Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with Planned 2010 Exploration Drilling Program Chukchi Sea, Alaska

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List of Attachments

List of Acronyms

4MP	Marine Mammal Monitoring and Mitigation Plan
µPa	micropascal
ADF&G	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AHD	nonpulse acoustic harassment devices
AISC	Alaska Ice Sea Commission
ATOC	Acoustic Thermometry of Ocean Climate
BCB	Bering-Chukchi-Beaufort stock (bowheads)
BWASP	Bowhead Whale Aerial Survey Program
CAA	Conflict Avoidance Agreement
CFR	Code of Federal Regulations
CI	Confidence Interval
CV	Coefficient of Variation
COMIDA	Chukchi Sea Offshore Monitoring in Drilling Area
Discoverer	*Frontier Discoverer*
dB	decibel
EP	Exploration Plan
EWC	Eskimo Walrus Commission
ft	feet
IHA	Incidental Harassment Authorization
IUCN	International Union for the Conservation of Nature
km	kilometers
m	meters
mi	statute miles
MMPA	Marine Mammal Protection Act
MMO	Marine Mammal Observer
MMS	Minerals Management Service
MONM	Marine Operations Noise Model (Jasco)
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NSB	North Slope Borough
NWAB	Northwest Arctic Borough
OCS	Outer Continental Shelf
OSR	Oil Spill Response
OSRB	Oil Spill response Barge
OSRV	Oil Spill Response Vessel
OST	Oil Spill Tanker
POC	Plan of Cooperation
PTS	Permanent Threshold Shift
RL	Received Level
rms	root mean squares
Shell	Shell Gulf of Mexico Inc.
TTS	Temporary Threshold Shift
TK	Traditional Knowledge
USFWS	United States Fish and Wildlife Service

Executive Summary

As described herein, during the 2010 drilling season, Shell Gulf of Mexico Inc. (Shell) plans to drill up to three exploration wells at three drill sites in the Chukchi Sea on Outer Continental Shelf (OCS) leases acquired from the U.S. Minerals Management Service (MMS). Shell plans to use the M/V *Frontier Discoverer (Discoverer)* drillship, attended by a minimum of seven support vessels for the purposes of ice management, anchor handling, oil spill response (OSR), refueling, and resupply.

The *Discoverer* is an industry-standard, ice-reinforced drillship similar to those routinely used in the Beaufort and Chukchi Seas since the 1980s, as well as elsewhere in the world's oceans. During drilling and associated operations, the drillship will emit near continuous non-pulse sounds that ensonify only 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 the non-pulse, continuous sounds generated by offshore exploration drilling. Shell requests an IHA pursuant to Section 101 (a) (5) (D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a) (5), to allow non-lethal takes of whales and seals incidental to the exploration drilling program.

Shell has calculated the estimated take of marine mammals from the low-level non-pulse sound generating sources active during drilling operations and, as detailed herein, determined that any takes that might result from the planned operations would not be of biological significance to marine mammal populations.

The only anticipated impacts to marine mammals associated with the drilling exploration program that might result in a take are propagation of sounds from the drillship. Any impacts to whales and seals would be temporary and result in only short-term displacement of seals and whales from within ensonified zones produced by such a sound source.

For example, an impact analysis of underwater sound generated by the planned 2010 exploration drilling program (included herein) determined that only 11 bowhead whales would be exposed to sounds ≥160 decibels (dB) re 1 µPa root mean squares (rms) equaling <1 percent of the population. An even smaller percentage of seal populations in the Chukchi Sea would be exposed to underwater sounds in excess of 160 dB re 1 µPa rms. The small numbers of other whale species and seals that may occur in the Chukchi Sea are unlikely to be present around the planned exploration drilling activities. In regard to the subsistence harvest of bowhead whale in the Chukchi Sea, as a consequence of Shell's planned mitigation measures any effects on the bowhead whale as a subsistence resource also will be negligible.

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 used the following guidance to prepare its request for IHA.

> 50 CFR 216.104 "Submission of Requests"
>
> (a) In order for the NMFS to consider authorizing the taking by U.S. citizens of small numbers of marine mammals incidental to a specified activity (other than commercial fishing), or to make a finding that incidental take is unlikely to occur, a written request must be submitted to the Assistant Administrator. All requests must include the following information for their activity:

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

Information required by 50 CFR§216.104 (a):

Shell plans to conduct an exploration drilling program on U.S. Department of the Interior, MMS Alaska OCS leases greater than 60 statute miles (mi) [97 kilometers (km)] from the Chukchi Sea coast during the 2010 drilling season (Chukchi Sea 2010 Exploration Drilling Program, hereinafter, the*" drilling program")* (Figure 1-1).

The leases were acquired during the Chukchi Sea Oil and Gas Lease Sales 193 held in February 2008. During the 2010 drilling program Shell plans to drill up to three exploration wells at five possible drill sites on seven possible leases at the prospects known as Burger, Crackerjack, and Southwest Shoebill (Table 1-1). All drilling is planned to be near vertical.

TABLE 1-1 CHUKCHI SEA 2010 EXPLORATION DRILLING PROGRAM – LEASE BLOCKS

Prospect	Protraction	Area	Block	Lease
Burger	NR03-02	Posey	6713	OCS-Y-2266
Burger	NR03-02	Posey	6714	OCS-Y-2267
Burger	NR03-02	Posey	6763	OCS-Y-2279
Burger	NR03-02	Posey	6764	OCS-Y-2280
Burger	NR03-02	Posey	6912	OCS-Y-2321
Crackerjack	NR03-01	Karo	6864	OCS-Y-2111
SW Shoebill	NR03-01	Karo	7007	OCS-Y-2142

The ice reinforced drillship *Discoverer* will be used to drill the wells. Specifications for the *Discoverer* are located in Attachment A. While on location at the drill sites, the *Discoverer* will be affixed to the seafloor using eight 7-ton Stevpris anchors arranged in a radial array.

During the 2010 drilling season, the *Discoverer* will be attended by a minimum of seven vessels that will be used for ice management[DSI1], anchor handling, OSR, refueling, resupply, and servicing of the drilling operations (Table 1-2).

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

TABLE 1-2 CHUKCHI SEA 2010 EXPLORATION DRILLING PROGRAM – PROPOSED VESSEL AND AIRCRAFT LIST

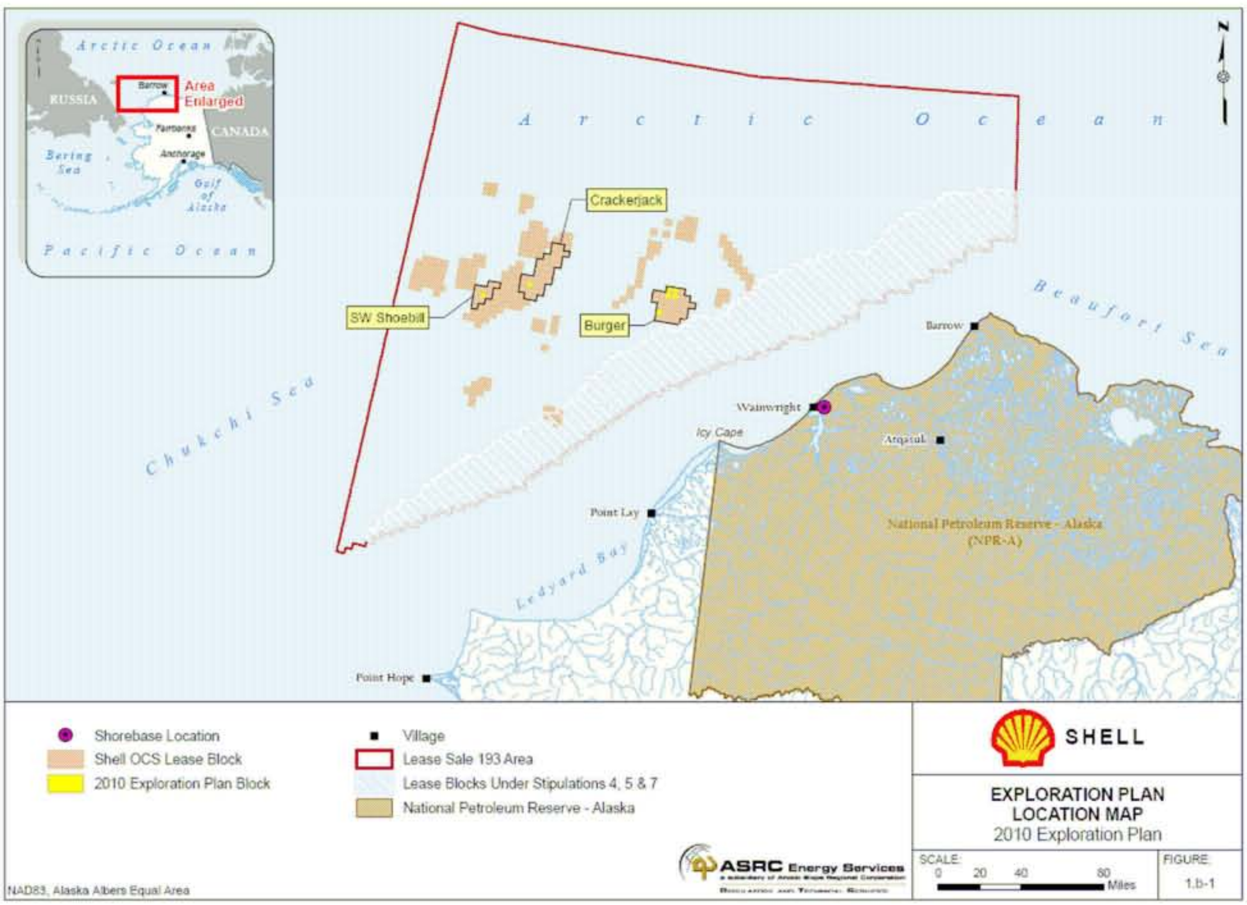
Vessel	Trip Frequency or Duration
Drillship and Drill Support (or similar)	
Frontier Discoverer	Stays in the prospect area throughout 2010 drilling season
Vladimir Ignatjuk – primary ice management vessel	Stays generally upwind of the drillship from 3-25 miles away throughout the 2010 drilling season
Shallow water landing craft	Approximately 3 trips/week between drill site and Wainwright
Tor Viking – anchor handler	Stays in the area of the drillship throughout the 2010 drilling season
Offshore supply boat	2-4 round trips between Dutch Harbor and the drill sites in Chukchi Sea
Oil Spill Response Fleet (or similar)	
Nanuq - OSR vessel	Stays in the area of the drillship throughout the 2010 drilling season
Endeavor -OSRB with associated ice class tug	Will be located near the Chukchi Sea coastline throughout the 2010 drilling season
OSR Workboats (4)	Stays in the area of the drillship throughout the 2010 drilling season
Affinity (OST) – recovered liquid storage and diesel fuel supply vessel	Stays in the area of the drillship throughout the 2010 drilling season
Aircraft (or similar)	
AW 139 or EC 255 - crew rotation	Approximately 30 trips per month between land and offshore vessels throughout the 2010 drilling season
Sikorsky 61 helicopter – search-and-rescue	Trips made only in emergency; training flights

The *Discoverer* and associated support vessels will transit through the Bering Strait into the Chukchi Sea on or about July 1, arriving on location in the Chukchi Sea 3-4 days later. Drilling will then commence on or about July 4, as ice, weather, and other conditions allow for safe drilling operations, and may last until October 31.

