Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with a Proposed Open Water Marine Survey Program in the Beaufort and Chukchi Seas, Alaska, During 2010

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Executive Summary

As described herein, during the open water season in 2010, Shell plans to complete several marine surveys designed to gather additional data relative to site clearance and shallow hazards, ice gouge, and strudel scour in select areas of the Beaufort Sea and ice gouge in the Chukchi Sea. These surveys are continuations of those completed by Shell in the Beaufort Sea beginning in 2006, and in the Chukchi Sea in 2008.

Site clearance and shallow hazards surveys will evaluate the seafloor, and shallow sub seafloor at prospective exploration drilling locations, focusing on the depth to seafloor, topography, the potential for shallow faults or gas zones, and the presence of archaeological features. The types of equipment used to conduct these surveys use low level energy sources focused on limited areas in order to characterize the footprint of the seafloor and shallow sub seafloor at prospective drilling locations. Ice gouge surveys will determine the depth and distribution of ice gouges into the seabed. Ice gouge surveys use low-level energy sources similar to the site clearance and shallow hazards.

The surveys planned by Shell are industry-standard, scientific surveys that have been routinely conducted in the Beaufort and Chukchi Seas since the early 1980s, as well as elsewhere in the world's oceans. The equipment used by Shell to complete these surveys employs low-level energy sources during discrete time periods over very limited areas of the ocean bottom and intervening water column. Since the early 1990s, the National Marine Fisheries Service (NMFS) has issued incidental harassment authorizations (IHAs) to industry for the non-lethal taking of small numbers of marine mammals related to these low level energy source surveys (See Figures 1 through 4).

In order for NMFS to consider authorizing the taking of small numbers of marine mammals incidental to Shell's open water marine survey program, or to make a finding that incidental take is unlikely to occur, Shell must submit a written request to the Assistant Administrator of NMFS. In this application, in keeping with the best available understanding of marine mammal densities and presence in the Beaufort and Chukchi Seas, Shell has calculated an estimated taking of small numbers of marine mammals from the low-level energy sources to be activated during these surveys, and none are of biological significance to the marine mammal populations.

The organization of this request for IHA follows the organization of Chapter 50 Code of Federal Regulations (CFR) 216.104 (a). The remainder of this document is organized as to follow 50CFR§216.104 (a) (1)-(14).

Shell Offshore Inc., the lessee for Outer Continental Shelf (OCS) leases in the Beaufort Sea, and Shell Gulf of Mexico Inc., the lessee for OCS leases in the Chukchi Sea, collectively known as Shell, used the following guidance to prepare its request for IHA.

50 CFR 216.104 "Submission of Requests"

(a) In order for the NMFS to consider authorizing the taking by U.S. citizens of small numbers of marine mammals incidental to a specified activity (other than commercial fishing), or to make a finding that incidental take is unlikely to occur, a written request must be submitted to the Assistant Administrator. All requests must include the following information for their activity.

Information required by 50 CFR§216.104 (a):

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

Overview of Program

Shell plans to complete the following surveys during the 2010 open-water season (collectively the proposed open water marine survey program, hereinafter referred to as the "Program):

- Beaufort Sea Site Clearance and Shallow Hazards Surveys
- Beaufort Sea Marine Surveys
  1. Ice Gouge Survey
  2. Strudel Scour Survey
- Chukchi Sea Marine Survey
  1. Ice Gouge Survey

Each of these individual surveys will require marine vessels to accomplish the work. Only vessels that are currently under contract to Shell, or a contractor to Shell, at the time of this IHA application are specifically named herein. The remainder of required vessels are to be determined (TBD). In this IHA application, Shell describes the tasks that TBD vessels are anticipated to conduct and, where possible, Shell may mention the name of a vessel previously contracted to perform such tasks. Also, the phrase "or similar vessel" is included when a vessel for a specific task remains TBD, because the vessel named in this application may eventually be selected to conduct the work, but perhaps not. Table 1-1 provides a comprehensive list of proposed vessel tasks to support the Program activities planned for coverage by an IHA to be issued for the period of planned operations for the 2010 open water season described in Section 2. Ice and weather conditions will influence when and where marine vessel survey operations can be conducted. But for initial planning purposes, Shell proposes that site clearance and shallow hazards surveys and ice gouge surveys may be conducted within the timeframe of July through October 2010 pending mitigation measures that may temporally or spatially impact proposed survey operations during this timeframe.

Beaufort Sea Site Clearance and Shallow Hazards Surveys

Site Clearance and Shallow Hazards

Description of Activity: Site clearance and shallow hazards surveys of potential proposed locations for exploration drilling will be executed as required by Minerals Management Service (MMS) regulations. These surveys gather data on: (1) bathymetry, (2) seabed topography and other seabed characteristics (e.g., boulder patches), (3) potential geohazards (e.g., shallow faults and shallow gas zones), and (4) the presence of any archeological features (e.g., shipwrecks).

Site clearance and shallow hazards surveys can be accomplished by one vessel with acoustic sources. No other vessels are necessary to accomplish the proposed work.

The focus of this activity will be on Shell's existing leases in Harrison Bay in the central Beaufort Sea. Actual locations of site clearance and shallow hazards surveys within Harrison Bay have not been definitively set as of this date, although these will occur on the OCS lease blocks in the Beaufort Sea shown on Figure 1. Before the commencement of operations, survey location information will be supplied to MMS, as ancillary activities authorizations and provided to other interested agencies as it becomes available.

<u>Primary Contractor</u>: The contractor has not yet been selected.

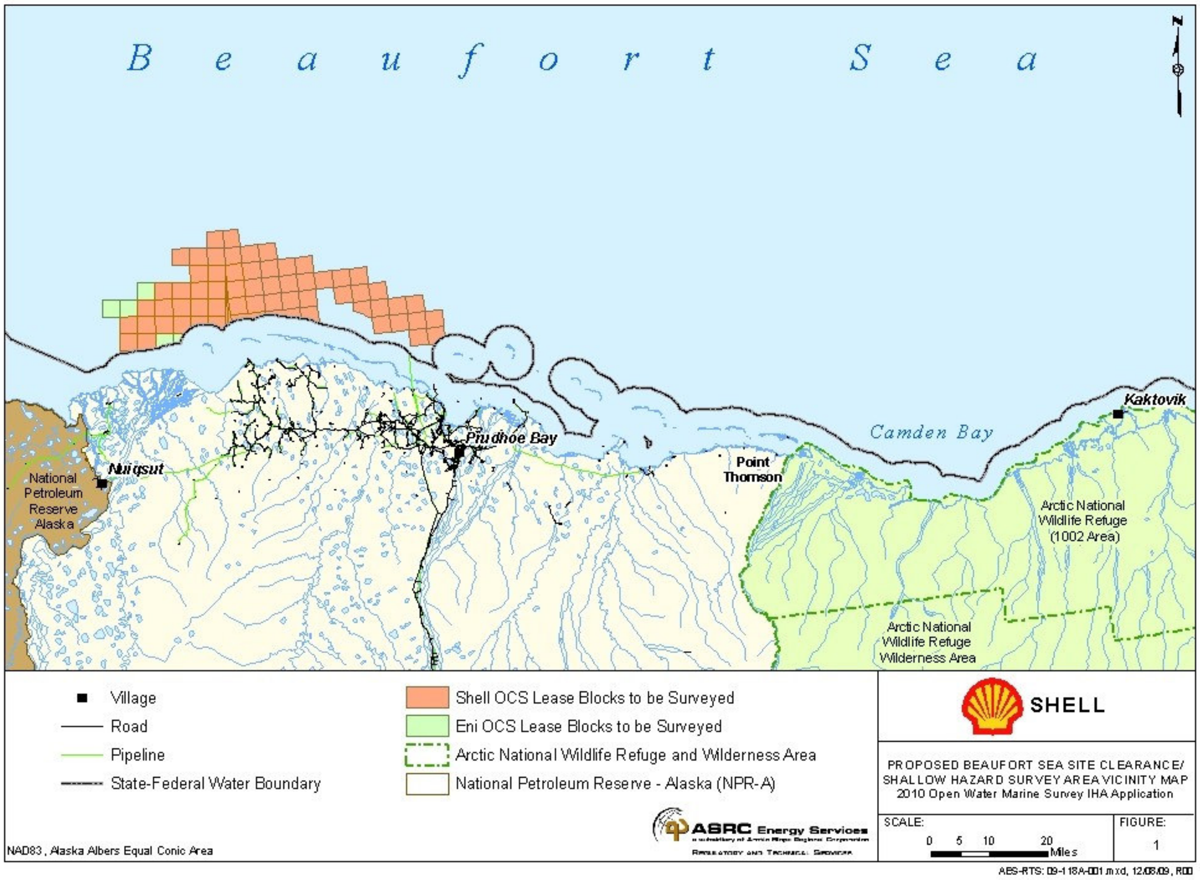
<u>Description of the site clearance and shallow hazards vessel and survey equipment</u>: These surveys are confined to small specific areas within OCS lease blocks. The vessel that will be conducting this activity is TBD, but will be similar to the R/V Mt. Mitchell which is the vessel that was used for surveys in the Chukchi Sea in 2009. The R/V Mt. Mitchell is a diesel powered-vessel, 70 meters (m; 231 feet [ft]) long, 12.7 m (42 ft) wide, with a 4.5 m (15 ft) draft.

<u>Project Timeline:</u> Ice and weather permitting, Shell is proposing to conduct this work within the timeframe of July 2010 through October 2010.

It is proposed that the following acoustic instrumentation, or something similar, be used.

- Dual-frequency side scan sonar, (100 - 400 kilohertz (kHz) or 300 - 600 kHz), or similar;
- Single beam Echo Sounder, (high: 100 - 340 kHz, low: 24 –50 kHz) or similar;
- Multibeam Echo Sounder, (240 kHz), or similar:
- Deep Penetration Profiler, (40 cu-in [in^3] airgun source with 48-channel streamer) or similar.
- Medium Penetration Profiler, (40 in^3 airgun source with 24-channel streamer) or similar.
- Shallow Sub-Bottom Profiler, (2 – 12 kHz); or similar

Figure 1 Beaufort Sea Proposed Site Clearance and Shallow Hazards Survey Area Vicinity Map



Beaufort Sea Marine Surveys

Overview of Beaufort Sea Marine Surveys: Two other marine survey activities are proposed for the Beaufort Sea: (1) ice gouge survey, and (2) strudel scour survey. Shell continues to conduct these types of marine surveys annually over a few years to enhance baseline and statistical understanding of the formation, longevity, and temporal distribution of sea floor features and baseline environmental and biologic conditions. Marine surveys for ice gouge and strudel scour surveys can be accomplished by one vessel for each. No other vessels are necessary to accomplish the proposed work.

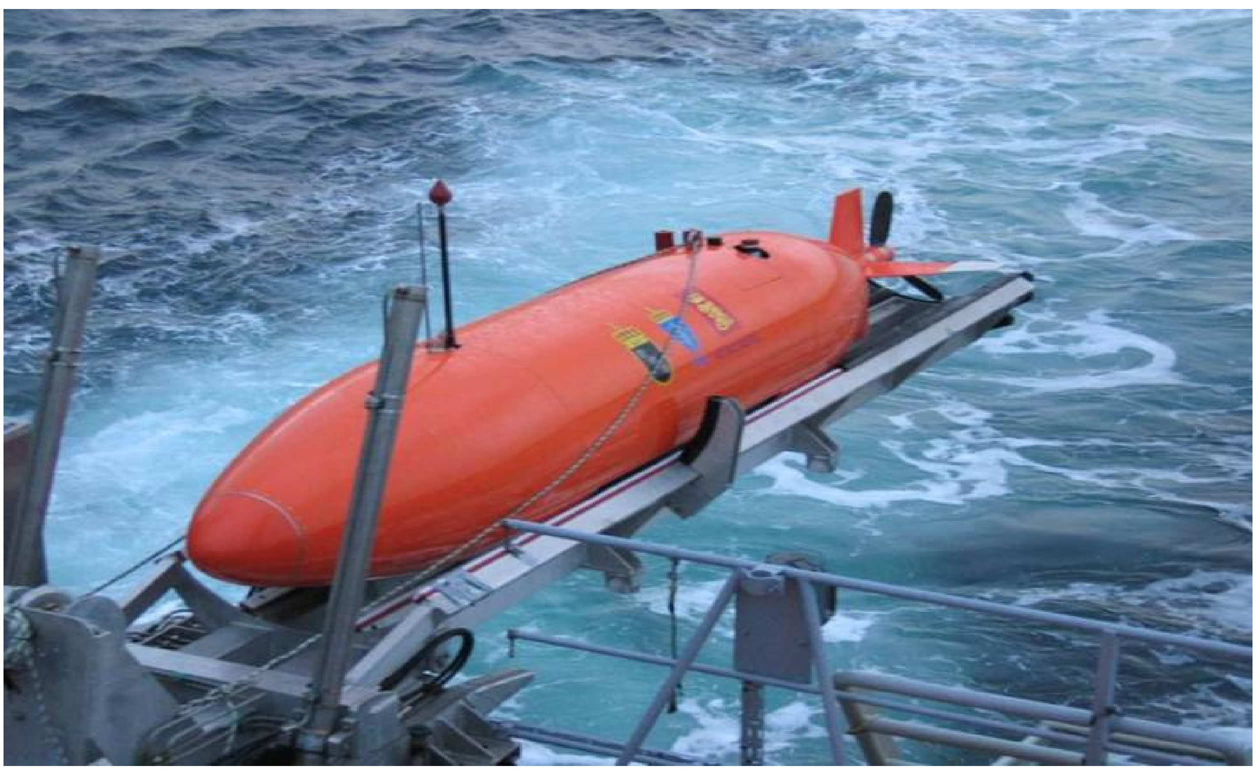
1. Ice Gouge Survey

Description of Activity: As part of the feasibility study for Shell's Alaskan prospects a survey is required to identify and evaluate seabed conditions. The 2010 ice gouge surveys will be conducted using the conventional survey method where the acoustic instrumentation will be towed behind the survey vessel, or possibly with the use of an Autonomous Underwater Vehicle (AUV). The same acoustic instrumentation will be used during both AUV and the conventional survey methods.

The AUV is a self-propelled autonomous vehicle that will be equipped with acoustic instrumentation and programmed for remote operation over the seafloor where the ice gouge survey is to be conducted, and the vehicle is launched and retrieved from a marine vessel (Picture 1). The dimensions of the type of AUV that may be used are 3.84-5.0 m (12.6-16.4 ft) long by 0.75 m (2.46 ft) long.

Ice gouging is created by ice keels, which project from the bottom of moving ice and gouge into seafloor sediment. Ice gouge features are mapped, and by surveying each year, new gouges can be identified. The ice gouge information is used to aid in predicting the prospect of, orientation, depth, and frequency of future ice gouges. Ice gouge information is required for the design of potential pipelines and for the design of pipeline trenching and installation equipment.

Picture 1 Photograph of the AUV on the vessel in preparation for launch



Operations:

The AUV will be launched from the stern of a vessel and will survey the seafloor close to the vessel. The vessel will transit an area, with the AUV surveying the area behind the vessel. Marine mammal observers onboard the vessel ensures the AUV has a minimal impact on the environment. The AUV also has a Collision Avoidance System and operates without a towline that reduces potential impact to marine mammals. Using bathymetric sonar or multibeam echo sounder the AUV can record the gouges on the seafloor surface caused by ice keels. The sub-bottom profiler can record layers beneath the surface to about 20 ft. The AUV is more maneuverable and able to complete surveys quicker than a conventional survey. This reduces the duration that vessels producing sound must operate. The AUV can continuously operate underwater for 24 hours, and will operate at about 4 knots, which is a similar speed to the conventional site clearance and shallow hazards surveys.

The proposed ice gouge surveys will be conducted in both State of Alaska waters and the Federal waters of the OCS in the Beaufort Sea. Actual locations of the ice gouge surveys have not been definitively set as of this date, although these will occur within the area outlined in Figure 2. Before the commencement of operations, survey location information will be supplied to MMS as ancillary activities authorizations and other interested agencies as it becomes available.

Contractor: A contractor has not been yet been selected.

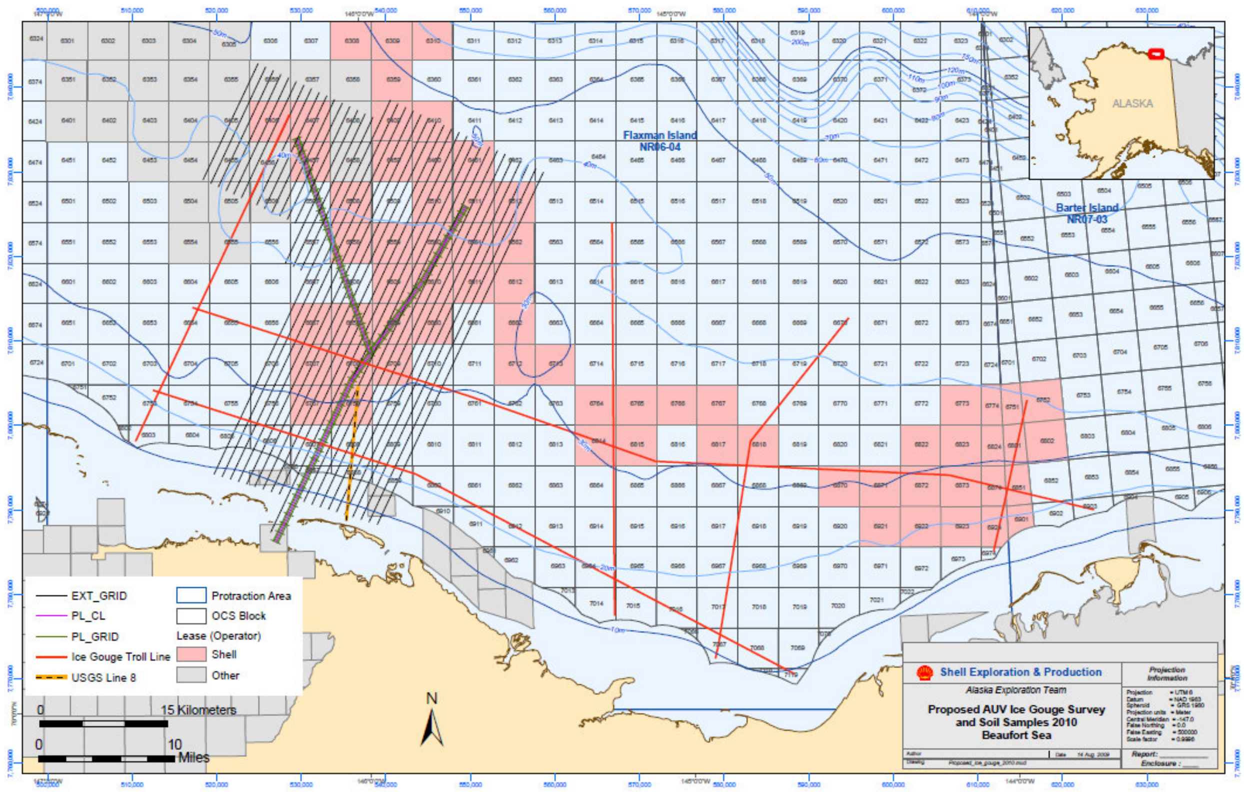
Description of the Ice Gouge vessel and survey equipment: The vessel has not been selected, but it is anticipated that the vessel would be similar to the R/V Mt. Mitchell, which is 70 m (231 ft), 12.7 m (42 ft) wide, and 4.5 m (15 ft) draft.

Project Timeline: Ice and weather permitting, Shell is proposing to conduct this work within the timeframe of July 2010 through October 2010.

It is proposed that the following acoustic instrumentation, or something similar, be used.

- Dual Frequency sub-bottom profiler; (2 to 7 kHz or 8 to 23 kHz) or similar;
- Multibeam Echo Sounder; (240 Hz); or similar and
- Side-scan sonar system; (190 to 210 kHz), or similar.

Figure 2 Beaufort Sea Proposed Ice Gouge Survey Area Vicinity Map



2. Strudel Scour Survey

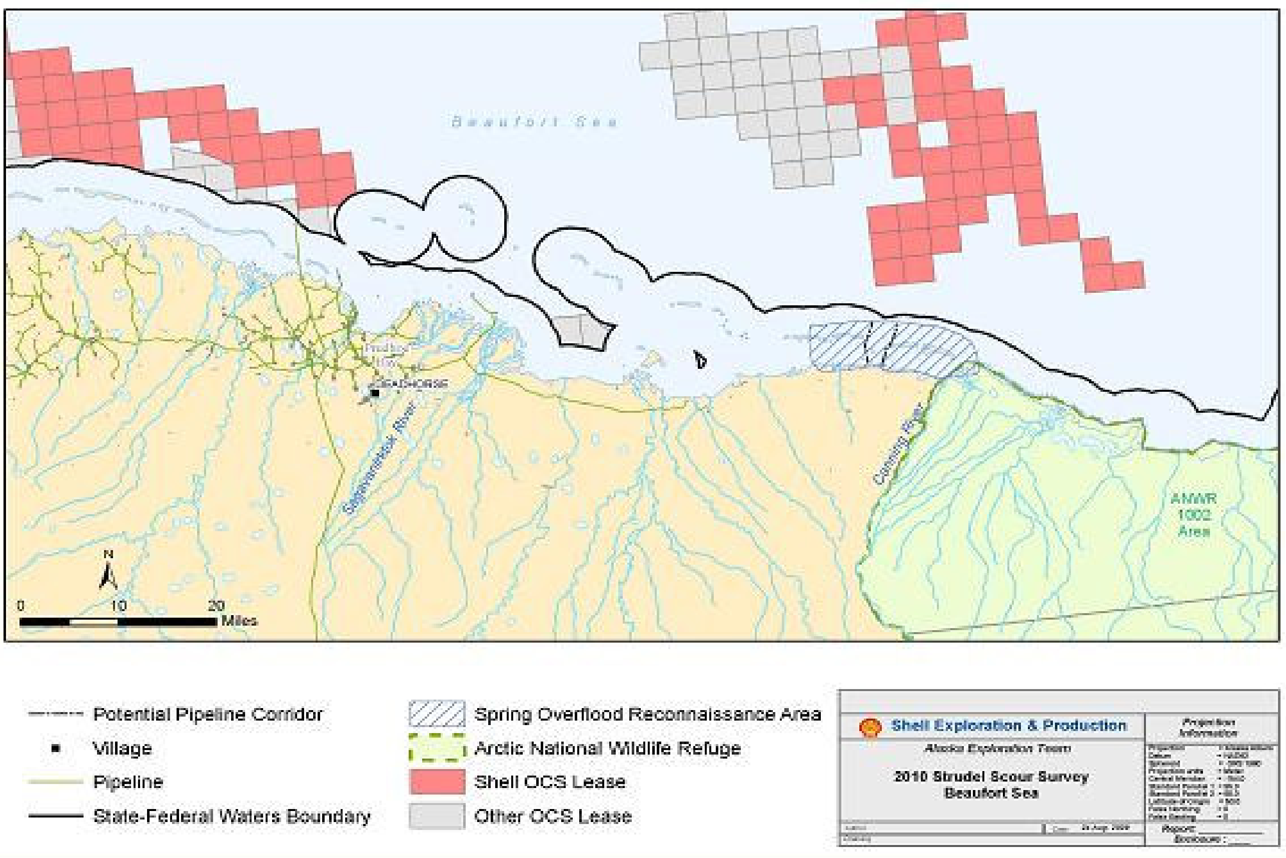
Description of Activity: During the early melt on the North Slope, the rivers begin to flow and discharge water over the coastal sea ice near the river deltas. That water flows down holes in the ice ("strudels") and scours the seafloor. These areas are called "strudel scours". Information on these features is required for prospective pipeline planning. Two proposed activities are required to gather this information: aerial survey via helicopter overflights during the melt to locate the strudels; and strudel scour marine surveys to gather bathymetric data. The overflights investigate possible sources of overflood water and will survey local streams that discharge in the vicinity of Point Thomson including the Staines River, which discharges to the east into Flaxman Lagoon, and the Canning River, which discharges to the east directly into the Beaufort Sea. These helicopter overflights will occur during late May/early June 2010 and, weather permitting, should take no more than two days. There are no planned landings during these overflights other than at the Deadhorse or Kaktovik airports. Areas that have strudel scour identified during the aerial survey will be verified and surveyed with a marine vessel after the breakup of nearshore ice. This proposed activity is not anticipated to take more than 5 days to conduct. The operation is conducted in the shallow water areas near the coast in the vicinity of Point Thomson, reference in Figure 3. This vessel will use the following equipment:

- Multibeam Echo Sounder, (240 Hz) or similar;
- Side-scan sonar system, (190 to 210 kHz) or similar;
- Single beam bathymetric sonar, (24 to 340 kHz) or similar.

