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 Chukchi and Beaufort Seas, Alaska, During 2009-2010

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Executive Summary

As described herein, during the open water seasons in 2009-2010, 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 and Chukchi Seas. 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. These types of surveys, collectively and individually, have not resulted in impacts of biological significance to marine mammals of the Arctic, or interference with the subsistence harvest of those marine mammals by the residents of the communities along the Beaufort and Chukchi Seas.

On August 20, 2008, NMFS issued Shell an IHA to conduct these types of marine surveys in the Beaufort and Chukchi Seas. That IHA is effective through August 19, 2009. The enclosed application describes Shell's request to extend authorization for one-year from the date of issue in 2009 for only site clearance and shallow hazards, ice gouge, and strudel scour surveys in select areas of the Beaufort and Chukchi Seas (see Figures 1-5).

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 Incidental Harassment Authorization (IHA).

> 50 CFR 216.104 "Submission of Requests"
>
> (a) In order for the National Marine Fisheries Service (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 2009-2010 open-water marine survey season (collectively the proposed open water marine survey program, hereinafter referred to as the "Program):

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

Each of these individual surveys will require marine vessels to accomplish the work. Vessels that are anticipated to be under contract to Shell, or a contractor to Shell, at the time of this IHA application are specifically named herein. . In this IHA application, Shell describes the tasks that 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 because the vessel named in this application may or may not eventually be selected to conduct the work. 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 August 20, 2009 to August 20, 2010.

Chukchi Sea Site Clearance and Shallow Hazards Surveys

Description of Activity: Site clearance and shallow hazards surveys of potential proposed locations for exploration drilling will be executed as required by 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 Chukchi Sea site clearance and shallow hazards surveys will be conducted on leases that were acquired in OCS LS 193. Site clearance surveys are confined to small specific areas within OCS blocks. Actual locations of site clearance and shallow hazards surveys have not been definitively set as of this date, although these will occur within the Chukchi Sea marine survey area of OCS lease blocks shown in 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.

The vessel that will be conducting the site clearance and shallow hazards surveys may also be used in the deployment and retrieval of underwater Ocean Bottom Hydrophones (OBHs) as described in the 4MP in Attachment A. These OBHs are anchored underwater buoys that record marine mammal vocalizations and other underwater sounds.

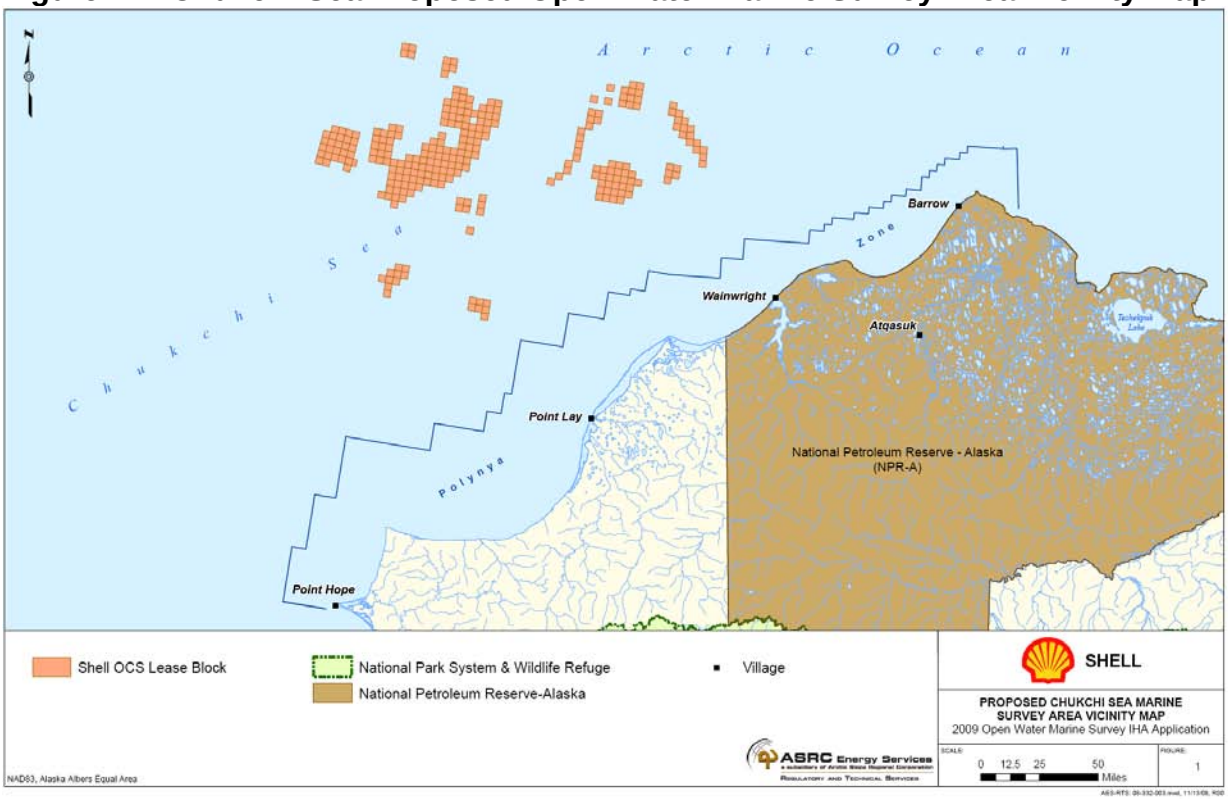
Primary Contractor: The contractor has not yet been selected.

Description of the site clearance and shallow hazards vessel and survey equipment: These surveys are confined to small specific areas within OCS blocks. The vessel that will be conducting this activity is the R/V Norseman II, or similar. The R/V Norseman II is a diesel powered vessel, 35.05 m (115 ft) long, 8.66 m (28.4 ft) wide, with a 4.08 m (13.4 ft) draft.

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

- Dual-frequency side scan sonar, or similar;
- Single beam Echo Sounder, or similar;
- Multibeam Echo Sounder, or similar;
- High resolution multi-channel 2D system, 20 cubic inches (in^3) (2 by 10) airgun array, or similar;
- Shallow Sub-Bottom Profiler, or similar;
- Medium Penetration Sub-Bottom Profiler, or similar.

Figure 1 Chukchi Sea Proposed Open Water Marine Survey Area Vicinity Map



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 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 the central and eastern Beaufort Sea. Actual locations of site clearance and shallow hazards surveys have not been definitively set as of this date, although these will occur on lease blocks in the Beaufort Sea shown on Figure 2. 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.

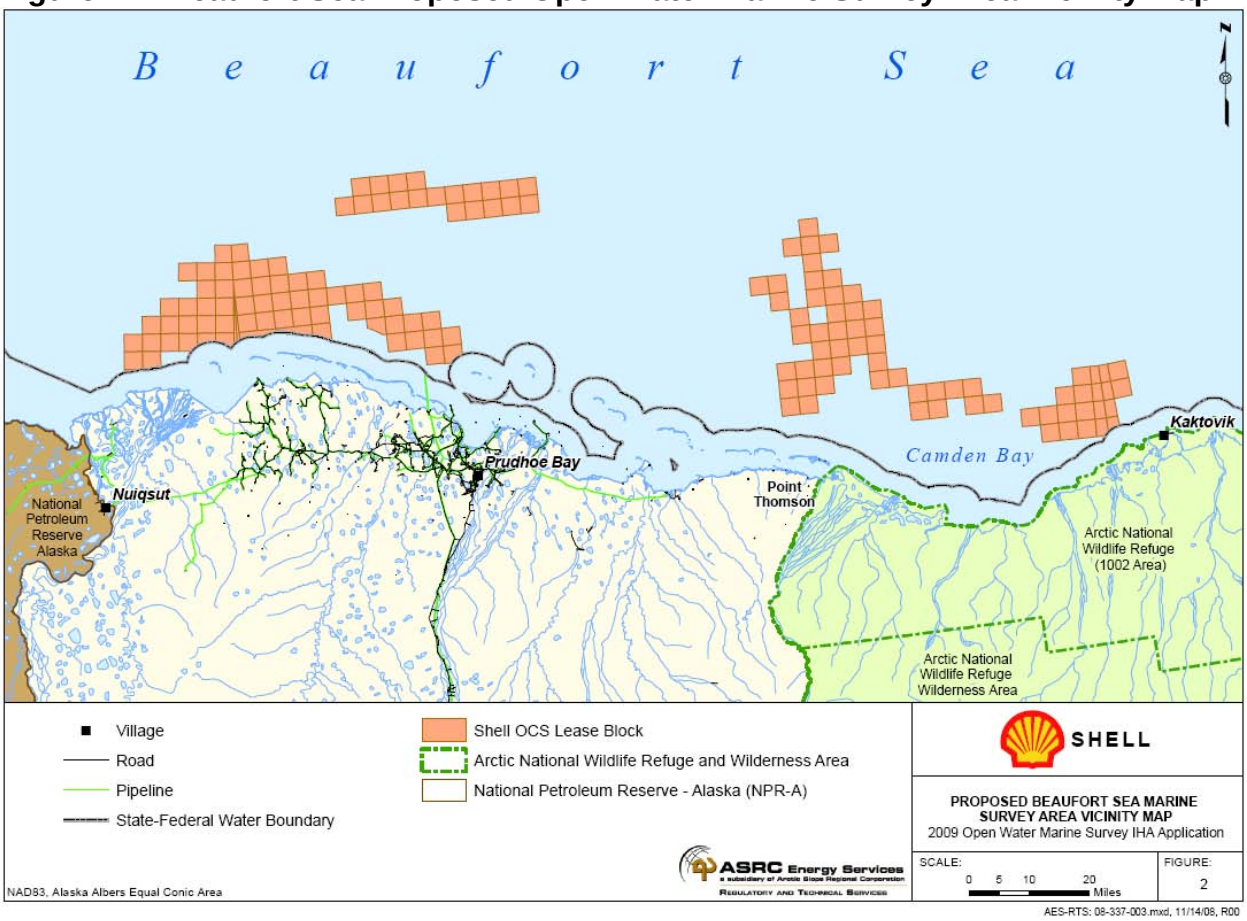
Primary Contractor: The contractor has not yet been selected.

Description of the site clearance and shallow hazards vessel and survey equipment: This program will use the R/V Norseman II, or a similar vessel. The R/V Norseman II is a diesel powered vessel, 35.05 m (115 ft) long, 8.66 m (28.4 ft) wide, with a 4.08 m (13.4 ft) draft.

It is proposed that the following acoustic instrumentation, or something similar, be used. This is the same equipment that was used during 2008:

- Dual-frequency side scan sonar, or similar;
- Single beam Echo Sounder, or similar;
- Multibeam Echo Sounder, or similar;
- High resolution multi-channel 2D system, 20 cubic inches (in^3) (2 by 10) airgun array, or similar;
- Shallow Sub-Bottom Profiler, or similar;
- Medium Penetration Sub-Bottom Profiler, or similar.

Figure 2 Beaufort Sea Proposed Open Water Marine Survey Area Vicinity Map



Beaufort Sea Marine Surveys

Overview of Beaufort Sea Marine Surveys: Two marine survey activities are proposed for the Beaufort Sea: (1) ice gouge survey and (2) strudel scour survey. Shell intends 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 can be accomplished by one vessel for each. Acoustic sources will be deployed from the ice gouge and strudel scour vessels. No other vessels are necessary to accomplish the proposed work.

1. Ice Gouge Survey

Description of Activity: Ice gouge surveys are a type of marine survey to determine the depth and distribution of ice gouges in the seabed. Ice gouge is created by ice keels which project from the bottom of moving ice that gouge into seafloor sediment. Remnant ice gouge features are mapped to aid in predicting the prospect orientation, depth, and frequency of future ice gouge. These surveys will focus on the potential, prospective pipeline corridor from near Point Thomson through Camden Bay, to the Shell leases blocks in the Beaufort Sea, and the other survey lines shown in Figure 3.

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 3. 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.

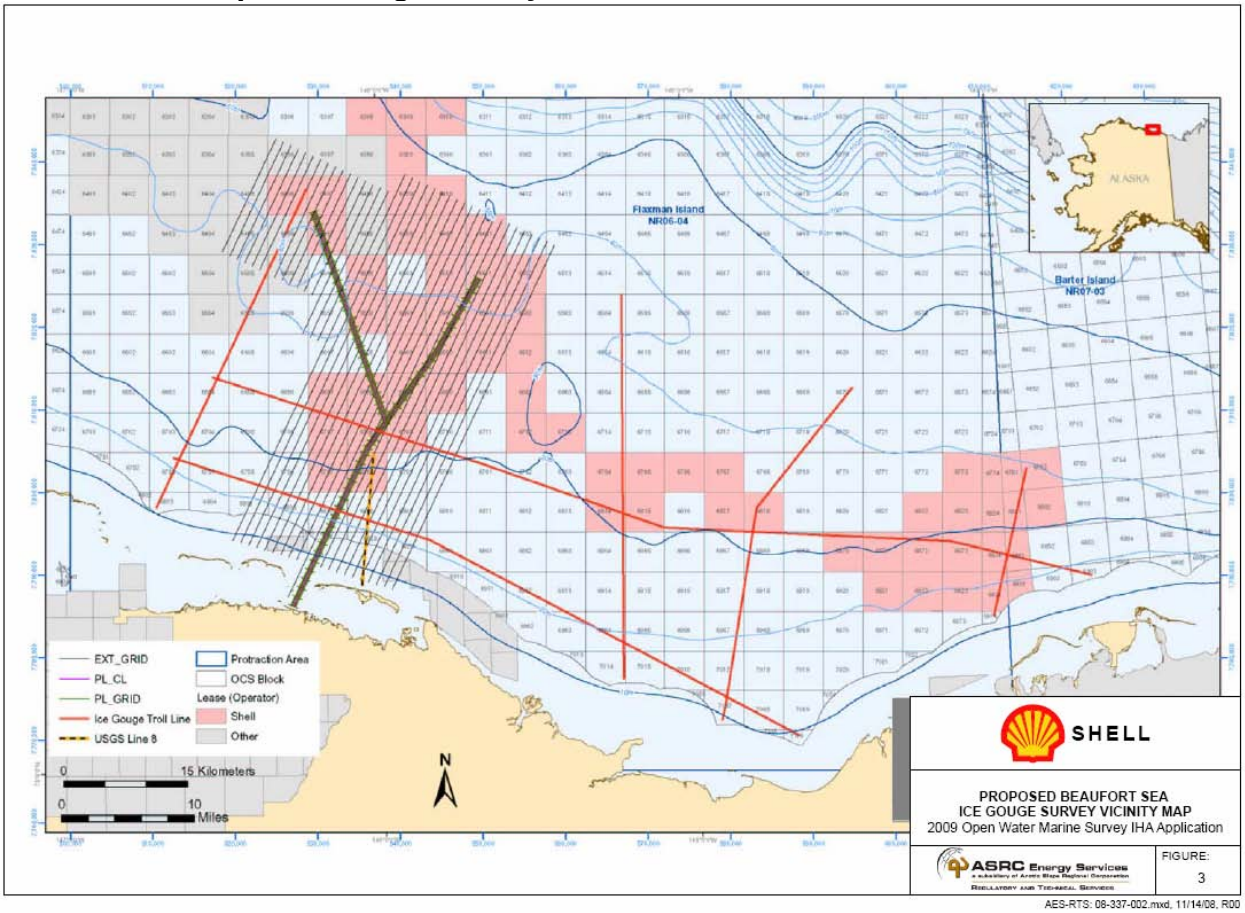
Contractor: A contractor has not been yet been selected.