Helicopters are planned to provide support for crew change, provision re-supply, and search-and-rescue operations during the drilling season.

At the end of the drilling season, the *Discoverer*, ice management vessels, and support vessels will transit south out of the Chukchi Sea through the Bering Strait into the Bering Sea to Dutch Harbor, Alaska.

Figure 1-1 Exploration Plan Location Map



Planned Mitigation

The *Discoverer* and all support vessels will operate in accordance with the provisions of a Plan of Cooperation (POC in Attachment C). Shell prepared a POC to mitigate effects of Shell's planned exploration drilling program where activities 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 POC was prepared in consultation with affected Chukchi Sea communities and marine mammal associations. During these meetings, Shell focused on lessons learned from prior years activities and presented mitigation measures for avoiding potential conflicts, which are outlined in the 2010 POC. Shell's POC addresses the issues of vessel transit, drilling and associated activities. The mitigation measures described in Section 12.3 are intended to minimize any adverse effects on the availability of marine mammals for subsistence uses.

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

Anticipated Duration of this Permit

Shell anticipates that the IHA issued by NMFS for the planned Chukchi Sea 2010 exploration drilling program will be valid for one year from the date of issuance.

Timing of Mobilization and Demobilization of the *Discoverer*

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

Exploration Drilling

The three Shell prospects included in the 2010 EP are Burger, SW Shoebill and Crackerjack (Fig.1). Shell has identified a total of seven 2010 Exploration Plan (EP) lease blocks (Table 1-1 and Fig. 1-1) on these three prospects. All of the seven leases listed on Table 1-1 are located more than 60 statute mi (97 km) off the coast in the Chukchi Sea. During the 2010 exploration season, the *Discoverer* will be used to drill up to three exploration wells on three of the seven possible leases (Table 1-1). Five possible drill site locations have been identified as indicated below in Table 2-1. For its 2010 exploration drilling program, Shell will mobilize into the Chukchi Sea on or about July 1, and commence drilling at the Burger prospect as soon as ice, weather, and other conditions allow for safe drilling operations. In the event ice and weather conditions prevent the *Discoverer* from reaching the Burger prospect, Shell will mobilize its exploration operations to one of the alternative drill sites in the SW Shoebill or Crackerjack prospects.

Activities associated with the 2010 Chukchi Sea exploration drilling program and analyzed herein include operation of the *Discoverer*, associated support vessels, crew change support and resupply. The *Discoverer* will remain at the location of the designated exploration drill sites except when mobilizing and demobilizing to and from the Chukchi Sea, transiting between drill sites, and temporarily moving off location if it is determined ice conditions require such a move to ensure the safety of personnel and/or the environment in accordance to Shell's Ice Management Plan. The anchor handler and OSR vessels will remain in close proximity to the drillship during drilling operations as indicated above in Table 1-2. The ice management vessel will generally be working upwind of the drillship from 3-25 miles away. Crew change/resupply vessels will transit to and from the drillship at the estimated frequencies shown in Table 1-2. Helicopter flight support will provide crew changes. Fixed-wing aircraft will transport crews to regional hub airports, and to support aerial survey's for the marine mammal monitoring program.

TABLE 2-1 DRILL SITE LOCATIONS AND WATER DEPTHS.

Drill site	Approximate Distance from shore (statute miles)	Lease Block No.	Surface Location (NAD 83)		Water Depth
			Latitude (north)	Longitude (west)	Feet
Burger C	64	6764	71° 18' 17.2739"	163° 12' 45.9891"	149
Burger F	64	6714	71° 20' 13.9640"	163° 12' 21.7460"	148
Burger J	64	6912	71° 10' 24.0292"	163° 28' 18.5219"	144
Crackerjack C	116	6864	71° 13' 58.9211"	166° 14' 10.7889"	142
SW Shoebill C	124	7007	71° 04' 24.4163"	167° 13' 38.0886"	149

Shell plans to cease drilling on or before October 31, after which the *Discoverer* will exit the Alaskan Chukchi Sea. Shell anticipates that the exploration drilling program will require approximately 37 days per well including mudline cellar construction. These estimates exclude any downtime for weather or other operational delays. Shell also assumes approximately 10 additional days will be needed for transit, drillship mobilization and mooring, drillship moves between locations, and drillship demobilization.

3. Species and Numbers of Marine Mammals in Area

Marine mammals that occur in the area of the planned exploration drilling activities belong to three taxonomic groups: odontocetes (toothed cetaceans, such as beluga whale and narwhal), mysticetes (baleen whales), and carnivora (pinnipeds and polar bears). Cetaceans and pinnipeds (except Pacific walrus) are the subject of this IHA application to NMFS. Pacific walrus and polar bear are managed by the U.S. Fish & Wildlife Service in the U.S. so these species are not discussed further in this application.

Marine mammal species under the jurisdiction of NMFS that are known to or may occur in the area of the planned exploration drilling activity include nine cetacean species and four species of pinnipeds (Table 3-1). Three of these species, the bowhead, humpback and fin whales, are listed as "endangered" under the Endangered Species Act. Bowhead whale is more common in the area than the other two species. The fin whale is unlikely to be encountered near the planned drilling activities, but a few sightings in the Chukchi Sea have been reported in recent years. Similarly, humpback whales are not known to regularly occur in the Chukchi Sea, but several humpback sightings were recorded during vessel-based surveys in the Chukchi Sea in 2007 (Reiser et al. 2009a). A single humpback whale sighting was recorded in the Beaufort Sea east of Barrow in 2007 (Green et al. 2007) suggesting that humpback whale use of Arctic waters may be increasing.

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

TABLE 3-1 THE HABITAT, ABUNDANCE , AND CONSERVATION STATUS OF MARINE MAMMALS INHABITING THE AREA

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
Odontocetes Beluga whale (*Delphinapterus leucas*) (Eastern Chukchi Sea Stock)	Offshore, Coastal, Ice edges	3,710[4]	Not listed	VU	
Beluga whale (Beaufort Sea Stock)	Offshore, Coastal, Ice edges	39,257[5]	Not listed	VU	
Narwhal (*Monodon monoceros*)	Offshore, Ice edge	Rare[6]	Not listed	DD	II
Killer whale (*Orcinus orca*)	Widely distributed	Rare	Not listed	LR-cd	II
Harbor Porpoise (*Phocoena phocoena*) (Bering Sea Stock)	Coastal, inland waters, shallow offshore waters	48,215[4] Common[7]	Not listed	VU	II
Mysticetes Bowhead whale (*Balaena mysticetus*)	Pack ice & coastal	11,800[8]	Endangered	LR-cd	I
Gray whale (*Eschrichtius robustus*) (eastern Pacific population)	Coastal, lagoons, shallow offshore waters	488[9] 17,500[10]	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	Endangered	EN	I
Humpback whale (*Megaptera novaeangliae*)	Shelf, coastal	Rare	Endangered	–	–
Pinnipeds Bearded seal (*Erignathus barbatus*)	Pack ice, shallow offshore waters	300,000-450,000[11] 4863[12]	In review for listing	–	–
Spotted seal (*Phoca largha*)	Pack ice, coastal haulouts, offshore	59,214[13] 101,568[14]	Arctic pop. segments not listed	–	–
Ringed seal (*Pusa hispida*)	Landfast & pack ice, offshore	~208,000-252,000[15]	In review for listing	–	–
Ribbon seal (*Histriophoca fasciata*)	pack ice, offshore	90-100,000[16]	Not Listed	–	–

[1] U.S. Endangered Species Act.
[2] IUCN Red List of Threatened Species (2003). Codes for IUCN classifications: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LR = Lower Risk (-cd = Conservation Dependent; -nt = Near Threatened; -lc = Least Concern); DD = Data Deficient.
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2004).
[4] Angliss and Allen (2009)
[5] Beaufort Sea population (IWC 2000, Angliss and Allen 2009).
[6] Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO 2004); very few enter the Beaufort Sea.
[7] Vessel-based observations from Industry activities in 2006–2008 (Haley et al. 2009b).
[8] 2004 Population estimate (Koski et al. 2009)
[9] Southern Chukchi Sea and northern Bering Sea (Clark and Moore 2002).
[10] North Pacific gray whale population (Rugh 2003 *in* Keller and Gerber 2004) ; see also Rugh et al. (2005).
[11] Alaska population (MMS 1996).
[12] Eastern Chukchi Sea population (NMML, unpublished data).
[13] Alaska population (from Rugh et al. 1995 and Lowry et al. 2004 *in* Angliss and Allen 2009).
[14] Eastern and Central Bering Sea (Boveng et al. 2009).
[15] Bering/Chukchi Sea population (Bengtson et al. 2005).
[16] Bering Sea, (Burns,1981a).

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

Sections 3 and 4 are integrated here to minimize repetition.

Marine mammal species under NMFS jurisdiction most likely to occur in the area of the planned exploration drilling activities in the Chukchi Sea include four cetacean species (beluga, bowhead and gray whales, and harbor porpoise), and three pinniped species (ringed, bearded, and spotted seals). Densities of marine mammals in the area of operations are likely to be higher if the ice edge occurs nearby. The marine mammal species that is likely to be encountered most widely (in space and time) throughout the period of the exploration drilling activities is ringed seal. Encounters with bowhead and gray whales are expected to be limited to particular seasons, as discussed below.