Primary Contractor: A contractor has not been yet selected.

Description of the Strudel Scour Survey Vessel: The vessel has not been contracted; however, it is anticipated that it will be the diesel-powered R/V Annika Marie which has been utilized 2006 through 2008 and measures 13.1 m (43 ft) long, or similar vessel.

Figure 3 Beaufort Sea Proposed Strudel Scour Survey Area Vicinity Map



Chukchi Sea Marine Surveys

Overview of Chukchi Sea Marine Surveys: One marine survey activity is proposed for the Chukchi Sea in 2010. Shell intends to conduct ice gouge surveys, annually over a few years to enhance baseline and statistical understanding of the formation, longevity, and temporal distribution of sea floor features and baseline environmental and biologic conditions. The ice gouge survey can be accomplished by one vessel. No other vessels are necessary to accomplish the proposed work.

1. Ice Gouge Survey

Description of Activity: The equipment and method to conduct the ice gouge survey in the Chukchi Sea will be the same as done in the Beaufort Sea.

The proposed ice gouge surveys will be conducted in both State of Alaska (SoA) waters and waters of the OCS in the Chukchi Sea.

Actual locations of the ice gouge surveys have not been definitively set as of this date, although these will occur within the area outlined in Figure 4. Before the commencement of operations, survey location information will be supplied to MMS as ancillary activities authorizations and other interested agencies as it becomes available.

Contractor: A contractor has not been yet been selected.

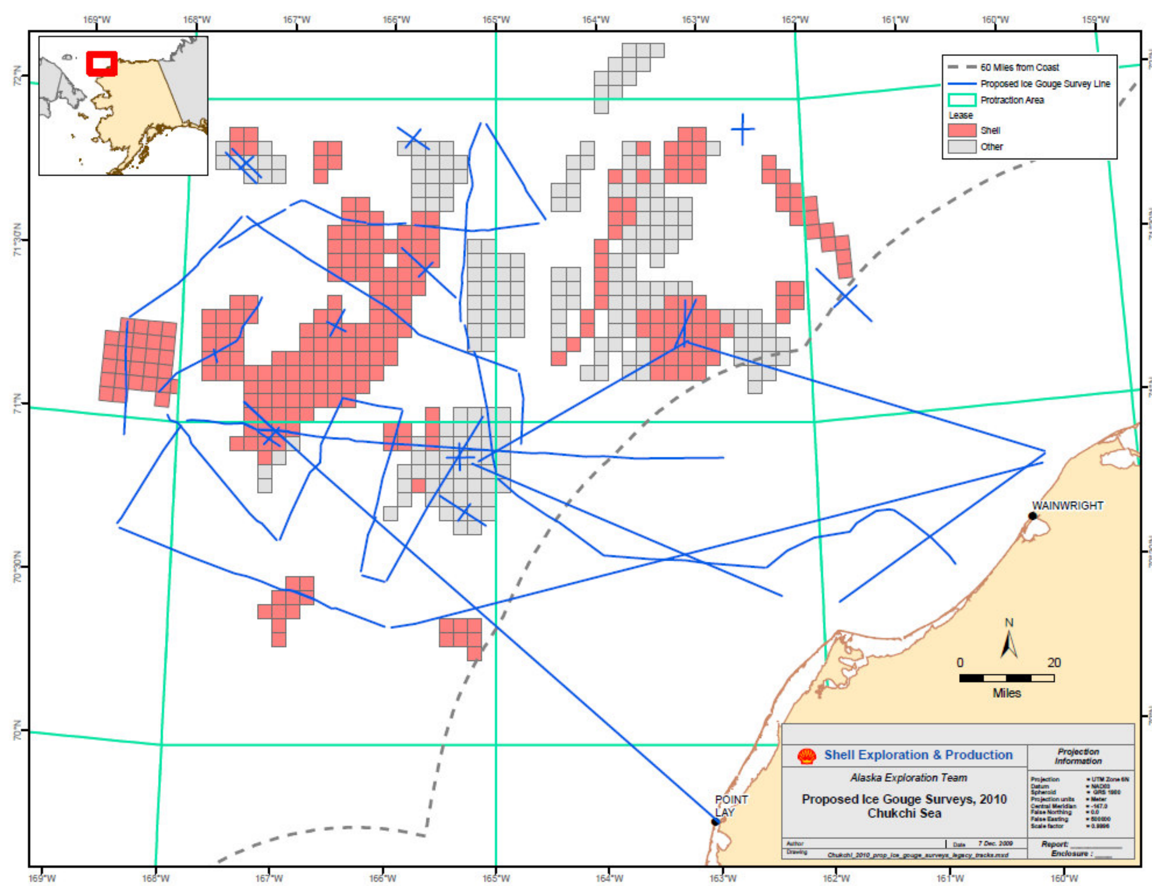
Description of the Ice Gouge vessel and survey equipment: The vessel has not been selected, but it is anticipated that the vessel would be similar to the R/V Mt. Mitchell, which is 70 m (231 ft), 12.7 m (42 ft) wide, and 4.5 m (15 ft) draft.

Project Timeline: Ice and weather permitting, Shell is proposing to conduct this work within the timeframe of July 2010 through October 2010.

It is proposed that the following acoustic instrumentation, or something similar, be used.

- Dual Frequency sub-bottom profiler; (2 to 7 kHz or 8 to 23 kHz) or similar;
- Multibeam Echo Sounder; (240 hertz [Hz]); or similar and
- Side-scan sonar system; (190 to 210 kHz), or similar.

Figure 4 Chukchi Sea Proposed Ice Gouge Survey Area Vicinity Map



Planned Mitigation for the Beaufort and Chukchi Seas Site Clearance and Shallow Hazards Surveys, Ice Gouge Surveys, and Strudel Scour Surveys: The proposed mitigations, via a Plan of Cooperation (POC), for these surveys was drawn from those mitigations described in Section 12(iii) applicable to Beaufort and Chukchi Sea locations and the lower impact acoustic sources deployed from these vessels.

This POC addresses adaptive mitigation measures to minimize any possible conflicts with marine subsistence activities, including the bowhead whale subsistence hunts by the villages of Kaktovik, Nuiqsut (Cross Island), Barrow, Wainwright, and other subsistence hunts of Point Lay, and Point Hope. Shell is committed to meeting its regulatory requirements by implementing the mitigation measures described in Section 12 (iii) of this IHA application and will implement these measures which are intended to minimize any adverse effects on the availability of marine mammals for subsistence uses.

TABLE 1-1 PROPOSED MARINE VESSELS FOR 2010 OPEN WATER MARINE SURVEYS PROGRAM

Chukchi Sea Marine Survey			
Vessel Task	**Notional Operating Timeframe**		**Proposed Vessel**
Ice Gouge	July through October		*Mt. Mitchell,* or similar vessel
Beaufort Sea Marine Surveys			
Vessel Task	**Notional Operating Timeframe**		**Proposed Vessel**
Site Clearance and Shallow Hazards	July through October		*Mt. Mitchell*, or similar vessel
Ice Gouge	July through October		*Mt. Mitchell,* or similar vessel
Strudel Scour	July to Mid-August		*Annika Marie*,or similar vessel

2. The dates and duration of such activity and the specific geographic region where it will occur:

Duration of time that this application is proposed to cover

This request for IHA application is for the period of planned operations for the 2010 open water season described below.

Dates and Duration of the Beaufort Sea Site Clearance and Shallow Hazards Surveys

This activity is proposed to be conducted within the timeframe of July through October 2010. As proposed, this program will last a maximum of 30 days of active data acquisition, excluding downtime due to ice, weather and other unforeseen delays, and should be complete by the end of October 2010.

The site clearance and shallow hazards surveys will occur on MMS OCS leases in Harrison Bay located in the Beaufort Sea, and will be conducted within an area of approximately 216 square miles (mi²) north of Thetis Island more than 3 miles (mi) offshore to approximately 20 mi offshore. The depth of the water in the survey area ranges from 35 to 85 ft. Approximately 63 mi² of data acquisition via 565 kilometers (km) of linear survey is planned within this general area.

Dates and Duration of the Beaufort Sea Marine Surveys

Ice Gouge Surveys: This activity is proposed to be conducted within the timeframe of July through October 2010. The total program will last a maximum of 45 days, excluding downtime due to ice, weather and other unforeseen delays, and should be complete by the end of October 2010.

The ice gouge surveys will occur in both SoA and waters of the OCS in the Beaufort Sea near Point Thomson ranging from near shore to approximately 37 mi offshore. The water depth in the survey area ranges between 15 to 120 ft, and the surveys will be conducted over approximately 2,050 km of linear survey within an area of 1,950 mi².

Strudel Scour Survey: The helicopter overflight portion of this activity is anticipated to require two days during late May or early June. The marine vessel portion of the activity is not anticipated to take more than 5 days to conduct, excluding downtime due to weather and other unforeseen delays. It is anticipated to occur in July thru mid-August time period.

The strudel scour survey will occur in SoA waters near Point Thomson ranging from near shore to 3 mi offshore. The water depth in the survey area ranges from 3 to 20 ft. The strudel scour survey will be conducted over approximately 200 km of linear survey in an area of approximately 140 mi².

<u>Dates and Duration of the Chukchi Sea Marine Surveys</u>

Ice Gouge Surveys: This activity is proposed to be conducted within the timeframe of July through October 2010. The total program will last a maximum of 60 days, excluding downtime due to ice, weather and other unforeseen delays, and should be complete by the end of October 2010.

The ice gouge surveys will occur in both SoA and waters of the OCS in the Chukchi Sea near Point Lay. The water depth in the survey area ranges between 20 and 120 ft, and the surveys will be conducted over approximately 2,473 km of linear survey in an area of 21,954 mi².

3. Species and Numbers of Marine Mammals in Area:

Marine mammals that occur in the area of the planned Harrison Bay 2010 site clearance and shallow hazards survey program belong to three taxonomic groups: odontocetes (toothed cetaceans, such as beluga whale and narwhal), mysticetes (baleen whales), and carnivora (pinnipeds and polar bears). Cetaceans and pinnipeds (except Pacific walrus) are the subject of this IHA application to NMFS. The Pacific walrus and polar bear are managed by the U.S. Fish & Wildlife Service (USFWS).

Eight cetacean and four seal species under the jurisdiction of NMFS are known to or may occur in the area of the planned survey. Two of these species, the bowhead and humpback whales, are listed as "Endangered" under the U.S. Endangered Species Act (ESA). Humpback whales normally do not occur in the Chukchi or Beaufort seas; however, several humpback sightings were recorded during vessel-based surveys in the Chukchi Sea in 2007 (Reiser et al. 2009), and a single humpback whale sighting was recorded in the Beaufort Sea east of Barrow in 2007 (Green et al. 2007).

To avoid redundancy, we have included the required information about the species that are known to or may be present and (insofar as it is known) numbers of these species in Section 4, below.

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

Sections 3 and 4 are integrated here to minimize repetition.

Eight cetacean and four seal species could occur in the general area of the site clearance and shallow hazards survey (Table 4-1). The marine mammal species under NMFS's jurisdiction most likely to occur in the general area near Harrison Bay in the Alaskan Beaufort Sea include two cetacean species (beluga and bowhead whales), and three seal species (ringed, bearded, and spotted seals). Most encounters are likely to occur in nearshore shelf habitats or along the ice edge. The marine mammal species that is likely to be encountered most widely (in space and time) throughout the period of the planned site clearance and shallow hazards surveys is the ringed seal. Encounters with bowhead and beluga whales are expected to be limited to particular regions and seasons, as discussed below.

Other cetacean species that have been observed in the Beaufort Sea but are uncommon or rarely identified in the project area include harbor porpoise, narwhal, killer whale, minke whale, humpback whale, and gray whale. These species could occur in the project area, but each of these species is uncommon or rare in the area and relatively few encounters with these species are expected during the site clearance and shallow hazards surveys. The narwhal occurs in Canadian waters and occasionally in the Beaufort Sea, but it is rare there and is not expected to be encountered.

TABLE 4-1
THE HABITAT, ABUNDANCE (IN THE BEAUFORT SEA), AND CONSERVATION STATUS OF MARINE MAMMALS INHABITING THE AREA OF THE PLANNED SITE CLEARANCE AND SHALLOW HAZARDS SURVEYS

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
Odontocetes Beluga whale (*Delphinapterus leucas*) (Eastern Chukchi Sea Stock)	Offshore, Coastal, Ice edges	3,710[4]	Not listed	VU	II
Beluga whale (Beaufort Sea Stock)	Offshore, Coastal, Ice edges	39,257[5]	Not Listed	VU	II
Narwhal (*Monodon monoceros*)	Offshore, Ice edge	Rare[6]	Not listed	DD	II
Killer whale (*Orcinus orca*)	Widely distributed	Rare	Not listed	LR-cd	II
Harbor Porpoise (*Phocoena phocoena*) (Bering Sea Stock)	Coastal, inland waters, shallow offshore waters	Uncommon	Not listed	VU	II
Mysticetes Bowhead whale (*Balaena mysticetus*)	Pack ice & coastal	11,800[7]	Endangered	LR-cd	I

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
Gray whale (*Eschrichtius robustus*) (eastern Pacific population)	Coastal, lagoons	Uncommon	Not listed	LR-cd	I
Minke whale (*Balaenoptera acutorostrata*)	Shelf, coastal	Rare	Not listed	LR-cd	I
Humpback whale (*Megaptera novaeangliae*)	Shelf, coastal	Rare	Endangered	–	–
Pinnipeds Bearded seal (*Erignathus barbatus*)	Pack ice, shallow offshore waters	300,000-450,000[8] 4863[9]	In review for listing	–	–
Spotted seal (*Phoca largha*)	Pack ice, coastal haulouts	1000[10]	Arctic pop. Segments not listed	–	–
Ringed seal (*Pusa hispida*)	Landfast & pack ice, offshore	326,500[11]	In review for listing	–	–
Ribbon seal (*Histriophoca fasciata*)	Offshore, pack ice	Rare	Not Listed	–	–

[1] U.S. Endangered Species Act.
[2] IUCN Red List of Threatened Species (2003). Codes for IUCN classifications: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LR = Lower Risk (-cd = Conservation Dependent; -nt = Near Threatened; -lc = Least Concern); DD = Data Deficient.
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2004). Appendix I = endangered/threatened; Appendix II = threatened/at risk; Appendix III = some restrictions on trade of animals/animal parts.
[4] Angliss and Allen (2009)
[5] Beaufort Sea population (IWC 2000, Angliss and Allen 2009).
[6] Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO 2004); very few enter the Beaufort Sea.
[7] 2004 Population estimate (Koski et al. 2009).
[8] Alaska population (USDI/MMS 1996).
[9] Eastern Chukchi Sea population (NMML, unpublished data).
[10] Alaska Beaufort Sea population (USDI/MMS 1996).
[11] Alaskan Beaufort Sea population estimate (Amstrup 1995).

(1) Odontocetes

(a) Beluga (Delphinapterus leucas)

Beluga whales are largely absent from the coast of the Alaskan Beaufort Sea during summer. A few beluga whales could be encountered there in late summer and autumn. There is a higher probability of encountering westward-migrating belugas farther offshore in the Beaufort Sea (>60 km, or water depths >200 m) during late summer and autumn than in nearshore locations.

The beluga whale is an arctic and subarctic species that includes several populations in Alaska and northern European waters. It has a circumpolar distribution in the Northern Hemisphere and occurs between 50ºN and 80ºN (Reeves et al. 2002). It is distributed in seasonally ice-covered seas and migrates to warmer coastal estuaries, bays, and rivers in summer for molting (Finley 1982).

Pod structure in beluga groups appears to be along matrilineal lines, with males forming separate aggregations. Small groups are often observed traveling or resting together. Belugas often migrate in groups of 100 to 600 animals (Braham and Krogman 1977) or more. The relationships between whales within groups are not known, although hunters have reported that belugas form family groups with whales of different ages traveling together (Huntington 2000).

In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). For the planned site clearance and shallow hazards surveys near Harrison Bay in the Beaufort Sea, only the Beaufort Sea stock and eastern Chukchi Sea stock may be encountered. Some eastern Chukchi Sea animals enter the Beaufort Sea in late summer (Suydam et al. 2005).

The most recent estimate of the ***eastern Chukchi Sea*** population is 3710 animals (Angliss and Allen 2009). This estimate was based on surveys conducted in 1989–1991. Survey effort was concentrated on the 170-km long Kasegaluk Lagoon where belugas are known to occur during the open-water season. The calculation was considered to be a minimum population estimate for the eastern Chukchi Sea stock because the surveys on which it was based did not include offshore areas where belugas are also likely to occur. This population is considered to be stable. It is assumed that beluga whales from the eastern Chukchi stock winter in the Bering Sea (Angliss and Allen 2009).

Although beluga whales are known to congregate in Kasegaluk Lagoon during summer, evidence from a small number of satellite-tagged animals suggests that some of these whales may subsequently range into the Arctic Ocean north of the Beaufort Sea. Suydam et al. (2005) put satellite tags on 23 beluga whales captured in Kasegaluk Lagoon in late June and early July 1998–2002. Five of these whales moved far into the Arctic Ocean and into the pack ice to 79–80°N. These and other whales moved to areas as far as 1,100 km offshore between Barrow and the Mackenzie River Delta spending time in water with 90% ice coverage.

The ***Beaufort Sea population*** was estimated to contain 39,258 individuals as of 1992 (DeMaster 1995; Angliss and Allen 2009). This estimate was based on the application of a sightability correction factor of 2× to the 1992 uncorrected census of 19,629 individuals made by Harwood et al. (1996). This estimate was obtained from a partial survey of the known range of the Beaufort Sea population and may be an underestimate of the true population size. This population is not considered by NMFS to be a strategic stock and is believed to be stable or increasing (Angliss and Allen 2009).

Beluga whales of the Beaufort stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate through offshore waters of western and northern Alaska (Angliss and Allen 2009). The majority of belugas in the Beaufort stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995).

Much of the Beaufort Sea seasonal population enters the Mackenzie River estuary for a short period during July–August to molt their epidermis, but they spend most of the summer in offshore waters of the eastern Beaufort Sea, Amundsen Gulf and more northerly areas (Davis and Evans 1982; Harwood et al. 1996; Richard et al. 2001). Belugas are rarely seen in the central Alaskan Beaufort Sea during the early summer, but a number were reported there during early July from aerial surveys in 2008 (Christie et al. 2009). During late summer and autumn, most belugas migrate westward far offshore near the pack ice (Frost et al. 1988; Hazard 1988; Clarke et al. 1993; Miller et al. 1999). During fall aerial surveys in the Alaskan Beaufort Sea, Lyons et al. (2009) reported the highest beluga sighting rates during the first two weeks of September and in the northern part of their survey area.

Moore (2000) and Moore et al. (2000b) suggested that beluga whales select deeper water at or beyond the shelf break independent of ice cover. However, during the westward migration in late summer and autumn, small numbers of belugas are sometimes seen near the north coast of Alaska (e.g., Johnson 1979). Christie et al. (2009) reported higher beluga sighting rates at locations >60 km offshore than at locations nearer shore during aerial surveys in the Alaskan Beaufort Sea in 2006-2008. The main fall migration corridor of beluga whales is ~100+ km north of the coast. Satellite-linked telemetry data show that some belugas of this population migrate west considerably farther offshore, as far north as 76º to 78ºN latitude (Richard et al. 1997, 2001).

In summary, beluga whales are largely absent from the coast of the Alaskan Beaufort Sea during summer, but a few beluga whales could be encountered there in late summer and autumn. There is a higher probability of encountering westward-migrating belugas farther offshore in the Beaufort Sea during late summer and autumn than in nearshore locations. Belugas of the eastern Chukchi population could also be encountered in the Beaufort Sea.

(b) Narwhal (Monodon monoceros)

Narwhals have a discontinuous arctic distribution (Hay and Mansfield 1989; Reeves et al. 2002). A large population inhabits Baffin Bay, West Greenland, and the eastern part of the Canadian Arctic archipelago, and much smaller numbers inhabit the Northeast Atlantic/East Greenland area. Population estimates for the narwhal are scarce, and the IUCN-World Conservation Union lists the species as Data Deficient (IUCN Red List of Threatened Species 2003). Innes et al. (2002) estimated a population size of 45,358 narwhals in the Canadian Arctic, although only part of the area was surveyed. There are scattered records of narwhal in Alaskan waters, including reports by subsistence hunters, where the species is considered extralimital (Reeves et al. 2002). Thus, it is possible, but very unlikely, that individuals could be encountered in the area of the planned site clearance and shallow hazards surveys.

(c) Harbor Porpoise (*Phocoena phocoena*)

Small numbers of harbor porpoises could occur in the general area of the planned site clearance and shallow hazards surveys.

The harbor porpoise is a small odontocete that inhabits shallow, coastal waters—temperate, subarctic, and arctic—in the Northern Hemisphere (Read 1999). Harbor porpoises occur mainly in shelf areas where they can dive to depths of at least 220 m and stay submerged for more than 5 min (Harwood and Wilson 2001) feeding on small schooling fish (Read 1999). Harbor porpoises typically occur in small groups of only a few individuals and tend to avoid vessels (Richardson et al. 1995).

The subspecies *P. p. vomerina* ranges from the Chukchi Sea, Pribilof Islands, Unimak Island, and the southeastern shore of Bristol Bay south to San Luis Obispo, California. Point Barrow, Alaska, is the approximate northeastern extent of their regular range (Suydam and George 1992), though there are extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada and recent sightings in the Beaufort Sea in the vicinity of Prudhoe Bay during surveys in 2007 and 2008 (Christie et al. 2009). MMOs onboard industry vessels reported one harbor porpoise sighting in the Beaufort Sea in 2006 and no sightings were recorded in 2007 or 2008 (Savarese et al. 2009). Monnett and Treacy (2005) did not report any harbor porpoise sightings during aerial surveys in the Beaufort Sea from 2002 through 2004.

(2) Mysticetes

(a) Bowhead Whale (*Balaena mysticetus*)

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunctive circumpolar distribution (Reeves 1980). The bowhead is one of only three whale species that spend their entire lives in the Arctic. Bowhead whales are found in the western Arctic (Bering, Chukchi, and Beaufort seas), the Canadian Arctic and West Greenland (Baffin Bay, Davis Strait, and Hudson Bay), the Okhotsk Sea (eastern Russia), and the Northeast Atlantic from Spitzbergen westward to eastern Greenland. Four stocks are recognized for management purposes. The largest is the Western Arctic or Bering–Chukchi–Beaufort (BCB) stock, which includes whales that winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea and Alaskan Beaufort Sea to the Canadian Beaufort Sea, where they feed during the summer. These whales migrate west through the Alaskan Beaufort Sea in the fall as they return to wintering areas in the Bering Sea. Satellite tracking data reported by the Alaska Department of Fish and Game (ADF&G) indicate that some bowhead whales continue migrating west past Barrow and through the Chukchi Sea to Russian waters where they may spend days to weeks apparently feeding before turning south toward the Bering Sea (ADFG 2009, Quakenbush 2009). Other researchers have also reported a westward movement of bowhead whales through the northern Chukchi Sea during fall migration (Moore et al. 1995; Mate et al. 2000).