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 M/V Alpha Helix which is 40.54 meters (m) (133 ft), 9.45 m (31 ft) wide, and 4.21 m (13.8 ft) draft. .

It is proposed that the following acoustic instrumentation, or something similar, be used. This is the same equipment as was used on the M/V Alpha Helix during 2008:

- Dual-frequency subbottom profiler, or similar;
- Medium penetration subbottom profiler, or similar;
- Side-scan sonar system, or similar;
- Multibeam bathymetric sonar, or similar;
- High resolution multi-channel 2D system, 20 cubic inches (in^3) (2 by 10) airgun array, or similar;
- Sub-bottom profiling system; or similar.

Figure 3 Beaufort Sea Proposed Open Water Marine Survey Area Vicinity Map, Ice Gouge Survey



2. Strudel Scour Survey

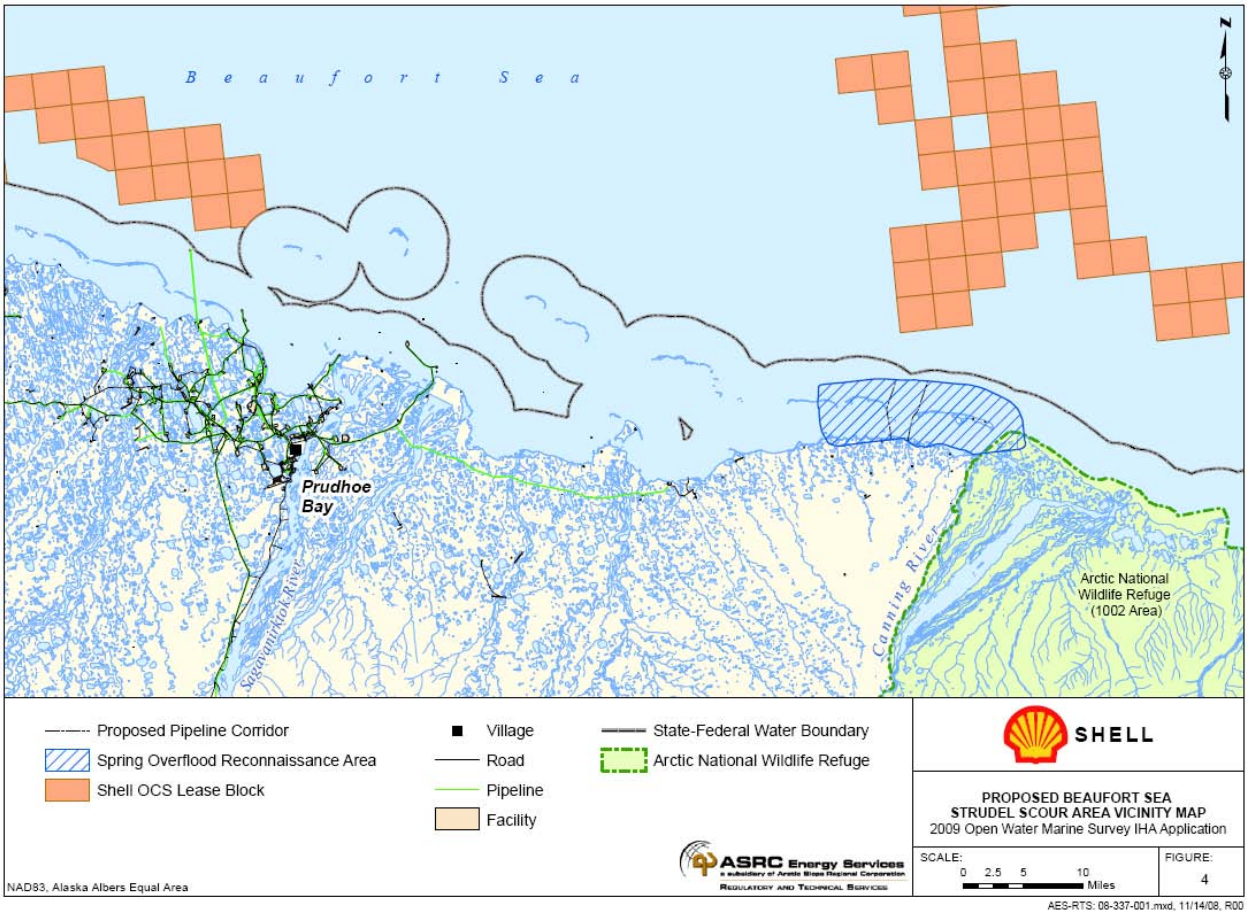
Description of Activity: During the early melt on the North Slope, the rivers begin to flow and discharge water over the coastal sea ice near the river deltas. That water rushes down holes in the ice ("strudels") and scours the seafloor. These erosional areas are called "strudel scours". Information 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 2009 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 4. This vessel will use the following equipment:

- Multi-beam bathymetric sonar, or similar;
- Side-scan sonar system, or similar;
- Single beam bathymetric sonar, 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 from 2006 through 2008 and measures 13.1 m (43 ft) long, or similar vessel.

Figure 4 Beaufort Sea Proposed Open Water Marine Survey Area Vicinity Map, Strudel Scour Survey



Chukchi Sea Marine Surveys

Overview of Chukchi Sea Marine Surveys: Two marine survey activities are proposed for the Chukchi Sea: (1) 2009 ice gouge survey and (2) 2010 strudel scour survey. Shell intends 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 can be accomplished by one vessel for each. Acoustic sources will be deployed only from the ice gouge and strudel scour vessels. No other vessels are necessary to accomplish the proposed work.

1. Ice Gouge Survey

Description of Activity: Ice gouge surveys are a type of marine survey to determine the depth and distribution of ice gouges in the seabed. Ice gouge is created by ice keels which project from the bottom of moving ice that gouge into seafloor sediment. Remnant ice gouge features are mapped to aid in predicting the prospect orientation, depth, and frequency of future ice gouge. These surveys will focus on the Foraker and Devil's Paw prospect to the nearest shore point between the areas as shown in Figure 5.

Actual locations of the ice gouge surveys have not been definitively set as of this date. 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.

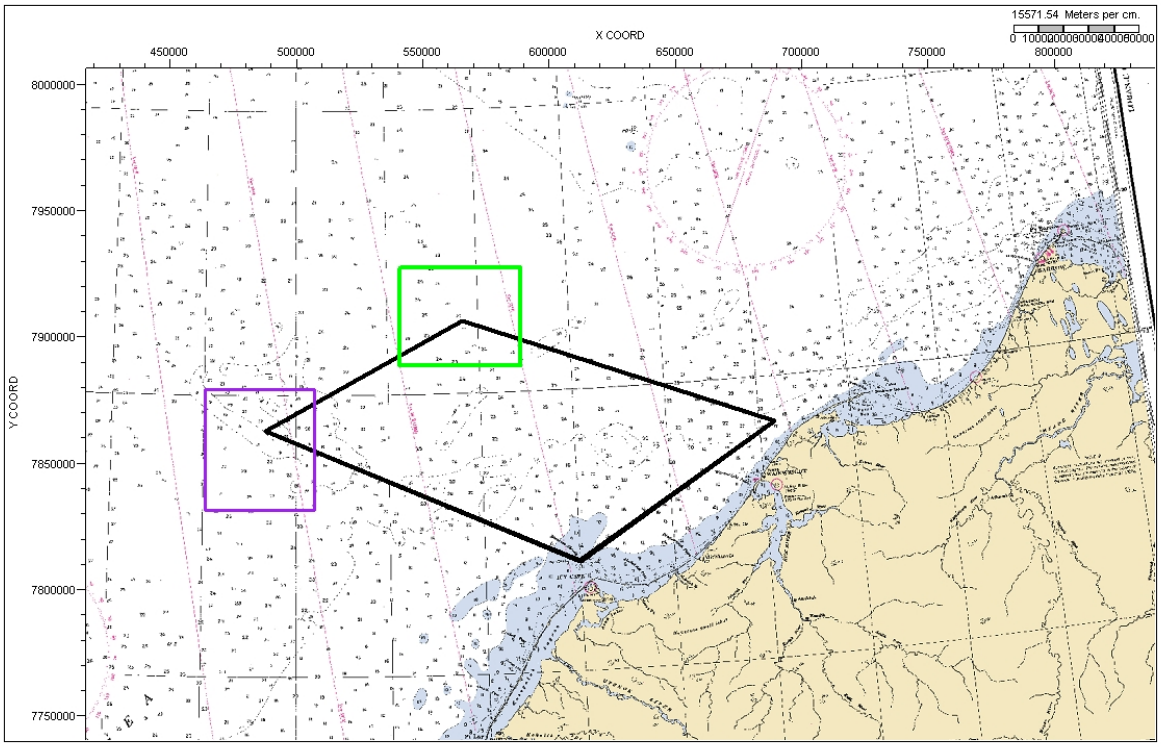
Contractor: A contractor has not been yet been selected.

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 M/V Alpha Helix which is 40.54 m (133 ft), 9.45 m (31 ft) wide, and 4.21 m (13.8 ft) draft. .

It is proposed that the following acoustic instrumentation, or something similar, be used. This is the same equipment as was used on the M/V Alpha Helix during 2008:

- Dual-frequency subbottom profiler, or similar;
- Medium penetration subbottom profiler, or similar;
- Side-scan sonar system, or similar;
- Multibeam bathymetric sonar, or similar;
- High resolution multi-channel 2D system, 20 cubic inches (in^3) (2 by 10) airgun array, or similar;
- Sub-bottom profiling system; or similar.

Figure 5 Chukchi Sea Proposed Open Water Marine Survey Area Vicinity Map, Ice Gouge Survey Area is outlined in black; purple boundary is Devil's Paw area and the Green is Foraker



2. Strudel Scour Survey

Description of Activity: During the early melt, the rivers begin to flow and discharge water over the coastal sea ice near the river deltas. That water rushes down holes in the ice ("strudels") and scours the seafloor. These erosional 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 potential pipeline shore crossings. These helicopter overflights will occur during mid May/early June 2010 and, weather permitting, should take no more than four days. There are no planned landings during these overflights other than at local 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 10 days to conduct. The specific locations for pipeline shore crossings have not yet been identified. This vessel will use the following equipment:

- Multi-beam bathymetric sonar, or similar;
- Side-scan sonar system, or similar; and
- Single beam bathymetric sonar, 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 from 2006 through 2008 and measures 13.1 m (43 ft) long, or similar vessel.

Planned Mitigation for the Chukchi and Beaufort 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 will be drawn from those mitigations described in Section 12(iii) applicable to Chukchi and Beaufort Sea locations and the lower impact acoustic sources deployed from these vessels. .

This POC will address 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 Pt. 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.

List of Proposed Marine Vessels for the Chukchi and Beaufort Seas Open Water Marine Surveys

Table 1-1 Proposed Marine Vessels for 2009 Open Water Marine Surveys Program

Chukchi Sea Marine Surveys			
Vessel Task	**Notional Operating Timeframe**		**Proposed Vessel**
Site Clearance	August thru October		*Norseman II, or similar vessel*
Ice Gouge	Mid-August thru September		*Alpha Helix*, or similar vessel
Strudel Scour (2010)	July to Mid-August		*Annika Marie*, or similar vessel
Beaufort Sea Marine Surveys			
Vessel Task	**Notional Operating Timeframe**		**Proposed Vessel**
Site Clearance	August		*Norseman II, or similar vessel*
Ice Gouge	July to Mid-October.		*Alpha Helix*, or similar vessel
Strudel Scour	Late-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

Shell's existing IHA for open water activities in the Chukchi and Beaufort Seas is valid through August 19, 2009. This request for IHA application is intended for the period between August 20, 2009 and August 19, 2010.

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

This activity is proposed to occur during August thru October 2009, and as proposed the total program will last a maximum 50 days of active data acquisition, excluding downtime due to weather and other unforeseen delays. This vessel also may be used to perform other activities such as deploying and retrieving the OBHs. The time for deploying and retrieving OBHs is not included in the 50-day estimate.

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

This activity is proposed to commence in the beginning August 2009. As proposed, this program will last a maximum of 20 days of active data acquisition, excluding downtime due to weather and other unforeseen delays, and should be complete by the end of August 2009.

Dates and Duration of the Beaufort Sea Marine Surveys

Ice Gouge Surveys

This activity is proposed to be conducted between July thru mid October. The total program will last a maximum of 30 days, excluding downtime due to weather and other unforeseen delays.

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 late-July thru mid-August.

Dates and Duration of the Chukchi Sea Marine Surveys

Ice Gouge Surveys

This activity is proposed to be conducted between mid-August thru the end of September. The total program will last a maximum of 15 days, excluding downtime due to weather and other unforeseen delays.

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

3. Species and Numbers of Marine Mammals in Area

Marine mammals that occur in the proposed survey areas belong to three taxonomic groups: 1) odontocetes (toothed cetaceans, such as beluga whale and narwhal), 2) mysticetes (baleen whales), and 3) carnivora (pinnipeds and polar bears). Cetaceans and pinnipeds (except walrus) are the subject of this IHA Application to NMFS. In the U.S., the walrus and polar bear are managed by the U.S. Fish &

Wildlife Service. A separate permit application for this survey has been submitted to USFWS for incidental "takes" specific to walruses and polar bears and these species are not discussed further in this application.

Marine mammal species under the jurisdiction of NMFS which are known to or may occur in the open water marine survey area include nine cetacean species and four species of pinnipeds (Table 4-1). Three of these species, the bowhead, humpback and fin whales, are listed as "Endangered" under the Endangered Species Act (ESA). Bowhead whale is more common in the survey area than other endangered species. Based on a small number of sightings, the fin whale is unlikely to be encountered along the planned trackline in the Chukchi Sea and is not expected to occur in the Beaufort Sea. Humpback whales normally are not found 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. 2008), 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) the abundance of these species in the project areas 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.

The marine mammal species under NMFS jurisdiction that are most likely to occur in the survey area include four cetacean species (beluga, bowhead, gray whale, and harbor porpoise), and three pinniped species (ringed, bearded, and spotted seals). Most encounters are likely to occur in nearshore shelf habitats or along the ice edge. Animal densities are generally expected to be lower in deep water, and at locations far-offshore. The marine mammal species that is likely to be encountered most widely (in space and time) throughout the survey period is the ringed seal. Encounters with bowhead and gray whales are expected to be limited to particular regions and seasons, as discussed below.