Five additional cetacean species—the narwhal, killer whale, minke whale, humpback whale, and fin whale—could occur, but each of these species is uncommon or rare in the project area and relatively few encounters with these species are expected during the exploration drilling program. The narwhal occurs in Canadian waters and occasionally occurs in the Alaskan Beaufort Sea and the Chukchi Sea, but is considered extralimital in US waters and is 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 latitude (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 planned project, only the Beaufort Sea and eastern Chukchi Sea stocks may be encountered.

The ***Beaufort Sea population*** was estimated to contain 39,257 individuals as of 1992 (Angliss and Allen 2009). Beluga whales of the Beaufort Sea stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate in offshore waters of western and northern Alaska (Angliss and Allen 2009). The majority of belugas in the Beaufort Sea stock migrate through the Chukchi Sea and into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late-March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995a,b). Beluga whales associated with the Beaufort Sea population would be most likely to occur near the planned drilling activities during fall migration through the Chukchi Sea in October.

The most recent estimate of the ***eastern Chukchi Sea population*** is 3710 animals (Angliss and Allen 2009). This estimate was based on surveys conducted in 1989–1991. Survey effort was concentrated on the 106 mi (170 km) long Kasegaluk Lagoon where belugas are found 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 Sea stock because the surveys on which it was based did not include offshore areas where belugas are also likely to occur. This population is considered to be stable. It is assumed that beluga whales from the eastern Chukchi stock winter in the Bering Sea (Angliss and Allen 2009).

Although beluga whales are known to congregate in Kasegaluk Lagoon during summer, evidence from a small number of satellite-tagged animals suggests that some of these whales may subsequently range into the Arctic Ocean north of the Beaufort Sea. Suydam et al. (2005) put satellite tags on 23 beluga whales captured in Kasegaluk Lagoon in late June and early July 1998–2002. Five of these whales moved far into the Arctic Ocean and into the pack ice to 79–80°N latitude. These and other whales moved to areas as far as 685 mi (1,100 km) offshore between Barrow and the Mackenzie River Delta spending time in water with 90 percent ice coverage.

During aerial surveys in nearshore areas ~23 mi (~37 km) offshore in the Chukchi Sea in 2006 and 2007, peak beluga sighting rates were recorded in July. Lowest monthly sighting rates were recorded in September (Thomas et al. 2009). When data from the two years were pooled, beluga whale sighting rates and number of individuals were highest in the band 16-22 mi (25-35 km) offshore. However the largest single groups were sighted at locations near shore in the band within 3 mi (5 km) of the shoreline.

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).

Belugas of the eastern Chukchi Sea population could occur in the vicinity of the planned drilling activities throughout the summer months. Based on the results of satellite telemetry data at least some of this stock may also pass the project area during fall migration; however, data from Thomas et al. (2009) suggests the highest concentration of Belugas may be expected to occur much closer to shore than Shell's planned drilling activities.

(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, while 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 the area of the planned exploration drilling activities in the Chukchi Sea.

(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 found in deep water (Dahlheim and Heyning 1999). The greatest abundance is thought to be within 497 mi (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. These 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 Allen 2009).

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 Allen 2009). Killer whales probably do not occur regularly in the Beaufort Sea although sightings have been reported (Lowry et al. 1987, George and Suydam 1998). 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 or fall. The number of killer whales likely to occur in the Chukchi Sea during the planned 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. 2009a).

(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 722 ft (220 m) and stay submerged for more than 5 minutes (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. 1995a).

The subspecies *Phocoena phocoena vomerina* ranges from the Chukchi Sea, Pribilof Islands, Unimak Island, and the southeastern shore of Bristol Bay south to San Luis Obispo, California. Point Barrow, Alaska, is the approximate northeastern extent of their regular range (Suydam and George 1992), though there are extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada and recent sightings in the Beaufort Sea in the vicinity of Prudhoe Bay during surveys in 2007 and 2008 (Lyons et al. 2009; LGL Limited, unpublished data).

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. Harbor porpoises present in the Chukchi Sea 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 latitude; Angliss and Allen 2009). 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 commonly encountered during summer and fall from 2006–2008 (Haley et al. 2009b).

Based on recent surveys the harbor porpoise is likely to be one of the most abundant cetaceans encountered throughout the Chukchi Sea and is likely to occur in the vicinity of the planned exploration drilling activities.

(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 reported by the Alaska Department of Fish and Game (ADF&G) indicate that most bowhead whales continue migrating west past Barrow and through the northern Chukchi Sea to Russian waters before turning south toward the Bering Sea (Quakenbush et al. 2009). Information on the ADF&G bowhead satellite tracking program is available online at http://www.wc.adfg.state.ak.us/index.cfm?adfg=marinemammals.bowhead. Other researchers have also reported a westward movement of bowhead whales through the northern Chukchi Sea during fall migration (Moore et al. 1995; Mate et al. 2000).

The pre-exploitation population of bowhead whales in the Bering, Chukchi, and Beaufort seas is estimated to have been 10,400-23,000 whales. Commercial whaling activities in the late-1800s and early-1900s may have reduced this population to as few as 3,000 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 percent per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995). A census in 2001 yielded an estimated annual population growth rate of 3.4 percent (95 percent confidence interval, 1.7–5 percent) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004, revised to 10,545 by Zeh and Punt (2005). A photo identification population estimate from data collected in 2004 estimated the population (in 2004) to be 11,800 (Koski et al. 2009), which further supports the estimated 3.4 percent population growth rate. Assuming a continuing annual population growth of 3.4 percent, the 2010 bowhead population may number around 14,247 animals. The large increases in population estimates that occurred from the late 1970s to the early 1990s were partly a result of actual population growth, but were also partly attributable to improved census techniques (Zeh et al. 1993). Although apparently recovering well, the BCB bowhead population is currently listed as endangered under the Endangered Species Act (ESA) and is classified as a ***strategic stock*** by NMFS and ***depleted*** under the MMPA (Angliss and Allen 2009).

The BCB stock of bowhead whales winters in the central and western Bering Sea and many of these whales summer in the Canadian Beaufort Sea (Moore and Reeves 1993). Spring migration through the Chukchi Sea occurs through offshore ice leads, generally from March through mid-June (Braham et al. 1984; Moore and Reeves 1993), well before the onset of the planned exploration drilling activities.

Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most may remain among the offshore pack ice of the Beaufort Sea until mid- summer. After feeding primarily in the Canadian Beaufort Sea and Amundsen Gulf, bowheads migrate westward from late August through mid- or late-October. Fall migration into 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, 2009; Greene et al. 2007). Consistent with this, Nuiqsut whalers have stated that the earliest arriving bowheads have apparently reached the Cross Island area earlier in recent years (T. Napageak, personal communication).

Westbound bowheads typically reach the Barrow area in mid-September, and remain there 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. (2009) 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.

Most spring-migrating bowhead whales would likely pass through the Chukchi Sea prior to the start of the planned drilling activities. However, a few whales that may remain in the Chukchi Sea during the summer could be encountered during the drilling activities or by transiting vessels. More encounters with bowhead whales would be likely to occur during the westward fall migration in late September through October. An ongoing GPS tagging study headed by the Alaska Department of Fish and Game (see http://www.wildlife.alaska.gov/index.cfm?adfg=marinemammals.bowhead) has provided information on fall bowhead movements across the Chukchi Sea. Most bowheads migrating in September and October appear to transit across the northern portion of the Chukchi Sea to the Chukotka coast before heading south toward the Bering Sea (Quakenbush et al. 2009). Some of these whales have traveled well north of the planned operations, but others have passed near to, or through, the proposed project area. In addition to other planned mitigation, Shell will operate in consultation with stakeholders to avoid disturbance to subsistence bowhead whaling activities in the Chukchi Sea, should such a subsistence bowhead hunt occur during the period of Shell's planned 2010 drilling activities.

(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 area of the planned exploration drilling activities. 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 ±3,122 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 ±1,780 in winter 2001-2002 and Rugh et al. (2008) estimated the population in winter 2006-2007 to have been 20,110 ±1,766. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

Eastern Pacific gray whales calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the calving season, most of these gray whales migrate about 5,000 mi (8,000 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, Nerini 1984, Moore et al. 2003, Bluhm et al. 2007). Most gray whales begin the southward migration in November with breeding and conception occurring in early December (Rice and Wolman 1971).

Most summering gray whales have historically congregated in the northern Bering Sea, particularly off St. Lawrence Island in the Chirikov Basin (Moore et al. 2000), 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 amplescid amphipod production in the Chirikov Basin had declined by 50 percent from the 1980s to 2002-2003 and that as little as 3-6 percent of the current gray whale population could consume 10-20 percent of the amplescid 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. 2000).

Gray whales routinely feed in the Chukchi Sea during the summer. Moore et al. (2000) 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 southwest of Point Barrow at Hanna Shoal and northwest 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 (Thomas et al. 2007), and in 2007, gray whales were most abundant in nearshore areas from Wainwright to Barrow (Thomas et al. 2009). 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.

Although they are most common in portions of the Chukchi Sea close to shore, gray whales may also occur in offshore areas of the Chukchi Sea, particularly over offshore shoals. Gray whales are likely to be in the vicinity of the planned exploration drilling activities in the Chukchi Sea and are likely to be one of the most commonly encountered cetacean species along with the harbor porpoise.

(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 Allen (2009) recognize two 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 the level of minke whale use of the Chukchi Sea is unknown. Leatherwood et al. (1982, *in* Angliss and Allen 2009) 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. (2009a) reported eight and five minke whale sightings in 2006 and 2007, respectively, during vessel-based surveys in the Chukchi Sea, and Jankowski et al. (2009) reported one minke whale sighting in the Beaufort Sea in 2007. Minke whales could be encountered during the exploration drilling activities in the Chukchi Sea.