The pre-exploitation population of bowhead whales in the Bering, Chukchi, and Beaufort seas is estimated to have been 10,400-23,000 whales. Commercial whaling activities may have reduced this population to perhaps 3000 animals (Woodby and Botkin 1993). Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2% per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995). A census in 2001 yielded an estimated annual population growth rate of 3.4% (95% CI 1.7–5%) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004, recently revised to 10,545 by Zeh and Punt [2005]). A population estimate from photo identification data collected in 2004 was 11,800 (Koski et al. 2009) which further supports the estimated 3.4 percent population growth rate. Assuming a continuing annual population growth of 3.4%, the 2010 bowhead population may number around 14,247 animals. The large increases in population estimates that occurred from the late 1970s to the early 1990s were partly a result of actual population growth, but were also partly attributable to improved census techniques (Zeh et al. 1993). Although apparently recovering well, the BCB bowhead population is currently listed as "***Endangered***" under the ESA and is classified as a ***strategic stock*** by NMFS and ***depleted*** under the marine mammal protection act (MMPA) (Angliss and Allen 2009).

The BCB stock of bowhead whales winters in the central and western Bering Sea and many of them summer in the Canadian Beaufort Sea and Amudsen Gulf (Moore and Reeves 1993). Spring migration through the Chukchi and the western Beaufort seas occurs through offshore ice leads, generally from mid-April to early June but with small numbers passing during March to mid-April and early- through mid-June (Braham et al. 1984; Moore and Reeves 1993; Koski et al. 2005).

Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most may remain among the offshore pack ice of the Beaufort Sea until mid-summer. After feeding primarily in the Canadian Beaufort Sea and Amundsen Gulf, bowheads migrate westward from late August through mid- or late October. Fall migration into the Alaskan Beaufort Sea is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004, 2008; Greene et al. 2007). Satellite tracking of bowheads has also shown that some whales move to the Chukchi Sea prior to September (ADFG 2009). Consistent with this, Nuiqsut whalers have stated that the earliest arriving bowheads have apparently reached the Cross Island area earlier in recent years than formerly.

The MMS has conducted or funded late-summer/autumn aerial surveys for bowhead whales in the Alaskan Beaufort Sea since 1979 (e.g., Ljungblad et al. 1986, 1987; Moore et al. 1989; Treacy 1988–1998, 2000, 2002a,b; Monnett and Treacy 2005; Treacy et al. 2006). Bowheads tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage than in years with less ice (Moore 2000; Treacy et al. 2006). In addition, the sighting rate tends to be lower in heavy ice years (Treacy 1997:67). During fall migration, most bowheads migrate west in water ranging from 15 to 200 m deep (Miller et al. 2002). Some individuals enter shallower water, particularly in light ice years, but very few whales are ever seen shoreward of the barrier islands in the Alaskan Beaufort Sea. Survey coverage far offshore in deep water is usually limited, and offshore movements may have been underestimated. However, the main migration corridor is over the continental shelf.

In autumn, westward-migrating bowhead whales typically reach the Kaktovik and Cross Island areas in early September when the subsistence hunts for bowheads typically begin in those areas (Kaleak 1996; Long 1996; Galginaitis and Koski 2002; Galginaitis and Funk 2004, 2005; Koski et al. 2005). In recent years the hunts at those two locations have usually ended by mid- to late September.

Westbound bowheads typically reach the Barrow area in mid-September, and are in that area until late October (e.g., Brower 1996). However, over the years, local residents report having seen a small number of bowhead whales feeding off Barrow or in the pack ice off Barrow during the summer. Recently, autumn bowhead whaling near Barrow has normally begun in mid-September to early October, but in earlier years it began as early as August if whales were observed and ice conditions were favorable (USDI/BLM 2005). The recent decision to delay harvesting whales until mid-to-late September has been made to prevent spoilage, which might occur if whales were harvested earlier in the season when the temperatures tend to be warmer. Whaling near Barrow can continue into October, depending on the quota and conditions.

Most spring-migrating bowhead whales will pass through the Beaufort Sea prior to the start of survey operations in early July. However, a few whales that may remain in the Barrow area or other parts of the Alaskan Beaufort Sea during the summer could be encountered during project activities or by the transiting vessel. More encounters with bowhead whales would occur during the westward fall migration in September and October.

(b) Gray Whale (Eschrichtius robustus)

Gray whales originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic populations are believed to have become extinct by the early 1700s. There are two populations in the North Pacific. A relic population which survives in the western Pacific summers near Sakhalin Island far from the planned area of the site clearance and shallow hazards surveys. The larger eastern Pacific or California gray whale population recovered significantly from commercial whaling during its protection under the ESA until 1994 and numbered about 29,758 ±3122 in 1997 (Rugh et al. 2005). However, abundance estimates since 1997 indicate a consistent decline followed by stabilization or gradual recovery. Rugh et al. (2005) estimated the population to be 18,178 ±1780 in winter 2001-2 and Rugh et al. (2008) estimated the population in winter 2006-7 to have been 20,110 ±1766. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

Eastern Pacific gray whales calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the calving season, most of these gray whales migrate about 8000 km, generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (Tomilin 1957; Rice and Wolman 1971; Braham 1984; Nerini 1984; Moore et al. 2003; Bluhm et al. 2007). Most gray whales begin a southward migration in November with breeding and conception occurring in early December (Rice and Wolman 1971).

Most summering gray whales have historically congregated in the northern Bering Sea, particularly off St. Lawrence Island in the Chirikov Basin (Moore et al. 2000a), and in the southern Chukchi Sea. More recently, Moore et al. (2003) suggested that gray whale use of Chirikov Basin has decreased, likely as a result of the combined effects of changing currents resulting in altered secondary productivity dominated by lower quality food. Coyle et al (2007) noted that ampeliscid amphipod production in the Chirikov Basin had declined by 50% from the 1980s to 2002-3 and that as little as 3-6% of the current gray whale population could consume 10-20% of the ampelischid amphipod annual production. These data support the hypotheses that changes in gray whale distribution may be caused by changes in food production and that gray whales may be approaching, or have surpassed, the carrying capacity of their summer feeding areas. Bluhm et al. (2007) noted high gray whale densities along ocean fronts and suggested that ocean fronts may play an important role in influencing prey densities in eastern North Pacific gray whale foraging areas. The northeastern-most of the recurring feeding areas is in the northeastern Chukchi Sea southwest of Barrow (Clarke et al. 1989).

Gray whales occur regularly near Point Barrow, but historically only a small number of gray whales have been sighted in the Beaufort Sea east of Point Barrow. Hunters at Cross Island (near Prudhoe Bay) took a single gray whale in 1933 (Maher 1960). Only one gray whale was sighted in the central Alaskan Beaufort Sea during the extensive aerial survey programs funded by MMS and industry from 1979 to 1997. However, during September 1998, small numbers of gray whales were sighted on several occasions in the central Alaskan Beaufort (Miller et al. 1999; Treacy 2000). More recently, a single sighting of a gray whale was made on 1 August 2001 near the Northstar production island (Williams and Coltrane 2002). Several gray whale sightings were reported during both vessel-based and aerial surveys in the Beaufort Sea in 2006-2008 (Christie et al. 2009; Saverese et al. 2009). Several single gray whales have been seen farther east in the Canadian Beaufort Sea (Rugh and Fraker 1981), indicating that small numbers must travel through the Alaskan Beaufort during some summers. In recent years, ice conditions have become reduced near Barrow, and gray whales may have become more common there and perhaps in the Beaufort Sea. In the springs of 2003 and 2004, a few tens of gray whales were seen near Barrow by early to mid-June (LGL Ltd and NSB-DWM, unpubl. data). However, no gray whales were sighted during cruises north of Barrow in 2002 or 2005 (Harwood et al. 2005; Haley and Ireland 2006).

Given the infrequent occurrence and nearshore distribution of gray whales in the Beaufort Sea in summer, no more than a few gray whales are expected to be near the planned survey area off Harrison Bay.

(c) Minke Whale (Balaenoptera acutorostrata)

It is not likely that minke whales will be observed in the project area.

Minke whales have a cosmopolitan distribution at ice-free latitudes (Stewart and Leatherwood 1985), and also occur in some marginal ice areas. Angliss and Allen (2009) recognize two minke whale stocks in U.S. waters including (1) the Alaska stock, and (2) the California/Oregon/Washington stock. There is no abundance estimate for the Alaska stock. Provisional estimates of Minke whale abundance based on surveys in 1999 and 2000 are 810 and 1003 whales in the central-eastern and southeastern Bering Sea, respectively. These estimates have not been corrected for animals that may have been submerged or otherwise missed during the surveys, and only a portion of the range of the Alaskan stock was surveyed. Minke whales range into the Chukchi Sea but are not likely to occur in the Beaufort Sea. Savarese et al. (2009) reported one Minke whale sighting in the Beaufort Sea in 2007 and 2008. Minke whales would be unlikely to be observed in the Beaufort Sea near the planned site clearance and shallow hazards surveys.

(d) Humpback Whale (*Megapter novaeangliae*)

It is not likely that humpback whales will occur in the project area during the survey activities.

Humpback whales are distributed in major oceans worldwide but have apparently been absent from Arctic waters of the North Pacific (Angliss and Allen 2009). In general, humpback whales spend the winter in tropical and sub-tropical waters where breeding and calving occur, and migrate to higher latitudes for feeding during the summer.

Humpback whales were hunted extensively during the 20^{th} century and worldwide populations may have been reduced to ~10% of their original numbers. The International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean in 1965 and humpbacks were listed as **Endangered** under the ESA and depleted under the MMPA in 1973. Most humpback whale populations appear to be recovering well.

Humpbacks feed on euphausiids, copepods, and small schooling fish, notably herring, capelin, and sandlance (Reeves et al. 2002). As with other baleen whales, the food is trapped and filtered when large amounts of water are taken into the mouth and forced out through the baleen plates. Humpbacks have large, robust bodies and long pectoral flippers which may reach 1/3 of their body length. They are frequently observed breaching or engaged in other surface activities. Adult male and female humpback whales average 14 and 15 m (46 and 49 ft) in length, respectively (Wynne 1997). Most individual humpback whales can be identified by distinctive patterns on the tail flukes. The dorsal fin is variable in shape and located well back toward the posterior 1/3 of the body on a hump which is particularly noticeable when the back is arched during a dive (Reeves et al. 2002).

During the summer months humpback whales are common in Prince William Sound, and along the south side of the Alaska Peninsula to Unimak Pass. Humpback whales are less common in the Bering Sea and rare in the Chukchi Sea. Green et al. (2007) reported and photographed a humpback whale cow/calf pair east of Barrow near Smith Bay in 2007, which is the first known occurrence of humpback whale in the Beaufort Sea. Humpback whales would be unlikely to occur near the planned surveys off Harrison Bay.

(3) Seals

(a) Bearded Seal (*Erignathus barbatus*)

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981b). During the open-water period, bearded seals occur mainly in relatively shallow areas, because they are predominantly benthic feeders (Burns 1981b). They prefer areas of water no deeper than 200 m (e.g., Harwood et al. 2005). No reliable estimate of bearded seal abundance is available for the Chukchi and Beaufort seas (Angliss and Allen 2009). The Alaska stock of bearded seals is not classified by NMFS as endangered or a strategic stock. However, a decision to list the species under the ESA, due to the potential impact to seal habitats resulting from current warming trends, is still under consideration by the NMFS.

In Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort seas (Burns 1981b). The Alaska stock of bearded seals may consist of about 300,000–450,000 individuals (MMS 1996).

The bearded seal is the largest of the northern phocids. Bearded seals have occasionally been reported to maintain breathing holes in sea ice; however, in winter they are found primarily in areas with persistent leads or cracks and in broken areas within the pack ice, particularly if the water depth is <200 m. Bearded seals apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas considerably more than 200 m deep.

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988). During winter, most bearded seals in Alaskan waters are found in the Bering Sea. In the Chukchi and Beaufort seas, favorable conditions are more limited, and consequently, bearded seals are less abundant there during winter. From mid-April to June, as the ice recedes, some of the bearded seals that overwintered in the Bering Sea migrate northward through the Bering Strait. During the summer, they are found near the widely fragmented margin of multi-year ice covering the continental shelf of the Chukchi Sea and in nearshore areas of the central and western Beaufort Sea. In the Beaufort Sea, bearded seals rarely use coastal haulouts.

In some areas, bearded seals are associated with the ice year-round; however, they usually move shoreward into open water areas when the pack ice retreats to areas with water depths greater than 200 m (Cameron et al. 2009). In the Beaufort Sea, suitable habitat is limited to areas where the continental shelf is narrow because the pack ice edge frequently occurs seaward of the shelf and over water too deep for benthic feeding. The preferred habitat in the western and central Beaufort Sea during the open-water period is the continental shelf seaward of the scour zone although a recent tagging study showed occasional movements of adult bearded seals seaward of the continental shelf (Cameron et al. 2009). WesternGeco conducted marine mammal monitoring during its open-water seismic program in the Alaskan Beaufort Sea from 1996 to 2001. Operations were conducted in nearshore waters, and of a total 454 seals that were identified to species while no airguns were operating, 4.4% were bearded seals, 94.1% were ringed seals and 1.5% were spotted seals (Moulton and Lawson 2002). Savarese et al. (2009) reported bearded seal densities in the Beaufort Sea ranging from 0.035 to 0.003 seals/km^2, during vessel-based surveys in 2006-2008.

(b) Spotted Seal (*Phoca largha*)

Spotted seals, also known as largha seals, occur in the Beaufort, Chukchi, Bering and Okhotsk seas, and south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977). They migrate south from the Chukchi Sea and through the Bering Sea in October (Lowry et al. 1998). Spotted seals overwinter in the Bering Sea and inhabit the southern margin of the ice during spring (Shaughnessy and Fay 1977).

An early estimate of the size of the world population of spotted seals was 370,000–420,000, and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000–250,000 animals (Bigg 1981). The current total number of spotted seals in Alaskan waters is not known (Angliss and Allen 2009), but the estimate is most likely between several thousand and several tens of thousands (Rugh et al. 1997). During the summer spotted seals are found in Alaska from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. The ADF&G placed satellite transmitters on 4 spotted seals and estimated that the proportion of seals hauled out was 6.8%. Based on an actual minimum count of 4145 hauled out seals, Angliss and Allen (2009) estimated the Alaskan population at 59,214 animals. The Alaska stock of spotted seals is not classified as endangered, threatened, or as a strategic stock by NMFS (Angliss and Allen 2009), although the southern distinct population segment (DPS) of spotted seals was recently listed as a threatened species, it occurs entirely outside of US waters.

During spring when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Subadults may be seen in larger groups of up to two hundred animals. During the summer, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July until September. At this time of year, spotted seals haul out on land part of the time, but they also spend extended periods at sea. Spotted seals are commonly seen in bays, lagoons and estuaries, but also range far offshore as far north as 69–72ºN. In summer, they are rarely seen on the pack ice, except when the ice is very near shore. As the ice cover thickens with the onset of winter, spotted seals leave the northern portions of their range and move into the Bering Sea (Lowry et al. 1998).

Relatively low numbers of spotted seals are present in the Beaufort Sea. A small number of spotted seal haulouts are (or were) located in the central Beaufort Sea in the deltas of the Colville

River and previously the Sagavanirktok River. Historically, these sites supported as many as 400–600 spotted seals, but in recent times <20 seals have been seen at any one site (Johnson et al. 1999). In total, there are probably no more than a few tens of spotted seals along the coast of the central Alaska Beaufort Sea during summer and early fall. A total of 12 spotted seals were positively identified near the source vessel during open-water seismic programs in the central Alaskan Beaufort Sea during the 6 years from 1996 to 2001 (Moulton and Lawson 2002, p. 317). Numbers seen per year ranged from zero (in 1998 and 2000) to four (in 1999). More recently Green et al. (2007) reported 46 spotted seal sightings during barge operations between West Dock and Cape Simpson. Most sightings occurred from western Harrison Bay to Cape Simpson with only one sighting offshore of the Colville River delta. Some of these could have been repeat sightings of the same individuals as the barges traversed the same area on numerous occasions. Small numbers of spotted seals could occur in the vicinity of the planned site clearance and shallow hazards surveys.

(c) Ringed Seal (*Phoca hispida*)

Ringed seals have a circumpolar distribution and occur in all seas of the Arctic Ocean (King 1983). They are closely associated with ice, and in the summer they often occur along the receding ice edges or farther north in the pack ice. In the North Pacific, they occur in the southern Bering Sea and range south to the seas of Okhotsk and Japan. They are found throughout the Beaufort, Chukchi, and Bering seas (Angliss and Allen 2009).

During winter, ringed seals occupy landfast ice and offshore pack ice of the Bering, Chukchi and Beaufort seas. In winter and spring, the highest densities of ringed seals are found on stable shorefast ice. However, in some areas where there is limited fast ice but wide expanses of pack ice, including the Beaufort Sea, Chukchi Sea and Baffin Bay, total numbers of ringed seals on pack ice may exceed those on shorefast ice (Burns 1970; Stirling et al. 1982; Finley et al. 1983). Ringed seals maintain breathing holes in the ice and occupy lairs in accumulated snow (Smith and Stirling 1975). They give birth in lairs from mid-March through April, nurse their pups in the lairs for 5–8 weeks, and mate in late April and May (Smith 1973; Hammill et al. 1991; Lydersen and Hammill 1993).

Ringed seals are year-round residents in the Beaufort Sea and the ringed seal is the most frequently encountered seal species in the area. No estimate for the size of the Alaska ringed seal stock is currently available (Angliss and Allen 2009). Past ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from 1–1.5 million (Frost 1985) to 3.3–3.6 million (Frost et al. 1988). Frost and Lowry (1981) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter. More recent estimates based on extrapolation from aerial surveys and on predation estimates for polar bears (Amstrup 1995) suggest an Alaskan Beaufort Sea population at ~326,500 animals. The Alaska stock of ringed seals is not endangered, and is not classified as a strategic stock by NMFS. However, a decision to list the species under the ESA, due to the potential impact to seal habitats resulting from current warming trends, is still under consideration by the NMFS.

Moulton et al. (2002) reported ringed seal densities (uncorrected) ranging from 0.43 to 0.63 seal/km^2 in nearshore areas (>3 m deep) during aerial surveys during late spring in the central Alaskan Beaufort Sea. Ringed seal will likely be the most abundant marine mammal species encountered in the areas area of the planned site clearance and shallow hazards surveys in the Beaufort Sea.

(d) Ribbon Seal (Histriophoca fasciata)

Ribbon seals are found along the pack-ice margin in the southern Bering Sea during late winter and early spring and they move north as the pack ice recedes during late spring to early summer (Burns 1970; Burns 1981a; Burns et al. 1981). Little is known about their summer and fall distribution, but Kelly (1988) suggested that they move into the southern Chukchi Sea based on a review of sightings during the summer. However, ribbon seals appeared to be relatively rare in the northern Chukchi Sea during recent vessel-based surveys in summer and fall of 2006 and 2007 with only two sightings among 1371 seal sightings identified to species (Reiser et al. 2009).

Ribbon seals do not normally occur in the Beaufort Sea; however, two ribbon seal sightings were reported during vessel-based activities near Prudhoe Bay in 2008 (Savarese et al. 2009). Regardless, ribbon seals are unlikely to occur in the vicinity of the planned site clearance and shallow hazards surveys.

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

Shell requests an IHA pursuant to Section 101(a)(5)(D) of the MMPA for incidental take by harassment during its planned site clearance and shallow hazards surveys in the Beaufort Sea during July-October, 2010

The operations outlined in sections 1 and 2 have the potential to take marine mammals by harassment. Sounds that may “harass” marine mammals will be generated by the airguns used during the site clearance and shallow hazards surveys. “Takes” by harassment will potentially result when marine mammals near the activities are exposed to the pulsed sounds generated by the airguns. The effects will depend on the species of cetacean or pinniped, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see section 7). Disturbance reactions are likely to vary among some of the marine mammals in the general vicinity of the tracklines of the source vessel. No “take” by serious injury is anticipated, given the nature of the planned operations and the mitigation measures that are planned (see section 11, “Mitigation Measures”). No lethal takes are expected.

6. Numbers of Marine Mammals that Might be “Taken by Harassment”:

All anticipated takes would be “takes by harassment”, involving temporary changes in behavior. The mitigation measures to be applied will minimize the possibility of injurious takes. (However, there is no specific information demonstrating that injurious “takes” would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate “take by harassment” and present estimates of the numbers of marine mammals that might be affected during the proposed site clearance and shallow hazards program in the Beaufort Sea. The estimates are based on data obtained during marine mammal surveys in and near the proposed survey area and on estimates of the sizes of the areas where effects could potentially occur. In some cases, these estimates were made from data collected in regions, habitats, or seasons that differ from those in the proposed site clearance and shallow hazards survey areas. Adjustments to reported population or density estimates were made to account for these differences insofar as possible.

The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection. There is some uncertainty about the representativeness of those data and the assumptions used below to estimate the potential "take by harassment". However, the approach used here is the best available at this time. "Take by Harassment" has been calculated by multiplying the expected densities of marine mammals that may occur near the site clearance and shallow hazards survey by the area of water likely to be exposed to pulsed sound levels of ≥160 dB re 1 µPa rms. The single exception to this method is for the estimation of exposures of bowhead whales during the fall migration where more detailed data were available allowing an alternate approach, described below, to be used.

Marine Mammal Density Estimates

This section describes the estimated densities of marine mammals that may occur in the site clearance and shallow hazards survey area. The area of water that may be ensonified to >160 dB is described further below in the section *Potential Number of "Takes by Harassment."* There is no evidence that avoidance at received sound levels of ≥160 dB would have significant effects on individual animals or that the subtle changes in behavior or movements would "rise to the level of taking" according to guidance by the NMFS (NMFS 2001). Any changes in behavior caused by sounds at or near the 160 dB rms level would likely fall within the normal variation in such activities that would occur in the absence of the site clearance and shallow hazards surveys.

Marine mammal densities near the surveys are likely to vary by season and habitat. However, sufficient published data allowing the estimation of separate densities during summer (July and August) and fall (September and October) are only available for beluga and bowhead whales. As noted above, exposures of bowhead whales during the fall are not calculated using densities (see below). So summer and fall densities have been estimated for beluga whales and a summer density has been estimated for bowhead whales. Densities of all other species have been estimated to represent the duration of both seasons. The estimated 30 days of site clearance and shallow hazards survey activity will take place in eastern Harrison Bay at approximately five potential prospective future drill sites. The surveys lines form a grid or survey "patch." It is expected that three of these patches will be surveyed during the summer and two during the fall. The area of water exposed to sounds during surveys at the patches are separated by season in this manner and as described further below.

Marine mammal densities are also likely to vary by habitat type. In the Alaskan Beaufort Sea, where the continental shelf break is relatively close to shore, marine mammal habitat is often defined by water depth. Bowhead and beluga occurrence within nearshore (0-40 m), outer continental shelf (40-200 m), slope (200-2000 m), basin (>2000 m), or similarly defined habitats have been described previously (Moore et al. 2000b, Richardson and Thomson 2002). The presence of most other species have, in most cases, only been described relative to the entire continental shelf zone (0-200 m) or beyond. Sounds produced by the site clearance and shallow hazards surveys are expected to drop below 160 dB within the nearshore zone (0-40 m water depth). Sounds ≥160 dB are not expected to occur in waters >200 m. Because airgun sounds at the indicated levels will not be introduced to the outer continental shelf, separate beluga and bowhead densities for the outer continental shelf have not been used in the calculations.

In addition to water depth, densities of marine mammals are likely to vary with the presence or absence of sea ice (see below for descriptions by species). At times during either summer or fall, pack-ice may be present in some of the area near Harrison Bay. However, because some of the survey equipment towed behind the vessel may be damaged by ice, site clearance and shallow hazards survey activities will generally avoid sea-ice. Therefore we have assumed that only 10% of the area exposed to sounds ≥160 dB by the survey will be near ice margin habitat. Ice-margin densities of marine mammals in both seasons have therefore been multiplied by 10% of the area exposed to sounds by the airguns, while open-water (nearshore) densities have been multiplied by the remaining 90% of the area (see area calculations below).

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 sections.

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% probability of sighting an animal that is present along the survey trackline. Some sources of densities used below included these correction factors in their reported densities. In other cases the best available correction factors were applied to reported results when they had not been included in the reported data (e.g. Moore et al. 2000b).

Cetaceans

As noted above, the densities of beluga and bowhead whales present in the Beaufort Sea are expected to vary by season and location. During the early and mid-summer, most belugas and bowheads are found in the Canadian Beaufort Sea and Amundsen Gulf or adjacent areas. Low numbers are found in the eastern Alaskan Beaufort Sea. Belugas begin to move across the Alaskan Beaufort Sea in August, and bowheads do so toward the end of August.