Table 4-1 The habitat, abundance (in the North Chukchi and Beaufort Sea), and conservation status of marine mammals inhabiting the proposed survey area

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
Odontocetes **Beluga whale** (***Delphinapterus leucas***)	Offshore, Coastal, Ice edges	50,000[4] 39,257[5]	Not listed	VU	
Narwhal (*Monodon monoceros*)	Offshore, Ice edge	Rare[6]	Not listed	DD	II
Killer whale (*Orcinus orca*)	Widely distributed		Not listed	LR-cd	II
Harbor Porpoise (*Phocoena phocoena*)	Coastal, inland waters, shallow offshore waters	Common (Chukchi) Uncommon (Beaufort)	Not listed	VU	II
Mysticetes Bowhead whale (*Balaena mysticetus*)	Pack ice & coastal	10,545[7]	Endangered	LR-cd	I
Gray whale (*Eschrichtius robustus*) (eastern Pacific population)	Coastal, lagoons	488[8] 17,500[9]	Not listed	LR-cd	I
Minke whale (*Balaenoptera acutorostrata*)	Shelf, coastal	Small numbers	Not listed	LR-cd	I
Fin whale (*Balaenoptera physalus*)	Slope, mostly pelagic	Rare (Chukchi)	Endangered	EN	I
Humpback whale (*Megaptera novaeangliae*)	Shelf, coastal	Rare	Endangered	–	–
Pinnipeds Bearded seal (*Erignathus barbatus*)	Pack ice	300,000-450,000[10] 4863[11]	In review for listing	–	–
Spotted seal (*Phoca largha*)	Pack ice	1000[12]	In review for listing	–	–
Ringed seal (*Pusa hispida*)	Landfast & pack ice	Up to 3.6 million [13] ~208,000-252,000[14] 326,500[15]	In review for listing	–	–
Ribbon seal (*Histriophoca fasciata*)	Offshore, pack ice	90-100,000[16]	In review for listing	–	–

[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).

[4] Total Western Alaska population, including Beaufort Sea animals that occur there during migration and in winter (Small and DeMaster 1995).

[5] Beaufort Sea population (IWC 2000).

[6] Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO 2004); very few enter the Beaufort Sea.

[7] Abundance of bowheads surveyed near Barrow, as of 2001 (George et al. 2004); revised to 10,545 by Zeh and Punt (2005).

[8] Southern Chukchi Sea and northern Bering Sea (Clark and Moore 2002).

[9] North Pacific gray whale population (Rugh 2003 *in* Keller and Gerber 2004) ; see also Rugh et al. (2005).

[10] Alaska population (USDI/MMS 1996).

[11] Eastern Chukchi Sea population (NMML, unpublished data).

[12] Alaska Beaufort Sea population (USDI/MMS 1996).

[13] Alaska estimate (Frost et al. 1988 *in* Angliss and Outlaw 2008).

[14] Bering/Chukchi Sea population (Bengston et al. 2005).

[15] Alaskan Beaufort Sea population estimate (Amstrup 1995).

[16] Burns, J.J. 1981a.

Five additional cetacean species—the narwhal, killer whale, minke whale, humpback whale, and fin whale—could occur in the project area, but each of these species is uncommon or rare in the survey area and relatively few encounters with these species are expected during the open water marine survey

program. The narwhal occurs in Canadian waters and occasionally in the Beaufort Sea, but is rare there and not expected to be encountered.

(1) Odontocetes

(a) Beluga (*Delphinapterus leucas*)

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 50º 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).

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 proposed project, 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 ***Beaufort Sea population*** was estimated to contain 39,258 individuals as of 1992 (Angliss and Outlaw 2008). 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 under-estimate 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 (DeMaster 1995).

Beluga whales of the Beaufort stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate in offshore waters of western and northern Alaska (Angliss and Outlaw 2008). 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. 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 aerial surveys in the Alaskan Beaufort Sea Lyons et al. (2008) reported the highest beluga sighting rates during the first two weeks of September.

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). Lyons et al. (2008) 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 and 2007. 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).

The ***eastern Chukchi Sea*** population is estimated at 3,710 animals (Angliss and Outlaw 2008). 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 actual number of beluga whales recorded during the surveys was much lower. Correction factors to account for animals that were underwater and for the proportion of newborns and yearlings that were not observed due to their small size and dark coloration were used to calculate the estimate. The calculation was considered to be a minimum population estimate for the eastern Chukchi 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 Bering Sea (Angliss and Outlaw 2008).

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.

During aerial surveys in nearshore areas (i.e., ~37 km offshore) of the Chukchi Sea in 2006 and 2007 peak beluga sighting rates were recorded in July and the lowest monthly sighting rates were recorded in September (Thomas et al. 2008). When data from the two years were pooled, beluga whale sighting rates and number of individuals were highest in the band 25-35 km offshore. However the largest single groups were sighted at locations near shore in the band within 5 km of shore.

Beluga whales from the eastern Chukchi Sea stock are an important subsistence resource for residents of the village of Point Lay, adjacent to Kasegaluk Lagoon, and other villages in northwest Alaska. Each year, hunters from Point Lay drive belugas into the lagoon to a traditional hunting location. The belugas have been predictably sighted near the lagoon from late June through mid- to late July (Suydam et al. 2001). In 2007 approximately 70 belugas were also harvested at Kivalina located southeast of Point Hope.

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). 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 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 be encountered either in the NE Chukchi Sea or 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 little of the area was surveyed. There are scattered records of narwhal in Alaskan waters where the species is considered extralimital (Reeves et al. 2002). Thus, it is possible, but very unlikely, that individuals could be encountered in either the Beaufort or Chukchi sea portions of the study area.

(c) Killer Whale (*Orcinus orca*)

Killer whales are cosmopolitan and globally fairly abundant. The killer whale is very common in temperate waters, but it also frequents the tropics and waters at high latitudes. Killer whales appear to prefer coastal areas, but are also known to occur in deep water (Dahlheim and Heyning 1999). The greatest abundance is thought to occur within 800 km of major continents (Mitchell 1975) and the highest densities occur in areas with abundant prey. Both resident and transient stocks have been described. The

resident and transient types are believed to differ in several aspects of morphology, ecology, and behavior including dorsal fin shape, saddle patch shape, pod size, home range size, diet, travel routes, dive duration, and social integrity of pods (Angliss and Outlaw 2008).

Killer whales are known to inhabit almost all coastal waters of Alaska, extending from southeast Alaska through the Aleutian Islands to the Bering and Chukchi seas (Angliss and Outlaw 2008). Killer whales probably do not occur regularly in the Beaufort Sea although sightings have been reported (Leatherwood et al. 1986; Lowry et al. 1987). George et al. (1994) reported that they and local hunters see a few killer whales at Point Barrow each year. Killer whales are more common southwest of Barrow in the southern Chukchi Sea and the Bering Sea. Based on photographic techniques, ~100 animals have been identified in the Bering Sea (ADFG 1994). Killer whales from either the North Pacific resident or transient stock could occur in the Chukchi Sea during the summer. The number of killer whales likely to occur in the Chukchi Sea during the proposed activity is unknown. Marine mammal observers (MMOs) onboard industry vessels in the Chukchi Sea recorded one killer whale sighting in 2006 and two sightings in 2007 (Reiser et al. 2008). MMOs onboard industry vessels did not record any killer whale sighting in the Beaufort Sea in 2006 or 2007 (Jankowski et al. 2008).

(d) Harbor Porpoise (*Phocoena phocoena*)

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 south-eastern 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 extra-limital 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 (Lyons et al. 2008; LGL Limited, unpubl. data). MMOs onboard industry vessels reported one harbor porpoise sighting in the Beaufort Sea in 2006 and no sightings were recorded in 2007 (Jankowski et al. 2008). Monnett and Treacy (2005) did not report any harbor porpoise sightings during aerial surveys in the Beaufort Sea from 2002 through 2004.

Although separate harbor porpoise stocks for Alaska have not been identified, Alaskan harbor porpoises have been divided into three groups for management purposes. These groups include animals from southeast Alaska, Gulf of Alaska, and Bering Sea populations. Chukchi Sea harbor porpoises belong to the Bering Sea group which includes animals from Unimak Pass northward. Based on aerial surveys in 1999, the Bering Sea population was estimated at 66,078 animals, although this estimate is likely conservative as the surveyed area did not include known harbor porpoise range near the Pribilof Islands or waters north of Cape Newenhan (~55°N; Angliss and Outlaw 2008). Suydam and George (1992) suggested that harbor porpoises occasionally occur in the Chukchi Sea and reported nine records of harbor porpoise in the Barrow area in 1985–1991. More recent vessel-based surveys in the Chukchi Sea found that the harbor porpoise was one of the most abundant cetaceans during summer and fall in 2006 and 2007 (Reiser et al. 2008; Ireland et al. 2008).

Based on recent surveys the harbor porpoise is likely to be one of the most abundant cetaceans encountered throughout the Chukchi Sea and small numbers may be encountered in shallow and nearshore areas in the Beaufort Sea.

(2) Mysticetes

(a) Bowhead Whale (*Balaena mysticetus*)

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunct 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 indicate that some bowhead whales continue migrating west past Barrow and through the Chukchi Sea to Russian waters before turning south toward the Bering Sea (Quakenbush 2007). 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 BCB stock of bowhead whales winter in the central and western Bering Sea and many of them summer in the Canadian Beaufort Sea (Moore and Reeves 1993). Spring migration through the Chukchi and the western Beaufort Sea occurs through offshore ice leads, generally from March through mid-June (Braham et al. 1984; Moore and Reeves 1993).

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. However, surveys by Shell in summer 2008 recorded a few bowheads throughout the July-August period (LGL unpubl. data) suggesting that a few bowheads may now summer in nearshore areas of the western Beaufort Sea. 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 Alaskan waters is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004, 2008; Greene et al. 2007; Goetz et al. 2008). 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 (T. Napageak, pers. comm.).

The Minerals Management Service (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 in Richardson and Thomson 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, and that is 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. Bowhead whales that are thought to be part of the Western Arctic stock may also occur in small numbers in the Bering and Chukchi seas during the summer (Rugh et al. 2003). Thomas et al. (2008) also reported bowhead sightings in 2006 and 2007 during summer aerial surveys in the Chukchi Sea. All sightings were recorded in the northern portion of the study area north of 70ºN latitude. Autumn bowhead whaling near Barrow normally begins in mid-September to early October, but may begin as early as August if whales are observed and ice conditions are favorable (USDI/BLM 2005). Whaling near Barrow can continue into October, depending on the quota and conditions.

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). Allowing for an additional census in 2001, the latest estimates are based on an 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]). Assuming a continuing annual population growth of 3.4%, the 2009 bowhead population may number around 13,800 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 MMPA (Angliss and Outlaw 2008).

Most spring-migrating bowhead whales will likely pass through the Chukchi and Beaufort seas prior to the start of the survey in early July. However, a few whales that may remain in the Chukchi Sea or in the Barrow area during the summer could be encountered during the survey activities or by transiting vessels. More encounters with bowhead whales would occur during the westward fall migration in September and October; however, Shell will operate in consultation with stakeholders through a POC to eliminate disturbance to subsistence bowhead whaling activities in the Beaufort and Chukchi seas.

(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 proposed survey area. 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 the population stabilizing or gradually recovering. 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 breed and 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 breeding and 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 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 feed by suctioning sediment and filtering benthic invertebrates from the sediment with their short, coarse baleen (Moore et al. 2000b).

Gray whales routinely feed in the Chukchi Sea during the summer. Moore et al. (2000b) reported that during the summer, gray whales in the Chukchi Sea were clustered along the shore primarily between Cape Lisburne and Point Barrow and were associated with shallow, coastal shoal habitat. In autumn, gray whales were clustered near shore at Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters northwest of Point Barrow at Hanna Shoal and southwest of Point Hope. The distribution of grays was different during aerial surveys in the Chukchi Sea in 2006 and 2007 (Thomas et al. 2009). In 2006, gray whales were most abundant along the coast south of Wainwright and offshore of Wainwright (vessel chapter), and in 2007, gray whales were most abundant in nearshore areas from Wainwright to Barrow (Thomas et al. 2008).

Gray whales occur fairly often 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 and 2007 (Jankowski et al. 2008; Lyons et al. 2008). Several single gray whales have been seen farther east in the Canadian Beaufort Sea (Rugh and Fraker 1981; LGL Ltd., unpubl. data), indicating that small numbers must travel through the Alaskan Beaufort during some summers. In recent years, ice conditions have become lighter near Barrow, and gray whales may have become more common there and perhaps in the Beaufort. 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 open water marine survey activities in the Beaufort Sea. Beaufort Sea gray whales would be expected to remain close to shore and thus distant from much of the proposed open water marine survey activity. Gray whales are more likely to be encountered during the Chukchi Sea portion of the open water marine surveys. Although they are most common in portions of the Chukchi Sea close to shore (where Shell will not conduct open water marine surveys), gray whales may also occur in offshore areas of the Chukchi Sea, particularly over offshore shoals.

(c) Minke Whale (*Balaenoptera acutorostrata*)

Minke whales have a cosmopolitan distribution at ice-free latitudes (Stewart and Leatherwood 1985), and also occur in some marginal ice areas. Angliss and Outlaw (2008) recognize 2 minke whale stocks in U.S. waters: (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 south-eastern 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. The level of Minke whale use of the Chukchi Sea is unknown. Leatherwood et al. (1982, in Angliss and Outlaw 2008) indicated that Minke whales are not considered abundant in any part of their range, but that some individuals venture north of the Bering Strait in summer. Reiser et al. (2008) reported 8 and 5 Minke whale sightings in 2006 and 2007, respectively, during vessel-based surveys in the Chukchi Sea, and Jankowski et al. (2008) reported one Minke whale sighting in the Beaufort Sea in 2007. Minke whales could be encountered during the survey activities in the Chukchi Sea but would be unlikely to be observed in the Beaufort Sea survey area.

(d) Fin Whale (*Balaenoptera physalus*)

Fin whales are widely distributed in all the world's oceans (Gambell 1985), but typically occur in temperate and polar regions. Fin whales feed in northern latitudes during the summer where their prey includes plankton as well as shoaling pelagic fish, such as capelin Mallotus villosus (Jonsgård 1966a,b). The North Pacific population summers from the Chukchi Sea to California (Gambell 1985), but does not range into the Alaskan Beaufort Sea or waters of the northern Chukchi Sea. Population estimates for the entire North Pacific population range from 14,620 to 18,630. Reliable estimates of fin whale abundance in the Northeast Pacific are not available (Angliss and Outlaw 2008). Provisional estimates of fin whale abundance in the central-eastern and south-eastern Bering Sea are 3,368 and 683, respectively. No estimates for fin whale abundance during the summer in the Chukchi Sea are available. Reiser et al. (2008) reported a fin whale sighting during vessel-based surveys in the Chukchi Sea in 2006. Fin whale is listed as "Endangered" under the ESA and by IUCN, is classified as a strategic stock by NMFS, and it is a CITES Appendix I species (Table 3).

(e) Humpback Whale (*Megapter novaeangliae*)

Humpback whales are distributed in major oceans worldwide but have apparently been absent from Arctic waters of the North Pacific (Angliss and Outlaw 2008). 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 20th 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 or filtered when large amounts of water taken into the mouth and the expanded throat area are forced out through the baleen plates. Individual humpback whales can often be identified by distinctive patterns on the tail flukes. 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). Humpbacks have large, robust bodies and long pectoral flippers which may reach 1/3 of their body length. 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).

Angliss and Outlaw (2008) reported that at least three humpback whale populations have been identified in the North Pacific. Two of these stocks may be relevant to the Chukchi Sea portion of the project area. The Central North Pacific stock winters in waters near Hawaii and migrates to British Columbia, Southeast Alaska, and Prince William Sound to Unimak Pass to feed during the summer. The Western North Pacific stock winters off the coast of Japan and probably migrates to the Bering Sea to feed during the summer. There may be some overlap between the Central and Western North Pacific stocks.