(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 include plankton, as well as shoaling pelagic fish, such as capelin *Mallotus villosus* (Jonsgård 1966a,b). The North Pacific population's summering grounds span from the Chukchi Sea to California (Gambell 1985). Three fin whale sightings were made in 2008 from industry vessels and NMFS/National Marine Mammal Laboratory (NMML) survey aircraft in the northern Chukchi Sea off of Ledyard Bay indicating that the range of fin whales may be expanding, but they have not been recorded in the Alaskan Beaufort 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 Allen 2009). Provisional estimates of fin whale abundance in the central-eastern and southeastern 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. (2009a) 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 the International Union for the Conservation of Nature (IUCN), is classified as a ***strategic stock*** by NMFS, and it is a CITES Appendix I species (Table 3-1). Fin whales could be encountered in very low numbers during the exploration drilling activities in the Chukchi Sea.

(e) Humpback Whale (Megaptera novaeangliae)

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

Humpback whales were hunted extensively during the 20th century and worldwide populations may have been reduced to ~10 percent 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 are taken into the mouth and 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 46 and 49 ft (14 and 15 m) in length, respectively (Wynne 1997). Humpbacks have large, robust bodies and long pectoral flippers, which may reach ⅓ of their body length. The dorsal fin is variable in shape and located well back toward the posterior ⅓ of the body on a hump which is particularly noticeable when the back is arched during a dive (Reeves et al. 2002).

Angliss and Allen 2009 (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 planned drilling activities in the Chukchi Sea. 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 Allen 2009). Recently there have been sightings of humpback whales in the Chukchi Sea and a single sighting in the Beaufort Sea (Green et al. 2007). Reiser et al. (2009a) reported four humpback whales during vessel-based surveys in the Chukchi Sea in 2007 and Haley et al. (2009a) reported one humpback whale sighting during 2008 operations. 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 remains unknown. Small numbers of humpback whales could occur within or near the project area in the Chukchi Sea.

(3) Pinnipeds

(a) Bearded Seal (*Erignathus barbatus*)

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981b). They have occasionally been reported to maintain breathing holes in sea ice and broken areas within the pack ice, particularly if the water depth is <656 ft (<200 m) (e.g., Harwood et al. 2005). Bearded seals apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas where water depth is considerably greater than 656 ft (200 m). During the summer period, bearded seals occur mainly in relatively shallow areas because they are predominantly benthic feeders (Burns 1981b). No reliable estimate of bearded seal abundance is available for the Chukchi Sea (Angliss and Allen 2009). The Alaska stock of bearded seals is not classified by NMFS as "endangered" or a ***strategic stock***. However, a decision to list the species under the ESA, due to the potential impact to seal habitats resulting from current warming trends, is still under consideration by the NMFS.

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 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 300,000–450,000 individuals (MMS 1996). Bengtson et al. (2005) reported bearded seal densities in the Chukchi Sea ranging from 0.18 to 0.36 seals/mi^2 (0.07 to 0.14 seals/km^2) in 1999 and 2000, respectively. No population estimates could be calculated since these densities were not adjusted for haulout behavior. Bearded seals are common in offshore pack ice, but there have been high bearded seal numbers observed near the shore south of the project area near Kivalina. Reiser et al. (2009a) reported bearded seal densities ranging from 0.03 to 0.08 seals/mi^2 (0.01 to 0.03 seals/km^2) 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 directly comparable since the latter densities were based on aerial surveys of seals on sea ice in late May and early June. Bearded seals are likely to be encountered during exploration drilling operations, although numbers are expected to be relatively small. Greater numbers of bearded seals are likely to be encountered if the ice edge occurs nearby.

(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 Allen 2009), but the estimate is most likely between several thousand and several tens of thousands (Rugh et al. 1997). During the summer, spotted seals are found in Alaska from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. The ADF&G placed satellite transmitters on four spotted seals in Kasegaluk Lagoon and estimated that the proportion of seals hauled out was 6.8 percent. Based on an actual minimum count of 4,145 hauled out seals, Angliss and Allen 2009 (2008) estimated the Alaskan population at 59,214 animals. The Alaska stock of spotted seals is not classified as "endangered", "threatened", or as a ***strategic stock*** by NMFS (Angliss and Allen 2009), although the southern distinct population segment of spotted seals was recently listed as a threatened species, it occurs entirely outside of US waters.

During spring when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Subadults may be seen in larger groups of up to 200 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 latitude. 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).

In the Chukchi Sea, Kasegaluk Lagoon and Icy Cape are important areas for spotted seals. Spotted seals haul out in this region from mid-July until freeze-up in late October or November. Frost and Lowry (1993) reported a maximum count of about 2,200 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 tagged at Kasegaluk Lagoon spent 94 percent 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. Few spotted seals are expected to occur near the planned exploration drilling activities in the Chukchi Sea.

(c) Ringed Seal (*Phoca hispida*)

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

Ringed seals are year-round residents in the Chukchi and Beaufort seas and the ringed seal is the most frequently encountered seal species in the area. 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).

No estimate for the size of the Alaska ringed seal stock is currently available (Angliss and Allen 2009). Past ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from 1–1.5 million (Frost 1985) to 3.3–3.6 million (Frost et al. 1988). During aerial surveys in 1999, Bengtson et al. (2005) reported ringed seal densities offshore from Shishmaref to Barrow ranging from 1.0 to 9.5 seals/mi^2 (0.4 to 3.7 seals/km^2) and estimated the total Chukchi Sea population at 245,048 animals. Bengtson et al. (2005) reported ringed seal densities of 5.0 seals/mi^2 (1.9 seals/km^2) in the eastern Chukchi Sea during aerial surveys in 1999. Densities were higher in nearshore than offshore locations. During vessel-based observations from industry activities in the Chukchi Sea, Reiser et al. (2009a) reported seal densities (assumed to be almost entirely ringed seals) from 0.10 to 0.28 seals/mi^2 (0.04 to 0.11 seals/km^2) in summer and fall, respectively. 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. Ringed seal will likely be the most abundant marine mammal species encountered in the Chukchi Sea during exploration drilling operations.

(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) suggested that they move into the southern Chukchi Sea, based on a review of sightings during the summer. However, ribbon seals appeared to be relatively rare in the northern Chukchi Sea. During recent vessel-based surveys in summer and fall of 2006 and 2007 there were only two ribbon seal sightings among the total of 1,371 seal sightings identified to species (Reiser et al. 2009a). Thus ribbon seals are expected to be rare in the planned project area.

5. Type of Incidental Take Authorization Requested

The only type of incidental taking sought in this application is that of takes by Level B harassment. The harassment would be caused by sound energy entering the marine environment. The only sources of project–created sound energy for the exploration drilling will be those produced by the drillship *Discoverer* and its support vessels and aircraft. Although the bulk of the activity will be centered in the area of exploration drilling, potential exposures or impacts to marine mammals also will occur as the drillship and associated vessels mobilize to and from the Chukchi Sea for the exploration drilling program.

Sound energy propagation measurements from *Discoverer* are not presently available. However, measurements of a similar drill ship, *Northern Explorer II*, were performed at two different times and locations in the Beaufort Sea (Miles et al. 1987, Greene 1987a,b). In both cases a support vessel was present in the vicinity of the drillship, thus providing an aggregate source level for modeling the combined drilling activities. These measurement results were used to model the likely sound propagation from the *Discoverer* and its support vessels at the planned drill site locations. These modeled sound radii have been used for calculation of estimated "takes by harassment" in this document. Acoustic source levels for the *Discoverer* and the *Vladimir Ignatjuk* were used for this modeling study; however, direct measurements were available only for the *Vladimir Ignatjuk*. Source levels for the *Discoverer* were estimated based on its similarity to the *Explorer II*, thus the *Explorer II* was used as a proxy source for the *Discoverer*. A comparison of the key specifications for the two vessels is given in Table 5-1.

TABLE 5-1 COMPARISON OF THE SPECIFICATIONS FOR THE *NORTHERN EXPLORER II* AND *FRONTIER DISCOVERER* (WORLD OIL 2003)

Parameter	*Explorer II*	*Discoverer*
Hull	115 x 30.5 x 8.7 m	155 x 21 x 11 m
Derrick	Pyramid 185'; 1,000,000 lb.	Pyramid, 170'; 1,333,000 lb.
Drawworks	Ideco E 2100	EMSCO E-2100
Pumps	2 x Nat'l 12P-160 triplex	2 x EMSCO FB-1600 triplex
Prime movers	4 x GE 752R, 3,000 bhp	6 x Cat. D-399 diesels, 1,325 hp
Top drive	Varco TDS-3	Varco TDS-3
Rotary table	Ideco LR-375	National C-495

The acoustic propagation model used in this study is JASCO Research's Marine Operations Noise Model (MONM). MONM computes received sound levels in rms units when source levels are specified also in those units.

MONM treats sound propagation in range-varying acoustic environments through a wide-angled parabolic equation solution to the acoustic wave equation. The specific parabolic equation code in MONM is based on the Naval Research Laboratory's Range-dependent Acoustic Model. This code has been extensively benchmarked for accuracy and is widely employed in the underwater acoustics community (Collins, 1993).

Sound propagation measurements will be performed on the *Discoverer* and support vessels in 2010, once these are on location in Chukchi Sea. The results of those measurements will be used during the season to implement mitigation measures as required by the permit.

6. Numbers of Marine Mammals That May be Taken:

Shell seeks authorization for potential "taking" of small numbers of marine mammals under the jurisdiction of the NMFS in the planned region of activity. Species most likely to be encountered include bowhead and gray whales, beluga, harbor porpoise, and ringed, spotted, and bearded seals. Exposure estimates and requests for takes of ribbon seal, fin whale, humpback whale, killer whale, minke whale, and narwhal are also included, but are minimal because sightings of these species in the Chukchi Sea are rare.

The only anticipated impacts to marine mammals are associated with underwater sound propagation from exploration drilling activities and associated support vessels. Impacts would consist of temporary displacement of seals and whales from within ensonified zones produced by such sound sources.

The exploration drilling activities in the Chukchi Sea planned by Shell are not expected to "take" more than small numbers of marine mammals, or have more than a negligible effect on their populations. Discussions of estimated "takes by harassment" are presented below.

6.1 Exposure Estimates for Exploration Drilling

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 planned exploration drilling program in the Chukchi Sea. The estimates are based on data obtained during marine mammal surveys in and near the planned exploration drilling sites and on estimates of the sizes of the areas where effects could potentially occur. Adjustments to reported population or density estimates were made to account for seasonal distributions and population increases or declines insofar as possible.