Beluga density estimates were derived from data in Moore et al. (2000b). During the summer, beluga whales are most likely to be encountered in offshore waters of the eastern Alaskan Beaufort Sea or areas with pack ice. The summer beluga whale nearshore density (Table 6-1) was based on 11,985 km of on-transect effort and 9 associated sightings that occurred in water ≤50 m in Moore et al. (2000b; Table 2). A mean group size of 1.63, a f(0) value of 2.841, and a g(0) value of 0.58 from Harwood et al. (1996) were also used in the calculation. Moore et al. (2000b) found that belugas were equally likely to occur in heavy ice conditions as open water or very light ice conditions in summer in the Beaufort Sea, so the same density was used for both nearshore and ice-margin estimates (Table 6-1). The fall beluga whale nearshore density was based on 72,711 km of on-transect effort and 28 associated sightings that occurred in water ≤50 m reported in Moore et al (2000b). A mean group size of 2.9 (CV=1.9), calculated from all Beaufort Sea fall beluga sightings in ≤50 m of water present in the BWASP database, along with the same f(0) and g(0) values from Harwood et al. (1996) were also used in the calculation. Moore et al. (2000b) found that during the fall in the Beaufort Sea belugas occurred in moderate to heavy ice at higher rates than in light ice, so ice-margin densities were estimated to be twice the nearshore densities. Based on the CV of group size maximum estimates in both season and habitats were estimated as four times the average estimates. “Takes by harassment” of beluga whales during the fall in the Beaufort Sea were not calculated in the same manner as described for bowhead whales (below) because of the relatively lower expected densities of beluga whales in nearshore habitat near the site clearance and shallow hazards surveys and the lack of detailed data on the likely timing and rate of migration through the area.

TABLE 6-1
EXPECTED SUMMER (JUL - AUG) DENSITIES OF BELUGA AND BOWHEAD WHALES IN THE ALASKAN BEAUFORT SEA. DENSITIES ARE CORRECTED FOR F(0) AND G(0) BIASES. SPECIES LISTED UNDER THE U.S. ESA AS ENDANGERED ARE SHOWN IN ITALICS.

	Nearshore		Ice Margin	
Species	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**
Beluga	0.0030	0.0120	0.0030	0.0120
Bowhead whale	0.0186	0.0717	0.0186	0.0717

TABLE 6-2
EXPECTED FALL (SEP - NOV) DENSITIES OF BELUGA AND BOWHEAD WHALES IN THE ALASKAN BEAUFORT SEA. DENSITIES ARE CORRECTED FOR F(0) AND G(0) BIASES. SPECIES LISTED UNDER THE U.S. ESA AS ENDANGERED ARE SHOWN IN ITALICS.

	Nearshore		Ice Margin	
Species	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**
Beluga	0.0027	0.0108	0.0054	0.0216
Bowhead whale [a]	*N/A*	*N/A*	*N/A*	*N/A*

[a] See text for description of how bowhead whales estimates were made.

Industry aerial surveys of the continental shelf near Camden by in 2008 recorded eastward migrating ***bowhead whales*** until 12 July (Lyons and Christie 2009). No bowhead sightings were recorded again, despite continued flights, until 19 August. Aerial surveys by industry operators did not begin until late August of 2006 and 2007, but in both years bowheads were also recorded in the region before the end of August (Christie et al. 2009). The late August sightings were likely of bowheads beginning their fall migration so the densities calculated from those surveys were not used to estimate summer densities in this region. The three surveys in July of 2008 resulted in density estimates of 0.0099, 0.0717, and 0.0186 whales/km^2 respectively. The estimate of 0.0186 whales/km^2 was used as the average nearshore density and the estimate of 0.0717 whales/km^2 was used as the maximum. Sea ice was not present during these surveys. Moore et al. (2000b) reported that bowhead whales in the Alaskan Beaufort Sea were distributed uniformly relative to sea ice, so the same nearshore densities were used for ice-margin habitat.

During the fall most bowhead whales will be migrating west past the site clearance and shallow hazards surveys, so it is less accurate to assume that the number of individuals present in the area from one day to the next will be static. However, feeding, resting, and milling behaviors are not entirely uncommon at this time and location either. In order to incorporate the movement of whales past the planned operations, and because the necessary data are available, we have developed an alternate method of calculating the number of individuals exposed to sounds produced by the site clearance and shallow hazards surveys. The method is founded on estimates of the proportion of the population that would pass within the ≥160 dB rms zones on a given day in the fall during survey activities.

Approximately 10 days of site clearance and shallow hazards survey activity are likely to occur during the fall period when bowheads are migrating through the Beaufort Sea. If the bowhead population has continued to grow at an annual rate of 3.4%, the current population size would be ~14,247 individuals based on a 2001 population of 10,545 (Zeh and Punt 2005). Based on data in Richardson and Thomson (2002, Appendix 9.1), the number of whales expected to pass each day was estimated as a proportion of the population. Minimum and maximum estimates of the number of whales passing each day were not available, so a single estimate based on the 10-day moving average presented by Richardson and Thomson (2002) was used. Richardson and Thomson (2002) also calculated the proportion of animals within water depth bins (<20m, 20-40m, 40-200m, >200m). Using this information we multiplied the total number of whales expected to pass the site clearance and shallow hazards surveys each day by the proportion of whales that would be in each depth category to estimate how many individuals would be within each depth bin on a given day. The proportion of each depth bin falling within the ≥160 dB rms zone was then multiplied by the number of whales within the respective bins to estimate the total number of individuals that would be exposed on each day. This was repeated for a total of 10 days (15-19 September and 1-4 October) and the results were summed to estimate the total number of bowhead whales that might be exposed to ≥160 dB rms during the migration period in the Beaufort Sea.

For ***other cetacean species*** that may be encountered in the Beaufort Sea, densities are likely to vary somewhat by season, but differences are not expected to be great enough to require estimation of separate densities for the two seasons. Harbor porpoises and gray whales are not expected to be present in large numbers in the Beaufort Sea during the fall but small numbers may be encountered during the summer. They are most likely to be present in nearshore waters (Table 6-3). Narwhals are not expected to be encountered during the site clearance and shallow hazards surveys. However, there is a chance that a few individuals may be present if ice is nearby. The first record of humpback whales in the Beaufort Sea was documented in 2007 so their presence cannot be ruled out. Since these species occur so infrequently in the Beaufort Sea, little to no data are available for the calculation of densities. Minimal densities have therefore been assigned for calculation purpose and to allow for chance encounters (Table 6-3).

Seals

Extensive surveys of ringed and bearded seals have been conducted in the Beaufort Sea, but most surveys have been conducted over the landfast ice, and few seal surveys have occurred in open water or in the pack ice. Kingsley (1986) conducted ***ringed seal*** surveys of the offshore pack ice in the central and eastern Beaufort Sea during late spring (late June). These surveys provide the most relevant information on densities of ringed seals in the ice margin zone of the Beaufort Sea.

The density estimate in Kingsley (1986) was used as the average density of ringed seals that may be encountered in the ice margin (Table 6-3). The average ringed seal density in the nearshore zone of the Alaskan Beaufort Sea was estimated from results of ship–based surveys at times without seismic operations reported by Moulton and Lawson (2002; Table 6-3)

Densities of ***bearded seals*** were estimated by multiplying the ringed seal densities by 0.051 based on the proportion of bearded seals to ringed seals reported in Stirling et al. (1982; Table 6-3). ***Spotted seal*** densities in the nearshore zone were estimated by summing the ringed seal and bearded seal densities and multiplying the result by 0.015 based on the proportion of spotted seals to ringed plus bearded seals reported in Moulton and Lawson (2002; Table 6-3). Minimal values were assigned as densities in the ice–margin zones (Table 6-3). Minimal values were used to estimate ***ribbon seal*** densities as their presence in the Beaufort Sea is very uncommon.

TABLE 6-3
EXPECTED DENSITIES OF CETACEANS (EXCLUDING BELUGA AND BOWHEAD WHALE) AND SEALS IN THE ALASKAN BEAUFORT SEA.

Species	Nearshore		Ice Margin	
	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Odontocetes				
Monodontidae				
Narwhal	0.0000	0.0000	0.0000	0.0001
Phocoenidae				
Harbor porpoise	0.0001	0.0004	0.0000	0.0000
Mysticetes				
Gray whale	0.0001	0.0004	0.0000	0.0000
Pinnipeds				
Bearded seal	0.0181	0.0724	0.0128	0.0512
Ribbon seal	0.0001	0.0004	0.0001	0.0004
Ringed seal	0.3547	1.4188	0.2510	1.0040
Spotted seal	0.0037	0.0149	0.0001	0.0004

Potential Number of "Takes by Harassment"

Best and Maximum Estimates of the Number of Individuals that may be Exposed to ≥160

Numbers of marine mammals that might be present and potentially disturbed are estimated below based on available data about mammal distribution and densities at different locations and times of the year as described above. The planned site clearance and shallow hazards survey would take place in the Beaufort Sea over two different seasons. The estimates of marine mammal densities have therefore been separated both spatially and temporarily in an attempt to represent the distribution of animals expected to be encountered over the duration of the site clearance and shallow hazards survey.

The number of individuals of each species potentially exposed to received levels ≥160 dB re 1 μPa (rms) within each season and habitat zone was estimated by multiplying

- the anticipated area to be ensonified to the specified level in each season and habitat zone to which that density applies, by
- the expected species density.

The numbers of potential individuals exposed were then summed for each species across the two seasons and habitat zones. Some of the animals estimated to be exposed, particularly migrating bowhead whales, might show avoidance reactions before being exposed to ≥160 dB re 1 μPa (rms). Thus, these calculations actually estimate the number of individuals potentially exposed to ≥160 dB that would occur if there were no avoidance of the area ensonified to that level.

The area of water potentially exposed to received levels ≥160 dB by airgun operations was calculated by buffering a typical site clearance and shallow hazards survey grid of lines by the estimated >160 dB distance from the airgun source, including turns between lines during which a single mitigation airgun will be active. Measurements of a 2 x 10 in^3 airgun array used in 2007 were reported by Funk et al. (2008). These measurements were used to model both of the potential airgun arrays that may be used in 2010, a 4 x10 in^3 array or a 2 x 10 in^3 + 1 x 20 in^3 array. The modeling results showed that the 40 cubic inch is likely to produce sound that propagates further than the alternative array, so those results were used. The modeled 160 dB distance from a 40 cubic inch was 1,220 m from the source. Because this is a modeled estimate(Greene 2009), but based on similar measurements at the same location, the estimated distance was only increased by a factor of 1.25 instead of a typical 1.5 factor. This results in a 160 dB distance of 1,525 m which was added to both sides of survey lines in a typical site clearance and shallow hazards survey grid. The resulting area that may be exposed to airguns sounds ≥160 dB is 81.6 km^2. In most cases the use of a single mitigation gun during turns will not appreciably increase the total area exposed to sounds ≥160 dB, but analysis of a similar survey pattern from the Chukchi Sea (but using the Beaufort sound radii) suggested use of the mitigation gun may increase this area to 82.3 km^2. As described above, three patches (246.9 km^2) are likely to be surveyed during the summer leaving two (164.6 km^2) for the fall. During both seasons, 90% of the area has been multiplied by nearshore (open-water) densities, and the remaining 10% by the ice-margin densities.

For analysis of potential effects on migrating bowhead whales we calculated the maximum distance perpendicular to the migration path ensonified to ≥160 dB rms by a typical survey patch as 11.6 km. This distance represents ~21% of the 56 km between the barrier islands and the 40 m bathymetry line so it was assumed that 21% of the bowheads migrating within the nearshore zone (water depth 0-40 m) may be exposed to sounds ≥160 dB if they showed no avoidance of the site clearance and shallow hazards survey activities.

Cetaceans

Cetacean species potentially exposed to airgun sounds with received levels ≥160 dB rms would involve mysticetes (bowhead, gray, humpback, and minke whales), monodontids (beluga and narwhal), and porpoise (harbor porpoise; Tables 6-4, 6-5, and 6-6). Species with an estimated average number of individuals exposed equal to zero are included here for completeness, but are not likely to be encountered. The average (and maximum) estimates of the number of individual bowhead whales exposed to received sound levels ≥160 dB is 381 (394) and belugas is 1 (5)(Table 6-7). Few other cetaceans are likely to be exposed to airgun sounds ≥160 dB, but maximum estimates have been included to account for chance encounters.

The estimates show that one endangered cetacean species (the bowhead whale) is expected to be exposed to sounds ≥160 dB rms unless bowheads avoid the area around the site clearance and shallow hazards survey areas (Tables 6-7). For species that may change their behavior or alter their migration route, those changes are likely to be within the normal range of activities for the animals and may not rise to the level of "taking" based on guidance in NMFS (2001). Animals that divert around the activity at lower sound levels would not approach close enough that they would alter their behavior to the degree that they would be "taken by harassment."

TABLE 6-4
ESTIMATES OF THE NUMBERS OF BELUGA AND BOWHEAD WHALES IN AREAS WHERE MAXIMUM RECEIVED SOUND LEVELS IN THE WATER WOULD BE ≥160 DB DURING SHELL'S PLANNED SITE CLEARANCE AND SHALLOW HAZARDS SURVEYS NEAR HARRISON BAY IN THE BEAUFORT SEA, ALASKA, JULY – AUG 2010. NOT ALL MARINE MAMMALS WILL CHANGE THEIR BEHAVIOR WHEN EXPOSED TO THESE SOUND LEVELS.

	Number of Exposure to Sound Levels ≥160 dB					
	Nearshore		Ice Margin		Total	
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Beluga	1	3	0	0	1	3
Bowhead whale	4	16	0	2	5	18

TABLE 6-5
ESTIMATES OF THE NUMBERS OF BELUGA AND BOWHEAD WHALES IN AREAS WHERE MAXIMUM RECEIVED SOUND LEVELS IN THE WATER WOULD BE ≥160 DB DURING SHELL'S PLANNED SITE CLEARANCE AND SHALLOW HAZARDS SURVEYS NEAR HARRISON BAY IN THE BEAUFORT SEA, ALASKA, SEP – OCTOBER 31, 2010. MAXIMUM VALUES FOR BOWHEAD WHALES WERE NOT CALCULATED DUE TO THE ALTERNATIVE METHOD USED TO ESTIMATE BOWHEAD WHALE EXPOSURES AS DESCRIBED IN THE TEXT. NOT ALL MARINE MAMMALS WILL CHANGE THEIR BEHAVIOR WHEN EXPOSED TO THESE SOUND LEVELS.

	Number of Exposure to Sound Levels ≥160 dB					
	Nearshore		Ice Margin		Total	
	Avg.	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Beluga	0	2	0	0	0	2
Bowhead whale [a]	376	*N/A*	*N/A*	*N/A*	376	*N/A*

[a] See text for description of bowhead whale estimates for the Fall in the Beaufort Sea

TABLE 6-6
ESTIMATES OF THE NUMBERS OF MARINE MAMMALS (EXCLUDING BELUGA AND BOWHEAD WHALES, WHICH ARE SHOWN IN TABLES 6-4 AND 6-5, IN AREAS WHERE MAXIMUM RECEIVED SOUND LEVELS IN THE WATER WOULD BE ≥160 DB DURING SHELL'S PLANNED SITE CLEARANCE AND SHALLOW HAZARDS SURVEYS NEAR HARRISON BAY IN THE BEAUFORT SEA, ALASKA, JULY – OCTOBER, 2010. NOT ALL MARINE MAMMALS WILL CHANGE THEIR BEHAVIOR WHEN EXPOSED TO THESE SOUND LEVELS.

	Number of Exposure to Sound Levels ≥120 dB and (≥160 dB)					
	Nearshore		Ice Margin		Total	
Species	Avg	Max	Avg	Max	Avg	Max
Odontocetes						
Monodontidae						
Narwhal	0	0	0	0	0	0
Phocoenidae						
Harbor porpoise	0	0	0	0	0	0
Mysticetes						
Gray whale	0	0	0	0	0	0
Pinnipeds						
Bearded seal	7	27	1	2	7	29
Ribbon seal	0	0	0	0	0	0
Ringed seal	131	525	10	41	142	567
Spotted seal	1	6	0	0	1	6
Total Pinnipeds	139	558	11	43	150	601

TABLE 6-7
SUMMARY OF THE NUMBER OF POTENTIAL EXPOSURES OF MARINE MAMMALS TO RECEIVED SOUND LEVELS IN THE WATER OF ≥160 DB DURING SHELL'S PLANNED SITE CLEARANCE AND SHALLOW HAZARDS SURVEYS NEAR HARRISON BAY IN THE BEAUFORT SEA, ALASKA, JULY – OCTOBER, 2010. MINIMUM ESTIMATES FOR SOME SPECIES HAVE BEEN REQUESTED AT THE ≥160 DB LEVEL TO ACCOUNT FOR ANY CHANCE ENCOUNTERS. NOT ALL MARINE MAMMALS WILL CHANGE THEIR BEHAVIOR WHEN EXPOSED TO THESE SOUND LEVELS.

Species	Total Number of Exposure to Sound Levels >160 dB	
	Avg.	Max.
Odontocetes		
Monodontidae		
Beluga	1	5
Narwhal	0	5
Phocoenidae		
Harbor porpoise	0	5
Mysticetes		
Bowhead whale [a]	381	394
Gray whale	0	5
Humpback Whale	0	5
Minke Whale	0	5
Total Cetaceans	381	409
Pinnipeds		
Bearded seal	7	29
Ringed seal	142	567
Ribbon Seal	0	5
Spotted seal	1	6
Total Pinnipeds	150	606

[a] See text for description of bowhead whale estimate calculation

Seals

Ringed Seals

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 site clearance and shallow hazards survey activities, and hence exposed to sounds with received levels ≥160 dB rms. The average (and maximum) estimate is that 142 (567) ringed seals might be exposed to sounds with received levels ≥160 dB rms from the airguns.

Other Seal Species

Two additional seal species are expected to be encountered. Average and maximum estimates for bearded seal exposures to sound levels ≥160 dB are 7 and 29, respectively. For spotted seal these exposure estimates were 1 and 6, respectively. The ribbon seal is unlikely to be encountered, but their presence cannot be ruled out.

Conclusions

Cetaceans

Effects on cetaceans are generally expected to be restricted to avoidance of an area around the site clearance and shallow hazards surveys and short-term changes in behavior, falling within the MMPA definition of “Level B harassment”.

Using the 160 dB criterion, the best (average) estimates of the numbers of individual cetaceans exposed to sounds ≥160 dB re 1 μPa (rms) represent varying proportions of the populations of each species in the Beaufort Sea and adjacent waters. For species listed as “Endangered” under the ESA, the estimates include ~381 bowheads. This number is ~2.7% of the Bering-Chukchi-Beaufort population of >14,247 assuming 3.4% annual population growth from the 2001 estimate of >10,545 animals (Zeh and Punt 2005). The small numbers of other mysticetes whales that may occur in the Beaufort Sea are unlikely to occur near the planned site clearance and shallow hazards surveys. The few that might occur would represent a very small proportion of their respective populations.

Some monodontids may be exposed to sounds produced by the airguns, and the numbers potentially affected are small relative to the population sizes (Table 6-7). Narwhals are extremely rare in the U.S. Beaufort Sea and few, if any, are expected to be encountered during the site clearance and shallow hazards surveys. The best estimate of the number of belugas that might be exposed to ≥160 dB (1) represents <1% of their population.

Seals

A few seal species are likely to be encountered in the study area, but ringed seal is by far the most abundant in this area. The best (average) estimates of the numbers of individuals exposed to sounds at received levels ≥160 dB rms during the site clearance and shallow hazards surveys are as follows: ringed seals (142), bearded seals (7), and spotted seals (1), (representing <1% of their respective Beaufort Sea populations).

7. Anticipated impact on species or stocks:

This section summarizes the potential impacts on marine mammals of the proposed airgun operations. Note that for completeness, examples or information are sometimes included for species that are not likely to be present in the proposed survey area.

(a) Summary of potential effects of airgun sounds

The effects of sounds from airguns might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995). *In* *theory* is added because it is unlikely that temporary or especially permanent hearing impairment and non-auditory physical effects would occur.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. In general, pinnipeds, small odontocetes, and sea otters seem to be more tolerant of exposure to airgun pulses than are baleen whales.

Masking

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data of relevance. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), a more recent study reports that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen et al. 2002). That has also been shown during recent work in the Gulf of Mexico (Tyack et al. 2003). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced in the presence of airgun pulses (Richardson et al. 1986; Greene et al. 1999; Blackwell et al. 2009). Masking effects of seismic pulses are expected to be negligible given the low number of cetaceans expected to be exposed, the intermittent nature of seismic pulses and the fact that ringed seals (the most abundant species in the area) are not vocal during this period.

Disturbance Reactions

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

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals could be significant. Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound. That likely overestimates the numbers of marine mammals that are affected in some biologically-important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based on behavioral observations during studies of several species. However, information is lacking for many species. Detailed studies have been done on humpback, gray, and bowhead whales, and on ringed seals. Less detailed data are available for some other species of baleen whales, sperm whales, small toothed whales, and sea otters.

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

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 µPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 4.5 to 14.5 km from the source. For the much smaller airgun array of this seismic survey distances to received levels in the 160–170 dB re 1 µPa rms range are 1200–435 m. Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array, however in the site clearance and shallow hazards survey area a limited number of baleen whales are expected to occur. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and recent studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 µPa rms. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). However, more recent research on bowhead whales (Miller et al. 2005) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 µPa rms (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 1999).

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

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades (Appendix A in Malme et al. 1984). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987). Populations of both gray whales and bowhead whales grew substantially during this time. In any event, the brief exposures to sound pulses from the proposed airgun source are highly unlikely to result in prolonged effects.

Toothed Whales — Few systematic data are available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales. However, systematic work on sperm whales is underway (Tyack et al. 2003), and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea et al. 2004; Moulton and Miller 2005).

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

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

Reactions of toothed whales to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for mysticetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (and pinnipeds), which tend to be less responsive than other cetaceans. However, based on the limited existing evidence, belugas should not be grouped with delphinids in the “less responsive” category.

Pinnipeds — Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources that will be used. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998). Even if reactions of the species occurring in the present study area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations. As for delphinids, a ≥170 dB disturbance criterion is considered appropriate for pinnipeds, which tend to be less responsive than many cetaceans.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds, but there has been no specific documentation of this for marine mammals exposed to sequences of airgun pulses. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and ≥190 dB re 1 µPa (rms), respectively (NMFS 2000). Those criteria have been used in defining the safety (shut down) radii planned for the proposed seismic survey. However, those criteria were established before there were any data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals.

- The 180 dB criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid temporary threshold shift (TTS), let alone permanent auditory injury, at least for belugas and delphinids.
- The minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.
- The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage.

NMFS is presently developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS 2005; D. Wieting in http://mmc.gov/sound/plenary2/pdf/plenary2summaryfinal.pdf). New science-based noise exposure criteria are also proposed by a group of experts in this field, based on an extensive review and syntheses of available data on the effect of noise on marine mammals (Southall et al., 2007) and this review seems to confirm that the current 180 dB and 190 dB are conservative.

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

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater pulsed 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 below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns and beaked whales do not occur in the present study area. It is unlikely that any effects of these types would occur during the present project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures (see below). The following subsections discuss in somewhat more detail the possibilities of TTS, permanent threshold shift (PTS), and non-auditory physical effects.

Temporary Threshold Shift (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.

For toothed whales exposed to single short pulses, the TTS threshold appears to be, to a first approximation, a function of the energy content of the pulse (Finneran et al. 2002, 2005). Given the available data, the received level of a single seismic pulse might need to be ~210 dB re 1 μPa rms (~221–226 dB pk–pk) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200–205 dB (rms) might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. Seismic pulses with received levels of 200–205 dB or more are usually restricted to a radius of no more than 200 m around a seismic vessel operating a large array of airguns. For the smaller airgun array used in the proposed survey this radius will be <35 m.