Humpback whale sightings in the Bering Sea have been recorded southwest of St. Lawrence Island, the southeastern Bering Sea, and north of the central Aleutian Islands (Moore et al. 2002; Angliss and Outlaw 2008). Recently there have been sightings of humpback whales in the Chukchi Sea and a single sighting in the Beaufort Sea. Reiser et al (2008) reported four humpback whales during vessel-based surveys in the Chukchi Sea in 2007. Green et al. (2007) reported and photographed a humpback whale cow/calf pair east of Barrow near Smith Bay in 2007. Whether these humpback whale sightings in the Chukchi and Beaufort seas are related to climate changes in the Arctic in recent years is unknown. Small numbers of humpback whales could occur within or near the project area in the Chukchi Sea but would be less likely to occur near the Beaufort Sea project area.

(3) Pinnipeds

(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 Outlaw 2008). The Alaska stock of bearded seals is not classified by NMFS as endangered or a strategic stock however there has recently been a petition to list this and other arctic seals due to the potential impact to seal habitats resulting from current warming trends.

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). Bengtson et al. (2005) reported bearded seal densities in the Chukchi Sea ranging from 0.07 to 0.14 seals/km2 in 1999 and 2000, respectively. No population estimates could be calculated since these densities were not adjusted for haulout behavior. Bearded seals were more common in offshore pack ice with the exception of high bearded seal numbers observed near the shore south of the project area near Kivalina. Reiser et al. (2008) reported bearded seal densities ranging from 0.01 to 0.03 seals/km2 in the summer and fall, respectively, during vessel-based surveys in the Chukchi Sea. These densities were lower than those reported by Bengtson et al. (2005) but are not comparable since the latter densities were based on aerial surveys of seals at ice holes in the late May and early June.

In the Beaufort Sea Jankowski et al. (2008) reported bearded seal densities ranging from 0.085 to 0.011 in the summer and fall, respectively during vessel-based surveys in 2007. In 2006 there was a tendency for higher bearded seal sighting rates at locations near ice than further from ice although survey effort was low in some cases. Little ice was present in the survey area in 2007 and it was difficult to make any determinations regarding bearded seal abundance and distance from ice.

The bearded seal is the largest of the northern phocids. Bearded seals have occasionally been reported to maintain breathing holes in sea ice and 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.

During the summer, when the Bering Sea is ice-free, the most favorable bearded seal habitat is found in the central or northern Chukchi Sea along the margin of the pack ice. Bearded seal densities in the pack ice of the northern Chukchi Sea appear to be low as only three bearded seals were observed during a survey that passed through the proposed open water marine survey area in early August of 2005 (Haley and Ireland 2006). Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and 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. WesternGeco conducted marine mammal monitoring during its open-water 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 guns were operating, 4.4% were bearded seals, 94.1% were ringed seals and 1.5% were spotted seals (Moulton and Lawson 2002).

(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 total number of spotted seals in Alaskan waters is not known (Angliss and Outlaw 2008), 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 in Kakegaluk Lagoon 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 Outlaw (2008) estimated the Alaskan population at 59,214 animals. The Alaska stock of spotted seals is not classified as endangered or as a strategic stock by NMFS (Hill and DeMaster 1998).

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 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.

In the Chukchi Sea, Kasegaluk Lagoon and Icy Cape are important areas for spotted seals. Spotted seals haul out in the area from mid-July until freeze-up in late October or November. Frost and Lowry (1993) reported a maximum count of about 2200 spotted seals in the lagoon during aerial surveys. No spotted seals were recorded along the shore south of Pt. Lay. Based on satellite tracking data, Frost and Lowry (1993) reported that spotted seals at Kasegaluk Lagoon spent 94% of the time at sea. Extrapolating the count of hauled-out seals to account for seals at sea would suggest a Chukchi Sea population of about 36,000 animals.

(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 Outlaw 2008).

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 northern Chukchi and Beaufort Seas 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 Outlaw 2008). 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 there has recently been a petition to list this and other arctic seals due to the potential impact to seal habitats resulting from current warming trends. Moulton et al. (2002) reported ringed seal densities (uncorrected) ranging from 0.43 to 0.63 seal per km2 in water over 3 m in depth during aerial surveys in the central Alaskan Beaufort Sea. Bengtson et al. (2000) reported ringed seal densities of 1.91 seals per km2 in the eastern Chukchi Sea during aerial surveys in 1999. Densities were higher in nearshore than offshore locations. During aerial surveys n 1999, Bengtson et al. (2000) reported ringed seal densities offshore from Shishmaref to Barrow ranging from 0.39 to 3.67 seals/km2 and estimated the total Chukchi Sea population at 245,048 animals.

Marine mammal observers aboard the *Healy* sighted as many as 50 ringed seals along 2,401 km of trackline between 70°N and 81°N during two weeks of travel in and north of the Chukchi Sea during August 2005 (Haley and Ireland 2006). Ringed seal will likely be the most abundant marine mammal species encountered in the Chukchi and Beaufort Sea project areas.

(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 et al. 1981a). Little is known about their summer and fall distribution, but Kelly (1988) suggests 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 2,679 seal sightings (Reiser et al. 2008). Thus ribbon seals are expected to be rare in the proposed survey area in the Chukchi Sea.

Ribbon seals do not normally occur in the Beaufort Sea however a recent ribbon seal sighting was reported during vessel-based activities near Prudhoe Bay in 2008 (LGL, unpublished data). Ribbon seals would be unlikely to occur in the vicinity of the proposed surveys in the Beaufort Sea in 2009.

5. Type of Incidental Take Authorization Requested

Shell requests an IHA pursuant to Section 101(a)(5)(D) of the MMPA for incidental take by harassment during its planned open water marine surveys in the Chukchi and Beaufort seas during for the period of August 20, 2009 to August 20, 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 airgun arrays used during the 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 and Chukchi seas. 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 survey areas. Adjustments to reported population or density estimates were made to account for these differences insofar as possible.

Although several systematic surveys of marine mammals have been conducted in the southern Beaufort Sea, few data (systematic or otherwise) are available on the distribution and numbers of marine mammals in the Chukchi Sea or Beaufort Sea beyond the 200 m bathymetry contour. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection. While there is some uncertainty related to the use of regional population densities for applications that are local in focus, these estimates are based on best available scientific data and represents standard practice.

Basis for Estimating "Take by Harassment"

This section provides estimates of the number of individuals potentially exposed to sound levels ≥160 dB re 1 µPa (rms). The estimates are based on a consideration of the number of marine mammals that might be disturbed appreciably by operations in the Chukchi and Beaufort seas.

For the Chukchi Sea, cetacean densities during the summer (Jul – Aug) were estimated from effort and sightings data in Moore et al. (2000b) while pinniped densities were estimated from Bengtson et al. (2005). Because few data are available on the densities of marine mammals other than large cetaceans in the Chukchi Sea in the fall (Sep – Oct), density estimates from the summer period have been adjusted to reflect the expected ratio of summer-to-fall densities based on the natural history characteristic of each species. Alternatively, some densities from data collected aboard industry vessels in 2006 and 2007 in the Chukchi Sea have been used.

Beluga and bowhead whales have very distinct distribution patters in the Beaufort Sea. The area to be surveyed in the Alaskan Beaufort Sea covers three general habitat zones of the beluga and bowhead whale with varying animal densities within those zones: (1) nearshore, (2) outer shelf, and (3) ice margin. For these two species, the nearshore habitat zone has been defined as the area between the shore and the 40 m line of bathymetry. The continental shelf habitat is in water depths between 40 and 200 m. The presence of ice varies greatly from year to year. To allow for the possibility that some survey operations may occur in areas near the ice margin, where some marine mammal species densities are likely to be elevated, we estimated that the ice margin zone covered 10% of the survey area in the nearshore and outer shelf zones.

Two habitat zones have been defined for all other species: (1) continental shelf and (2) ice margin. For these species, the nearshore region has been defined as the waters between the shore and the 200 m line of bathymetry. For the reasons described above, ice-margin habitat was considered to cover 10% of the continental shelf zone.

Marine mammal densities in the Beaufort Sea are also likely to vary by season. Thus, different densities have been identified for the summer (Jul – Aug) and fall (Sep – Oct) seasons. Within those seasons, some species also show a longitudinal distribution pattern so the 148°W line of longitude has been used to separate the Alaskan Beaufort Sea into East and West regions. Harrison Bay falls within the west region and Camden Bay falls within the east region

As noted above, there is some uncertainty about the representativeness of the data and assumptions used in the calculations. To provide some allowance for the uncertainties, "maximum estimates" as well as "average estimates" of the numbers of marine mammals potentially affected have been derived. For a few marine mammal species, several density estimates were available, and in those cases, the average and maximum estimates were calculated from the survey data. In other cases only one, or no applicable estimate was available so arbitrary correction factors were used to arrive at "average" and "maximum" estimates. These are described in detail in the following sections. Except where noted, the "maximum" estimates have been calculated as 2× the "average" estimates. The densities presented are believed to be similar to, or in most cases higher than, the densities that will actually be encountered during the survey.

Detectability bias, quantified in part by $f(0)$, is associated with diminishing sightability with increasing lateral distance from the survey trackline. Availability bias [$g(0)$] refers to the fact that there is <100% probability of sighting an animal that is present along the survey trackline. These correction factors were applied to the data from Moore et al. (2000b) and were already included in data provided by Richardson and Thompson (eds., 2002) on beluga and bowhead whales, and where possible were applied to the available data for other species.

Chukchi Sea

Estimated densities of marine mammals in the Chukchi Sea during the "summer" (Jul and Aug) site clearance, shallow hazards, and ice gouge surveys are presented in Table 6-1. Densities of marine mammals estimated for the fall period of Shell's activities in the Chukchi Sea (Sep) are presented in Table 6-2. Again, "average" and "maximum" densities are shown in the tables. Unless otherwise noted, maximum densities are 2× average densities.

Cetaceans

Nine species of cetaceans are known to occur in the Chukchi Sea area of the proposed Shell project. Only four of these (bowhead, beluga, and gray whales, and harbor porpoise) are expected to be encountered in meaningful numbers during the proposed survey. Three of the nine species (bowhead, fin, and humpback whales) are listed as endangered under the ESA.

Summer densities of ***beluga whales*** in offshore waters are expected to be very low. Aerial surveys have recorded very few belugas in the offshore Chukchi Sea during the summer months (Moore et al. 2000b). Additionally, no belugas were observed during >42,000 km of useable visual effort from industry vessels operating in the Chukchi Sea in 2006 and 2007 (Ireland et al. 2007a,b, Patterson et al. 2007, Reiser et al. 2008). Shallow hazards and site clearance survey activities in 2009 will largely be restricted to open-water areas as were the 2006 and 2007 surveys. Expected densities have been calculated from data in Moore et al. (2000b; Table 6-1).

In the fall, beluga whale densities in the Chukchi Sea are expected to be higher than in the summer because individuals of the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Angliss and Outlaw 2008). Densities are assumed to be similar in open–water and ice–margin areas although they are probably somewhat higher along the edge of the pack ice than in open-water areas where shallow hazards and site clearance surveys will be conducted. Densities derived from survey results in the northern Chukchi Sea in Moore et al. (2000b) were used as the average density for open–water and ice–margin fall estimates (Table 6-2).

By July, most ***bowhead whales*** are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea resulting in low density estimates for the Chukchi Sea (Moore et al. 2000b). The summer estimate in the Chukchi Sea was calculated by assuming there was one bowhead sighting during the 10,684 km of survey effort in the Chukchi Sea during the summer months reported in Moore et al. (2000b) although no bowheads were actually observed during those surveys. During the autumn, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf are migrating west and south to their wintering grounds in the Bering Sea making it more likely that bowheads will be encountered in the Chukchi Sea. However, many bowheads appear to travel through the northern Chukchi Sea to reach Russian waters north of the Chukotsk Peninsula (Quakenbush 2007). Thus, a correction factor of ×0.05 has been used to adjust the observed autumn densities from the Beaufort Sea (Richardson and Thomson 2002) to estimated densities in the Chukchi Sea, for the following reasons: (1) the migration corridor is narrower in the Beaufort Sea where available data have been obtained, (2) bowheads sometimes linger to feed for extended periods in the Beaufort Sea but extended feeding has not been documented in the central and eastern Chukchi Sea in autumn, and (3) most bowheads will travel through the Chukchi Sea north of the shallow hazards and site clearance survey area after activities are expected to be completed in 2009.

Gray whale densities were estimated from summer aerial surveys by Moore et al. (2000b). Moore et al. (2000b) found large summer concentrations of gray whales off the Seward Peninsula, far to the south of planned open water marine surveys. The distribution of gray whales in the proposed survey area was scattered and limited to nearshore areas where most whales were observed in water less than 35 m deep (Moore et al. 2000b). A density calculated from effort and sightings in Morre et al. (2000b) in water >35m in depth was used as the average estimate for the Chukchi Sea during the summer period. In the autumn, gray whales may be dispersed more widely through the northern Chukchi Sea (in the area of the survey), and densities are expected to be slightly higher. A density calculated from effort and sightings in water >35m deep during autumn in Moore et al. (2000b) was used as the average estimate for the Chukchi Sea during the fall period.

Table 6-1 Expected densities of cetaceans and seals in areas of the Chukchi Sea, Alaska, during the planned summer (Aug) period of the Site Clearance and Shallow Hazards program. Species listed under the U.S. ESA as endangered are in italics.

Species	Open Water[a]		Ice Margin[b]	
	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Odontocetes				
Monodontidae				
Beluga	0.0008	0.0016	0.0016	0.0032
Delphinidae				
Killer whale	0.0001	0.0002	0.0001	0.0002
Phocoenidae				
Harbor porpoise	0.0056	0.0112	0.0056	0.0112
Mysticetes				
Bowhead whale	*0.0004*	*0.0008*	*0.0008*	*0.0016*
Fin whale	*0.0001*	*0.0002*	*0.0001*	*0.0002*
Gray whale	0.0108	0.0216	0.0108	0.0216
Humpback whale	*0.0001*	*0.0002*	*0.0001*	*0.0002*
Minke whale	0.0001	0.0002	0.0002	0.0004
Pinnipeds				
Bearded seal [c]	0.0180	0.0270	0.0360	0.0540
Ribbon seal	0.0001	0.0002	0.0002	0.0004
Ringed seal [c]	0.5200	0.8100	1.0400	1.6200
Spotted seal	0.0036	0.0072	0.0072	0.0144

[a] Open water regions for the Chukchi Sea are considered to be 90% of the survey lines.

[b] Ice Margin regions for the Chukchi Sea are considered to be 10% of the survey lines.

[c] Maximum density estimate available from the data source was used.

Table 6-2 Expected densities of cetaceans and seals in areas of the Chukchi Sea, Alaska, during the fall (Sep) period of the Shallow Hazards and Site Clearance program. Species listed under the U.S. ESA as endangered are in italics.