The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection. There is some uncertainty about the representativeness of those data and the assumptions used below to estimate the potential "take by harassment". However, the approach used here is the best available at this time.

Basis for Estimating "Take by Harassment"

"Take by Harassment" is calculated in this section by multiplying the expected densities of marine mammals that may occur near the exploratory drilling operations by the area of water likely to be exposed to continuous sound levels of ≥120 dB and ≥160 dB rms. Marine mammal occurrence near the operation is likely to vary by season and habitat, mostly related to the presence or absence of sea ice. This section provides descriptions of the estimated densities of marine mammals and areas of water exposed to the indicated sound levels over the course of the planned operations. There is no evidence that avoidance at received sound levels of ≥120 dB or ≥160 dB rms would have significant biological effects on individual animals or that the subtle changes in behavior or movements would "rise to the level of taking" according to guidance by the NMFS (NMFS 2001). Any changes in behavior caused by sounds at or near the 120 dB rms level would likely fall within the normal variation in such activities that would occur in the absence of drilling activities.

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

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 mean and maximum estimates were from the reported results. In other cases only one, or no applicable estimate was available, so correction factors were used to arrive at "average" and "maximum" estimates. Except where noted, the "maximum" estimates have been calculated as 4× the "average" estimates. This factor was chosen as it was believed to be large enough to allow for chance encounters with unexpected large groups of animals or overall higher densities than expected.

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 percent probability of sighting an animal that is present along the survey trackline. Some sources below included these correction factors in the reported densities (e.g. ringed seals in Bengtson et al. 2005) and the best available correction factors were applied to reported results when they had not already been included (e.g. Moore et al. 2000).

Estimated densities of marine mammals in the Chukchi Sea project area during the "summer" (July and August) are presented in Table 6-1. Densities of marine mammals estimated for the fall period of Shell's exploration drilling operations in the Chukchi Sea (September and October) are presented in Table 6-2. Descriptions of the individual density estimates shown in the tables are provided below by species.

Cetaceans

Nine species of cetaceans are known to occur in the planned project area in the Chukchi Sea. Only four of these (bowhead and gray whales, beluga, and harbor porpoise) are expected to be encountered during the planned exploration drilling activities. Three of the nine species (bowhead, fin, and humpback whales) are listed as “endangered” under the ESA.

Summer densities of ***belugas*** in offshore waters are expected to be low. Aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore et al. 2000). Aerial surveys of the Chukchi Sea in 2008-2009 flown by the NMML as part of the Chukchi Offshore Monitoring in Drilling Area project (COMIDA) have only reported 5 beluga sightings during >8,700 mi (>14,000 km) of on-transect effort, only 2 of which were offshore (COMIDA 2009). Additionally, only one beluga sighting was recorded during >37,900 mi (>61,000 km) of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September-October of 2006-2008 (Haley et al. 2009b). If belugas are present during the summer, they are more likely to occur in or near the ice edge or close to shore during their northward migration. Expected densities were calculated from data in Moore et al. (2000). Data from Moore et al (2000; Figure 6 and Table 6) used in the average open-water density estimate included two on-transect beluga sightings during 6,640 mi (10,684 km) of on-transect effort in the Chukchi Sea during summer. A mean group size of 7.1 (Coefficient of Variation [CV]=1.7) was calculated from 10 Chukchi Sea summer sightings present in the Bowhead Whale Aerial Survey Program (BWASP) database. A f(0) value of 2.841 and g(0) value of 0.58 from Harwood et al. (1996) were also used in the calculation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in both open-water and ice-margin habitats. Specific data on the relative abundance of beluga in open-water versus ice-margin habitat during the summer in the Chukchi Sea is not available. However, Moore et al. 2000 reported higher than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas. This would suggest that densities near ice may actually be lower than open water, but belugas are commonly associated with ice, so an inflation factor of only 2 (instead of 4) was used to estimate the average ice-margin density from the open-water density. Based on the very low densities observed from vessels operating in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (0.003/mi^2 0.0001/km^2; Haley et al. 2009b), the densities shown in Table 6-1 are likely biased high.

In the fall, beluga whale densities in the Chukchi Sea are expected to be somewhat higher than in the summer because individuals of the eastern Chukchi Sea stock and the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Angliss and Allen 2009). Consistent with this, the number of on-effort beluga sightings reported during COMIDA flights in September-October of 2008-2009 was over 3 times more (17) than during July-August with a very similar amount of on-transect effort (COMIDA 2009). However, there were no beluga sightings reported during >11,200 mi (>18,000 km) of vessel based effort in good visibility conditions during 2006-2008 industry operations in the Chukchi Sea. Densities derived from survey results in the northern Chukchi Sea in Moore et al. (2000) were used as the average density for open-water and ice-margin fall season estimates (see Table 6-2). Data from Moore et al. (2000; Table 8) used in the average open-water density estimate included 123 beluga sightings and 27,560 mi (44,352 km) of on-transect effort in water depths 36-50 m. A mean group size of 2.39 (CV=0.92) came from the average group size of 82 Chukchi Sea fall sightings in waters 115-164 ft (35-50 m) deep present in the BWASP database. A f(0) value of 2.841 and g(0) value of 0.58 from Harwood et al. (1996) were used in the calculation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in both open-water and ice-margin habitats. Moore et al. 2000 reported higher than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas, so an inflation value of only 2 was used to estimate the average ice-margin density from the open-water density. Based on the lack of any beluga sightings from vessels operating in the Chukchi Sea during non-seismic periods and locations in Sep-Oct of 2006-2008 (Haley et al. 2009b), the densities shown in Table 6-1 are likely biased high.

By July, most ***bowhead whales*** are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea. No bowheads were reported during 6,640 mi (10,684 km) of on-transect effort in the Chukchi Sea by Moore et al. (2000). Aerial surveys in 2008-2009 by the NMML as part of the COMIDA project reported only 4 sightings during >8,700 mi (>14,000 km) of on-transect effort. Two of the four sightings were offshore, both of which occurred near the end of August. Bowhead whales were also rarely reported in July-August of 2006-2008 during aerial surveys of the Chukchi Sea coast (Thomas et al. 2009). This is consistent with movements of tagged whales (see ADFG 2009, Quakenbush et al. 2009), all of which moved through the Chukchi Sea by early May 2009, and tended to travel relatively close to shore, especially in the northern Chukchi Sea. The estimate of bowhead whale density in the Chukchi Sea was calculated by assuming there was one bowhead sighting during the 6,640 mi (10,684 km) of survey effort in the Chukchi Sea during the summer months reported in Moore et al. (2000) although no bowheads were actually observed during those surveys. The more recent COMIDA data were not used as the NMML has not released a report summarizing the data so they are not considered to be final. Only two sightings are present in the BWASP database during July and August in the Chukchi Sea, both of which were of individual whales. The mean group size from combined July-August sightings in the BWASP, COMIDA, and 2006-2008 industry database is 1.33 (CV=0.58). This value, along with a f(0) value of 2 and a g(0) value of 0.07, both from Thomas et al. (2002) were used to estimate a summer density of bowhead whales. The CV of group size and standard errors reported in Thomas et al (2002) for f(0) and g(0) correction factors suggest that an inflation factor of 2 is appropriate for estimating the maximum density from the average density. Bowheads are not expected to be encountered in higher densities near ice in the summer (Moore et al. 2000), so the same density estimates are used for open-water and ice-margin habitats. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2009b) ranged from 0.0003-0.0013/mi^2 (0.0001-0.0005/km^2) with a maximum 95 percent confidence interval (CI) of 0.0049/mi^2 (0.0019 km^2). This suggests the densities used in the calculations and shown in Table 6-1 are somewhat higher than are likely to be observed from vessels near the area of planned operations.

During the fall, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf migrate west and south to their wintering grounds in the Bering Sea making it more likely that bowheads will be encountered in the Chukchi Sea at this time of year. Moore et al. (2002; Table 8) reported 34 bowhead sightings during 27,560 mi (44,354 km) of on-transect survey effort in the Chukchi Sea during September-October. Thomas et al. (2009) also reported increased sightings on coastal surveys of the Chukchi Sea during September and October of 2006-2008. Aerial surveys in 2008-2009 (COMIDA 2009) reported 20 bowhead sightings during 8,803 mi (14,167 km) of on-transect effort, eight of which were offshore. GPS tagging of bowheads appear to show that migration routes through Chukchi Sea are more variable than through the Beaufort Sea (ADFG 2009; Quakenbush et al. 2009). Some of the routes taken by bowheads remain well north of the planned drilling activities while others have passed near to or through the area. Kernel densities estimated from GPS locations of whales suggest that bowheads do not spend much time (e.g. feeding or resting) in the north-central Chukchi Sea near the area of planned activities (Quakenbush et al. 2009). The mean group size from September-October Chukchi Sea bowhead sightings in the BWASP database is 1.59 (CV=1.08). This is slightly below the mean group size of 1.85 from all the preliminary COMIDA sightings during the same months, but above the value of 1.13 from only on-effort COMIDA sightings (COMIDA 2009). The same f(0) and g(0) values that were used for the summer estimates above were used for the fall estimates. As with the summer estimates, an inflation factor of 2 was used to estimate the maximum density from the average density in both habitat types. Moore et al. (2000) found that Bowheads were detected more often than expected in association with ice in the Chukchi Sea in September-October, so a density of twice the average open-water density was used as the average ice-margin density. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2009b) ranged from 0.0003 to 0.0129/mi^2 (0.0001-0.0050/km^2) with a maximum 95 percent CI of 0.1243/mi^2 (0.0480 km^2). This suggests the densities used in the calculations and shown in Table 6-1 are somewhat higher than are likely to be observed from vessels near the area of planned operations.

TABLE 6-1 EXPECTED DENSITIES OF CETACEANS AND SEALS IN AREAS OF THE CHUKCHI SEA, ALASKA, FOR THE PLANNED SUMMER (JULY–AUGUST) PERIOD. SPECIES LISTED UNDER THE U.S. ESA AS ENDANGERED ARE IN ITALICS.