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

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

A marine mammal within a radius of ~30 m (~98 ft) around the proposed airgun array might be exposed to a few seismic pulses with levels of ≥205 dB, and possibly more pulses if the mammal moved with the seismic vessel. (As noted above, most cetacean species tend to avoid operating airguns, although not all individuals do so.) However, several of the considerations that are relevant in assessing the impact of typical seismic surveys with arrays of airguns are not directly applicable here:

- "Ramping up" (soft start) is standard operational protocol during startup of airgun arrays in many jurisdictions. Ramping up involves starting the airguns in sequence, usually commencing with a single airgun and gradually adding additional airguns. This practice will be employed when either airgun array is operated.
- It is unlikely that cetaceans would be exposed to airgun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS, given the small airgun array and the movement of both the vessel and the marine mammal.
- With a large array of airguns, TTS would be most likely in any odontocetes that bow-ride or in any odontocetes or pinnipeds that linger near the airguns. In the proposed project, Shell anticipates the 190 and 180 dB distances to be 35 m and 125 m, respectively, for the 4 x $10in^3$ array. Only seals could be expected to be potentially close to the airguns and no species that occur within the project area are expected to bow-ride.
- There is a possibility that a small number of seals (which often show little or no avoidance of approaching seismic vessels) could occur close to the airguns and that they might incur slight TTS if no mitigation action (shutdown) were taken.

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 µPa (rms). The 180 and 190 dB distances for the planned airgun array have been estimated as (35 m and 125 m, respectively) until results from field measurements are available. Furthermore, established 190 and 180 dB re 1 µPa (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. As summarized above, data that are now available imply that TTS is unlikely to occur unless bow-riding odontocetes are exposed to airgun pulses much stronger than 180 dB re 1 µPa rms (Southall et al. 2007). Since no bow-riding species occur in the study area, it is unlikely such exposures will occur.

Permanent Threshold Shift (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 pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that mammals close to an airgun array might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns 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 if the animal were exposed to the strong sound pulses with very rapid rise time.

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause permanent hearing impairment during a project employing the airgun sources planned here. In the proposed project, marine mammals are unlikely to be exposed to received levels of seismic pulses strong enough to cause more than slight TTS. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, even the levels immediately adjacent to the airgun may not be sufficient to induce PTS, especially because a mammal would not be exposed to more than one strong pulse unless it swam immediately alongside the airgun for a period longer than the inter-pulse interval. Baleen whales, and apparently belugas as well, generally avoid the immediate area around operating seismic vessels. The planned monitoring and mitigation measures, including visual monitoring, power downs, and shut downs of the airguns when mammals are seen within the “safety radii”, will minimize the already-minimal probability of exposure of marine mammals to sounds strong enough to induce PTS.

Non-auditory Physiological Effects — Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are very limited. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for sufficiently long that significant physiological stress would develop. That is especially so in the case of the proposed project where the airgun configuration focuses most energy downward and the source vessels are moving at 4–5 knots.

In general, little is known about the potential for seismic survey sounds to cause auditory impairment or other physical effects in marine mammals. Available data suggest that such effects, if they occur at all, would be limited to short distances and probably to projects involving large arrays of airguns. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects. Also, the planned monitoring and mitigation measures include shut downs of the airguns, which will reduce any such effects that might otherwise occur.

Stranding and Mortality

Marine mammals close to underwater detonations of high explosive can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Airgun pulses are less energetic and have slower rise times, and there is no proof that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a 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. However, no beaked whales are found within this project area. The shallow water environment, small airgun arrays and planned monitoring and mitigation measures of the proposed survey are not expected to result in mortality of other marine mammal species.

(b) Summary of potential effects of bathymetric sonar signals

Bathymetric sonar equipment planned for use during the 2010 site clearance and shallow hazards survey include dual-frequency side scan sonar (operating at 100–400 kHz or 300–600 kHz), single-beam echo sounder (100–340 kHz or 24–50 kHz), and multibeam echo sounder (240 kHz). These sonar devices emit very short pulses, depending on water depth. Most of the energy in the sound pulses emitted by bathymetric sonar is at moderately high frequencies. The beam is narrow in fore-aft extent and wider in the cross-track extent. Any given mammal at depth near the trackline would be in the main beam for only a fraction of a second. Therefore, marine mammals that encounter these sonar devices at close range are unlikely to be subjected to repeated pulses because of the narrow fore–aft width of the beam, and will receive only limited amounts of pulse energy because of the short pulses. Similarly, Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when a multibeam sonar emits a pulse is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to be subjected to sound levels that could cause TTS.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans (1) generally are more powerful than the equipment proposed for the current surveys, (2) have longer pulse duration, and (3) are directed close to horizontally vs. downward for the proposed equipment. The area of possible influence of the bathymetric sonar is much smaller—a narrow band oriented in the cross-track direction below the source vessel. In assessing the possible impacts of a similar multibeam system (the 15.5 kHz Atlas Hydrosweep multibeam bathymetric sonar), Boebel et al. (2004) noted that the critical sound pressure level at which TTS may occur is 203.2 dB re 1 µPa (rms). The critical region included an area of 43 m (141 ft) in depth, 46 m (151 ft) wide athwartship, and 1 m (3 ft) fore-and-aft. In the more distant parts of that (small) critical region, only slight TTS would be incurred.

Recent measurements of underwater sound propagation from equipment similar to that proposed for the 2010 bathymetric surveys in the Beaufort Sea indicated relatively low sound levels and small sound radii. Underwater sound propagation ranged from 3 to 14 m (10 to 46 ft) for 160 dB rms sound radii, and from 306 to 1360 m (1004 to 4462 ft) for 120 dB rms sound radii during measurements in the Beaufort Sea in 2008 (Mouy and Hannay 2008; Zykov and Sneddon 2008). The small disturbance radii indicate that it would be extremely unlikely that any marine mammal would approach the operating bathymetric sonar close enough be affected in a biologically significant manner.

Masking

Marine mammal communications will not be masked appreciably by the bathymetric sonar signals given the low duty cycle of the sonar and the brief period when an individual mammal is likely to be within the sonar beam. Furthermore, the bathymetric sonar equipment proposed for the 2010 site clearance and shallow hazards surveys will not overlap with the predominant frequencies in baleen whale calls, further reducing any potential for masking in that group.

Odontocetes generally have better hearing capabilities at higher frequencies than baleen whales. Hearing range is known to extend to 80-150 kHz for some species. Some odontocetes are also capable of hearing low frequencies (e.g., <500 Hz) but their sensitivity at these low frequencies seems poor (Richardson et al. 1995). Beluga whale is the only odontocete likely to occur in the proposed survey area, although harbor porpoise occurrence appears to be increasing in the Chukchi Sea and small numbers of harbor porpoise could occur in the survey area. The relatively high frequency of the proposed bathymetric sonar equipment will be above the best hearing frequencies of beluga whales and harbor porpoises, and will be unlikely to produce any masking effects for these species. Additionally these species would have to be very close to the sound source due to the small radii of sound propagation from these low energy sources.

Behavioral Responses

Behavioral reactions of free-ranging marine mammals to military and other sonars appear to vary by species and circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins et al. 1985), increased vocalizations and no dispersal by pilot whales (Rendell and Gordon 1999), and previously mentioned beachings by beaked whales. Also, Navy personnel have described observations of dolphins bow-riding adjacent to bow-mounted mid-frequency sonars during sonar transmissions. During exposure to a 21–25 kHz whale-finding sonar with a source level of 215 dB re 1 μPa•m, gray whales showed slight avoidance (~200 m or 656 ft) behavior (Frankel 2005).

However, all of those observations are of limited relevance to the present situation. Pulse durations from the Navy sonars were much longer than those of the bathymetric sonars to be used during the proposed study, and a given mammal would have received many pulses from the naval sonars. During Shell's proposed operations, the individual pulses will be very short, and a given mammal would not receive many of the downward-directed pulses as the vessel passes by.

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

We are not aware of any data on the reactions of pinnipeds to sonar sounds at frequencies similar to those of the bathymetric sonar equipment. Additionally, pinniped hearing sensitivity is probably low at the relatively high frequencies of the proposed sonars. Based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to the bathymetric sonar sounds, pinniped reactions to the sonar sounds are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Polar bears would not occur below the sound source or elsewhere at sufficient depth to be in the main beam of the bathymetric sonar, so would not be affected by the sonar sounds. As noted earlier, NMFS (2001) has concluded that momentary behavioral reactions "do not rise to the level of taking". Thus, brief exposure of cetaceans or pinnipeds to small numbers of signals from a bathymetric sonar system would not result in a "take" by harassment.

Hearing Impairment and Other Physical Effects

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

(c) Summary of potential effects of sub-bottom profiler signals

A shallow, sub-bottom profiler (operating at 2–12 kHz) is planned for use during the 2010 site clearance and shallow hazards surveys. In addition, Shell plans to use a dual frequency, sub-bottom profiler (2–7 kHz or 8–23 kHz) during ice gouge surveys. As discussed above for bathymetric sonar, the sonar equipment to be used for sub-bottom profiling during the proposed survey is relatively low energy compared to Navy sonar. Laurinolli et al. (2007) measured sound threshold levels for similar equipment (Datasonics CAP6000 profiler) in the Beaufort Sea in 2007. Underwater sound propagation ranged from 1 to 260 m (3 to 853 ft) for the 160 to 120 dB rms sound level radii.

Masking

Marine mammal communications will not be masked appreciably by the sub-bottom profiler signals given its relatively low duty cycle, directionality, and the brief period when an individual mammal is likely to be within its beam. The frequencies of sonar signals will not overlap with the predominant low frequencies in baleen whale calls, further reducing potential for masking for those species.

The only odontocetes likely to occur in the proposed survey area are beluga whale and possibly harbor porpoise. Belugas can be abundant in the Beaufort Sea during fall migration, however their migration path is generally well offshore and few belugas would be expected to occur in the nearshore locations of the proposed survey. Belugas can hear sounds ranging from 1.2 to 120 kHz with their peak sensitivity from ~10-15 kHz, which may overlap with some of the frequencies used by the sub-bottom profiling equipment (Fay 1988). However, the sub-bottom profiling equipment operates at low energy levels and sound propagation is low and unlikely to be audible to most beluga whales.

Behavioral Responses

Marine mammal behavioral reactions to other pulsed sound sources are discussed above, and responses to the sub-bottom profiler are likely to be similar to those for other pulsed sources if received at the same levels. However, the pulsed signals from the sub-bottom profiler are weaker than those from the bathymetric sonar and those from the proposed airgun array. Therefore, behavioral responses are not expected unless marine mammals are very close to the source. NMFS (2001) has concluded that momentary behavioral reactions “do not rise to the level of taking”. Thus, brief exposure of cetaceans to small numbers of signals from the sub-bottom profiler would not result in a “take” by harassment.

Hearing Impairment and Other Physical Effects

Source frequencies of the sub-bottom profilers are much lower than those of the bathymetric sonar described above. As with the bathymetric sonar, the sub-bottom profiler pulses are brief and concentrated in a downward beam. A marine mammal would be in the beam of the sub-bottom profiler only briefly, reducing its received sound energy. Thus, it is unlikely that the sub-bottom profiler will produce pulse levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source.

The sub-bottom profiler may be operated simultaneously with other higher-power acoustic sources. Many marine mammals will move away in response to the approaching higher-power sources or the vessel itself before the mammals would be close enough for there to be any possibility of effects from the sub-bottom profiler. In the case of mammals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of the higher-power sources would further reduce or eliminate any minor effects of the sub-bottom profiler.

(d) Summary of potential effects of helicopter activities

Helicopter flights are scheduled for late May and early June 2010 for reconnaissance of strudel scour locations. The reconnaissance area will extend from the Canning River west to approximately Point Thomson in State waters from the mainland shore to north of the barrier islands. The type of helicopter to be used has not yet been determined. The helicopter will fly at a minimum altitude of 305 m (1000 ft) and will remain a minimum of one mile away from any known polar bear dens.

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

Cetaceans

The nature of sounds produced by helicopter activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however minor and short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including the Beaufort Sea (Richardson et al. 1985a,b; Patenaude et al. 2002). Cetacean reactions to helicopters depend on several variables including the animal's behavioral state, activity, group size, habitat, and the flight patterns used, among other variables (Richardson et al. 1995). During spring migration in the Beaufort Sea, beluga whales reacted to helicopter noise more frequently and at greater distances than did bowhead whales (38% vs. 14% of observations, respectively). Most reaction occurred when the helicopter passed within 250 m (820 ft) lateral distance at altitudes $\leq$150 m (492 ft). Neither species exhibited noticeable reactions to single passes at altitudes >150 m. Belugas within 250 m of stationary helicopters on the ice with the engine running showed the most overt reactions (Patenaude et al. 2002). Whales were observed to make only minor changes in direction in response to sounds produced by helicopters, so all reactions to helicopters were considered brief and minor. Cetacean reactions to helicopter disturbance are difficult to predict and may range from no reaction at all to minor changes in course or (infrequently) leaving the immediate area of the activity.

The only cetaceans likely to be in the vicinity of the proposed helicopter flights during late May and early June will be bowhead and beluga whales. These whales usually migrate in open leads at distances relatively far offshore compared to the nearshore locations of strudel scour reconnaissance. The helicopter activities associated with strudel scour reconnaissance during late May and early June would not be likely to disturb any cetaceans.

Pinnipeds

Few systematic studies of pinniped reactions to aircraft overflights have been completed. Documented reactions range from simply becoming alert and raising the head to escape behavior such as hauled out animals rushing to the water. Ringed seals hauled out on the surface of the ice have shown behavioral responses to aircraft overflights with escape responses most probable at lateral distances <200 m (656 ft) and overhead distances ≤150 m (492 ft; Born et al. 1999). Although specific details of altitude and horizontal distances are lacking from many largely anecdotal reports, escape reactions to a low flying helicopter (<150 m altitude) can be expected from all three species of pinnipeds potentially encountered during the proposed operations. These responses would likely be relatively minor and brief in nature. Whether any response would occur when a helicopter is at the higher suggested operational altitudes (below) is difficult to predict and probably a function of several other variables including wind chill, relative wind chill, and time of day (Born et al. 1999).

As mentioned in the previous section, momentary behavioral reactions to industrial activities "do not rise to the level of taking" (NMFS 2001). In order to limit behavioral reactions of marine mammals during reconnaissance activities, helicopters will maintain a minimum altitude of 305 m (1000 ft) above the sea ice except when taking off or landing, which will not occur on the sea ice. At this elevation the helicopter will be unlikely to have any disturbance effects on pinnipeds.

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

Subsistence hunting continues to be an essential aspect of Inupiat Native life, especially in rural coastal villages. The Inupiat participate in subsistence hunting activities in and around the Beaufort and Chukchi Seas. The animals taken for subsistence provide a significant portion of the food that will last the community through the year. Marine mammals represent on the order of 60-80% of the total subsistence harvest. Along with the nourishment necessary for survival, the subsistence activities strengthen bonds within the culture, provide a means for educating the young, provide supplies for artistic expression, and allow for important celebratory events. In this IHA application Shell specifically discusses the potential impact from the site clearance and shallow hazards surveys planned in eastern Harrison Bay, and ice gouge surveys in Camden Bay and the Chukchi Sea to subsistence use of the bowhead whale, beluga, and seals, which are the primary marine mammals harvested for subsistence that are also covered under this authorization of incidental take by NMFS.

Bowhead Whale. Activities associated with Shell's planned site clearance and shallow hazards surveys in eastern Harrison Bay would have no or negligible effect on the availability of bowhead whales for the Kaktovik, Nuiqsut, and Barrow subsistence whaling harvests. During the proposed period of activity (July through October) most marine mammals are expected to be dispersed throughout the area, except during the peak of the bowhead whale migration in the Beaufort Sea, which occurs from late August into October. Bowhead whales are expected to be in the Canadian Beaufort Sea during much of the time prior to subsistence whaling and, therefore, are not expected to be affected by the site clearance and shallow hazards surveys prior to then. Further, site clearance and shallow hazards surveys will be conducted over 50-100 mi west of the furthest west boundary of the traditional bowhead hunting waters used by Kaktovik hunters, 10-50 mi west of Cross Island from where Nuiqsut hunters base their harvest, and over 35 mi east of the furthest east boundary of the traditional bowhead hunting waters used by Barrow hunters. In light of the small sound source for these surveys and resulting ensonified area @ 160dB (1,525 m) and the discussed reactions/behaviors of bowhead whales to marine sound sources in Section 6 and 7 of this application, the sheer distances from where these site clearance and shallow hazards surveys will occur from the areas of Kaktovik and Barrow bowhead hunts serve to mitigate any prospect of impact to the hunts. Site clearance and shallow hazards surveys will be timed to occur beyond the traditional boundary of Nuiqsut hunts, besides occurring 10-50 mi west of Cross Island and "downstream" of this bowhead whale hunt. Thereby mitigating the prospect of impact to Nuiqsut whaling. In addition, Shell will execute a communication plan and use communication and call centers located in coastal villages of the Beaufort Sea (see Section 12 of this application) to communicate activities and routine vessel traffic with subsistence users throughout the period in which all surveys will be conducted. As a result of the distance and spatial location of site clearance and shallow hazards surveys from traditional bowhead whale subsistence harvest, any effects on the bowhead whale, as a subsistence resource, will be negligible.

Activities associated with Shell's planned ice gouge surveys in Camden Bay would have no or negligible effect on the availability of bowhead whales for the Kaktovik, Nuiqsut, and Barrow subsistence whaling harvests. Mitigation of the impact from ice gouge surveys includes the possible use of either an AUV, or conventional survey method without airguns, and timing and location of surveys. The AUV will be launched from the stern of a vessel and will survey the seafloor close to the vessel. The vessel will transit an area, with the AUV surveying the area behind the vessel. Marine mammal observers onboard the vessel ensures the AUV has a minimal impact on the environment. The AUV also has a Collision Avoidance System and operates without a towline that reduces potential impact to marine mammals. Using bathymetric sonar or multibeam echo sounder the AUV can record the gouges on the seafloor surface caused by ice keels. The Sub-bottom profiler can record layers beneath the surface to about 20 ft. The AUV is more maneuverable and able to complete surveys quicker than a conventional survey. This reduces the duration that vessels producing sound must operate. Also, the ice gouge surveys will be timed to avoid locations east of Mary Sachs Entrance in Camden Bay during the bowhead subsistence harvest of Kaktovik. The ice gouge survey locations through Mary Sachs Entrance and out into Camden Bay are more than 40 mi east of Cross Island, and given this distance plus the low-level sound source of the ice gouge surveys, this will mitigate impact to the Nuiqsut bowhead whale subsistence harvest. Timing of activities will be coordinated via the nearest communication and call centers operating in the Beaufort Sea, presumably in Kaktovik and Deadhorse. As a result of the timing, location, and lack of an airgun source for the ice gouge surveys, any effects on the bowhead whale, as a subsistence resource, will be negligible.

Ice gouge survey activities in the Chukchi Sea will be scheduled to avoid impact to bowhead whale subsistence harvests that could be conducted in the Chukchi Sea communities of Wainwright or Point Hope. Scheduling will be coordinated via the nearest communication and call center operating in the Chukchi Sea communities.

Beluga. Beluga are not a prevailing subsistence resource in the communities of Kaktovik, Nuiqsut, or Barrow. Thus, given the location and timing of site clearance and shallow hazards and ice gouge surveys in the Beaufort Sea, any such behavioral response by beluga to these activities would have a no significant effect on them as a subsistence resource.

Beluga are a prevailing subsistence resource in the Chukchi Sea community of Point Lay. The Point Lay beluga hunt is concentrated in the first two weeks of July (but sometimes continues into August), when belugas are herded by hunters with boats into Kasegaluk Lagoon and harvested in shallow waters. Ice gouge survey activities in the Chukchi Sea will be scheduled to avoid the traditional subsistence beluga hunt in the community of Point Lay. Timing of any ice gouge survey activities will be coordinated via the nearest communication and call centers operating in the Chukchi Sea, presumably in Wainwright and Barrow.

Seals. Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest of both Kaktovik and Nuiqsut. Seals can be hunted year-round, but are taken in highest numbers in the summer months in the Beaufort Sea (MMS 2008). Seal-hunting trips can take Nuiqsut hunters several miles offshore; however, the majority of seal hunting takes place closer to shore. The mouth of the Colville River is considered a productive seal hunting area (AES 2009), as well as the edge of the sea ice. Lease blocks where site clearance and shallow hazards surveys will occur are located over 15 mi (24 km) from the mouth of the Colville River, so there is less chance for impact on subsistence hunting for seals. Ice gouge surveys in Mary Sachs Entrance in Camden Bay will be conducted (AES 2009) over 30 miles from the westernmost extent of seal hunting by Kaktovik hunters (AES 2009). The remainder of ice gouge lines will be much further offshore than where Kaktovik seal hunts typically occur which is inside the barrier islands (AES 2009). It is assumed that effects on subsistence seal harvests would be negligible given the distances between Shell's proposed site clearance and shallow hazards and ice gouge surveys and the subsistence seal hunting areas of Nuiqsut and Kaktovik.

Seals are an important subsistence resource in the Chukchi Sea community of Wainwright. Ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring (May-July) which is before Shell's ice gouge survey would commence, but some harvest continues into the open water period. Hunting that does occur during the open water season generally occurs within 10 mi of the coastline (AES 2009), while the majority of ice gouge survey activity will be much further offshore. Timing of activities will be coordinated via the nearest communication and call centers operating in the Chukchi Sea, presumably in Wainwright and Barrow. It is assumed that effects on subsistence seal harvests would be negligible given the timing and distances between Shell's proposed ice gouge survey and the subsistence seal hunting area of Wainwright.

All survey activities will be operated in accordance with the procedures of the Marine Mammal Monitoring and Mitigation Plan (4MP) that accompanies this program. This potential impact is mitigated by application of the procedures established in the 4MP and to be detailed in the POC. Adaptive mitigation measures may be employed during times of active scouting, whaling, or other subsistence hunting activities that occur within the traditional subsistence hunting areas of the potentially affected communities. (See Section 12).

Shell will continue its adopted spatial and temporal operational strategy that, when combined with its community outreach and engagement program, will provide effective protection to the bowhead migration and subsistence hunt. There should be no adverse impacts on the availability of any marine mammal species for subsistence uses.

9. Anticipated impact on habitat:

The activities will not result in any permanent impact on habitats used by marine mammals, or to their prey sources. Site clearance and shallow hazards and ice gouge surveys will occur during the time of year when bowhead whales are present (i.e., July through October). Any effects would be temporary and of short duration at any one place. The primary potential impacts to marine mammal habitat is associated with acoustic sound levels from the proposed site clearance and shallow hazards survey work discussed in detail earlier in Sections 6 and 7. Ice gouge surveys in both the Beaufort and Chukchi Seas will be carried out without use of airguns therefore impact to habitat via association with underwater sound will be negligible, and of very short during at any one place. A broad discussion on the various types of potential effects of exposure to fish and invertebrates can be found in LGL (2005), and includes a summary of direct mortality (pathological/physiological) and indirect (behavioral) effects.

Mortality to fish, fish eggs and larvae from energy sources would be expected within a few meters (0.5 to 3 m) from the sound source. Direct mortality has been observed in cod and plaice within 48 hours that were subjected to pulses 2 m from the source (Matishov 1992); however other studies did not report any fish kills from sound source exposure (La Bella et al. 1996, IMG 2002, Hassel et al. 2003). To date, fish mortalities associated with normal operations are thought to be slight. Saetre and Ona (1996) modeled a worst-case mathematical approach on the effects of energy on fish eggs and larvae, and concluded that mortality rates caused by exposure to sounds are so low compared to natural mortality that issues relating to stock recruitment should be regarded as insignificant.

Limited studies on physiological effects on marine fish and invertebrates to acoustic stress have been conducted. No significant increases in physiological stress from sound energy were detected for various fish, squid, and cuttlefish (McCauley et al. 2000) or in male snow crabs (Christian et al. 2003). Behavioral changes in fish associated with sound exposures are expected to be minor at best. Because only a small portion of the available foraging habitat would be subjected to sound pulses at a given time, fish would be expected to return to the area of disturbance anywhere from 15 to 30 minutes (McCauley et al. 2000) to several days (Engas et al. 1996).