Species	Open Water [a]		Ice Margin [b]	
	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Odontocetes				
Monodontidae				
Beluga	0.0112	0.0224	0.0224	0.0448
Delphinidae				
Killer whale	0.0001	0.0002	0.0001	0.0002
Phocoenidae				
Harbor porpoise	0.0021	0.0042	0.0021	0.0042
Mysticetes				
Bowhead whale	*0.0011*	*0.0060*	*0.0021*	*0.0120*
Fin whale	*0.0001*	*0.0002*	*0.0001*	*0.0002*
Gray whale	0.0148	0.0296	0.0148	0.0296
Humpback whale	*0.0001*	*0.0002*	*0.0001*	*0.0002*
Minke whale	0.0001	0.0002	0.0002	0.0004
Pinnipeds				
Bearded seal [c]	0.0180	0.0270	0.0720	0.0540
Ribbon seal	0.0001	0.0002	0.0002	0.0004
Ringed seal [c]	0.3484	0.5427	0.6968	1.0854
Spotted seal	0.0036	0.0072	0.0072	0.0144

[a] Open water regions for the Chukchi Sea are considered to be 90% of the seismic lines.

[b] Ice Margin regions for the Chukchi Sea are considered to be 10% of the seismic lines.

[c] Maximum density estimate available from the data source was used.

Harbor Porpoise densities were estimated from industry data collected during 2006 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006, however, commonly recorded sightings throughout the Chukchi Sea during the summer and early autumn months. A density estimate from these data has been used for the summer period. No sightings were recorded during the majority of the fall period, so minimal values have been used for that time period.

The remaining four cetacean species that could be encountered in the Chukchi Sea during Shell's proposed open water marine survey include the humpback whale, killer whale, minke whale, and fin whale. Although there is evidence of the occasional occurrence of these species in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the proposed survey. George and Suydam (1998) reported killer whales, Brueggeman et al. (1990) reported one minke whale, Suydam and George (1992) and Ireland et al. (2008) reported harbor porpoise, and Gambell (1985) recorded the northern extent of fin whales to be in the Chukchi Sea. Small numbers of minke and humpback whales were observed during industry activities in 2006 and 2007 (Ireland et al. 2008).

Pinnipeds

Four species of pinnipeds may be encountered in the Chukchi Sea portion of Shell's proposed shallow hazards and site clearance program: ringed seal, bearded seal, spotted seal, and ribbon seal. Each of these species, except the spotted seal, is associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be

found in the southern margin of the retreating sea ice, before they move to shore. However, satellite tagging has shown that they sometimes undertake long excursions into offshore waters during summer (Lowry et al. 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Ireland et al. 2007a, Patterson et al. 2007) so minimal values have been used for expected densities.

For ***ringed seal*** and ***bearded seals*** both "average" and "maximum" summer densities are available in Bengtson (2005) from spring surveys in the offshore pack ice zone of the northern Chukchi Sea (Tables 6-1 and 6-2). The ringed seal density estimates calculated from data collected during 2006 and 2007 industry operations were 0.262 and 0.041seals/km^2, respectively (Jankowski et al. 2007, Reiser et al. 2008) are lower than those estimated by Bengtson (2005). The fall density of ringed seals in the Chukchi Sea has been estimated as 2/3 the summer densities because at that time of year ringed seals reoccupy nearshore fast ice areas as the fast ice forms.

Very little information on ***spotted seal*** densities in offshore areas of the Chukchi Sea is available. Spotted seal densities were estimated by multiplying the bearded seal density from Bengtson et al. (2005) by 0.2 based on the ratio of abundance estimates of spotted seal to bearded seal.

Beaufort Sea

Cetaceans

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 migrate across the northern Beaufort Sea in August, and bowheads begin to 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 highest beluga whale density calculated from Moore et al. (2000b) was used as the average ice-margin density for the summer period in the eastern Alaskan region (Table 6-3). That density was adjusted by a factor of 0.1 to estimate the nearshore and outer shelf zone densities (Table 6-3). Very few beluga whales are expected to be encountered in the western Beaufort Sea in the summer period. Therefore, 10% of the highest calculated beluga whale density from Moore et al. (2000b) for the eastern zone was used in the offshore region while 1% was used in nearshore and outer shelf zones (Table 6-4).

Table 6-3 Expected summer densities of beluga and bowhead whales in the Alaskan Beaufort Sea from Cross Island East to Canadian waters. Densities are corrected for f(0) and g(0) biases. Species listed under the U.S. ESA as endangered are in italics.

Species	Nearshore [a]		Outer Shelf [b]		Ice Margin [c]	
	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Beluga	0.0021	0.0042	0.0021	0.0042	0.0210	0.0420
Bowhead whale	*0.0115*	*0.0430*	*0.0115*	*0.0430*	*0.0115*	*0.0430*

[a] Water from 0–40 m in depth.
[b] Water from 40–200 m in depth.
[c] 10% of the survey lines

Table 6-4 Expected summer densities of beluga and bowhead whales in the Alaskan Beaufort Sea from Cross Island west to Point Barrow. Densities are corrected for f(0) and g(0) biases. Species listed under the U.S. ESA as endangered are in italics.

Species	Nearshore [a]		Outer Shelf [b]		Ice Margin [c]	
	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Beluga	0.0002	0.0004	0.0002	0.0004	0.0021	0.0042
Bowhead whale	*0.0012*	*0.0043*	*0.0012*	*0.0043*	*0.0012*	*0.0043*

[a] Water from 0–40 m in depth.
[b] Water from 40–200 m in depth.
[c] 10% of the survey lines

The highest density of beluga whales is expected to occur along the ice margin (should it be present in the survey area) during the fall. Because beluga whales are migrating in the fall, the density is expected to be roughly equal across the eastern and western regions. All three densities were calculated from data in Moore et al. (2000b; Table 6-5). "Takes by harassment" of beluga whales during this time period 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 the nearshore area where a majority of the survey activity will occur and the lack of detailed data on the likely timing and rate of migration through the area.

Industry aerial surveys in late August of 2006 and 2007 recorded ***bowhead whales*** in the Alaska Beaufort Sea. Results from these surveys were used to estimate the density of bowhead whales that may be present during July and August operations instead of the previously used results from Richardson and Thomson (eds. 2002). Most of these sightings occurred in nearshore and outer-shelf habitats, so the same densities have been used across all habitat zones. Bowhead whales encountered during summer will likely not be migrating so these densities have been used in the standard method (described below) of calculating "takes by harassment."

Table 6-5 Expected autumn 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 in italics.

Species	Nearshore [a]		Outer Shelf [b]		Ice Margin [c]	
	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Beluga	0.0057	0.0114	0.0655	0.1310	0.1340	0.2680
Bowhead whale [d]	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

[a] Water from 0–40 m in depth.

[b] Water from 40–200 m in depth.

[c] 10% of the survey lines

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

During the fall, most bowhead whales will be migrating past the ice gouge survey area, so it is not accurate to assume that the same individuals would be present in or near the survey area from one day to the next. We have therefore developed an alternate method of calculating the number of individuals exposed to sounds >160 dB. The method is founded on estimates of the proportion of the population that would pass within the >160 dB zone on a given day during the proposed survey activities.

The total planned ice gouge survey activity in the Beaufort Sea during the fall migration should be completed in ~20 days. Approximately 1/3 of the population of bowhead whales is expected to pass the survey area before 15 Sep (Richardson and Thomson 2002, Appendix 9.1). During that time, it is assumed that survey activity will not occur in order to avoid disturbing the subsistence harvest. The remainder of the population would be expected to pass while survey activity was ongoing between 15 Sep and mid Oct. If the bowhead population has continued to grow at an annual rate of 3.4%, the current population size would be 13,779 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 after 15 Sep was estimated as a proportion of the population.

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 open water marine survey area 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 the total ≥160 dB zone within each depth bin 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 20 days and the results were summed to estimate the total number of bowhead whales that may be exposed to ≥160 dB during the migration period in the Beaufort Sea if they showed no avoidance of the survey activities.

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 estimate separate densities for the two seasons. Narwhals are not expected to be encountered within the proposed survey area. However, there is a chance that a few individuals may be present in the eastern most portions of the Beaufort Sea near the ice margin and therefore an arbitrary low density has been applied to the ice–margin region (Table 6-6). Harbor porpoises and gray whales are similarly not expected to be encountered 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. The first record of humpback whales in the Beaufort Sea was documented in 2007 so their presence cannot be ruled out. Arbitrarily assigned low densities have therefore been used in nearshore waters for those species (Table 6-6).

Table 6-6 Expected densities of cetaceans and seals in the Alaskan Beaufort Sea during both the summer and autumn seasons.

Species	Continental Shelf [a]		Ice Margin [b]	
	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	0.0002	0.0000	0.0000
Mysticetes				
Gray whale	0.0001	0.0002	0.0000	0.0000
Humpback whale	0.0001	0.0002	0.0000	0.0000
Pinnipeds				
Bearded seal	0.0181	0.0362	0.0128	0.0256
Ribbon seal	0.0000	0.0000	0.0000	0.0001
Ringed seal	0.3547	0.7094	0.2510	0.5020
Spotted seal	0.0037	0.0075	0.0001	0.0002

[a] Water from 0–200 m in depth.

[b] 10% of planned tracklines.

Pinnipeds

Although densities are likely to vary within each of the three habitat zones by season, there is neither sufficient data nor are differences expected to be great enough to justify estimating separate densities of pinnipeds for the two seasons. 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 survey area. The density estimate in Kingsley (1986) was used as the average density of ringed seals that may be encountered in the ice margin (Table 6-6). The average ringed seal density in the nearshore zone of the Alaskan Beaufort Sea was estimated from results of ship surveys at times without seismic operations during a nearshore OBC seismic survey (Moulton and Lawson 2002; Table 6-6)

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 6-6). ***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 and bearded seals reported in Moulton and Lawson (2002; Table 6-6). Minimal values were assigned as densities in the open–water and ice–margin zones to accommodate any chance encounters (Table 6-6).

Potential Number of "Takes by Harassment"

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

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 proposed surveys would take place in both the Chukchi and Beaufort seas 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 survey.

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

- the anticipated area to be ensonified to the specified level in the survey region, time period, 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 survey regions, 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 the proposed operations was calculated by multiplying the planned trackline distance by the cross-track distance of the sound propagation measured during previous field seasons. For site clearance and shallow hazards surveys in the Beaufort Sea in 2008 the ≥160 dB radius from the *Henry Christoffersen's* two 10 in^3 airguns was measured at 490 m and the single 10 in^3 airgun was measured at 280 m. A ≥160 dB radius of 830 m was measured from the *Alpha Helix's* two 10 in^3 airguns and 590 m from a single 10 in^3 airgun used for ice gouge surveys in the Beaufort Sea in 2008. In the Chukchi Sea, the ≥160 dB radius from the *Cape Flattery's* two 10 in^3 airguns used for site clearance and shallow hazards surveys in 2008 was also 830 m and the single 10 in^3 airgun was 440 m.

Closely spaced survey lines and large cross-track distances of the ≥160 dB radii can result in repeated exposure of the same area of water. Excessive amounts of repeated exposure can lead to overestimation of the number of animals potentially exposed through double counting. However, the relatively short cross-track distances of the ≥160 dB radii associated with the site clearance and shallow hazards, and ice gouge surveys result in little overlap of exposed waters during the survey so multiple exposures due to overlap of ensonified areas have not been removed from the area calculations.

Shallow hazards and site clearance surveys in the Chukchi Sea are planned to occur along ~480 km of survey lines (plus ~120 km of mitigation gun activity between survey lines) from Aug – Sep exposing ~900 km^2 of water to ≥160 dB. Ice gouge surveys along 2500 km of trackline (plus ~625 km of mitigation gun activity between survey lines) are also planned in the Chukchi Sea in Aug and Sep and will expose an additional ~4700 km^2 of water to ≥160 dB. Ice gouge survey activities will take place along prospective pipeline routes between offshore lease holdings and the coastline from Icy Cape to Pt. Franklin. Surveys will not occur within 5 mi of the coast and this should avoid disturbance of spotted seal haul outs in the area. Nearshore activity, especially in the Icy Cape region, will be performed as early in the season as possible after the bowhead and beluga whale harvests and not continue into August when spotted seals begin to haul out.

Density estimates in the Chukchi Sea have been derived for two time periods, the summer period (Aug), and the fall period (Sep). Animal densities encountered in the Chukchi Sea during both of these time periods will further depend on the habitat zone within which the source vessel is operating: (1) open water, or (2) ice margin. The survey vessel is not an icebreaker and cannot tow survey equipment through

pack ice. Under this assumption, densities of marine mammals expected to be observed in or near ice margin areas have been applied to 10% of the proposed survey trackline. Densities of marine mammals expected to occur in open-water areas have been applied to the remaining 90% of the survey trackline.

Approximately half of the proposed Chukchi Sea site clearance and shallow hazards survey is planned to be completed in Aug so the summer density estimates have been applied to 50% of the trackline falling within each habitat zone. The other half of the trackline is planned to be surveyed in Sep, so the fall marine mammal densities have also been applied to 50% of the trackline in each habitat zone.

Site clearance and shallow hazards surveys are planned in the Beaufort Sea along ~700 km of trackline (plus ~175 km of mitigation gun activity between survey lines) in Aug exposing ~392 km^2 of water to ≥160 dB. Approximately half of this effort is planned to occur in the Harrison Bay area and the other half in the Camden Bay area. In both locations, most (70%) of the trackline is expected to occur in water <40 m deep, with the remainder (30%) occurring in water from 40 – 200 m deep. The marine surveys for ice gouge between Pt. Thompson and Shell lease blocks in Camden Bay are planned along ~2116 km of survey lines (plus ~530 km of mitigation gun activity between survey lines) from Jul – Oct exposing ~4137 km^2 of water to ≥160 dB. The estimated area of sound exposure from the ice gouge surveys has been split evenly between summer and fall periods with 70% expected to occur in water <40 m deep and the remainder (30%) occurring in water from 40 – 200 m deep.

Based on the operational plans and marine mammal densities described above the estimates of marine mammals potentially exposed to sounds ≥ 160 dB in the Chukchi Sea are presented in table 6-7. Estimates for operations in the Beaufort Sea are presented in Tables 6-8 – 6-11 and summarized in Table 6-12. Chukchi and Beaufort Sea estimates are complied and presented in Table 6-13. Discussion of the number of potential exposures is summarized by species in the following subsections.

Cetaceans

Based on density estimates, one endangered cetacean species (bowhead whale) is expected to be exposed to received sound levels ≥160 dB unless bowheads avoid the survey vessel before the received levels reach 160 dB. Migrating bowheads are likely to do so, though many of the bowheads engaged in other activities, particularly feeding and socializing may not. Our estimate of the number of bowhead whales potentially exposed to ≥160 dB in the Chukchi and Beaufort seas combined is 283 (Table 6-13). Two other endangered cetacean species that may be encountered in the area (fin whale and humpback whale) are unlikely to be exposed given their low "average" density estimates in the area.

Most of the cetaceans exposed to marine survey sounds with received levels ≥160 dB would involve mysticetes (bowheads and gray whales), monodontids (belugas), and porpoise (harbor porpoise). Average and maximum estimates of the number of exposures of cetaceans other than bowheads, in descending order, are beluga (119 and 237), gray whale (72 and 145), and harbor porpoise (22 and 45). Estimates for other cetacean species are lower (Table 6-13).