	Open Water		Ice Margin	
Species	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Odontocetes				
Monodontidae				
Beluga	0.0033	0.0066	0.0162	0.0324
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0011	0.0016	0.0011	0.0016
Mysticetes				
Bowhead whale	*0.0018*	*0.0036*	*0.0018*	*0.0036*
Fin whale	*0.0001*	*0.0004*	*0.0001*	*0.0004*
Gray whale	0.0081	0.0162	0.0081	0.0162
Humpback whale	*0.0001*	*0.0004*	*0.0001*	*0.0004*
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ribbon seal	0.0003	0.0012	0.0003	0.0012
Ringed seal	0.3668	0.6075	0.4891	0.8100
Spotted seal	0.0073	0.0122	0.0098	0.0162

Gray whale densities are expected to be much higher in the summer months than during the fall. Moore et al. (2000) found the distribution of gray whales in the planned operational area was scattered and limited to nearshore areas where most whales were observed in water less than 114 ft (35 m) deep. With similar amounts of on-transect effort between the two seasons in the preliminary COMIDA data from aerial surveys in 2008-2009, there were 3 times as many gray whale sightings in July-August than September-October, five times as many if you consider all effort and sightings. Thomas et al. (2009) also reported substantial declines in the sighting rates of gray whales in the fall. The average open-water summer density was calculated from effort and sightings in Moore et al. (2000; Table 6) for water depths 118-164 ft (36-50 m) including 4 sightings during 3,901 mi (6,278 km) of on-transect effort. An average group size of 3.11 (CV=0.97) was calculated from all July-August Chukchi Sea gray whale sightings in the BWASP database and used in the summer density estimate. This value was higher than the average group size in the preliminary COMIDA data (1.71; COMIDA 2009) and from coastal aerial surveys in 2006-2008 (1.27; Thomas et al. 2009). Correction factors f(0) = 2.49 (Forney and Barlow 1998) and g(0) = 0.30 (Forney and Barlow 1998, Mallonee 1991) were also used in the density calculation because the group size used in the average density estimate was relatively high compared to other data sources and the

CV near one, an inflation factor of 2 was used to estimate the maximum densities from average densities in both habitat types. Gray whales are not commonly associated with sea ice, but may be present near it, so the same densities were used for ice-margin habitat as were derived for open-water habitat during both seasons. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2009b) ranged from $0.0023/mi^2$ to $0.0088/mi^2$ ($0.0009/km^2$ to $0.0034/km^2$) with a maximum 95 percent CI of 0.0378 mi^2 (0.0146 km^2). This suggests the densities used in the calculations and shown in Table 6-1 are somewhat higher than are likely to be observed from vessels near the area of planned operations.

In the fall, gray whales may be dispersed more widely through the northern Chukchi Sea (Moore et al. 2000), but overall densities are likely to be decreasing as the whales begin migrating south. A density calculated from effort and sightings (27 sightings during 27,559 mi (44,352 km) of on-transect effort) in water 118-164 ft (36-50 m) deep during autumn in Moore et al. (2000; Table 12) was used as the average estimate for the Chukchi Sea during the fall period. A group size value of 2.49 (CV=1.37) calculated from the BWASP database was used in the density calculation, along with the same f(0) and g(0) values described above. The group size value of 2.49 was again higher than the average group size calculated from preliminary COMIDA data (1.24; COMIDA 2009) and reported from coastal aerial surveys in 2006-2008 (1.12; Thomas et al. 2009). Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2009b) ranged from $0.0028/mi^2$ to $0.0062/mi^2$ ($0.0011/km^2$ to $0.0024/km^2$) with a maximum 95 percent CI of 0.0474 mi^2 (0.0183 km^2. This suggests the densities used in the calculations and shown in Table 6-1 are somewhat higher than are likely to be observed from vessels near the area of planned operations.

Harbor Porpoise densities were estimated from industry data collected during 2006-2008 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006–2008, however, recorded sightings throughout the Chukchi Sea during the summer and early fall months. Density estimates from 2006-2008 observations during non-seismic periods and locations in July-August ranged from $0.0023/mi^2$ to $0.0041/mi^2$ ($0.0009/km^2$ to $0.0016/km^2$) with a maximum 95 percent CI of $0.0041/km^2$ ($0.0016/km^2$) (Haley et al. 2009b). The median value from the summer season of those three years ($0.0028/mi^2$ /$0.0011/km^2$) was used as the average open-water density estimate while the high value ($0.0041/mi^2$ / $0.0016/km^2$) was used as the maximum estimate (Table 6-1). Harbor porpoise are not expected to be present in higher numbers near ice, so the open-water densities were used for ice-margin habitat in both seasons. Harbor porpoise densities recorded during industry operations in the fall months of 2006-2008 were slightly lower and ranged from $0.0005/mi^2$ to $0.0034/km^2$ ($0.0002/km^2$ to $0.0013/km^2$) with a maximum 95 percent CI of $0.0114/mi^2$ ($0.0044/km^2$). The median value $0.0026/mi^2$ ($0.0010/km^2$) was again used as the average density estimate and the high value $0.0034/mi^2$ ($0.0013/km^2$) was used as the maximum estimate (Table 6-2).

TABLE 6-2 EXPECTED DENSITIES OF CETACEANS AND SEALS IN AREAS OF THE CHUKCHI SEA, ALASKA, FOR THE FALL (SEPTEMBER–OCTOBER) PERIOD. SPECIES LISTED UNDER THE U.S. ESA AS ENDANGERED ARE IN ITALICS.

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

The remaining five cetacean species that could be encountered in the Chukchi Sea during Shell's planned exploration drilling program include the humpback whale, killer whale, minke whale, fin whale, and narwhal. Although there is evidence of the occasional occurrence of these animals in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned drilling program. George and Suydam (1998) reported killer whales, Brueggeman et al. (1990) and Haley et al. (2009b) reported minke whale, Suydam and George (1992) and Haley et al. (2009b) reported harbor porpoise, and COMIDA (2009) and Haley et al. (2009b) reported fin whales off of Ledyard Bay in the Chukchi Sea. Narwhal sightings in the Chukchi Sea have not been reported in recent literature, but subsistence hunters occasionally report observations near Barrow, and Reeves et al. (2002) indicated a small number of extralimital sightings in the Chukchi Sea.

Pinnipeds

Three species of pinnipeds under NMFS jurisdiction are likely to be encountered in the Chukchi Sea portion of Shell's planned exploration drilling program: ringed seal, bearded seal, and spotted seal. Each of these species, except for the spotted seal, is associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be found in the southern margin of the retreating sea ice. However, satellite tagging has shown that they sometimes undertake long excursions into offshore waters during summer (Lowry et al. 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Patterson et al. 2007, Haley et al. 2009b).

Ringed seal and ***bearded seals*** "average" and "maximum" summer ice-margin densities (Table 6-1) were available in Bengtson et al. (2005) from spring surveys in the offshore pack ice zone (zone 12P) of the northern Chukchi Sea. However, corrections for bearded seal availability, g(0), based on haulout and diving patterns were not available. Densities of ringed and bearded seals in open water are expected to be somewhat lower in the summer when preferred pack ice habitat may still be present in the Chukchi Sea. Average and maximum open-water densities have been estimated as 3/4 of the ice margin densities during both seasons for both species. The fall density of ringed seals in the offshore Chukchi Sea has been estimated as 2/3 the summer densities because ringed seals begin to reoccupy nearshore fast ice areas as it forms in the fall. Bearded seals may also begin to leave the Chukchi Sea in the fall, but less is known about their movement patterns so fall densities were left unchanged from summer densities. For comparison, the ringed seal density estimates calculated from data collected during summer 2006-2008 industry operations ranged from 0.0212/mi^2 to 0.0572/mi^2 (0.0082/km^2 to 0.0221/km^2) with a maximum 95 percent CI of 0.1494/mi^2 (0.0577/km^2) (Haley et al. 2009b). These estimates are lower than those made by Bengtson et al. (2005) which is not surprising given the different survey methods and timing.

Little information on ***spotted seal*** densities in offshore areas of the Chukchi Sea is available. Spotted seal densities in the summer were estimated by multiplying the ringed seal densities by 0.02. This was based on the ratio of the estimated Chukchi populations of the two species (Table 3-1). Chukchi Sea spotted seal abundance was estimated by assuming that 8 percent of the Alaskan population of spotted seals is present in the Chukchi Sea during the summer and fall (Rugh et al. 1997), the Alaskan population of spotted seals is 59,214 (Angliss and Allen 2009), and that the population of ringed seals in the Alaskan Chukchi Sea is >208,000 animals (Bengtson et al. 2005). In the fall, spotted seals show increased use of coastal haulouts so densities were estimated to be 2/3 of the summer densities.

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

As described in earlier sections, the assumed start date of exploration drilling in the Chukchi Sea using the drillship *Discoverer* and associated support vessels is 4 July. Up to three wells may be drilled, with an average of 37 days at each drill site, including five days of mudline cellar excavation. The order in which the wells will be drilled, ice permitting, will likely be Burger, SW Shoebill, and Crackerjack. Drilling operations are expected to be completed on or before 31 October.

Expected sound propagation from the drillship *Discoverer* was modeled at the three possible drill sites. Changes in the water column of the Chukchi Sea through the course of the drilling season will likely affect the propagation of sounds produced by drilling activities, so models were run for expected oceanographic conditions in July and October to bracket the seasonal variability. Sounds from the *Discoverer* have not previously been measured in the Arctic or elsewhere, but sounds from a similar drillship, *Explorer II*, were measured twice in the Beaufort Sea (Greene 1987a,b; Miles et al. 1987). The back-propagated source levels from these measurements (175 dB re 1 µPa rms), which included sounds from a support vessel operating nearby, were used as a proxy for modeling the sounds likely to be produced by drilling activities from the *Discoverer*. Results of sound propagation modeling that were used in the calculations of areas exposed to various levels of received sounds are summarized in Table 6-3. If ice conditions permit, the Burger well would be drilled first, SW Shoebill well would be drilled second, and the Crackerjack well would be drilled last.