Available data indicate that mortality and behavioral changes of various fish or invertebrates do occur within very close range (< 2 m) to the energy source. The proposed acquisition activities in distinct areas in the Beaufort Sea would impact less than 0.1% of available food resources, which is a negligible effect.

10. Anticipated impact of habitat loss or modification:

The effects of the planned activities are expected to be negligible, as described in Section 9. It is estimated that only a small portion of the animals utilizing the areas of the proposed activities would be temporarily displaced.

During the period of open water survey acquisition (July through October), most marine mammals would be dispersed throughout the area. The peak of the bowhead whale migration through the Beaufort Sea typically occurs in mid-September and October, and efforts to reduce potential impacts during this time, such as conducting the majority of the site clearance and shallow hazards surveys during August and September, will provide effective protection of the bowhead migration and subsistence hunt. This timing of site clearance and shallow hazards surveys in the central Beaufort Sea will take place when the whales are present in relatively low numbers. Starting in late August bowheads may travel in proximity to the aforementioned activity areas to hear sounds from vessel traffic and site clearance and shallow hazards surveys. The numbers of cetaceans and pinnipeds that might be subject to displacement, are small in relation to abundance estimates for the mammals addressed under this IHA.

In addition, feeding does not appear to be an important activity by bowheads migrating through the eastern and central part of the Alaskan Chukchi and Beaufort Seas in most years. A few bowheads can be found in the Chukchi and Bering Seas during the summer and Rugh et al. (2003) suggests that this may be an expansion of the western Arctic stock although more research is needed. In the absence of important feeding areas, the potential diversion of a small number of bowheads is not expected to have any significant or long-term consequences for individual bowheads or their population. Bowheads, gray, or beluga whales are not predicted to be excluded from any habitat.

The proposed activities are not expected to have any habitat-related effects that would produce long-term affects to marine mammals or their habitat due to the limited extent of the acquisition areas and timing of the activities.

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

Four main mitigations regarding site clearance and shallow hazards surveys in the Beaufort Sea are proposed: (1) the timing and locations for active survey acquisition work; (2) to configure air guns in a manner that directs energy primarily down to the seabed thus decreasing the range of horizontal spreading of noise; (3) using a energy source which is as small as possible while still accomplishing the survey objectives; (4) curtailing active survey work when the marine mammal observers sight visually (from shipboard) the presence of marine mammals within identified ensonified zones. Details of the proposed mitigations are discussed further in the 4MP that is included as an Attachment A to this application.

12. Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

12.1 A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation.

Shell is preparing to implement a POC) pursuant to MMS Lease Sale Stipulation No. 5, which requires that all exploration operations be conducted in a manner that prevents unreasonable conflicts between oil and gas activities and the subsistence activities and resources of residents of the North Slope. This stipulation also requires adherence to, and USFWS and NMFS regulations, which require an operator to implement a POC to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR § 18.124(c)(4) and 50 CFR § 216.104(a)(12)).

The POC relies upon 2010 Beaufort and Chukchi Sea Communication Plans (Attachment B) to identify the measures that Shell has developed in consultation with North Slope subsistence communities and will implement during its planned 2010 site clearance and shallow hazards surveys and ice gouge surveys to minimize any adverse effects on the availability of marine mammals for subsistence uses. In addition, the POC will detail Shell's communications and consultations with local subsistence communities concerning its planned 2010 program, potential conflicts with subsistence activities, and means of resolving any such conflicts (50 CFR § 18.128(d) and 50 CFR § 216.104(a) (12) (i), (ii), (iv)). Shell continues to document its contacts with the North Slope subsistence communities, as well as the substance of its communications with subsistence stakeholder groups.

The POC will be, and has been in the past, the result of numerous meetings and consultations between Shell, affected subsistence communities and stakeholders, and federal agencies. The POC identifies and documents potential conflicts and associated measures that will be taken to minimize any adverse effects on the availability of marine mammals for subsistence use. Outcomes of POC meetings are typically included in updates attached to the POC as addenda and distributed to federal, state, and local agencies as well as local stakeholder groups that either adjudicate or influence mitigation approaches for Shell's open water programs.

Meetings for Shell's 2010 program in the Beaufort and Chukchi Seas occurred in Kaktovik, Barrow, Point Hope, Point Lay, Wainwright, and Kotzebue during the 1st quarter of 2010. Shell met with the marine mammal commissions and committees including the Alaska Eskimo Whaling Commission (AEWC), Eskimo Walrus Commission (EWC), Alaska Beluga Whale Committee (ABWC), Alaska Ice Seal Committee (AISC), and the Alaska Nanuuq Commission (ANC) on December 8, 2009 in co-management meeting. Throughout 2010 Shell anticipates continued engagement with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research.

Following the 2010 season, Shell intends to have a post-season co-management meeting with the commissioners and committee heads to discuss results of mitigation measures and outcomes of the preceding season. The goal of the post-season meeting is to build upon the knowledge base, discuss successful or unsuccessful outcomes of mitigation measures, and possibly refine plans or mitigation measures if necessary.

Shell attended the 2009 Conflict Avoidance Agreement (CAA) negotiation meetings in support of their 2009 site clearance and shallow hazards surveys that tool place in the Chukchi Sea, and signed a CAA in 2009. Shell remains committed to a CAA process and will demonstrate this by making a good-faith effort to negotiate an agreement every year it has planned activities. However, Shell does not assume that a CAA is required to mitigate the planned activities of the 2010 program, nor necessary for the issuance of an IHA to Shell by NMFS.

12.2 A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation.

Shell held community meetings in Barrow, Nuiqsut, Kaktovik, Wainwright, Point Hope, and Point Lay, and Kotzebue regarding its Beaufort and Chukchi Seas 2010 program. During these meetings, Shell focused on lessons learned from the 2009 program and began preparing mitigation measures for avoiding potential conflicts, which are outlined in the 2010 Communication Plans. Shell held a December 2009 meeting with the above-mentioned marine mammal commissions that are focused on ice seals, walrus, polar bears, and beluga. Throughout 2010 Shell anticipates continued engagement with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research.

12.3 A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing;

Shell introduced the following mitigation measures, plans and programs to potentially affected subsistence groups and communities. These measures, plans, and programs have been effective in past seasons of work in the Arctic and were developed in past consultations with these communities. These measures, plans, and programs will be implemented by Shell during its 2010 program 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 2010 are listed and discussed below. These mitigation measures reflect Shell's experience conducting exploration activities in Alaska over the last four years and its ongoing efforts to engage with local subsistence communities to better understand their concerns and develop appropriate and effective mitigation measures to address those concerns. This most recent version of Shell's planned mitigation measures was presented to community leaders and subsistence user groups in the 1st quarter of 2010 and may evolve in response to information learned during the consultation process.

Subsistence Mitigation Measures

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 any subsistence hunts:

- To minimize impacts on marine mammals and subsistence hunting activities, the source vessel will transit through the Chukchi Sea along a route that lies offshore of the polynya zone. This entry into the Chukchi Sea will not occur before July 1, 2010. In the event the transit outside of the polynya zone results in Shell having to move away from ice, the source vessel may enter into the polynya zone. 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 Com Centers.
- Shell has developed Communication Plans (Attachment B) and will implement the plans before initiating the 2010 program 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 Plans includes procedures for coordination with Communication and Call Centers to be located in coastal villages along the Beaufort and Chukchi Seas during Shell's program in 2010.
- 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 may be up nine subsistence advisor-liaison positions (one per village), to work approximately 8-hours per day and 40-hour weeks through Shell's 2010 program. 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 program activities. 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.
- Shell will also implement flight restrictions prohibiting aircraft from flying within 300 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude (except during takeoffs and landings or in emergency situations) while over land or sea.

12.4 What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

Shell met with the potentially affected communities of the Beaufort and Chukchi Sea to introduce the 2010 program. These meetings served to facilitate early identification of key issues and permitting requirements.

Through the SA and Com and Call Center program for 2010, Shell will continue to stay in contact with the potentially affected communities. The SA provides the residents of the communities a way to communicate where and when subsistence activities so that industry may avoid conflicts with planned subsistence activities. The Com and Call Center protocols enable industry to inform residents daily of industry activities and planned movements. These programs provide for two-way communication and foster opportunities for mitigation of industry activities that may in some way potentially conflict with planned subsistence activities.

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

The proposed 4MP for the site clearance and shallow hazards surveys in the Beaufort Sea, and ice gouge surveys in the Beaufort and Chukchi Seas, is included as Attachment A of this application.

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

Various agencies and programs may undertake marine mammal studies in the Beaufort or Chukchi Seas during the course of the 2010 open water season. It is unclear if these studies might be relevant to Shell's proposed activities. Shell is prepared to share information obtained during implementation of our 4MP with a variety of groups who may find the data useful in their research. A suggested list of recipients includes:

- The North Slope Borough Department of Wildlife Management (T. Hepa)
- The USFWS Office of Marine Mammal Management (C. Perham and J. Garlich-Miller)
- The MMS's Bowhead Whale Aerial Survey Program (C. Monnett)
- National Oceanic and Atmospheric Association, National Marine Mammal Laboratory (Robyn Angliss)
- The Kuukpik Subsistence Oversight Panel (KSOP)
- Alaska Eskimo Whaling Commission (H. Brower - Barrow)
- Beluga Whale Committee (W. Goodwin - Kotzebue)
- Alaska Ice Seal Commission (John Goodwin)
- Inupiat Community of the Arctic Slope (Martha Ipalook Faulk - Barrow)

- North Slope Science Initiative (J. Payne)
- MMS Field Supervisor (Jeff Walker)
- Alaska Department of Natural Resources (D. Perrin)
- Alaska Department of Fish and Game

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Attachment A –
Marine Mammal Monitoring and Mitigation Plan

MARINE MAMMAL MONITORING AND MITIGATION PLAN

for

Proposed Open Water Marine Survey Program in the Beaufort and Chukchi Seas, Alaska, During 2010

Shell Offshore Inc.
Shell Gulf of Mexico Inc.

Original Submission December 2009
Revised Submission April 2010

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ACRONYMS

4MP	Marine Mammal Monitoring and Mitigation Plan
ADF&G	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AUV	Autonomous Underwater Vehicle
DASAR	Directional Autonomous Seafloor Acoustic Recorder
dB	decibel
CD	Compact Disc
GPS	Global Positioning System
ft	feet
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
km	kilometer
LGL	LGL Alaska Research Associates, Inc.
LOA	Letter of Authorization
m	meters
mi	miles
MMO	Marine Mammal Observer
MMS	Minerals Management Service
NMFS	National Marine Fisheries Service
NSB	North Slope Borough
NVD	Night-vision Device
rms	Root Mean Square
Scripps	Scripps Institute of Oceanography
Shell	Shell Offshore Inc., Shell Gulf of Mexico Inc.
SPL	Sound Pressure Level
USFWS	U.S. Fish and Wildlife Service

Introduction

Shell Offshore Inc., the lessee for Outer Continental Shelf (OCS) leases in the Beaufort Sea, and Shell Gulf of Mexico Inc., the lessee for OCS leases in the Chukchi Sea, collectively known as Shell submits the following Marine Mammal Monitoring and Mitigation Program (4MP) for site clearance and shallow hazards survey activities in the Beaufort Sea during the 2010 open-water season. The 4MP developed for Shell's 2010 site clearance and shallow hazards survey program is designed to protect the marine mammal resources in the area, fulfill reporting obligations to the Minerals Management Service (MMS), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS), and establish a means for gathering additional data on marine mammals for future operations planning.

Shell plans to conduct site clearance and shallow hazards survey within existing lease holdings of shell and partners in the Beaufort Sea. One vessel will be used in the Beaufort Sea during the 2010 open-water season.

Shell's 4MP is a combination of active monitoring of the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. If marine mammals are observed within or about to enter specific safety radii around the proposed survey activities, mitigation will be initiated by vessel-based marine mammal observers (MMOs). The size of the 180 and 190 dB re 1 μPa (rms) safety radii were modeled and are described below in the section *Mitigation Measures during Survey Activities.* These radii will be used to initiate mitigation during initial survey activities at which time an acoustics contractor will measure underwater sound propagation from the airguns to empirically determine the size of safety radii. These measured radii will be used for mitigation purposes as soon as they become available. An initial sound source analysis will be supplied to NMFS and the site clearance and shallow hazards survey operators within 120 hours of completion of the measurements. A more detailed report describing the sounds produced by the airguns will be provided to NMFS as part of the 90-day report following the end of the survey.

Monitoring during airgun activity and periods when airguns are not active will provide information on the numbers of marine mammals potentially affected by the survey activities and facilitate real time mitigation to prevent impacts to marine mammals by industrial sounds or activities. Vessel-based MMOs onboard the survey vessel will record the numbers and species of marine mammals observed in the area and any observable reaction of marine mammals to the survey activities. Aerial monitoring, designed primarily for detecting cetaceans during the bowhead migration, will be used to identify any large scale distributional changes of cetaceans relative to the activities and add to the existing database on the abundance and distribution of observed species. An acoustic program will characterize the sounds produced by the airguns and document the potential reactions of marine mammals in the area, particularly bowhead whales, to the activities.

Vessel-Based Marine Mammal Monitoring Program

Introduction

The vessel-based operations of Shell's 4MP are designed to meet the requirements of the Incidental Harassment Authorization (IHA) and Letter of Authorization (LOA) which will be issued by NMFS and USFWS, respectively, for this project, and to meet any other stipulation agreements between Shell and other agencies or groups. The objectives of the program will be:

- To ensure that disturbance to marine mammals and subsistence hunts is minimized and all permit stipulations are followed,
- To document the effects of the proposed survey activities on marine mammals, and
- To collect baseline data on the occurrence and distribution of marine mammals in the study area.

The 4MP will be implemented by a team of experienced MMOs, including both biologists and Inupiat personnel. MMOs will be stationed aboard the survey vessel through the duration of the site clearance and shallow hazards survey. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of "takes" as stipulated in the IHA and LOA.

The vessel-based portion of Shell's 4MP will be required to support the survey activities near Harrison Bay in the Alaskan Beaufort Sea. The survey dates and specific operating areas will depend upon ice and weather conditions, along with Shell's arrangements with agencies and stakeholders. Survey activities are expected to occur during July through October 2010.

The vessel-based work will provide:

- The basis for real-time mitigation, if necessary, as required by the various permits that Shell receives,
- Information needed to estimate the number of "takes" of marine mammals by harassment, which must be reported to NMFS and USFWS,
- Data on the occurrence, distribution, and activities of marine mammals in the areas where the survey program is conducted,
- Information to compare the distances, distributions, behavior, and movements of marine mammals relative to the survey vessel at times with and without airgun activity,
- A communication channel to coastal communities including Inupiat whalers, and
- Employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Inupiat MMOs.

The 4MP will be operated and administered consistent with monitoring programs conducted during seismic and site clearance and shallow hazards surveys in 2006–2009 or such alternative requirements as may be specified in the IHA issued by NMFS for this project. Any other stipulation agreements between Shell and agencies or groups such as MMS, USFWS, the North Slope Borough (NSB), and the Alaska Eskimo Whaling Commission (AEWC) will also be fully incorporated. All MMOs will be provided training through a program approved by NMFS and Shell, as described later. At least one observer on each vessel will be an Inupiat who will have the additional responsibility of communicating with coastal communities and directly with Inupiat whalers during the whaling season. Details of the vessel-based marine mammal monitoring program are described below.

Mitigation Measures during Survey Activities

Shell's planned site clearance and shallow hazards survey 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 below. Survey design features include:

- Timing and locating survey activities to avoid interference with the annual fall bowhead whale hunts from Kaktovik, Nuiqsut (Cross Island), and Barrow;
- Identifying transit routes and timing to avoid other subsistence use areas and communicate 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.

The potential disturbance of marine mammals during survey operations will be minimized further through the implementation of several ship-based mitigation measures if mitigation becomes necessary.

<u>Safety and Disturbance Zones</u>

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around industrial sound sources are customarily defined as the distances within which received sound levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. These safety criteria are based on an assumption that sound energy received at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the safety radii (Richardson et al. 1995).

Initial safety and disturbance radii for the sound levels produced by the survey activities have been modeled. These radii will be used for mitigation purposes until results of direct measurements are available early during the exploration activities. The planned survey will use an airgun source composed of either 40 cubic inch airguns or 1 x 20-in^3

plus 2 x 10-in^3 airguns. The total source volume will be 4 x 10 in^3. Measurements of a 2 x 10-in^3 airgun array used in 2007 were reported by Funk et al. (2008). These measurements were used as the basis for modeling both of the potential airgun arrays that may be used in 2010. The modeling results showed that the 40 cubic inch array is likely to produce sounds that propagate further than the alternative array, so those results were used to estimate "takes by harassment" in the IHA application to NMFS and will also be used during initial survey activities prior to in-field sound source measurements. The modeled 190 and 180 dB distances from a 40 cubic inch array were 35 and 125 m, respectively. Because this is a modeled estimate, but based on similar measurements at the same location, the estimated distances for initial safety radii were only increased by a factor of 1.25 instead of a typical 1.5 factor. This results in a 190-dB distance of 44 m and a 180-dB distance of 156 m.

A single 10-in^3 airgun will be used as a mitigation gun during turns or if a power down of the full array is necessary due to the presence of a marine mammal close to the vessel. Underwater sound propagation of a 10-in^3 airgun was measured near Harrison Bay in 2007 and results were reported in Funk et al. (2008). The 190 dB and 180 dB distances from those measurements, 5 m and 20 m respectively, will be used as the pre-sound source measurement safety zones during use of the single mitigation gun.

An acoustics contractor will perform the direct measurements of the received levels of underwater sound versus distance and direction from the energy source arrays using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify (and if necessary adjust) the safety distances. The mitigation measures to be implemented at the 190 and 180 dB sound levels will include power downs and shut downs as described below.

Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shut down is the immediate cessation of firing of all energy sources. The array will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable safety zone of the full array, but is outside the applicable safety zone of the single mitigation source. If a marine mammal is sighted within or about to enter the applicable safety zone of the single mitigation airgun, the entire array will be shut down (i.e., no sources firing).

Ramp Ups

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

During the proposed site clearance and shallow hazards survey program, the seismic operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start after a shut down, when no airguns have been firing) will begin by firing a single airgun in the array. The minimum duration of a shut-down period, i.e., without air guns firing, which must be followed by a ramp up typically is the amount of time it would take the source vessel to cover the 180-dB safety radius. The actual time period depends on ship speed and the size of the 180-dB safety radius. We estimate that period to be about 1-2 minutes based on the modeling results described above and a survey speed of 4 kts.

A full ramp up, after a shut down, will not begin until there has been a minimum of 30 min of observation of the safety zone by MMOs to assure that no marine mammals are present. The entire safety zone must be visible during the 30-minute lead-in to a full ramp up. If the entire safety zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the safety zone during the 30-minute watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

During turns and transit between seismic transects, at least one airgun will remain operational. The ramp-up procedure still will be followed when increasing the source levels from one air gun to the full arrays. However, keeping one airgun firing will avoid the prohibition of a cold start during darkness or other periods of poor visibility. Through use of this approach, seismic operations can resume upon entry to a new transect without a full ramp up and the associated 30-minute lead-in observations. MMOs will be on duty whenever the airguns are firing during daylight, and during the 30-min periods prior to ramp-ups as well as during ramp-ups. Daylight will occur for 24 h/day until mid-August, so until that date MMOs will automatically be observing during the 30-minute period preceding a ramp up. Later in the season, MMOs will be called out at night to observe prior to and during any ramp up. The seismic operator and MMOs will maintain records of the times when ramp-ups start, and when the airgun arrays reach full power.

Monitoring Prior to and during AUV deployment

In addition to the site clearance and shallow hazards surveys in the Beaufort Sea, Shell plans to use a vessel equipped for seafloor sampling and deployment of an autonomous underwater vehicle (AUV) outfitted with sonar equipment for mapping the seafloor, in both the Beaufort and Chukchi Seas. The vessel will be operated for ~10 days in the Sivulliq prospect, and ~4 days in the Burger prospect. The AUV is more maneuverable and able to more quickly complete surveys compared to conventional methods, and operates without a towline which reduces potential impact to marine mammals. This reduces the duration during which vessels producing sound must operate. The AUV can record the gouges on the seafloor surface caused by ice keels and will be equipped with:

- Dual frequency sub-bottom profiler (2 to 7 kHz or 8 to 23 kHz);
- Multi-beam bathymetric sonar (240 Hz) or similar; and
- Side-scan sonar system (190 to 210 kHz) or similar.

The AUV will be deployed from the vessel and travel in the water column autonomously along pre-programmed survey lines. The AUV will be remotely operated within 1 km (0.6 mi) of the deployment vessel. Because the vehicle travels under the surface of the water, the vehicle will not be visible by MMOs once deployed from the vessel. However, the vehicle will have a collision avoidance system that will keep it from coming in contact with marine mammals. The AUV will detect a marine mammal or other object at 100 meters. Should the AUV avoidance system detect an object the vehicle will veer away from the detected object, returning to its programmed course after the vehicle has cleared the object. The AUV will be in the range within which MMOs can effectively monitor marine mammals. In addition, MMOs will advise the vehicle operators prior to deployment if aggregations of marine mammals have been observed in the survey area which might increase the likelihood of the vehicle encountering an animal or otherwise disturbing a group of animals.

Marine Mammal Observers

Vessel-based monitoring for marine mammals will be done by trained MMOs throughout the period of survey activities to comply with expected provisions in the IHA and LOA that Shell receives. The observers will monitor the occurrence and behavior of marine mammals near the survey vessel during all daylight periods during operation, and during most daylight periods when airgun operations are not occurring. MMO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the survey operations; and documenting "take by harassment" as defined by NMFS.

Number of Observers

A sufficient number of MMOs will be required onboard the survey vessel to meet the following criteria:

- 100% monitoring coverage during all periods of survey operations in daylight;
- Maximum of 4 consecutive hours on watch per MMO;
- Maximum of ~12 hours of watch time per day per MMO.

MMO teams will consist of Inupiat observers and experienced field biologists. An experienced field crew leader will supervise the MMO team onboard the survey vessel. At least one MMO will be on duty during all daylight operations and two MMOs during 30 min pre-ramp up watches and ramp ups. Consistent with previous years surveys, two MMOs will likely be on duty during most daylight operations. The total number of MMOs may decrease later in the season as the duration of daylight decreases assuming NMFS does not require continuous nighttime monitoring.

Crew Rotation

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

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers in 2010 will be individuals with experience as observers during one or more of the 1996-2009 seismic or site clearance and shallow hazards monitoring projects in Alaska, the Canadian Beaufort, or other offshore areas in recent years.

Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring and mitigation projects. Resumés for those individuals will be provided to NMFS for review and acceptance of 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 marine mammal observers' handbook, adapted for the specifics of the planned survey program will be prepared and distributed beforehand to all MMOs (see below).

Most observers, including Inupiat observers, will also complete a two-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2010 open-water season. Any exceptions will have or receive equivalent experience or training. The training session(s) will be conducted by qualified marine mammalogists with extensive crew-leader experience during previous vessel-based seismic monitoring programs.

Primary objectives of the training include:

- Review of the marine mammal monitoring plan for this project, including any amendments specified by NMFS or USFWS in the IHA or LOA, by MMS, or by other agreements in which Shell may elect to participate;
- Review of marine mammal sighting, identification, and distance estimation methods;
- Review of operation of specialized equipment (reticle binoculars, night vision devices, and GPS system);
- Review of, and classroom practice with, data recording and data entry systems, including procedures for recording data on marine mammal sightings, monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers;
- Review of the specific tasks of the Inupiat Communicator.