Table 6-7 Estimates of the numbers of marine mammals in areas where maximum received sound levels in the water would be ≥160 dB during Shell's proposed site clearance and shallow hazards surveys in summer (Aug) and fall (Sep), 2009 in the Chukchi Sea, Alaska.

	Number of Exposure to Sound Levels ≥160 dB									
	Summer				Fall					
	Open Water [a]		Ice Margin [b]		Open Water [a]		Ice Margin [b]		Total	
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Odontocetes										
Monodontidae										
Beluga	0	1	0	0	5	9	1	2	6	12
Delphinidae										
Killer whale	0	0	0	0	0	0	0	0	0	5
Phocoenidae										
Harbor porpoise	2	5	0	1	1	2	0	0	3	7
Mysticetes										
Bowhead whale	0	0	0	0	0	2	0	1	1	5
Fin whale	0	0	0	0	0	0	0	0	0	5
Gray whale	4	9	0	1	6	12	1	1	12	23
Humpback Whale	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	5
Total Cetaceans	3	6	0	1	12	26	2	4	22	67
Pinnipeds										
Bearded seal	7	11	2	2	7	11	3	2	19	27
Ribbon seal	0	0	0	0	0	0	0	0	0	5
Ringed seal	211	329	47	73	141	220	31	49	431	671
Spotted seal	1	3	0	1	1	3	0	1	4	7
Total Pinnipeds	220	343	49	76	150	234	35	52	454	710

[a] Open water regions for the Chukchi Sea are considered to be 90% of the survey lines.

[b] Ice Margin regions for the Chukchi Sea are considered to be 10% of the survey lines.

Table 6-8 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 proposed site clearance and shallow hazards surveys during the summer (Aug), 2009 in the Beaufort Sea, Alaska.

	Number of Exposure to Sound Levels ≥160 dB							
	Summer							
	Nearshore [a]		Outer Shelf [b]		Ice Margin [c]		Total	
Species	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Western Beaufort								
Beluga	0	0	0	0	0	0	0	0
Bowhead whale	0	1	0	0	0	0	0	2
Eastern Beaufort								
Beluga	1	1	0	0	1	2	2	3
Bowhead whale	3	11	1	5	0	2	5	17

[a] Water from 0–40 m in depth.

[b] Water from 40–200 m in depth.

[c] 10% of planned tracklines.

Table 6-9 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 proposed ice gouge survey during summer (Jul – Aug) and fall (Sep – Oct), 2009 in the Beaufort Sea, Alaska.

	Number of Exposure to Sound Levels ≥160 dB													
	Summer						Fall							
	Nearshore [a]		Outer Shelf [b]		Ice Margin [c]		Nearshore [a]		Outer Shelf [b]		Ice Margin [c]		Total	
Species	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Eastern Beaufort														
Beluga	3	5	1	2	4	9	7	15	37	73	28	55	80	160
Bowhead whale	15	56	6	24	2	9	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	24	89

[a] Water from 0–40 m in depth.

[b] Water from 40–200 m in depth.

[c] 10% of planned tracklines.

Table 6-10 Estimates of the numbers of marine mammals (excluding beluga and bowhead whales) in areas where maximum received sound levels in the water would be ≥160 dB during Shell's proposed site clearance and shallow hazards surveys in Aug, 2009 in the Beaufort Sea, Alaska.

	Number of Exposure to Sound Levels ≥160 dB					
	Continental Shelf [a]		Ice Margin [b]		Total	
Species	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Odontocetes						
Monodontidae						
Narwhal	0	0	0	1	0	1
Phocoenidae						
Harbor porpoise	0	1	0	0	0	1
Mysticetes						
Gray whale	0	1	0	0	0	1
Humpback whale	0	1	0	0	0	1
Pinnipeds						
Bearded seal	11	22	1	2	12	24
Ribbon Seal	0	0	0	1	0	1
Ringed seal	219	438	17	34	236	472
Spotted seal	2	5	0	0	2	5
Total Pinnipeds	232	465	18	37	251	502

[a] Water from 0–200 m in depth.

[b] 10% of planned tracklines.

Table 6-11 Estimates of the numbers of marine mammals (excluding beluga and bowhead whales) in areas where maximum received sound levels in the water would be ≥160 dB during Shell's proposed ice gouge surveys in the Beaufort Sea, Alaska, Jul – Oct, 2009.

	Number of Exposure to Sound Levels ≥160 dB					
	Continental Shelf [a]		Ice Margin [c]		Total	
Species	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Odontocetes						
Monodontidae						
Narwhal	0	0	0	0	0	0
Phocoenidae						
Harbor porpoise	0	1	0	0	0	1
Mysticetes						
Gray whale	0	1	0	0	0	1
Humpback whale	0	1	0	0	0	1
Pinnipeds						
Bearded seal	57	114	4	9	62	123
Ribbon Seal	0	0	0	1	0	1
Ringed seal	1121	2243	88	176	1209	2419
Spotted seal	12	24	0	0	12	24
Total Pinnipeds	1190	2381	93	186	1283	2567

[a] Water from 0–200 m in depth.

[c] 10% of planned tracklines.

Table 6-12 Summary of the estimated number of marine mammals potentially exposed to received sound levels ≥160 dB during Shell's proposed site clearance and shallow hazards, and ice gouge surveys during the summer (Jul – Aug) and fall (Sep – Oct) of 2009 in the Beaufort Sea, Alaska.

	Number of Exposure to Sound Levels ≥ 160 dB					
	Summer		Fall		Total	
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Odontocetes						
Monodontidae						
Beluga	9	35	72	143	81	178
Narwhal	0	1	0	0	0	1
Phocoenidae						
Harbor porpoise	0	1	0	1	0	2
Mysticetes						
Bowhead whale	25	262	250	250	275	512
Gray whale	0	2	0	0	0	2
Humpback whale	0	2	0	0	0	2
Total Cetaceans	34	301	322	394	356	697
Pinnipeds						
Bearded seal	43	86	31	62	74	147
Ribbon seal	0	2	0	0	0	2
Ringed seal	841	1682	605	1209	1446	2891
Spotted seal	8	16	6	12	14	28
Total Pinnipeds	892	1786	641	1283	1534	3069

Table 6-13 Summary of the estimated number of marine mammals potentially exposed to underwater received sound levels of ≥160 dB during Shell's proposed site clearance and shallow hazards, and ice gouge surveys in the Chukchi Sea and Beaufort Sea, Alaska, Jul – Oct, 2009. Not all marine mammals will change their behavior when exposed to these sound levels, although some might alter their behavior at somewhat lower levels (see text).

	Number of Individuals Exposed to Sound Levels ≥160 dB					
	Chukchi Sea		Beaufort Sea		Total	
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Odontocetes						
Monodontidae						
Beluga	37	74	82	163	119	237
Narwhal	0	0	0	1	0	5
Delphinidae						
Killer whale	1	1	0	0	1	5
Phocoenidae						
Harbor porpoise	22	43	0	2	22	45
Mysticetes						
Bowhead whale [a]	4	21	279	357	283	378
Fin whale	1	1	0	0	1	5
Gray whale	72	143	0	2	72	145
Humpback whale	1	1	0	2	1	5
Minke whale	1	1	0	0	1	5
Total Cetaceans	137	286	362	527	499	813
Pinnipeds						
Bearded seal	121	166	74	147	195	314
Ribbon seal	1	1	0	2	1	5
Ringed seal	2676	4168	1446	2891	4122	7059
Spotted seal	22	44	14	28	36	73
Total Pinnipeds	2820	4380	1534	3069	4353	7449

[a] See text for description of bowhead whale estimate for the Beaufort Sea

For the common species, the requested numbers are calculated as described above and based on the average densities from the data reported in the different studies mentioned above. For less common species, estimates were somewhat arbitrary involving small numbers of animals.

Pinnipeds

Ringed seal is the most widespread and abundant pinniped in ice-covered arctic waters, and there is a great deal of annual variation in population size and distribution of these marine mammals. Ringed seals account for the vast majority of marine mammals expected to be encountered, and hence exposed to airgun sounds with received levels ≥160 dB re 1 µPa (rms) during the proposed open water marine survey. The average (and maximum) exposure estimate is that 4122 (7059) ringed seals might be exposed to marine survey sounds with received levels ≥160 dB.

Two additional pinniped species (other than the Pacific walrus) are expected to be encountered. They are the bearded seal (185 and 314, average and maximum estimates, respectively), and the spotted seal (36 and 73; Table 6-13). Survey activities near spotted seal haulouts at Icy Cape in the Chukchi Sea will remain ≥5 mi from shore and be timed to minimize the chance of disturbance to hauled-out seals. The ribbon seal is unlikely to be encountered, but their presence cannot be ruled out.

Conclusions

Cetaceans

Most of the bowhead whales encountered during the summer will likely show overt disturbance (avoidance) only if they receive airgun sounds with levels ≥160 dB re 1 µPa (rms). The relatively small airgun arrays proposed for use in these surveys greatly limits the size of the 160 dB zone around the ship. These smaller airgun arrays will result in fewer bowhead whales being disturbed by the surveys.

Odontocete reactions to seismic energy pulses are usually assumed to be limited to lesser distances from the airgun(s) than are those of mysticetes, probably in part because odontocete low-frequency hearing is less sensitive than that of mysticetes. However, at least when in the Canadian Beaufort Sea in summer, belugas appear to be fairly responsive to seismic energy, with few being sighted within 10–20 km of seismic vessels during aerial surveys (Miller et al. 2005). Belugas will likely occur in small numbers in the Chukchi Sea during the survey period and few will likely be affected by the survey activity. In the Beaufort Sea belugas generally occur further offshore than the proposed survey area and are also not likely to be affected by survey activities.

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

Based on the ≥160 dB disturbance criterion, the *best (average) estimates* of the numbers of cetacean *exposures* to sounds ≥160 dB re 1 µPa (rms) represent varying proportions of the populations of each species in the Chukchi and Beaufort seas and adjacent waters (*cf.* Table 6-1). For species listed as "*Endangered*" under the ESA, our estimates suggest it is unlikely that fin whales or humpback whales will be exposed to received levels ≥160 dB rms, but that ~283 bowheads may be exposed at this level. The latter is ~2% of the Bering–Chukchi–Beaufort population of >13,779 assuming 3.4% annual population growth from the 2001 estimate of >10,545 animals (Zeh and Punt 2005).

Some monodontids may be exposed to sounds produced by the airgun arrays during the proposed surveys, and the numbers potentially affected are small relative to the population sizes (Table 6-13). Narwhals are rare in the U.S. Beaufort Sea and few, if any, are expected to be encountered during the survey. The best estimate of the number of belugas that might be exposed to ≥160 dB (119) represents <1% of their population.

Varying estimates of the numbers of marine mammals that might be exposed to sounds from the airgun arrays during the 2009 Shell shallow hazards and site clearance surveys have been presented (average vs. maximum). The relatively short-term exposures that will occur are not expected to result in any long-term negative consequences for the individuals or their populations.

The many reported cases of apparent tolerance by cetaceans of seismic exploration, vessel traffic, and some other human activities show that co-existence is possible. Mitigation measures such as controlled vessel speed, dedicated marine mammal observers, non-pursuit, shut downs or power downs when marine mammals are seen within defined ranges, and avoiding migration pathways when animals are likely most sensitive to noise will further reduce short-term reactions and minimize any effects on hearing sensitivity. In all cases, the effects are expected to be short-term, with no lasting biological consequence. Subsistence issues are addressed below in section 8.

Shell has adopted a 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.

Potential Bowhead Disturbance at Lower Received Levels

Aerial surveys during fall seismic surveys in the Beaufort Sea showed that migrating bowhead whales appeared to avoid seismic activities at distances of 20–30 km and received sound levels of 120–130 dB rms (Miller et al. 1999; Richardson et al. 1999). Therefore, it is possible that a larger number of bowhead whales than estimated above may be disturbed to some extent if reactions occur at or near ~130 dB (rms). The number of migrating bowhead whales exposed to sounds ≥120 dB by the proposed surveys would be ~8.5× the number estimated at ≥160 dB. However, acoustic data collected in the vicinity of seismic surveys in the Beaufort Sea in 2007 indicated that bowhead whales did not avoid the sound source at distances equivalent to 120 dB (rms) and instead tolerated sounds at higher levels while likely changing their calling behavior (Blackwell et al. 2008).

Reducing operations during the bowhead whale subsistence harvest is meant to accomplish two mitigation objectives. It greatly reduces the potential for conflicts with subsistence hunting activities and it allows a large proportion of the bowhead population to migrate past the survey area without being exposed to survey sounds ≥160 dB (rms) or ≥120 dB (rms).

Pinnipeds

A few pinniped species are likely to be encountered in the study area, but ringed seal is by far the most abundant marine mammal species in the survey area. The best (average) estimates of the numbers of individuals seals exposed to airgun sounds at received levels ≥160 dB re 1 μPa (rms) during the open water marine survey are as follows: ringed seals (4112), bearded seals (195), and spotted seals (36), (representing ~2%, <1%, and <2%, respectively, of the Bearing–Chukchi–Beaufort populations for each species). It is probable that only a small percentage of the animals exposed to sound level ≥160 dB would actually be disturbed. The short-term exposures of pinnipeds to airgun sounds are not expected to result in any long-term negative consequences for the individuals or their populations.

7. The anticipated impact of the activity on the species or stock

The only anticipated impacts to marine mammals associated with Shell activities in respect to noise propagation are from vessel movements, and air gun operations. The impacts, short-term displacement of seals and whales from within ensonified zones would be temporary and not biologically significant. Any impacts on the whale and seal populations of the Beaufort or Chukchi Seas activity areas are likely to be short-term and transitory arising from the temporary displacement of individuals or small groups from locations they may occupy at the times they are exposed to sounds at the 160 to 190 decibel (dB) received levels. As noted in Section 6 above, it is highly unlikely that animals will be exposed to sounds of such intensity and duration as to physically damage their auditory mechanisms. In the case of bowhead whales that displacement might well take the form of a deflection of the swim paths of migrating bowheads away from (seaward of) received noise levels greater than 160 dB (Richardson et al. 1999). The cited and other studies conducted to test the hypothesis of the deflection response of bowheads have determined that bowheads return to the swim paths they were following at relatively short distances after their exposure to the received sounds. There is no evidence that bowheads so exposed have incurred injury to their auditory mechanisms. Additionally, there is no conclusive evidence that exposure to sounds exceeding 160 dB have displaced bowheads from feeding activity (Richardson, and Thomson 2002).

There is no evidence that seals are more than temporarily displaced from ensonified zones and no evidence that seals have experienced physical damage to their auditory mechanisms even within ensonified zones.

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

There could be an adverse impact on the Inupiat bowhead subsistence hunt if the whales were deflected seaward (further from shore) in traditional hunting areas. The impact would be that whaling crews would have to travel greater distances to intercept westward migrating whales thereby creating a safety hazard for whaling crews and/or limiting chances of successfully striking and landing bowheads. 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 and whaling within the traditional subsistence hunting areas of the potentially affected communities. (See Section 12, below). Survey activities in the Chukchi Sea will be scheduled to avoid the traditional subsistence beluga huntwhich annually occurs in July in the community of Pt. Lay.