TABLE 6-3 SOUND PROPAGATION MODELING RESULTS OF DRILLING ACTIVITIES AT THREE LOCATIONS IN THE CHUKCHI SEA

Location	Received Level (dB re 1 µPa)	Modeling Results (km)	Used in Calculations (km)
Burger	120	1.36	2.04
(Summer)	160	< 0.10	0.15
SW Shoebill	120	0.51	0.77
(Summer)	160	< 0.10	0.15
SW Shoebill	120	0.57	0.86
(Fall)	160	< 0.10	0.15
Crackerjack	120	0.59	0.89
(Fall)	160	< 0.10	0.15

Potential Number of "Takes by Harassment"

Numbers of marine mammals that might be present and potentially disturbed are estimated below based on available mammal distribution and density data at different locations and times of the year as described above and summarized in Tables 6-1 and 6-2. Exposure estimates are based on a single drillship (*Discoverer*) and associated support vessels drilling up to three wells in the Chukchi Sea from 4 July through 31 October as described in the previous section.

The number of individuals of each species potentially exposed to received levels ≥160 dB and ≥120 dB re 1 µPa rms, within each season and habitat zone, was estimated by multiplying the anticipated area to be ensonified in the time period and habitat zone to which a density applies, by the expected species density. The numbers of exposures were then summed for each species across the seasons and habitat zones.

Estimated Area Exposed to Sounds ≥160 dB rms

Distances shown in Table 6-3 were used to estimate the area ensonified to ≥160 dB rms around the drillship in the summer and fall seasons. Drilling activities at the SW Shoebill location may occur in both seasons. In order to produce a cautionary estimate of the potential number of takes, the entire area that may be exposed to sounds by operations at the SW Shoebill location have been included in calculations for both seasons using the corresponding distances shown in Table 6-3. The area of water potentially exposed to received sound levels >160 dB rms by exploration drilling operations during each season was estimated to be 0.14 km^2, or 0.07 km^2 × two drill sites.

Estimated Area Exposed to Sounds ≥120 dB rms

Distances shown in Table 6-3 were used to estimate the area ensonified to ≥120 dB rms around the drillship in the summer and fall seasons. As noted above, drilling activities at the SW Shoebill location may occur in both seasons so the entire area that may be exposed to sounds by operations at the SW Shoebill location have been included in calculations for both seasons. The area of water potentially exposed to received sound levels >120 dB rms by exploration drilling operations was estimated to be 14.94 km^2 in the summer at Burger and SW Shoebill, and 4.81 km^2 in the fall at SW Shoebill and Crackerjack.

Cetaceans

Estimates of the average and maximum number of individual cetaceans that would be exposed to received sound levels ≥120 dB and ≥160 dB rms are shown by season and habitat in Tables 6-4 and 6-5. The totals for each season are summed in Table 6-6. Based on the calculations, all species have an estimated average number of individuals exposed to ≥120 dB of less than one. However, chance encounters with a few individuals of any species are possible as all listed species are known to occur in the Chukchi Sea. Minimal estimates have therefore been included in the Total (Max) column to account for chance encounters or where greater numbers may be encountered than calculations suggested (Table 6-6). No animals are expected to be exposed to sounds ≥160 dB rms due to the small size of this zone. Most cetaceans are likely to avoid the immediate area around the drilling vessel due to the vessel traffic, however, not all marine mammals will change their behavior when exposed to these sound levels.

TABLE 6-4 THE NUMBER OF POTENTIAL EXPOSURES OF MARINE MAMMALS TO RECEIVED SOUND LEVELS IN THE WATER OF ≥120 DB RMS AND (≥160 DB RMS) DURING PLANNED ACTIVITIES IN THE CHUKCHI SEA, ALASKA, SUMMER (JULY–AUGUST) 2010

	Number of Exposures to Sound Levels ≥120 dB and (≥160 dB)					
	Summer					
	Open Water		Ice Margin		Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes						
Monodontidae						
Beluga	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Narwhal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Delphinidae						
Killer whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Phocoenidae						
Harbor porpoise	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mysticetes						
Bowhead whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fin whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gray whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Humpback Whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Minke whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Cetaceans	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Pinnipeds						
Bearded seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ribbon seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ringed seal	3 (0)	5 (0)	4 (0)	6 (0)	6 (0)	11 (0)
Spotted seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Pinnipeds	3 (0)	5 (0)	4 (0)	6 (0)	7 (0)	11 (0)

TABLE 6-5 THE NUMBER OF POTENTIAL EXPOSURES OF MARINE MAMMALS TO RECEIVED SOUND LEVELS IN THE WATER OF ≥120 DB RMS AND (≥160 DB RMS) DURING PLANNED ACTIVTIES IN THE CHUKCHI SEA, ALASKA, FALL (SEPTEMBER–OCTOBER) 2010.

	Number of Exposures to Sound Levels ≥120 dB and (≥160 dB)					
	Fall					
	Open Water		Ice Margin		Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes						
Monodontidae						
Beluga	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Narwhal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Delphinidae						
Killer whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Phocoenidae						
Harbor porpoise	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mysticetes						
Bowhead whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fin whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gray whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Humpback Whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Minke whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Cetaceans	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pinnipeds						
Bearded seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ribbon seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ringed seal	1 (0)	2 (0)	0 (0)	1 (0)	1 (0)	2 (0)
Spotted seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Pinnipeds	1 (0)	2 (0)	0 (0)	1 (0)	1 (0)	2 (0)

TABLE 6-6 SUMMARY OF THE NUMBER OF POTENTIAL EXPOSURES OF MARINE MAMMALS TO RECEIVED SOUND LEVELS IN THE WATER OF ≥120 DB RMS AND (≥160 DB RMS)

	Number of Exposures to Sound Levels ≥120 dB and (≥160 dB)					
	Summer		Fall		Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes						
Monodontidae						
Beluga	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Narwhal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Delphinidae						
Killer whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Phocoenidae						
Harbor porpoise	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Mysticetes						
Bowhead whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Fin whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Gray whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Humpback Whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Minke whale	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Total Cetaceans	0 (0)	1 (0)	0 (0)	0 (0)		
Pinnipeds						
Bearded seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Ribbon seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Ringed seal	6 (0)	11 (0)	1 (0)	2 (0)	8 (0)	13 (5)
Spotted seal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
Total Pinnipeds	7 (0)	11 (0)	1 (0)	2 (0)		

Pinnipeds

Many of the animals exposed to sound levels near 120 dB rms would not react to those sound levels, particularly pinnipeds, and exposure to this sound level should not be considered as "takes". Even for species that may change their behavior or alter their migration route, those changes are likely to be within the normal range of activities for the animals and may not rise to the level of "taking" based on guidance in NMFS (2001). Animals that divert around the activity at the lower sound levels would not approach close enough that they would alter their behavior to the degree that they would be "taken by harassment." Thus, the actual number of animals that will be "taken" lies somewhere between the number exposed to ≥120 and ≥160 dB rms.

Average and maximum estimates of the number of pinnipeds that would be exposed to received sound levels ≥120 dB and ≥160 dB rms are shown by season and habitat in Tables 6-4 and 6-5. The totals for each season are summed in Table 6-6. Ringed seal is the most widespread and abundant pinniped in ice-covered Arctic waters, and there appears to be a great deal of year-to-year variation in abundance and distribution of these marine mammals. Ringed seals account for the only appreciable number of marine mammals expected to be encountered during exploration drilling activities, and the only seal species anticipated to be exposed to sounds with received levels ≥120 dB rms. The average (and maximum) estimate is that 8 (13) ringed seals might be exposed to sounds with received levels ≥120 dB rms from exploration drilling activities, and minimal numbers to sounds ≥160 dB rms.

Two additional pinniped species are expected to be encountered: bearded and spotted seals. However, based on density calculations neither of these species are expected to be exposed to sound levels ≥120 dB rms. Maximum estimates of 5 exposures for each species of pinnipeds at ≥120dB and ≥160dB have been included for completeness.

Conclusions

The planned exploration drilling activities in the Chukchi Sea will involve a drillship that will introduce continuous sounds into the ocean while it is active. Other routine vessel operations are conventionally assumed not to affect marine mammals sufficiently to constitute "taking."

Cetaceans

Effects on cetaceans are generally expected to be restricted to avoidance of an area around the drilling operation and short-term changes in behavior, falling within the MMPA definition of "Level B harassment."

Using the 120 dB re 1 μPa rms criterion and available information on densities, no individual cetaceans are expected to be exposed to sounds ≥120 dB rms in the Chukchi Sea and adjacent waters. However, for species listed as endangered under the ESA, our estimate includes 5 bowhead whales that may be exposed to sounds ≥120 dB rms to allow for chance encounters. This number is <1 percent of the Bering-Chukchi-Beaufort population of >14,247 assuming 3.4 percent annual population growth from the 2001 estimate of >10,545 animals (Zeh and Punt 2005) which is supported by a 2004 population estimate of 11,800 by Koski et al. (2009). Gray whale is the most common species of cetacean expected to be present during the planned exploration drilling operations, and density calculations suggest that fewer than five of these are likely to be exposed to sounds ≥120 dB rms thereby representing <1 percent of the population. The small numbers of other mysticete whales that may occur in the Chukchi Sea are unlikely to be present around the planned operations but are similarly included to allow for chance encounters with small numbers of individuals. The few that might occur would represent a very small proportion of their respective populations.

Some odontocetes may be exposed to sounds produced by the drilling activities, but only a small number (five or fewer of each species) are likely to occur near the operations (Table 6-6). Few animals are expected to be exposed to levels ≥160 dB rms, although minimal numbers have been requested to allow for chance encounters.

Pinnipeds

A few pinniped species are likely to be encountered in the study area, but ringed seal is by far the most abundant in this area, and the only pinniped expected to be exposed to sounds ≥120 dB rms based on density calculations. The best (average) estimate of the numbers of ringed seals exposed to sounds at received levels ≥120 dB rms during the exploration drilling activities is 8 ringed seals which represents <1 percent of its Chukchi Sea population. Pinnipeds are unlikely to react to continuous sounds until they are much stronger than 120 dB rms, so it is probable that an even smaller number of these animals would actually be disturbed. Fewer pinnipeds are estimated to be exposed to sounds ≥160 dB rms, although minimal estimates have been included to allow for chance encounters.

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

The likely or possible impacts of the planned offshore exploratory drilling program on marine mammals will be related primarily to acoustic effects. Petroleum development and associated activities in marine waters introduce sound into the environment. The acoustic sense of marine mammals probably constitutes their most important distance receptor system, and underwater sounds could (at least in theory) have several types of effects on marine mammals. Potential acoustic effects relate to sound produced by drilling activity, vessels and aircraft.