MMO Handbook

A Marine Mammal Observers' Handbook will be prepared for Shells' monitoring program. Handbooks contain maps, illustrations, and photographs, as well as text, and are intended to provide guidance and reference information to trained individuals who will participate as MMOs. The following topics will be covered in the MMO Handbook for the Shell project:

- Summary overview descriptions of the project, marine mammals and underwater noise, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements), the NMFS IHA and USFWS LOA and other regulations/permits/agencies, the Marine Mammal Protection Act;
- Monitoring and mitigation objectives and procedures, initial safety radii;
- Responsibilities of staff and crew regarding the marine mammal monitoring plan;
- Instructions for ship crew regarding the marine mammal monitoring plan;
- Data recording procedures: codes and coding instructions, common coding mistakes, electronic database; navigational, marine physical, field data sheet;
- Use of specialized field equipment (reticle binoculars, NVDs, laser rangefinders);
- Reticle binocular distance scale;
- Table of wind speed, Beaufort wind force, and sea state codes;
- Data storage and backup procedures;
- List of species that might be encountered: identification, natural history;
- Safety precautions while onboard;
- Crew and/or personnel discord; conflict resolution among MMOs and crew;
- Drug and alcohol policy and testing;
- Scheduling of cruises and watches;
- Communications;
- List of field gear that will be provided;
- Suggested list of personal items to pack;
- Suggested literature, or literature cited; and
- Copies of the NMFS IHA and USFWS LOA when available.

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the survey vessel, typically the bridge. The observer(s) will scan systematically with the unaided eye and 7×50 reticle binoculars, supplemented with 20 x 60 image-stabilized Zeiss Binoculars or Fujinon 25 x 150 “Big-eye” binoculars and night-vision equipment when needed (see below). Personnel on the bridge will assist the marine mammal observer(s) in watching for marine mammals.

Information to be recorded by marine mammal observers 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:

- Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from observer, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace.
- Time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare.
- The positions of other vessel(s) in the vicinity of the observer location.

The ship's position, speed of the vessel, 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 7×50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.

Observers may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience has shown that a Class 1 eye-safe device was not able to measure distances to seals more than about 70 m (230 ft) away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 600 m (1968 ft)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. Humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20% when given immediate feedback about actual distances during training.

When a marine mammal is seen within the safety radius applicable to that species, the geophysical crew will be notified immediately so that mitigation measures called for by the IHAs can be implemented. As in 2006–2009, it is expected that the airgun arrays will be shut down within several seconds—often before the next shot would be fired, and almost always before more than one additional shot is fired. The marine mammal observer will then maintain a watch to determine when the mammal(s) appear to be outside the safety zone such that airgun operations can resume.

Monitoring At Night and In Poor Visibility

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

Specialized Field Equipment

Shell will provide or arrange for the following specialized field equipment for use by the onboard MMOs: reticle binoculars, Big-eye binoculars, GPS unit, laptop computers, night vision binoculars, and possibly digital still and digital video cameras.

Field Data-Recording, Verification, Handling, and Security

The observers will record their observations onto datasheets or directly into handheld computers. During periods between watches and periods when operations are suspended, those data will be entered into a laptop computer running a custom computer database. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking of the database printouts. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing. Quality control of the data will be facilitated by (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season.

The data will be backed up regularly onto CDs and/or USB disks, and stored at separate locations on the vessel. If possible, data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data CDs carried back to the Anchorage office during crew rotations.

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

Field Reports

Throughout the survey program, the observers will prepare a report each day or at such other interval as the IHA, LOA, or Shell may require summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS and to the survey operators.

Reporting

The results of the 2010 vessel-based monitoring, including estimates of "take by harassment", will be presented in the 90-day and final technical reports. Reporting will address the requirements established by NMFS in the IHA.

The technical report(s) will include:

- Summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the study period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- Analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of observers, and fog/glare;

- Species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories, group sizes, and ice cover;
- Analyses of the effects of survey operations:
- Sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability);
- Initial sighting distances versus airgun activity state;
- Closest point of approach versus airgun activity state;
- Observed behaviors and types of movements versus airgun activity state;
- Numbers of sightings/individuals seen versus airgun activity state;
- Distribution around the survey vessel versus airgun activity state;
- Estimates of "take by harassment".

Aerial Survey Program

Objectives

An aerial survey program will be conducted in support of the site clearance and shallow hazards program in the Beaufort Sea during the fall of 2010. The site clearance and shallow hazards survey program may start in the Beaufort Sea as early as July 2010, however, aerial surveys would not begin until the start of the bowhead whale migration, ~20 August. The objectives of the aerial survey will be:

- To advise operating vessels as to the presence of marine mammals (primarily cetaceans) in the general area of operation;
- To collect and report data on the distribution, numbers, movement and behavior of marine mammals near the survey operations with special emphasis on migrating bowhead whales;
- To support regulatory reporting related to the estimation of impacts of survey operations on marine mammals;
- To investigate potential deflection of bowhead whales during migration by documenting how far east of survey operations a deflection may occur, and where whales return to normal migration patterns west of the operations, and
- To monitor the accessibility of bowhead whales to Inupiat hunters.

Safety

Safety will be of primary importance in all decisions regarding the planning and conduct of the aerial surveys. Safety-related considerations during planning have included choice of aircraft, aircraft operator, and pilots; outfitting of the aircraft; lengths and locations of survey grids; and safety training. Safety during aerial survey operations will include careful and judicious consideration of weather and avoidance of flight in questionable conditions. Although the pilots will have ultimate authority, the aerial survey crew will also be required to make their own judgments and to avoid flying in questionable circumstances. To this end, the aerial survey teams will have a crew leader with experience conducting this type of survey in arctic conditions, and will have the authority to cancel or (in agreement with the pilots) amend flight operations as necessary for safety.

Selection of Aircraft

Specially-outfitted Twin Otter aircraft have an excellent safety record and are expected to be the survey aircraft. These aircraft will be specially modified for survey work and have been used extensively by NMFS, ADF&G, COPAC, NSB, and LGL during many marine mammal projects in Alaska, including Industry funded projects as recent as the 2006–2008 seasons. The aircraft will be provided with a comprehensive set of survival equipment appropriate to offshore surveys in the Arctic. For safety reasons, the aircraft will be operated with two pilots.

Survey Procedures

Flight and Observation Procedures

Aerial survey flights will begin ~20 August. Surveys will then be flown daily during site clearance and shallow hazards survey operations, weather and flight conditions permitting, and continued for 5 to 7 days after all activities at the site have ended.

The aerial survey procedures will be generally consistent with those used during earlier industry studies (Davis et al. 1985; Johnson et al. 1986; Evans et al. 1987; Miller et al. 1997, 1998, 1999, 2002; Patterson 2007). This will facilitate comparison and pooling of data where appropriate. However, the specific survey grids will be tailored to Shell's operations. During the 2010 open-water season Shell will coordinate and cooperate with the aerial surveys conducted by MMS/NMFS and any other groups conducting surveys in the same region.

It is understood that site clearance and shallow hazards survey timing and specific location offshore of Harrison Bay are subject to change as a result of unpredictable weather and ice conditions. The aerial survey design is therefore intended to be flexible and able to adapt at short notice to changes in the operations.

For marine mammal monitoring flights, aircraft will be flown at ~120 knots ground speed and usually at an altitude of 1000 ft. Flying at a survey speed of 120 knots greatly increases the amount of area that can be surveyed, given aircraft limitations, with minimal effect on the ability to detect bowhead whales. Surveys in the Beaufort Sea are directed at bowhead whales and an altitude of 900-1000 ft is the lowest survey altitude that can normally be flown without concern about potential aircraft disturbance; it is also the altitude recommended by NMFS for IHA monitoring efforts for bowhead whales. Aerial surveys at an altitude of 1000 ft do not provide much information about seals but are suitable for both bowhead and beluga whales. The need for a 900-1000+ ft cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher minimum altitude for surveys (e.g. 1500 ft) would result in a significant reduction in the number of days surveys would be possible, impairing the ability of the aerial program to meet its objectives.

Two primary observers will be seated at bubble windows on either side of the aircraft and a third observer will observe part time and record data when necessary. All observers need bubble windows to facilitate downward viewing. For each marine mammal sighting, the observer will dictate the species, number, size/age/sex class when determinable, activity, heading, swimming speed category (if traveling), sighting cue, ice conditions (type and percentage), and inclinometer reading to the marine mammal into a digital recorder. The inclinometer reading will be taken when the animal's location is 90° to the side of the aircraft track, allowing calculation of lateral distance from the aircraft trackline.

Transect information, sighting data and environmental data will be entered into a GPS-linked computer by the third observer, and simultaneously recorded on digital voice recorders for backup and validation. At the start of each transect, the observer recording data will record the transect start time and position, ceiling height (ft), cloud cover (in 10ths), wind speed (knots), wind direction (°T) and outside air temperature (°C). In addition, each observer will record the time, visibility (subjectively classified as excellent, good, moderately impaired, seriously impaired or impossible), sea state (Beaufort wind force), ice cover (in 10ths) and sun glare (none, moderate, severe) at the start and end of each transect, and at 2-min intervals along transect. This will provide data in units suitable for statistical summaries and analyses of effects of these variables (and position relative to the survey vessel) on the probability of detecting animals (see Davis et al. 1982; Miller et al. 1999; Thomas et al. 2002). The data logger will automatically record time and aircraft position (latitude and longitude) for sightings and transect waypoints, and at pre-selected intervals along transects.

Supplementary Data

Ice observations during aerial surveys will be recorded and satellite imagery may be used, where available, during post-season analysis to determine ice conditions adjacent to the survey area. These are standard practices for surveys of this type, and are necessary in order to interpret factors responsible for variations in sighting rates.

Shell will, as a high priority, assemble the information needed to relate marine mammal observations to the locations of the survey vessel, and to the estimated received levels of industrial sounds at mammal locations. During the aerial surveys, Shell will record relevant information on other industry vessels, whaling vessels, low-flying aircraft, or any other human activities that are observed in the survey area.

Coordination with MMS/NMFS Aerial Surveys

The MMS is planning to continue its wide-ranging aerial surveys of bowhead whales and other marine mammals in the Beaufort Sea during the autumn of 2010. In 2010, the surveys will be contracted to the National Marine Mammal Laboratory in Seattle. These surveys include the area where site clearance and shallow hazards survey activities will occur. Shell will co-ordinate with MMS/NMML to share data, both during the surveys and for use in analyses and reports.

Shell will also consult with MMS/NMML regarding coordination during the survey activities and real-time sharing of data. The aims will be:

- To ensure aircraft separation when both crews conduct surveys in the same general region;
- To coordinate the 2010 aerial survey projects in order to maximize consistency and minimize duplication;
- To use data from MMS's broad-scale surveys to supplement the results of the more site-specific Shell surveys for purposes of assessing the effects of site clearance and shallow hazards survey activities on whales and estimating "take by harassment";
- To maximize consistency with previous years' efforts insofar as feasible.

It is expected that raw bowhead sighting and flightline data will be exchanged between MMS and Shell on a daily basis during the survey period, and that each team will also submit its sighting information to NMFS in Anchorage each day. After the Shell and MMS data files have been reviewed and finalized, they will be exchanged in digital form.

Shell is not aware of any other related aerial survey programs presently scheduled to occur in the Alaskan Beaufort Sea in areas where Shell is anticipated to be conducting survey operations during July–October 2010. However, one or more other programs are possible in support of other industry and research operations. If another aerial survey project were planned, Shell would seek to coordinate with that project to ensure aircraft separation, maximize consistency, minimize duplication, and share data.

Survey Design

During the late summer and fall, bowhead whale is the primary species of concern, but belugas and gray whales are also present. Bowheads and belugas migrate through the Alaskan Beaufort Sea from summering areas in the central and eastern Beaufort Sea and Amundsen Gulf to their wintering areas in the Bering Sea (Clarke et al. 1993; Moore et al. 1993; Miller et al. 2002). Small numbers of bowheads are sighted in the eastern Alaskan Beaufort Sea starting mid-August and near Barrow starting late August but the main migration does not start until early September. Recent surveys (COMIDA 2009) and GPS tagging (ADFG 2009) have also recorded some bowheads in the western Alaskan Beaufort Sea in July and August. The bowhead migration tends to be through nearshore and shelf waters, although in some years small numbers of whales are seen near the coast and/or far offshore. Bowheads frequently interrupt their migration to feed (Ljungblad et al. 1986a, 1986b; Lowry 1993; Landino et al. 1994; Würsig et al. 2002; Lowry et al. 2004) and their stop-overs vary in duration from a few hours to a few weeks (Koski et al. 2002). A commonly used feeding area is in and near Smith Bay, east of Barrow. Less consistently used feeding areas are in coastal and shelf waters near and east of Kaktovik. In 2007 and 2008 bowhead whales also used areas near Camden Bay to feed during the migration (Ireland et al. 2008; Funk et al. 2009).

To address concerns regarding deflection of bowheads at greater distances the survey pattern around site clearance and shallow hazards operations has been designed to document whale distribution from about 40 km east of the vessel operations to about 60 km west of operations (Fig. 1).

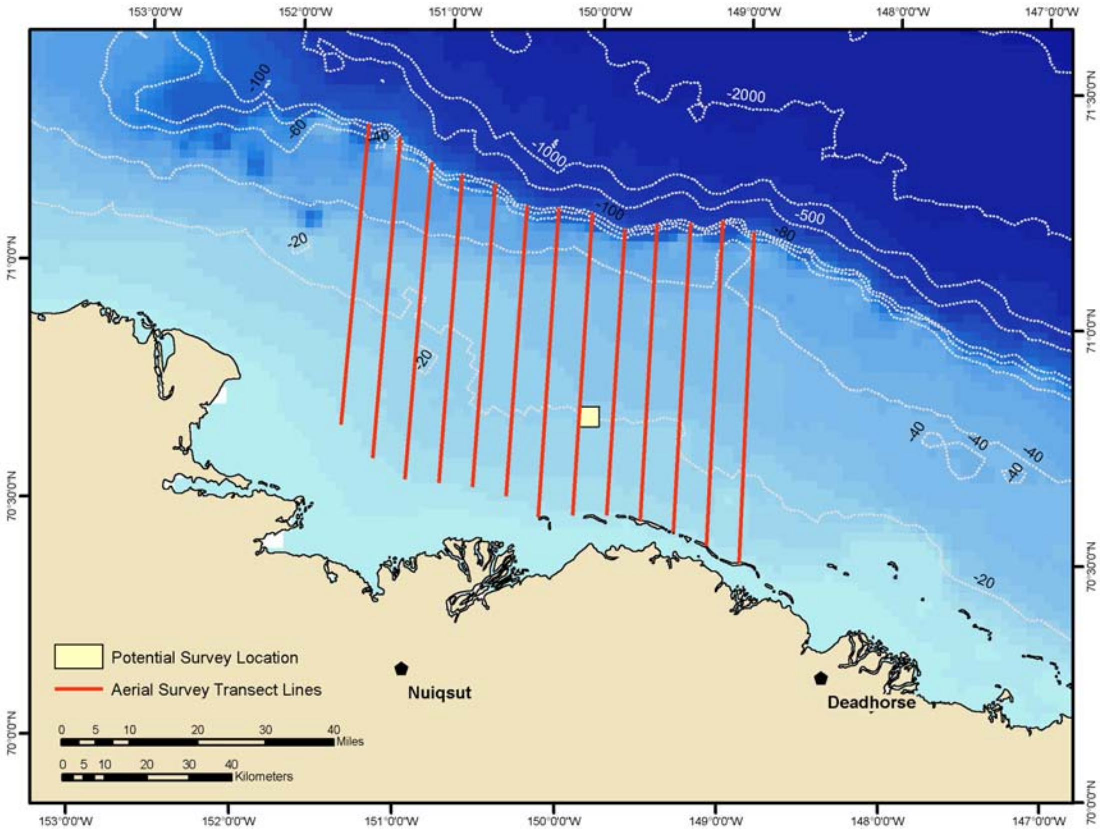

FIGURE 1. Central Alaskan Beaufort Sea showing a representative aerial survey pattern that will be flown daily during late summer and fall. The survey grid will be moved east or west depending on the precise location of the survey activities and lines will be shifted slightly within the grid for each survey in order to randomize their location and meet sampling design objectives.

Bowhead whale movements during the late summer/autumn are generally from east to west, and transects should be designed to intercept rather than parallel whale movements. The transect lines in the grid will be oriented north-south, equally spaced at 8 km, and randomly shifted in the east-west direction for each survey by no more than the transect spacing. The survey grid may total up to 1100 km in length, requiring 5-6 h to survey at a speed of 220 km/h (120 knots), plus ferry time. Exact lengths and durations will vary somewhat depending on the position of the survey operation and thus of the grid, the sequence in which lines are flown (often affected by weather), and the number of refueling/rest stops.

Weather permitting, transects making up the grid in the Beaufort Sea will be flown in sequence from west to east. This decreases difficulties associated with double counting of whales that are (predominantly) migrating westward.

Analysis of Aerial Survey Data

During the field program, preliminary maps and summaries of the daily surveys will be provided to NMFS as normally required by the terms of the IHA. While in the field, data will be checked for entry errors and files will be backed up to CDs or portable memory drives. Two levels of analyses will be conducted at the end of the season. The first level will consist of basic summaries that are required for the 90-day report specified by the IHA. These include summaries of numbers of marine mammals recorded, survey effort by date, maps summarizing sightings, and estimates of numbers of marine mammals that are "taken" according to NMFS criteria. The second level of analyses will be presented in the subsequent comprehensive report. The comprehensive report will provide more detailed analyses of the data to quantify the effect of the survey program on the distribution and movements of marine mammals.

Estimation of Numbers "Taken"

Shell has used this methodology, which was developed using past studies in the Beaufort and Chukchi sea regions (Miller et al. 1999; Haley and Ireland 2006) and other areas of the world (Lawson et al. 1998; Holst et al. 2005; Ireland et al. 2005), for estimating the numbers of marine mammals that are "taken" (as defined by NMFS). "Take" numbers are determined by estimating the numbers of animals present near or passing the survey activities during periods without airgun activity and assuming that similar numbers would have passed during periods when airguns were active. The planned approach has been accepted by NMFS as satisfying the requirements for "take" estimates for previous monitoring programs.

The criteria to be used in tabulating and estimating numbers of cetaceans potentially exposed to various sound levels will be consistent with those used during previous related projects in 1996-2009, unless otherwise directed by NMFS. Only cetaceans will be addressed using the aerial survey data because the altitude of the surveys is too high to reliably detect and identify pinnipeds. As in previous studies, Shell anticipates that there will be four components:

1. *Numbers of cetaceans observed within the area ensonified by the survey activities.* For cetaceans, Shell will estimate the numbers of animals exposed to received levels of sounds exceeding 120, 160 dB and 180 dB rms re 1 μPa, as required by NMFS.

2. *Numbers of cetaceans observed showing apparent reactions to survey activities, e.g., heading in an "atypical" direction.* Animals exhibiting apparent responses to the activities will be counted as affected by the programs if they were exposed to sounds from those activities.

3. *Numbers of cetaceans estimated to have been subjected to sound levels ≥160 and ≥180 dB re 1μ Pa (rms) when no monitoring observations were possible*. This will involve using the observations from the survey aircraft, supplemented by relevant vessel-based observations, to estimate how many cetaceans were exposed over the full course of Shell's 2010 site clearance and shallow hazards survey program to situations where received sound levels were ≥160 and ≥180 dB rms. In the case of bowhead whale, Shell will estimate proportions of observed whales that were close enough to shore to have passed through the area where exposure might occur, and could have passed

while survey operations were underway. Shell's aerial survey design, together with the complementary aerial surveys to be conducted by MMS, will provide the needed data.

4. *The number of bowheads whose migration routes came within 20 km of the survey activity, or would have done so if they had not been displaced farther offshore, will be estimate*d. If the 2010 data indicate that the avoidance distance exceeds 20 km, the larger avoidance distance will also be used for estimating the numbers of whales potentially responding to the survey activity. These estimates will be obtained by determining the displacement distance based on the aerial survey results, and then estimating how many bowheads were likely to approach the avoided area during times while the survey vessel was active.

Effects of Survey Activities on Bowhead Migration

The location of the bowhead migration corridor in 2010 will be determined by examining data from periods without survey activities and/or from east of the operations. The MMS aerial survey data will be a useful supplement for areas well east of the survey program. Shell will contrast the numbers of bowhead sightings and individuals vs. distance from shore:

- During periods with vs. without survey operations, and
- Near vs. east vs. west of the survey areas.

The distance categories will be linked to received sound levels based on the results from the acoustic measurement task. Analyses will be done on a sightings-per-unit effort basis to allow meaningful interpretation even though aerial survey effort is inevitably inconsistent at different distances offshore.

To determine how far east, north and west displacement effects (if any) extend, additional analyses will be conducted on bowhead sightings and survey effort in relation to distance and bearing from the survey vessel during times with and without airgun activity. Shell anticipates applying a logistic or Poisson regression approach to assess the effects of distance and direction from the survey activities on sighting probability of bowhead whales, allowing for the confounding influence of sightability (sea state, ice conditions, etc) and other covariates. Such an approach has been used extensively in analyses of whale and seal distribution in the Beaufort Sea (Manly et al. 2004; Moulton et al. 2005). Other analyses that may be useful to describe the effects of the survey activities on the bowhead migration path, including summaries of headings, behavior and swimming speeds, will be included in the technical report.

The data from the current survey may not provide enough sightings to be able to quantify the effects of Shell's 2010 activities on the bowhead whale migration path. That could occur if Shell's operations in the Beaufort Sea during the bowhead whale migration season were limited due to ice or other factors, or if 2010 is a year when weather conditions are poorer than average, which would limit the periods when aerial surveys could be conducted.

The aerial survey data pertaining to other species of marine mammals will also be mapped and analyzed insofar as is useful. However, the main migration corridor of belugas is far offshore, and generally north of the aerial survey area proposed here. Few gray whales and walruses are likely to be seen because of their rarity in the Beaufort Sea area (although gray whales were seen in the area in 1998 (Miller et al. 1999) and small numbers have been seen during several recent surveys by MMS (Treacy 1998, 2000, 2002) and LGL (Patterson et al. 2007). Therefore, the proposed aerial surveys are expected to document the infrequent use of continental shelf waters of the Beaufort Sea by beluga whales, gray whales and walruses, but detailed analyses for these species probably will not be warranted. Seals cannot be surveyed quantitatively during aerial surveys at altitudes 900 to 1500 ft over open water. The aerial surveys will provide only incidental data on the occurrence of bearded and especially ringed seals in the area.

Acoustic Monitoring Plan

Sound Source Measurements

As described above, previous measurements of airguns in the Harrison Bay area were used to model the distances at which received levels are likely to fall below 160, 180, and 190 dB rms from the planned airgun sources. These modeled distances will be used as temporary safety radii until measurements of the airgun sound source are conducted. The measurements will be made at the beginning of the field season and the measured radii used for the remainder of the survey period.

The objectives of the sound source verification measurements planned for 2010 in the Beaufort Sea will be (1) to measure the distances in the broadside and endfire directions at which broadband received levels reach 190, 180, 170, 160, and 120 dB_{rms} re 1 μPa for the energy source array combinations that may be used during the survey activities. The configurations will include at least the full array and the operation of a single source that will be used during power downs. The measurements of energy source array sounds will be made at the beginning of the survey and the distances to the various radii will be reported as soon as possible after recovery of the equipment. The primary radii of concern will be the 190 and 180 dB safety radii for pinnipeds and cetaceans, respectively, and the 160 dB disturbance radii. In addition to reporting the radii of specific regulatory concern, nominal distances to other sound isopleths down to 120 dB_{rms} will be reported in increments of 10 dB.

Data will be previewed in the field immediately after download from the ocean bottom hydrophone (OBH) instruments. An initial sound source analysis will be supplied to NMFS and the airgun operators within 120 hours of completion of the measurements, if possible. The report will indicate the distances to sound levels between 190 dB_{rms} re 1 μPa and 120 dB_{rms} re 1 μPa based on fits of empirical transmission loss formulae to data in the endfire and broadside directions. The 120-hour report findings will be based on analysis of measurements from at least three of the OBH systems. A more detailed report including analysis of data from all OBH systems will be issued to NMFS as part of the 90-day report following completion of the acoustic program.