Shell has adopted a 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 the whale 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 activities will occur during the time of year when bowhead whales are present (i.e., August and September). Any effects would be temporary and of short duration at any one place. The primary potential impacts to marine mammals 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.

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 Chukchi and Beaufort Seas 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 early October), most marine mammals would be dispersed throughout the area. The peak of the bowhead whale migration through the Chukchi and Beaufort Seas typically occurs in mid-September and October, and efforts to reduce potential impacts during this time, such as conducting site clearance and shallow hazards surveys during August and September, will provide effective protection of the bowhead migration and subsistence hunt. The timing of open water survey activities in the eastern 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 open water survey activities, of which some might be displaced seaward by the planned activities. The numbers of cetaceans and pinnipeds subject to displacement of 0.6 to 1.2 km and 0.4 to 0.9 km (or more), respectively, 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 in the Chukchi and Beaufort Seas 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) or aerially 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:

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

Shell will prepare and implement a draft Plan of Cooperation (POC) for its 2009 activities. The POC will also describe concerns received during 2008 and will submit this information in spring 2009 to federal agencies as well as to subsistence stakeholders. Shell is developing the POC to mitigate and avoid any unreasonable interference from Shell-planned activities with North Slope subsistence uses and resources. 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. To be effective, the POC must be a dynamic document which will expand to incorporate the communications and consultation that will continue to occur throughout 2009 and 2010. 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 2009 open water activities in the Beaufort and Chukchi Seas have not been held yet but are planned Nuiqsut, Kaktovik, Barrow, Point Hope, Point Lay, Wainwright, and Kotzebue. During 2009, Shell will continue to meet 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). Throughout 2009 Shell anticipates meeting with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research.

Also during 2009, Shell will meet at least twice each year with the commissioners and committee heads of ABC, ANC, EWC, and AISC jointly in co-management meetings. During a pre-season co-management meeting Shell will present pre-season planning to the commissioners and committee leads in order to gather their input on subsistence use concerns, consider their traditional knowledge in the design of project mitigations, and to hear about their involvement in research on marine mammals and/or traditional use. Following the season, Shell will have a post-season co-management meeting with the commissioners and committee heads to discuss results of mitigation measures and outcomes of the preceding season. The goal of the post-season meeting is to build upon the knowledge base, discuss successful or unsuccessful outcomes of mitigation measures, and possibly refine plans or mitigation measures if necessary.

Shell plans to begin its POC meeting process in the 1st quarter of 2009 and will present its open water marine survey program for the Beaufort and Chukchi Seas. Federal, state, and local agencies as well as North Slope subsistence stakeholder groups will be invited to attend this meeting. At these meetings, Shell will present its program and discuss local concerns regarding subsistence activities

In addition, Shell intends to discuss adaptive conflict avoidance mechanisms to address concerns expressed by subsistence user in the North Slope communities.

ii 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 plans to hold community meetings in Barrow, Nuiqsut, Kaktovik, Wainwright, Point Hope, and Point Lay, and Kotzebue regarding its Beaufort and Chukchi Seas 2009 open water marine surveys program. During these meetings, Shell will focus on lessons learned from the 2008 open water program and begin preparing mitigation measures for avoiding potential conflicts, which will be outlined in the 2009 POC. Shell will also facilitate meetings with the above-mentioned marine mammal commissions that are focused on ice seals, walrus, polar bears, and beluga.

iii 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 will work in good faith to mitigate possible adverse impacts on subsistent hunts for bowhead whales and seals and will incorporate these mitigation measures as operational limitations described as follows:

1. The vessel transits in the Chukchi Sea spring lead system must not occur prior to July 1, 2009 and 2010.

The POC will specify times and areas to avoid in order to minimize possible conflicts with traditional subsistence hunts by North Slope villages for transit and the open water activities.

iv 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 will meet with federal agencies to introduce the proposed Beaufort and Chukchi Sea 2009 open water program in early 2009, times and locations to be determined. These meetings will serve to facilitate early identification of key issues and permitting requirements. The agencies attendees can assist Shell in conducting constructive discussion focusing on the success of the 2009 POC mitigation measures and

assist Shell and affected subsistence communities in continuing a communicative relationship for conflict avoidance during the 2009 program. The agencies and stakeholders may also assist Shell in developing an appropriate schedule for conducting POC meetings in the communities continuing through 2009.

POC meetings will also be held during 2009 in the affected communities. In addition, the applicant will meet with North Slope officials and community leaders on an as-requested basis before the 2009 open water season in order to discuss the proposed 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 Marine Mammal Monitoring and Mitigation Plan (4MP) for the site clearance and shallow hazards surveys in the Chukchi and Beaufort Seas, and marine surveys in the Chukchi and Beaufort 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 Sea during the course of the 2009 and 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)
- The Kuukpik Subsistence Oversight Panel (KSOP**)**
- Alaska Eskimo Whaling Commission (H. Brower - Barrow)
- Alaska Beluga Whale Committee (W. Goodwin - Kotzebue)
- Alaska Ice Seal Commission (John Goodwin)
- Inupiat Community of the Arctic Slope (Martha Ipalook Faulk - Barrow)
- MMS – Resource Evaluation (R. Wall)
- North Slope Science Initiative (J. Payne)
- Alaska Department of Natural Resources (D. Perrin)

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Attachment A –
Marine Mammal Monitoring and Mitigation Plan

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Marine Mammal Monitoring and Mitigation Plan

for

Site Clearance and Shallow Hazards Data Acquisition in the Alaskan Chukchi Sea, 2009

Shell

Prepared by

Alaska Research Associates, Inc.

JASCO RESEARCH

TABLE OF CONTENTS

Introduction

Shell Gulf of Mexico Inc., the lessee for OCS leases in the Chukchi Sea known as Shell has contracted LGL Alaska Research Associates, Inc. (LGL) to design and conduct a Marine Mammal Monitoring and Mitigation Program (4MP) for their open-water shallow hazards data acquisition activities in the Chukchi Sea in 2009. The goal of the 4MP is to develop a program that supports protection of the marine mammal resources in the area, fulfills reporting obligations to the Minerals Management Service (MMS), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS), and provides data useful for monitoring and understanding the impacts of survey activities on cetaceans and pinnipeds.

The program consists of monitoring and mitigation during Shell's various activities related to survey data acquisition, including transit and data acquisition. This program will provide information on the numbers of marine mammals potentially affected by the survey program and real time mitigation to prevent possible injury of marine mammals by sources of sound, or other, energy, and other vessel related activities. The first portion of this monitoring plan describes the methods that Shell plans to use to accomplish the monitoring and mitigation tasks associated with its offshore survey program in the Chukchi Sea in 2009. Monitoring efforts will be initiated to collect data to address the following specific objectives:

- improve the understanding of the distribution and abundance of marine mammals in the Chukchi Sea project area;
- assess the effects of sound and vessel activities on marine mammals inhabiting the project area and their distribution relative to the local people that depend on them for subsistence hunting.

These objectives and the monitoring and mitigation goals will be addressed through the utilization of vessel-based marine mammal observers on the survey source and other support vessels.

Vessel–Based Marine Mammal Monitoring Program

Introduction

Vessel–based marine mammal observers will be a component of the program for the Shell survey program in the Chukchi Sea. The 4MP will be designed primarily to meet the requirements of the IHA issued by the NMFS and LOA by USFWS for this project, and to meet any other stipulations or requests agreed to between Shell and other agencies or groups such as the MMS and the AEWC. The objectives of the stipulations or agreed actions are to ensure that disturbance of marine mammals and subsistence hunts are minimized, that effects on cetaceans and pinnipeds are documented, and to monitor the occurrence and distribution of all marine mammals encountered in the study area

including cetacean and pinniped species. Those objectives will be achieved through the vessel-based monitoring and mitigation program.

The Program will be implemented by a team of experienced marine mammal observers (MMOs), including both biologists and Inupiat personnel. The MMOs will be stationed aboard the survey source vessel and other support vessels throughout the active field season. The duties of the MMOs will include watching for and identifying cetaceans and pinnipeds (as well as seabirds when possible); recording their numbers, distances, and reactions to the survey operations; initiating mitigation measures when appropriate; and reporting the results. MMOs aboard the survey source vessel will be on watch during all daylight periods when the energy sources are in operation, and when energy source operations are to start up at night (details below). Reporting of the results of the vessel-based monitoring program will include the estimation of the number of "takes", as stipulated in the IHA. Take estimates will be based on data collected from the source vessel during periods with and without survey activities and upon published accounts of marine mammal population densities and abundance levels.

Source Vessel Monitoring

Vessel-based operations of the 4MP will be required to support the survey source vessel prior to and during operations (approximately August thru September) in the Chukchi Sea. The dates will depend upon ice and weather conditions, along with industry's arrangements with agencies and stakeholders. Vessel-based monitoring for cetaceans and pinnipeds will be done throughout the period of survey operations to comply with anticipated provisions in the IHA that Shell expects to receive from NMFS and potentially in LOAs Shell receives from USFWS.

The vessel-based work will provide

- the basis for real-time mitigation (power downs and, as necessary, shut downs), as called for by the IHA,
- information needed to estimate the "take" 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 source vessels at times with and without survey activity,
- a communication channel to Inupiat whalers through the Subsistence Advisors in coastal villages, and
- continued employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Inupiat MMOs.

The Program will be operated and administered consistent with MMS NTL 2004-G01 or such alternative requirements as may be specified in the NMFS IHA or USFWS LOA or other authorizations issued MMS for this project. Any other stipulations or agreements made between Shell and agencies or groups such as MMS, USFWS, and AEWC will also

be fully taken into account. All MMOs will be certified through a training program approved by NMFS and industry participants, as described below. At least one observer on the survey vessel will be an Inupiat who will have the additional responsibility of communicating with the Inupiat community and (during the whaling season) directly with the Subsistence Advisors in coastal villages. Details of the vessel-based marine mammal monitoring program are described below.

Mitigation Measures

The proposed survey program incorporates both design features and operational procedures for minimizing potential impacts on cetaceans and pinnipeds and on subsistence hunts. The design features and operational procedures have been described in the IHA application submitted to NMFS and requests for LOA submitted to USFWS and are summarized below. Survey design features include:

- timing and locating survey activities to avoid interference with the annual fall bowhead whale and other marine mammal hunts;
- selecting and configuring the energy source array in such a way that it minimizes energy introduced into the marine environment and, specifically, so that it minimizes horizontal propagation;
- limiting the size of the acoustic energy source to only that required to meet the technical objectives of the survey; and
- early season field assessment to establish and refine (as necessary) the appropriate 180 dB and 190 dB safety zones, and other radii relevant to behavioral disturbance.

The potential disturbance of cetaceans and pinnipeds during survey operations will be minimized further through the implementation of several ship-based mitigation measures.

Safety and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around energy arrays are customarily defined as the distances within which received pulse levels are ≥180 dB re 1 µPa (rms) for cetaceans and ≥190 dB re 1 µPa (rms) for pinnipeds. The ≥190 dB re 1 µPa (rms) guideline was also employed by the USFWS for polar bears and ≥180 dB for walruses in its IHA issued to Shell in 2008. These safety criteria are based on an assumption that acoustic pulses at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels *might* have some such effects. Marine mammals exposed to ≥160 dB (rms) are assumed by NMFS to be potentially subject to behavioral disturbance.

Shell anticipates that monitoring similar to that conducted in the Chukchi Sea in 2008 will also be required in 2009. Shell plans to use MMOs onboard the survey vessel to monitor the 190 and 180 dB (rms) safety radii for pinnipeds and cetaceans, respectively and to implement appropriate mitigation as discussed below. .

During previous survey operations in the Chukchi Sea, Shell utilized early season sound source verification to establish safety zones for the above sound level criteria. As the equipment being utilized in 2009 is similar to that used in 2008 Shell will initially utilize the derived (i.e. measured) sound criterion distances from 2008. 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 will include power downsand shut downs as described below.

Ramp Ups

A ramp up of an energy source array provides a gradual increase in energy levels, and involves a step-wise increase in the number and total volume of energy released until the full complement is achieved. The purpose of a ramp up (or "soft start") is to "warn" cetaceans and pinnipeds in the vicinity of the energy source 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 survey program, the operator will ramp up energy sources slowly, if the energy source being utilized generates sound energy within the frequency spectrum of cetacean or pinniped hearing. Full ramp ups (i.e., from a cold start after a shut down, when no airguns have been firing) will begin by firing one small airgun. 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, which are not known at this time. If energy sources other than airguns are used, the ramp up procedures are not necessary.

A full ramp up, after a shut down, will not begin until there has been a minimum of a one half hour period of observation by MMOs of the safety zone 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 periods of turn around and transit between survey transects, at least one airgun (or energy source) will remain operational. The ramp-up procedure still will be followed when increasing the source levels from one air gun to the second air gun. Keeping one air gun firing, however, will avoid the prohibition of a cold start during darkness or other periods of poor visibility. Through use of this approach, survey 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 vessel operator and MMOs will maintain records of the times when ramp-ups start, and when the airgun arrays reach full power.

Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shut down is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable safety zone of the full arrays, but is outside the applicable safety zone of the single source. If a marine mammal is sighted within the applicable safety zone of the single energy source, the entire array will be shut down (i.e., no sources firing). Although observers will be located on the bridge ahead of the center of the airgun array, the shutdown criterion for animals ahead of the vessel will be based on the distance from the bridge (vantage point for MMOs) rather than from the airgun array – a precautionary approach. For marine mammals sighted alongside or behind the airgun array, the distance is measured from the array.

Marine Mammal Observers

Vessel-based monitoring for marine mammals will be done throughout the period of survey operations to comply with provisions in the IHA. Those provisions will be implemented during the program by a team of trained MMOs. The observers will monitor the occurrence and behavior of marine mammals near the source vessels during all daylight periods when the source arrays are operating, and during most daylight periods when they are not operating. Their duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the operations; advising survey personnel of the presence of mammals within or approaching the designated "safety zones"; initiating mitigation measures (power downs, shut downs) when appropriate; and documenting "take by harassment" as defined by NMFS.

Number of Observers

A sufficient number of MMOs will be required onboard the source vessel to meet the following criteria if stipulated in the IHA issued by NMFS, or LOA issued by USFWS:

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

To meet those criteria, Shell plans to place MMOs aboard the source vessel during all active acoustic survey operations. The specific number of MMOs during any period will depend on day length, size of anticipated safety zones (safety zones of less than 500 m can adequately be monitored by one observer), berthing availability, lifeboat space, IHAs and other permit requirements, and the planned survey operations. NMFS requirements specify that MMOs not be on duty for more than 4 consecutive hours although more than one 4-hour shift per day is acceptable. MMOs also require sufficient time for daily data entry, data checking, and other tasks aside from visual watches, and for sleep and meals.

MMO teams aboard survey vessels will consist of at least one Inupiat observer (two if available) and one to three biologists. An experienced field crew leader will be a member of every MMO team onboard survey source vessels at all times during the data acquisition programs. The total number of MMOs aboard vessels may decrease later in the season as the duration of daylight decreases and if there is no requirement for continuous nighttime

monitoring. If operations occur during the whaling season, the Inupiat observer(s) also will serve as a part-time communicator with subsistence advisors in the coastal villages.

