Corporation, 2005).

#### *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.

#### *Plan of Cooperation (POC)*

Regulations at 50 CFR 216.104(a)(12) require IHA applicants for activities that take place in Arctic waters to provide a POC or information that identifies what measures have been taken and/or will be taken to minimize adverse effects on the availability of marine mammals for subsistence purposes. Shell has developed a Draft POC for its 2010 Chukchi Sea, Alaska, exploration

drilling program to minimize any adverse impacts on the availability of marine mammals for subsistence uses. A copy of the Draft POC was distributed to the communities, subsistence user groups, NMFS, and other Federal and State agencies in May 2009. An updated Communications Plan was then submitted to NMFS as an attachment to the POC in early 2010. Shell conducted POC meetings throughout 2009 regarding its planned 2010 activities in both the Beaufort and Chukchi Seas. During these meetings, Shell focused on lessons learned from prior years' activities and presented mitigation measures for avoiding potential conflicts, which are outlined in the 2010 POC and this document. Shell's POC addresses issues of vessel transit, drilling, and associated activities. Communities that were consulted regarding Shell's 2010 Arctic Ocean operations include: Barrow, Kaktovik, Wainwright, Kotzebue, Kivalina, Point Lay, and Point Hope. Attempts were made to meet individually with whaling captains and to hold a community meeting in Nuiqsut; however, after receipt of a request by the Mayor, the scheduled meeting was cancelled. Shell subsequently sent correspondence to all post office box holders in Nuiqsut on February 26, 2009, indicating its willingness to visit and have dialogue on the proposed plans.

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

Shell presented the proposed project to the NWAB Assembly on January 27, 2009, to the NSB Assembly on February 2, 2009, and to the NSB and NWAB Planning Commissions in a joint meeting on March 25, 2009. Meetings were also scheduled with representatives from the Alaska Eskimo Whaling Commission (AEWC), and presentations on proposed activities were given to the Inupiat Community of the Arctic Slope, and the Native Village of Barrow. A full list of POC meetings conducted by Shell between January and April 2009 can be found in Table 4.2-1 of Shell's POC. Shell has successfully completed additional POC meetings with several communities since submitting the Draft POC, including:

- June 1, 2009: NSB Assembly meeting;
- June 2, 2009: Point Lay meeting with village leadership;
- June 3, 2009: Kaktovik meeting with village leadership;
- June 17, 2009: Point Hope meeting with village leadership;
- August 5, 2009: NWAB Assembly meeting; and
- August 27, 2009: NSB Planning Commission meeting.

On December 8, 2009, Shell held consultation meetings with representatives from the various marine mammal commissions. Prior to drilling in 2010, Shell will also hold additional consultation meetings with the affected communities and subsistence user groups, NSB, and NWAB to discuss the mitigation measures included in the POC.

The following mitigation measures, plans and programs, are integral to the POC and were developed during consultation with potentially affected subsistence groups and communities. These measures, plans, and programs will be implemented by Shell during its 2010 exploration drilling operations in both the Beaufort and Chukchi Seas to monitor and mitigate potential impacts to subsistence users and resources. The mitigation measures Shell has adopted and will implement during its 2010 Chukchi Sea offshore exploration drilling operations are listed and discussed below. This most recent version of Shell's planned mitigation measures was presented to community leaders and subsistence user groups starting in January of 2009 and has evolved since in response to information learned during the consultation process.

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

(1) The drillship and support vessels will not enter the Chukchi Sea before July 1 unless authorized by the USFWS based upon a review of seasonal ice conditions and other factors to minimize effects on marine mammals that frequent open leads and to minimize effects on spring bowhead or beluga whale hunts.

(2) To minimize impacts on marine mammals and subsistence hunting activities, vessels that can safely travel outside of the polynya zone will do so. In the event the transit outside of the

polynya zone results in Shell having to break ice (as opposed to managing ice by pushing it out of the way), the drillship and support vessels will enter into the polynya zone far enough so that ice breaking is not necessary. If it is necessary to move into the polynya zone, Shell will notify the local communities of the change in the transit route through the Communication Centers (Com Centers);

(3) Shell has developed a Communication Plan and will implement the plan before initiating exploration drilling operations to coordinate activities with local subsistence users as well as Village Whaling Associations in order to minimize the risk of interfering with subsistence hunting activities and keep current as to the timing and status of the bowhead whale migration, as well as the timing and status of other subsistence hunts. The Communication Plan includes procedures for coordination with Com and Call Centers to be located in coastal villages along the Chukchi and Beaufort Seas during Shell's proposed activities in 2010;