Airgun pressure waveform data from the OBH systems will be analyzed using JASCO's suite of custom signal processing software that implements the following data processing steps:

- Energy source pulses in the OBH recordings are identified using an automated detection algorithm. The algorithm also chooses the 90% energy time window for rms sound level computations.
- Waveform data is converted to units of microPascals (μPa) using the calibrated acoustic response of the OBH system. Gains for frequency-dependent hydrophone sensitivity, amplifier and digitizer are applied in this step.
- For each pulse, the distance to the airgun array is computed from GPS deployment positions of the OBH systems and the time referenced DGPS navigation logs of the survey vessel.
- The waveform data are processed to determine flat-weighted peak sound pressure level (PSPL), rms sound pressure level (SPL) and sound exposure level (SEL).
- Each energy pulse is Fast Fourier Transformed (FFT) to obtain 1-Hz spectral power levels in 1-second steps.
- The spectral power levels are integrated in standard 1/3-octave bands to obtain band sound pressure levels (BSPL) for bands from 10 Hz to 20 kHz. M-weighted SPL's for each airgun pulse may be computed in this step for species of interest.

The output of the above data processing steps includes listings and graphs of airgun array narrow band and broadband sound levels versus range, and spectrograms of shot waveforms at specified ranges. Of particular importance are the graphs of level versus range that are used to compute representative radii to specific sound level thresholds.

Acoustic Study of Bowhead Deflections

Shell plans to deploy arrays of acoustic recorders in the Beaufort Sea in 2010, similar to those deployed in 2007 and 2008 using DASARs supplied by Greeneridge. These directional acoustic systems permit localization of bowhead whale and other marine mammal vocalizations. The purpose of the array will be to further understand, define, and document sound characteristics and propagation resulting from site clearance and shallow hazards surveys that may have the potential to cause deflections of bowhead whales from their migratory pathway. Of particular interest will be the east-west extent of deflection, if any (i.e., how far east of a sound source do bowheads begin to deflect and how far to the west beyond the sound source does deflection persist). Of additional interest will be the extent of offshore (or towards shore) deflection that might occur.

In previous work around seismic operations in the Alaskan Beaufort Sea, the primary method for studying this question has been aerial surveys. Acoustic localization methods will provide supplementary information for addressing the whale deflection question.

Compared to aerial surveys, acoustic methods have the advantage of providing a vastly larger number of whale detections, and can operate day and night, independent of visibility, and to some degree independent of ice conditions and sea state—all of which prevent or impair aerial surveys. However, acoustic methods depend on the animals to call, and to some extent assume that calling rate is unaffected by exposure to industrial noise. Bowheads call frequently in fall, but there is some evidence that their calling rate may be reduced upon exposure to industrial sounds, complicating interpretation. The combined use of acoustic and aerial survey methods will provide a suite of information that should be useful in assessing the potential effects of survey operations on migrating bowhead whales.

Objective

The objective of this study is to provide information on bowhead migration paths along the Alaskan coast, particularly with respect to industrial operations, and whether and to what extent there is deflection due to industrial sound levels. Using passive acoustics with directional autonomous recorders, the locations of calling whales will be observed for a six- to ten-week continuous monitoring period at five coastal sites (subject to favorable ice and weather conditions). An example of the whale call locations measured from a similar array of DASARs in 2008 is presented in Figure 2 (Blackwell et al. 2009).

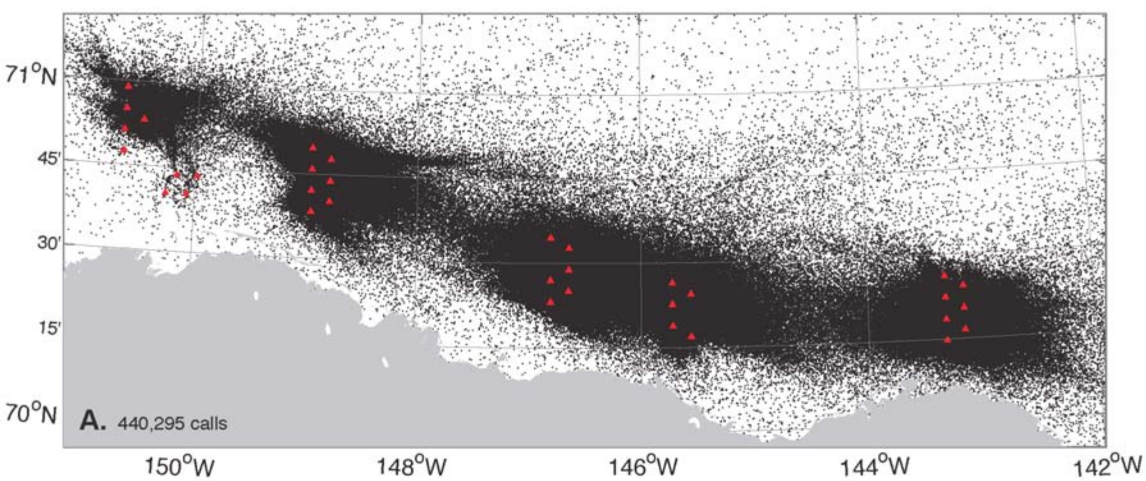

Figure 2. Bowhead whale call locations determined from the received bearings at five arrays of DASARs in the Beaufort Sea in 2008.

Monitoring Plan

Shell plans to conduct the whale migration monitoring using the passive acoustics techniques developed and used successfully since 2001 for monitoring the migration past Northstar production island northwest of Prudhoe Bay and from Kaktovik to Harrison Bay during the 2007–2009 migrations. Those techniques involve using DASARs to measure the arrival angles of bowhead calls at known locations, then triangulating to locate the calling whale. Hundreds of thousands of whale calls were successfully located in 2007 and 2008.

In attempting to assess the responses of bowhead whales to the planned industrial operations, it will be essential to monitor whale locations at sites both near and far from industry activities. Shell plans to monitor at five sites along the Alaskan Beaufort coast as shown in Figure 3. The eastern-most site (#5 in Fig.3) will be just east of Kaktovik and the western-most site (#1) will be in the vicinity of Harrison Bay. Site 2 will be located west of Prudhoe Bay. Sites 4 and 3 will be west of Camden Bay. These five sites will provide information on possible migration deflection well in advance of whales encountering an industry operation and on "recovery" after passing such operations should a deflection occur.

The proposed geometry of DASARs at each site is comprised of seven DASARs oriented in a north-south pattern comprising five equilateral triangles with 7-km element spacing. This geometry is illustrated in Figure 3. Five kilometer spacing has been used successfully in the migration studies at Northstar, but whale calls are received reliably at greater spacing and the 7 km spacing will result in greater coverage of whales along the north-south dimension, which will aid in detecting possible deflection.

DASARs will be installed at planned locations using a GPS. However, each DASAR's orientation once it settles on the bottom is unknown and must be determined to know how to reference the call angles measured to the whales. That is, where is true north relative to the DASAR orientation? Also, the internal clocks used to sample the acoustic data typically drift slightly, but linearly, by an amount up to a few seconds after six weeks of autonomous operation. Knowing the time differences within a second or two between DASARs is essential for identifying identical whale calls received on two or more DASARs. Solving these two problems is accomplished during calibration by transmitting known sounds at known times from known locations (by GPS) at six points around each DASAR at the beginning and at the end of the operational period. (Shell also will use a mid-season calibration.) Because of the equilateral triangular geometry, it requires 25 transmission stations for each site. Each set of transmissions requires less than half a minute. For the 5-km spacing, experience has been that it requires an hour to do 4 calibration transmissions, including transit. For our planned 7-km spacing, we estimate three calibration transmissions per hour. With 25 transmissions at each site, calibration of a site will require ~8 hours.

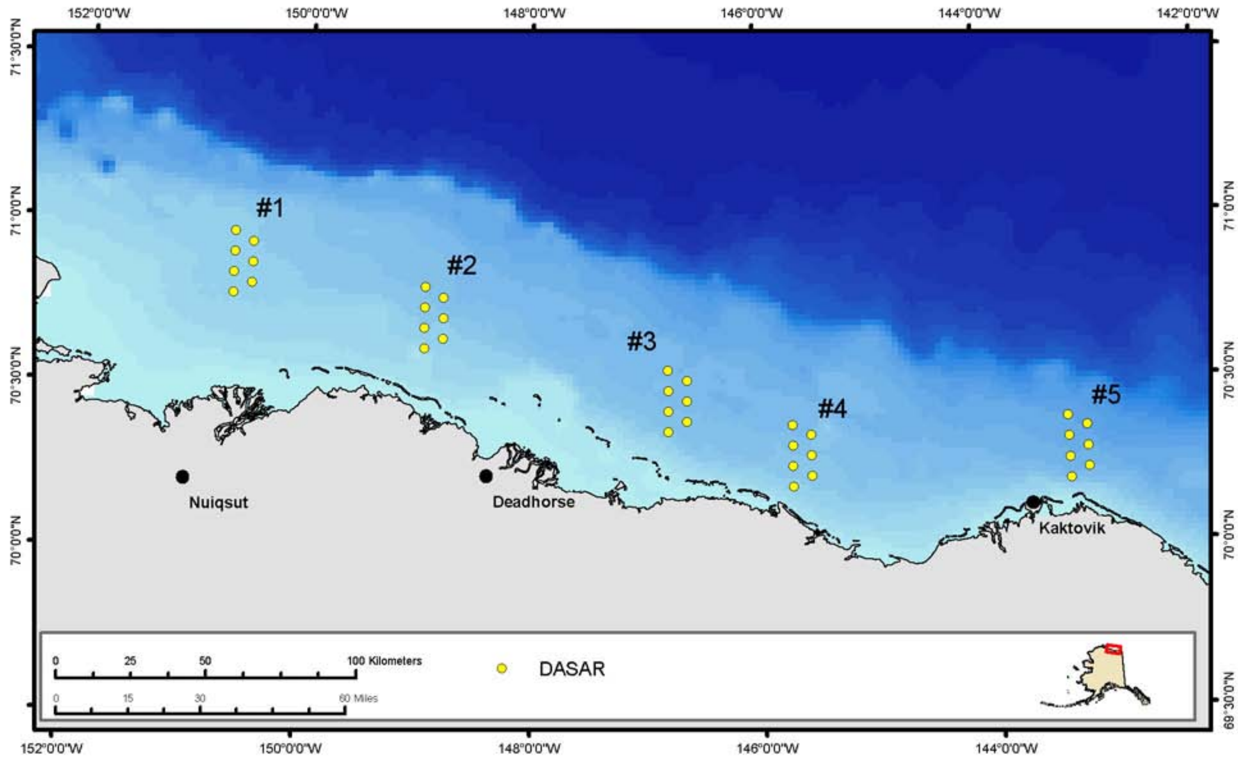

Figure 3. The Alaskan Beaufort Sea coast showing DASAR site locations for whale call location studies. The DASAR array locations at the five sites are shown to scale, with seven DASARs forming five equilateral triangles with a unit spacing of 7 km and a north-south extent of 21 km to aid being able to observe possible offshore deflection.

The calibration transmissions are made using a small projector easily deployed and retrieved over the side of a vessel by a single person. Maximum source level is only 150 dB re 1μPa at 1 m. The received level at a distance of 100 m will be ~110 dB, a level less than any known to cause disturbance to marine life.

Bowhead migration begins in late August with the whales moving westward from their feeding sites in the Canadian Beaufort Sea. It continues through September and well into October. Shell will attempt to install the 21 DASARs at three sites (3, 4 and 5 in Figure 3) in early August. The remaining 14 DASARs will be installed at sites 1 and 2 in late August. Thus, we propose to be monitoring for whale calls from before 15 August until sometime before the 15th of October.

At the end of the season the 4th DASAR in each array will be refurbished, recalibrated, and redeployed to collect data through the winter. The other DASARs in the arrays will be recovered. The redeployed DASARs will be programmed to record 35 minutes every three hours with a disk capacity of 10 months at that recording rate. This should be ample space to allow over-wintering from ~mid-October 2010 through mid-July 2011.

Whale call analysis for the Northstar DASARs has been a manual process in which analysts observe acoustic spectrograms in one-minute periods, looking for patterns caused by a whale call. Listening to the sound, the analyst verifies that a sound is or is not a whale call. The bearing is calculated for whale calls and stored for localization if the same call is present at one or more other DASARs in an array. In the proposed 2010 project, machine-aided call detection software will be used to simplify and accelerate the call analysis. Such software was developed with Shell's sponsorship in 2006 and is described in Greene et al. (2007). The software has been tested during data collection efforts in 2008 and is currently undergoing additional tests to determine its ability to accurately locate whale calls.

When the call locations have been assessed for accuracy, the locations will be analyzed for evidence of migration deflection. However, one must assess where the migration path would have been in the absence of industrial activities. The migration path is known to vary from year to year as a consequence of various factors. To control for this inter-annual variation, array pairs east and west of industrial activities will be used to compare offshore distances prior to and after whales pass through areas exposed to varying levels of anthropogenic sound. All DASAR arrays, and potentially those deployed for other studies (i.e., those supporting BP's studies of migration past its Northstar development), could be used to quantify density contours of the bowhead whale migration corridor. This estimation of the migration corridor would amount to an unprecedented quantification in terms of the extent of the coastline covered and the amount of data included.

Many interesting analyses will be available from the data collected by the five array sites. Only two analyses are discussed here.

One analysis will estimate the location of the migration corridor across the extent of our study area. The migration corridor will be estimated by contours for the distribution of whale locations along the coast from array #1 to array #5. Density contours will be estimated using kernel density estimation (Silverman 1998). To be included in this analysis, call precision must be high, or alternatively, calls will be inversely weighted according to the size of their error ellipse. Because Shell anticipates that calls occurring between arrays will have very low precision, the variance of density estimates in these areas will be high. If the migration corridor is generally close to shore at arrays #5 and #4, but far offshore at the locations of arrays #2, and #1, an offshore displacement of the corridor near the planned survey activity might be inferred. Shell plans to use block bootstrapping (Lahiri 2003) of raw data to assess variation in contours when appropriate. Block bootstrapping accounts for potential autocorrelation among locations collected during short time intervals. This analysis does not depend on quantification of underwater industrial sounds emanating from survey operations.

A second analysis to assess deflection will relate changes in offshore distribution to changes in industrial sound levels. These analyses are predicated on the assumption that industrial sound levels will vary from below background to substantially above background throughout the season, and that reliable measurements of industrial sound at the source are available. Assuming source levels vary substantially throughout the season, this analysis will use periods of low industrial sound as "reference" periods, and relate shifts in the offshore distribution to increased levels of sound using regression or quantile regression analysis (Koenker and Park 1996; Koenker and Geling 2001; Koenker and Xiao 2002).

To illustrate the second analysis, consider DASAR sites #1 and #2 in Figure 3. Over a standard reporting period, for example 6 hours, calls located by these two arrays will be collected, as well as other environmental covariates such as water depth, ambient sound levels, time of day, etc. From these data, summary statistics for offshore distribution, and all covariates of interest will be calculated. For example, the 25th percentile of offshore distance may be calculated, as well as the average water depth of all call locations in the 6-hour reporting period. Differences in offshore summary statistics among arrays will then be calculated and used in a regression or quantile regression analysis. Using the example above, the difference in 25th percentile of offshore distance between array #1 and array #2 could be related to the average industrial sound level output by the source. Assuming displacement occurs somewhere between arrays #1 and #2, a constant difference in the 25th percentile of offshore distance when sound levels are low, and larger differences in offshore distance when industrial sound levels increase would be expected. A significant slope of the regression relating offshore distance difference to sound levels will indicate a statistically significant displacement between the arrays in question. This type of analysis can be run using any pair of DASAR arrays (e.g., between #5 and #3 or between #4 and #1, etc.).

Analysis assumptions:

- Changes in the offshore distribution of call locations reflect either changes in whale locations or changes in calling behavior.
- Industrial sound levels will vary substantially throughout the season. "Substantial" means by a level that is both detectable and biologically important to bowhead whales. In other words, extended periods of both low and high sound production need to be present.
- Industrial sound levels surrounding the airgun sources need to be accurately quantified at varying distances in such a way that industrial sound levels and whale locations can be matched. An accurate propagation model for industrial sounds hopefully can be constructed from the collected data.
- A large number of whales will swim through the areas where arrays can reliably locate their calls.

Analysis Report

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

Comprehensive Report on industry activities and marine Mammal monitoring efforts in the Beaufort and Chukchi Seas

Following the 2010 site clearance and shallow hazards surveys 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.

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Attachment B –
2010 Beaufort and Chukchi Sea Communications Plans

COMMUNICATION PLAN
2010 MARINE SURVEYS BEAUFORT SEA, ALASKA

The following Communication Plan will be used during the 2010 marine surveys program ("Program"; shallow hazards survey; ice gouge survey; seafloor soil sampling; marine environmental baseline studies) in the Beaufort Sea to coordinate activities with local subsistence users. These users include the Alaska Eskimo Whaling Commission (AEWC), Alaska Eskimo Walrus Commission (AWC), Alaska Nanuuq Commission (ANC), Alaska Beluga Whale Committee (ABWC), Ice Sea Committee (ICS), village Whaling Captains Associations (WCA), village residents, and industry representatives. The planned Program is anticipated to continue from July through October.

The Communications Plan will be implemented in two phases. Phase I describes the guidelines already in place to ensure proper communication during the Program. Phase II describes what to do in the event Shell activities potentially affect subsistence activities and how to keep subsistence user groups informed of Shell activities. Phase I and II are designed to minimize the potential for interference of Shell activities with subsistence activities and resources and to keep operators up-to-date regarding the timing and status of the bowhead whale migration in the Beaufort Sea as well as the timing and status of other subsistence hunts.

Program operations will be performed in compliance with all applicable permits and authorizations, including:

- Plan of Cooperation (U.S. Fish & Wildlife Service (USFWS); National Marine Fisheries Service (NMFS) and Minerals Management Service (MMS);
- Letter of Authorization per USFWS;
- Incidental Harassment Authorization per NMFS;
- Ancillary Activity Authorization per MMS;
- Lease Stipulation 5 from Outer Continental Shelf lease sales 195 and 202 per MMS;
- Geophysical Exploration Permit (Department of Natural Resources – Division of Oil and Gas); and
- Conditional Development Permit (North Slope Borough)

PHASE I

- Marine Mammal Observers (MMOs) will be onboard the Program vessel(s) with responsibilities to: monitor for the presence of marine mammals; assist with the maintenance of marine mammal safety radii around vessels; monitor and record avoidance or exposure behaviors; and communicate with the Communication and Call Centers (Com Centers) and local subsistence hunters by marine radio.

- If a conflict arises between Program activities and subsistence hunting, the MMOs will immediately contact the vessel captain and the Com Centers. The Com Centers will then contact Shell's simultaneous operations response team. If avoidance is not possible, the next phase will include communication between a Shell representative and a representative from the impacted subsistence hunter group(s) to resolve the issue and plan an alternative course of action by either industry or the subsistence groups.

- Shell will employ local Subsistence Advisors from the Beaufort Sea villages to provide consultation and guidance regarding the affected species migration, the subsistence hunt, and other subsistence activities. The Subsistence Advisors will work approximately 8-hours per day and 40-hour weeks through 2010. Responsibilities of the Subsistence Advisors will include: reporting any subsistence concerns or conflicts, within 4-hours if the conflict appears imminent, to the Com Centers (who will then contact Shell's simultaneous operations emergency response team); coordinating with subsistence users to advise on location and timing of Shell's activities; reporting subsistence-related comments, concerns, and information to Shell staff; and, advising Shell how to avoid subsistence conflicts and subsistence users. A subsistence advisor handbook will be developed and provided to each Subsistence Advisor. The handbook will outline contact numbers, communication procedures, and communication timelines for reporting and communicating potential conflict situations.

- Helicopter traffic flight restrictions will be in place to prohibit aircraft from flying within 1,000 ft (300 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. If flights need to deviate from this path due to emergency landings or other unavoidable reasons, the new flight information will be immediately shared, as outlined by Shell HSSE requirements, with Com Centers so area subsistence users can be notified.

PHASE II

All guidelines in Phase I will be adhered to in addition to the following:

- If potential conflicts are identified between Shell activities and subsistence activities; the Communications Plan will be used to manage the issue.

- Once transiting of vessel(s) begins through the Beaufort Sea, during marine surveys activities, and during mobilization from the Beaufort Sea, depending on the pending routes and timing of transit, Shell will continue with engagements and regular communications with the AEWC, AWC, ANC, ABWC, ISC, and/or the WCAs of Barrow, Nuiqsut, and Kaktovik.

COMMUNICATION PLAN
2010 MARINE SURVEYS CHUKCHI SEA, ALASKA

The following Communication Plan will be used during the 2010 marine surveys program ("Program"; ice gouge survey; seafloor soil sampling; marine environmental baseline studies) in the Chukchi Sea to coordinate activities with local subsistence users. These users include the Alaska Eskimo Whaling Commission (AEWC), Alaska Eskimo Walrus Commission (AWC), Alaska Nanuuq Commission (ANC), Alaska Beluga Whale Committee (ABWC), Ice Sea Committee (ICS), village Whaling Captains Associations (WCA), and industry representatives. The planned Program is anticipated to continue from July through October.

The Communications Plan will be implemented in two phases. Phase I describes the guidelines already in place to ensure proper communication during the Program. Phase II describes what to do in the event Shell activities potentially affect subsistence activities and how to keep subsistence user groups informed of Shell activities. Phase I and II are designed to minimize the potential for interference of Shell activities with subsistence activities and resources and to keep operators up-to-date regarding the timing and status of the bowhead whale migration in the Chukchi Sea as well as the timing and status of other subsistence hunts.

Program operations will be performed in compliance with all applicable permits and authorizations, including:

- Plan of Cooperation (U.S. Fish & Wildlife Service (USFWS); National Marine Fisheries Service (NMFS) and Minerals Management Service (MMS);
- Letter of Authorization per USFWS;
- Incidental Harassment Authorization per NMFS;
- Ancillary Activity Authorization per MMS;
- Lease Stipulation 5 from Outer Continental Shelf lease sale 193 per MMS;
- Geophysical Exploration Permit (Department of Natural Resources – Division of Oil and Gas); and
- Conditional Development Permit (North Slope Borough)

PHASE I

- Marine Mammal Observers (MMOs) will be onboard the Program vessel(s) with responsibilities to: monitor for the presence of marine mammals; assist with the maintenance of marine mammal safety radii around vessels; monitor and record avoidance or exposure behaviors; and communicate with the Communication and Call Centers (Com Centers) and local subsistence hunters by marine radio.

- If a conflict arises between Program activities and subsistence hunting, the MMOs will immediately contact the vessel captain and the Com Centers. The Com Centers will then contact Shell's simultaneous operations response team. If avoidance is not possible, the next phase will include communication between a Shell representative and a representative from the impacted subsistence hunter group(s) to resolve the issue and plan an alternative course of action by either industry or the subsistence groups.

- Shell will employ local Subsistence Advisors from the Chukchi Sea villages to provide consultation and guidance regarding the affected species migration, the subsistence hunt, and other subsistence activities. The Subsistence Advisors will work approximately 8-hours per day and 40-hour weeks through 2010. Responsibilities of the Subsistence Advisors will include: reporting any subsistence concerns or conflicts, within 4-hours if the conflict appears imminent, to the Com Centers (who will then contact Shell's simultaneous operations emergency response team); coordinating with subsistence users to advise on location and timing of Shell's activities; reporting subsistence-related comments, concerns, and information to Shell staff; and, advising Shell how to avoid subsistence conflicts and subsistence users. A subsistence advisor handbook will be developed and provided to each Subsistence Advisor. The handbook will outline contact numbers, communication procedures, and communication timelines for reporting and communicating potential conflict situations.

- Helicopter traffic flight restrictions will be in place to prohibit aircraft from flying within 1,000 ft (300 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. If flights need to deviate from this path due to emergency landings or other unavoidable reasons, the new flight information will be immediately shared, as outlined by Shell HSSE requirements, with Com Centers so area subsistence users can be notified.

- To minimize impacts on marine mammals and subsistence hunting activities, the marine surveys vessel(s) will transit through the Chukchi Sea along a route that allows for the highest degree of safety regarding ice conditions and sea states.

PHASE II

All guidelines in Phase I will be adhered to in addition to the following:

- If potential conflicts are identified between Shell activities and subsistence activities; the Communications Plan will be used to manage the issue.

- Once transiting of vessel(s) begins through Chukchi Sea, during marine surveys activities, and during mobilization from the Chukchi Sea, depending on the pending routes and timing of transit, Shell will continue with engagements and regular communications with the AEWC, AWC, ANC, ABWC, ISC, and/or the WCAs of Barrow, Wainwright, Point Lay and Point Hope.