Crew Rotation

Shell anticipates that there will be provision for crew rotation every five to six weeks. To facilitate monitoring consistency during MMO crew changes, detailed hand-over notes will be prepared for the oncoming crew leader. There will also be communications (e.g., email, fax, and/or phone) between the current and oncoming crew leaders during each cruise.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers in 2009 will be individuals with experience as observers during one or more of the 1996-2008 monitoring projects for Shell, WesternGeco or BP, and/or subsequent offshore monitoring projects for other clients in Alaska, the Canadian Beaufort, or other offshore areas.

Biologist-observers to be assigned will have previous marine mammal observation experience and field crew leaders will be highly experienced with previous vessel-based monitoring projects. Résumés for those individuals will be provided to NMFS so that NMFS can review and accept their qualifications. Inupiat observers will be experienced in the region, and familiar with the marine mammals of the area. A marine mammal observers' handbook, adapted for the specifics of the proposed survey programs from the handbooks created for previous monitoring projects will be prepared and distributed beforehand to all MMOs (see below).

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 2009 open-water season. (Any exceptions will have or receive equivalent experience or training.) The training session(s) will be conducted by marine mammalogists with extensive crew-leader experience during previous vessel-based 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, or by MMS;
- review of marine mammal sighting, identification, and distance estimation methods, including any amendments specified by NMFS or USFWS in the 2009 IHA or LOA;
- review of operation of specialized equipment (reticle binoculars, Big-Eye 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 mammal sightings, acoustic and monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers.

MMO Handbook

A Marine Mammal Observers' Handbook has been prepared for use by MMOs onboard the survey source and support vessels. The handbook contains maps, illustrations, and

photographs as well as text and is 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 survey monitoring project in the Chukchi Sea:

- summary overview descriptions of the project, marine mammals and underwater noise, survey operations, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements, special studies), the NMFS and USFWS IHA or LOA and other regulations/permits/agencies, the Marine Mammal Protection Act, issues (e.g., subsistence hunt), and the Plan of Cooperation;
- monitoring and mitigation objectives and procedures, safety radii;
- responsibilities of staff and crew regarding the marine mammal monitoring plan and the operations of the survey vessels;
- 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, and operational data recording, field data sheet;
- use of specialized field equipment (reticle binoculars, Big-Eye binoculars NVDs, laser rangefinders);
- reticle binocular distance scale;
- table of wind speed, Beaufort wind force, and sea state codes;
- data storage and backup procedures;
- list of species that might be encountered: identification, natural history;
- safety precautions while onboard;
- crew and/or personnel discord; conflict resolution among 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.
- copies of the NMFS and USFWS IHA and LOA.

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the operating source vessel, which is usually the bridge or flying bridge. The observer(s) will scan systematically with the naked eye and 7×50 reticle binoculars, supplemented with 20 x 50 image stabilized binoculars, and night-vision equipment when needed (see below). Personnel on the bridge will assist the marine mammal observer(s) in watching for pinnipeds and whales.

The observer(s) will give particular attention to the areas within the "safety zone " around the source vessels. These zones are the maximum distances within which received levels may exceed 180 dB re 1 μPa (rms) for cetaceans, or 190 dB re 1 μPa (rms) for other marine mammals.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during previous monitoring programs 1998-2008 in the Chukchi and Beaufort seas (Moulton and Lawson 2002, Patterson et al. 2007). 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 source vessel, apparent reaction to source vessel (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace.
- Time, location, heading, speed, and activity of the vessel, and operational state (e.g., operating airguns.), sea state, ice cover, visibility, and sun glare.
- The positions of other vessel(s) in the vicinity of the source vessel. This information will be recorded by the MMOs at times of whale (but not seal) sightings.

The ship's position, heading, and speed, the operational state (e.g., number and size of operating energy sources), and water temperature (if available), water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch and, during a watch, every 30 minutes and whenever there is a change in one or more of those variables.

Distances to nearby marine mammals, e.g., those within or near the 190 dB (or other) safety zone applicable to pinnipeds, will be estimated with binoculars (7×50) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.

Observers will use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. Previous experience showed that this Class 1 eye-safe device was not able to measure distances to seals more than about 70 m (230 ft) away. However, it 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. In our experience, 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 IHA can be implemented. As in 1996-2001 and in 2006 and 2007, it is expected that the airgun array 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 needed. (Prior to mid-August, there will be no hours of total darkness.) Our past experience with night-vision devices (NVDs) in the Chukchi Sea

and elsewhere shows that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002). Tests of NVDs during seismic surveys in other areas have provided similar results.

Specialized Field Equipment

The operators will provide or arrange for the following specialized field equipment for use by the onboard MMOs: reticle binoculars, 20 x 50 image stabilized binoculars, "Big-eye binoculars, laser rangefinders, inclinometer, laptop computers, night vision binoculars, and possibly digital still and digital video cameras.

Field Data-Recording, Verification, Handling, and Security

The observers on the source vessels 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 onto CDs and USB keys, 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 LGL Anchorage office during crew rotations. Daily data updates will also be provided via email to LGL Anchorage and Shell offices. Upon completion of QA/QC evaluation, these daily updates will be shared with NMFS, MMS, and USFWS.

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 lead MMO will prepare a report each week (or at such other interval as the IHA or Shell may require) summarizing the recent results of the monitoring program. The reports will be provided to NMFS and will summarize the species and numbers of marine mammals sighted during periods with and without various operations, and the number of shut downs and power downs by species.

Reporting

The results of the 2009 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, USFWS, and other agencies and stakeholders in their negotiations with Shell.

The technical reports will include:

- summaries of monitoring effort: total hours, total distances, and marine mammal distribution through study period versus operational state, sea state, and other factors affecting visibility and delectability of marine mammals;
- summaries of the occurrence of power-downs and shutdowns;
- analyses of the effects of various factors influencing detectability of marine mammals: 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 operations including
    - sighting rates of marine mammals versus operational state (and other variables that could affect detectability);
    - initial sighting distances versus operational state;
    - closest point of approach versus operational state;
    - observed behaviors and types of movements versus operational state;
    - numbers of sightings/individuals seen versus operational state; and
    - distribution around the acoustic source vessel versus operational state.

Estimates of "take by harassment" will be calculated using two different methods to provide minimum and maximum estimates. The minimum estimate will be based on the numbers of marine mammals directly seen within the relevant safety radii by observers on the source vessel, or nearby support vessels, during survey activities. The maximum estimate will be calculated using densities of marine mammals determined for non-acoustic areas and times. These density estimates will be calculated from data collected during a) vessel based surveys in non-operational areas, or b) observations from the source vessel or supply boats during non-operational periods. The estimated densities in areas without data acquisition activity will be applied to the amount of area exposed to the relevant levels of sound to calculate the maximum number of animals potentially exposed or deflected.

Aerial Survey Program

No manned aerial overflights are recommended or anticipated during the 2009 shallow hazards and marine survey activities. In the Chukchi Sea all shallow hazards activities will be conducted beyond 60 miles from shore and well away from coastal communities or nearshore concentrations of subsistence resources.

Nearshore manned aerial overflights conducted in 2006-2008 have not revealed significant patterns of marine mammal distribution or behavior despite extensive programs of 2D and 3D seismic acquisition by multiple parties. In that the energy source to be utilized by survey operations is minimal by comparison to larger scale seismic operations, it is not anticipated that manned overflights would accomplish any direct mitigative effects or monitoring purpose.

Acoustic Monitoring Plan

Acoustic Sound Source Verification Measurements

Background

As part of the IHA application process for similar shallow hazards and marine survey acquisition in 2006 - 2008, Shell contracted JASCO Research Ltd. to conduct acoustic measurement of vessel and energy source arrays on source and support to broadband received levels of 190, 180, 170, 160, and 120 dB_{rms} re 1 μPa (Table 1).

Table 1: Sound threshold level radii (in meters) to 190, 180, 170, 160 and 120 dB re μPa (rms) for the 4 x 10 in^3 airgun array from M/V Cape Flattery in the Chukchi Sea, Alaska 2008.

Received Level (rms)	Preliminary and Final Radii
120 dB	24000
160 dB	1400
170 dB	490
180 dB	160
190 dB	50

Source: Marine Mammal Monitoring and Mitigation During Open Water Seismic Exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July-October 2008: 90-Day Report; LGL Ltd., environmental research associates and JASCO Research Ltd; January 2009.

The radii measured by these previous Sound Source Verifications (SSVs) will be utilized as temporary safety radii until current sound source verification measurements of the actual airgun array sound are available. The measurements will be made at the beginning of the field season and the measured radii used for the remainder of the survey period. Measured radii were found to exceed the corresponding radii predicted by the model

In 2009 Shell plans to utilize similar equipment aboard its survey source vessel. Shell intends to make new sound source verification measurements at the start of its 2009 Chukchi Sea survey even though the equipment planned for 2009 surveying operations are similar to the one used in 2006 – 2008. Verification measurements will be performed on or as close as possible to the actual survey locations, with ice conditions being the limiting factor.

While an SSV will be performed for the source vessel in 2009 at the initiation of operations to support establishment of mitigation safety zones, other vessels not being used as energy sources will not be measured by the above program. As indicated below, Shell and ConocoPhillips are conducting an extensive acoustic assessment program both widely over the Chukchi Sea lease area and intensively in the vicinity of primary leaseholds for each company. One goal of this acoustic program is to understand the soundscape of the Chukchi Sea. One aspect of gaining such an understanding is the collection of data on vessel traffic within the system. As such, the acoustic array will be utilized by Shell to collect Sound Source information on each of the vessels that we have in theater. The locations of each recorder will be utilized to identify opportunistic steam

by measurements. By recording vessel track, date, and time as each vessel steams over a recorder, it will be possible to recover these non-mitigation setting data upon retrieval of the units at the end of the season. Sound profiles for each vessel will be incorporated into the Comprehensive Report.

The locations of the recorder arrays will also be made available to all vessels traversing the Chukchi Sea with the understanding that, if they conduct a steam by (while documenting vessel track, position, date and time), the data from the recorders will be available to support sound assessment.

Objectives

The objectives of the sound source verification measurements planned for 2009 in the Chukchi 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 processes. The configurations will include at least the full array operating 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 measurements. 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.

Field analysis and reporting:

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 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 a 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-ay 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.

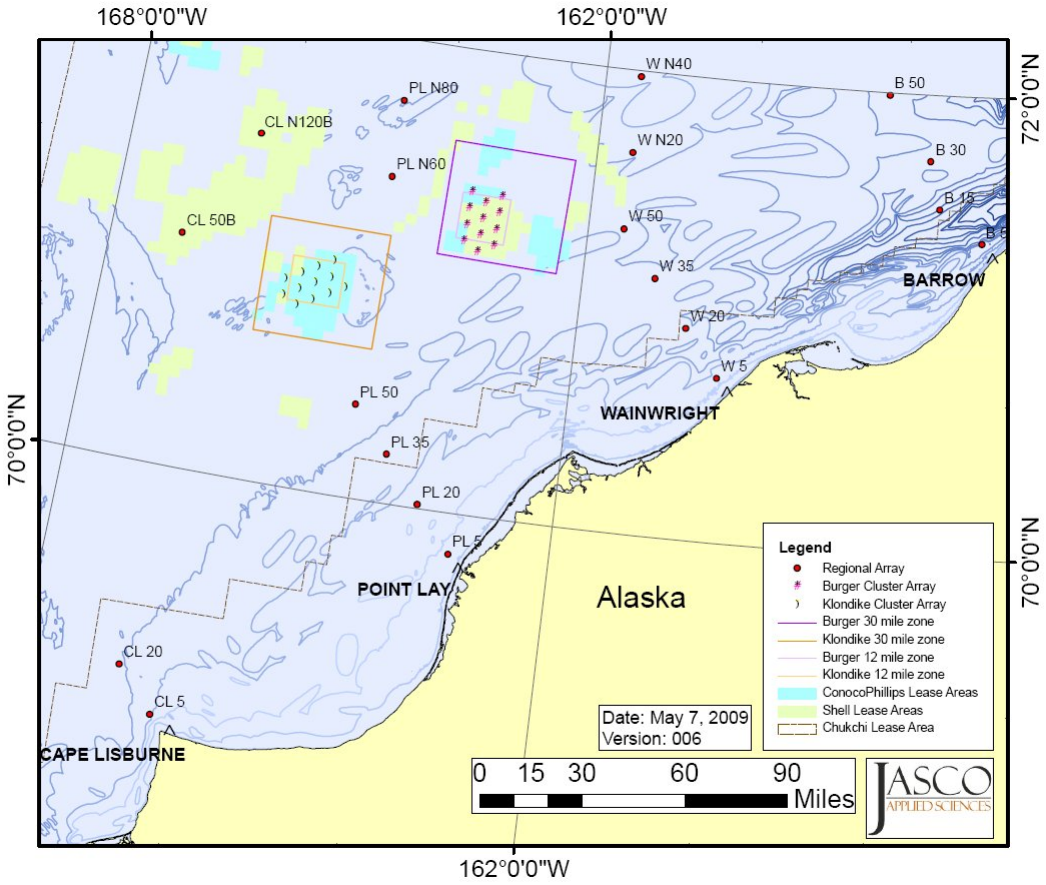
- For each pulse, the distance to the airgun array is computed from GPS deployment positions of the OBH systems and the time referenced DGPS navigation logs of the survey vessel.
- The waveform data are processed to determine flat-weighted peak sound pressure level (PSPL), rms sound pressure level (SPL) 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.

Chukchi Sea Acoustic Arrays

Shell and ConocoPhillips are jointly funding an extensive acoustic monitoring program in the Chukchi Sea in 2009. This program incorporates the acoustic programs of 2006-2008 with a total of 44 recorders distributed both broadly across the Chukchi lease area and nearshore environment and intensively on the Burger and Klondike lease areas. The broad area arrays are designed to capture both general background soundscape data and marine mammal call data across the lease area. From these recordings it is anticipated that we may be able to gain insights into large-scale distribution of marine mammals, identification of marine mammal species present, movement and migration patterns, and general abundance data.

The intense area arrays are designed to support localization of marine mammal calls on and around the leasehold areas. In the case of the Burger prospect, where Shell intends to conduct shallow hazards data acquisition, localized calls will enable investigators to understand response of marine mammals to survey operations both in terms of distribution around the operation and behavior (i.e. calling behavior).



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

Following the 2009 open water season a comprehensive report describing the acoustic, and vessel-based, 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 their impacts on marine mammals in the Chukchi Sea during 2009. The report will help to establish long-term data sets that can assist with the evaluation of changes in the Chukchi 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.

This report will consider data from many different sources including two relatively different types of aerial surveys; several types of acoustic systems for data collection (net array and OBH systems), and vessel based observations. Collection of comparable data across the wide array of programs will help with the synthesis of information and allow integration of the data sets over a period years. Data protocols for the acoustic operations will be similar to those used in 2006 –2008 to facilitate this integration.

Cumulative effects of Shells activities will be evaluated to the extent possible, but to truly capture 'cumulative' effects of offshore activities would involve collecting data on

operations supporting NSB villages, research vessels, and other activities occurring in the Chukchi Sea. Data will be presented and discussed at a workshop on cumulative effects associated with offshore activities if a workshop can be organized. This will provide an opportunity for all stakeholders to engage in the development of a cumulative effects strategy for future activities.

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