(4) Shell will employ local Subsistence Advisors from the Beaufort and Chukchi Sea villages to provide consultation and guidance regarding the whale migration and subsistence hunt. There will be a total of nine subsistence advisor-liaison positions (one per village), to work approximately 8-hours per day and 40-hour weeks through Shell's 2010 exploration project. The subsistence advisor will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and advise as to ways to minimize and mitigate potential impacts to subsistence resources during the drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; and advising how to avoid subsistence conflicts. A subsistence advisor handbook will be developed prior to the operational season to specify position work tasks in more detail;

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

(6) Shell will implement flight restrictions prohibiting aircraft from

flying within 1,000 ft (305 m) of marine mammals or below 1,500 ft (457 m) altitude (except during takeoffs and landings or in emergency situations) while over land or sea; and

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

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

For several years, a Conflict Avoidance Agreement (CAA) has been negotiated between the AEWC, affected whaling captains' associations, and the oil and gas industry to avoid conflicts between industry activity and bowhead whale subsistence hunts. While the signing of a CAA is not a requirement to obtain an IHA, the CAA often contains measures that help NMFS make its no unmitigable adverse impact determination for bowhead whales. Shell reviewed the draft 2010 CAA and made some revisions to the CAA before signing the document.

#### *Unmitigable Adverse Impact Analysis and Preliminary Determination*

NMFS has preliminarily determined that Shell's proposed Chukchi Sea offshore exploration drilling program will not have an unmitigable adverse impact on the availability of species or stocks for taking for subsistence uses. This preliminary determination is supported by information contained in this document and Shell's POC. Shell has adopted a spatial and temporal strategy for its Chukchi Sea operations that should minimize impacts to subsistence hunters. Shell will enter the Chukchi Sea far offshore, so as to not interfere with July hunts in the Chukchi Sea villages and will communicate with the Com Centers to notify local communities of any changes in the transit route. After the close of the July

beluga whale hunts in the Chukchi Sea villages, very little whaling occurs in Wainwright, Point Hope, and Point Lay. Although the fall bowhead whale hunt in Barrow will occur while Shell is still operating (mid- to late September to October), Barrow is located 140 mi (225 km) east of the proposed drill sites. Based on these factors, Shell's Chukchi Sea survey is not expected to interfere with the fall bowhead harvest in Barrow. In recent years, bowhead whales have occasionally been taken in the fall by coastal villages along the Chukchi coast, but the total number of these animals has been small.

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

Shell will also support the village Com Centers in the Arctic communities and employ local Subsistence Advisors from the Beaufort and Chukchi Sea villages to provide consultation and guidance regarding the whale migration and subsistence hunt. The Subsistence Advisors will provide advice to Shell on

ways to minimize and mitigate potential impacts to subsistence resources during the drilling season. Support activities, such as helicopter flights, could impact nearshore subsistence hunts. However, Shell will use flight paths to avoid adverse impacts to hunts and will communicate regularly with the Com Centers.

Based on the measures described in Shell's Draft POC, the proposed mitigation and monitoring measures (described earlier in this document), and the project design itself, NMFS has determined preliminarily that there will not be an unmitigable adverse impact on subsistence uses from Shell's Chukchi Sea offshore exploration drilling activities.

#### **Endangered Species Act (ESA)**

There are three marine mammal species listed as endangered under the ESA with confirmed or possible occurrence in the proposed project area: the bowhead, humpback, and fin whales. NMFS' Permits, Conservation and Education Division has initiated consultation with NMFS' Endangered Species Division under section 7 of the ESA on the issuance of an IHA to Shell

under section 101(a)(5)(D) of the MMPA for this activity. Consultation will be concluded prior to a determination on the issuance of an IHA.

#### **National Environmental Policy Act (NEPA)**

NMFS is currently preparing an Environmental Assessment, pursuant to NEPA, to determine whether or not this proposed activity may have a significant effect on the human environment. This analysis will be completed prior to the issuance or denial of the IHA.

#### **Proposed Authorization**

As a result of these preliminary determinations, NMFS proposes to authorize the take of marine mammals incidental to Shell's 2010 Chukchi Sea, Alaska, exploration drilling program, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated.

Dated: May 3, 2010.

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[FR Doc. 2010-10880 Filed 5-6-10; 8:45 am]

**BILLING CODE 3510-22-P**