Noise Characteristics and Effects

The effects of sound on marine mammals are highly variable, and can be categorized as follows (based on Richardson et al. 1995a):

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

2. The sound may be audible but not strong enough to elicit any overt behavioral response. This has been demonstrated upon exposure of bowhead whales to low levels of seismic, drilling, dredge, or icebreaker sounds (Richardson et al. 1986; 1990; 1995a,b,).

3. The sound may elicit reactions of variable conspicuousness and variable relevance to the well being of the animal. These can range from subtle effects on respiration or other behaviors (detectable only by statistical analysis) to active avoidance reactions.

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

5. Any man made sound that is strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as ice or surf noise.

6. Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity. Effects of non-explosive sounds on hearing thresholds of some marine mammals have been studied. Data are available for two species of odontocetes exposed to a single strong noise pulse lasting one second (Ridgway et al. 1997 and pers. comm.) and for three species of pinnipeds exposed to moderately strong sound for 20-22 minutes (Kastak et al. 1999). Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift (TTS) to occur. The TTS threshold depends on duration of exposure; the sound level necessary to cause TTS is higher for short sound exposures than for long sound exposures. Received levels must be even higher to risk permanent hearing impairment (probably at least 10 dB above the TTS threshold).

Drilling Sounds

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

Most drilling sounds generated from vessel-based operations occur at relatively low frequencies below 600 Hz although tones up to 1,850 Hz were recorded by Greene (1987a) during drilling operations in the Beaufort Sea. At a range of 0.1 mi (0.17 km) the 20-1000 Hz band level was 122-125 dB re 1μPa for the drillship *Explorer I*. Underwater sound levels were slightly higher (134 db re 1μPa) during drilling activity from the *Explorer II* at a range of 0.20 km (0.12 mi) although tones were only recorded below 600 Hz. Underwater sound measurements from the Kulluk at 0.61 mi (0.98 km) were higher (143 dB re 1μPa) than from the other two vessels.

Aircraft Noise

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

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

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

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drillship will generally maintain straight-line routes at altitudes of 1,500 ft (305 m) ASL, thereby limiting the received levels at and below the surface.

Vessel Noise

In addition to the drillship, various types of vessels will be used in support of the operations including ice management vessels, anchor handlers, and oil-spill response vessels. Sounds from boats and vessels have been reported extensively (Greene and Moore 1995; Blackwell and Greene 2002, 2005, 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort seas. Results of these measurements were reported in various 90-day and comprehensive reports since 2007. For example, Garner and Hannay (2009) estimated sound pressure levels of 100 db re 1 μPa at distances ranging from ~1.5 to 2.3 mi (~2.4 to 3.7 km) from various types of barges. MacDonnell et al. (2008) estimated higher underwater sound pressure levels from the seismic vessel *Gilavar* of 120 db re 1 μPa at ~13 mi (~21 km) from the source, although the sound level was only 150 dB at 85 ft (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies.

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

Summary of Potential Effects of Exposure to Underwater Sounds

The potential effects of sounds from the proposed exploratory drilling activities might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995a). It is unlikely that there would be any cases of temporary or especially permanent hearing impairment, or non-auditory physical effects.

Tolerance

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

Masking

Masking effects of underwater sounds on marine mammal calls and other natural sounds are expected to be limited. Some whales are known to continue calling in the presence of pulsed sound. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), a more recent study reports that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen et al. 2002). That has also been shown during recent work in the Gulf of Mexico (Tyack et al. 2003). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the numbers of calls detected may sometimes be reduced (Richardson et al. 1986; Greene et al. 1999; Blackwell et al. 2009). Masking effects of drilling sounds are expected to be negligible in the case of the smaller odontocetes, given the intermittent nature of seismic pulses. Sounds important to small odontocetes for communication are predominantly at much higher frequencies than are drilling sounds.

Disturbance Reactions

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

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

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

Baleen Whales—Baleen whale responses to pulsed sound have been studied more thoroughly than responses to continuous sound. Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much greater distances. However, baleen whales exposed to strong noise pulses often react by deviating from their normal migration route. In the case of migrating gray and bowhead whales, observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors. Baleen whale responses to pulsed sound however, may depend on the type of activity in which the whales are engaged. Some evidence suggests that feeding bowhead whales may be more tolerant of underwater sound than migrating bowheads (Miller et al. 2005; Lyons et al. 2009; Christi et al. 2009).

Richardson et al. (1995b) reported changes in surfacing and respiration behavior, and the occurrence of turns during surfacing in bowhead whales exposed to playback of underwater sound from drilling activities. These subtle behavioral effects were temporary and localized, and occurred at distances up to 1.2-2.5 mi (2-4 km). Safety radii for the proposed drilling activities are expected to be small and are not expected to result in significant disturbance to baleen whales.

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

Brewer et al. (1993) and Hall et al. (1994) reported numerous sightings of marine mammals including bowhead whales in the vicinity of offshore drilling operations in the Beaufort Sea. One bowhead whale sighting was reported within ~1,312 ft (~400 m) of a drilling vessel although other sightings were at much greater distances. Few bowheads were recorded near industrial activities by aerial observers, but observations by surface observers suggested that bowheads might have been closer to industrial activities than was suggested by results of aerial observations.

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

Patenaude et al. (2002) reported fewer behavioral responses to aircraft overflights by bowhead compared to beluga whales. Behaviors classified as reactions consisted of short surfacings, immediate dives or turns, changes in behavior state, vigorous swimming, and breaching. Most bowhead reaction resulted from exposure to helicopter activity and little response to fixed-wing aircraft was observed. Most reactions occurred when the helicopter was at altitudes ≤492 (≤150 m) and lateral distances ≤820 ft (≤250 m). Restriction on aircraft altitude will be part of the mitigation measures during the proposed drilling activities and likely to have little or no disturbance effects on baleen whales. Any disturbance that did occur would likely be temporary and localized.

Southall et al. (2007 Appendix C) reviewed a number of papers describing the responses of marine mammals to non-pulsed sound. In general, little or no response was observed in animals exposed at received levels from 90-120 dB rms. Probability of avoidance and other behavioral effects increased when received levels were 120-160 dB rms. Some of the relevant reviews of Southall et al. (2007) are summarized below.

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

Malme et al. (1983, 1984) used playback of sound from helicopter overflight and drilling rigs and platforms to study behavioral effects on migrating gray whales. Received levels exceeding 120 dB induced avoidance reactions. Malme et al. (1984) calculated 10%, 50%, and 90% probabilities of gray whale avoidance reactions at received levels of 110, 120, and 130 dB re 1 µPa, respectively.

Malme et al. (1986) observed the behavior of feeding gray whales during four experimental playbacks of drilling sounds (50 to 315 Hz; 21- min overall duration and 10% duty cycle; source levels 156 to 162 dB re 1 µPa-m). In two cases for received levels of 100 to 110 dB re 1 µPa, no behavioral reaction was observed. Avoidance behavior was observed in two cases where received levels were 110 to 120 dB re 1 µPa.

Richardson et al. (1990) performed 12 playback experiments in which bowhead whales in the Alaskan Arctic were exposed to drilling sounds. Whales generally did not respond to exposures in the 100 to 130 dB re 1 µPa range, although there was some indication of minor behavioral changes in several instances.

McCauley et al. (1996) reported several cases of humpback whales responding to vessels in Hervey Bay, Australia. Results indicated clear avoidance at received levels between 118 to 124 dB re 1 µPa in three cases for which response and received levels were observed/measured.

Palka & Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of Minke whales. Minor changes in locomotion speed, direction, and/or diving profile were reported at ranges from 563 to 717 m at received levels (RLs) of 110 to 120 dB re 1 µPa.

Biassoni et al. (2000) and Miller et al. (2000) reported behavioral observations for humpback whales exposed to a low-frequency sonar stimulus (160- to 330-Hz frequency band; 42-s tonal signal repeated every 6 min; source levels 170 to 200 dB re 1 μPa-m) during playback experiments. Exposure to measured received levels ranging from 120 to 150 dB re 1 μPa resulted in variability in humpback singing behavior.

Croll et al. (2001) investigated responses of foraging fin and blue whales to the same low frequency active sonar stimulus off southern California. Playbacks and control intervals with no transmission were used to investigate behavior and distribution on time scales of several weeks and spatial scales of tens of kilometers. The general conclusion was that whales remained feeding within a region for which 12 to 30% of exposures exceeded 140 dB re 1 μPa.

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

Finally, Nowacek et al. (2004) used controlled exposures to demonstrate behavioral reactions of northern right whales to various nonpulse sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-min "alert" sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB re 1 μPa (i.e., ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise and the other four were exposed to both stimuli. These whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

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

At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson et al. 1995b). Received levels from the icebreaker playback were estimated at 78-84 dB re 1 μPa in the 1/3-octave band centered at 5,000 Hz, or 8-14 dB above ambient. If beluga whales reacted to an actual icebreaker at received levels of 80 dB, reactions would be expected to occur at distances on the order of 6 mi (10 km). Finley et al. (1990) also reported beluga avoidance of icebreaker activities in the Canadian High Arctic at distances of 22 to 31 mi (35 to 50 km). In addition to avoidance, changes in dive behavior and pod integrity were also noted. Beluga whales have also been report to avoid active seismic vessels at distances of 6-12 mi (10-20 km) (Miller et al. 2005). It is likely that at least some beluga whales may avoid the vicinity of the proposed activities thus reducing the potential for exposure to high levels of underwater sound.

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

In reviewing responses of cetaceans with best hearing in mid-frequency ranges, which includes toothed whales, Southall et al. (2007) reported that combined field and laboratory data for mid-frequency cetaceans exposed to nonpulse sounds did not lead to a clear conclusion about received levels coincident with various behavioral responses. In some settings, individuals in the field showed profound (significant) behavioral responses to exposures from 90 to 120 dB re 1 μPa, while others failed to exhibit such responses for exposure to received levels from 120 to 150 dB re 1 μPa. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating noise exposure, may also explain why there was great disparity in results from field and laboratory conditions—exposures in captive settings generally exceeded 170 dB re 1 μPa before inducing behavioral responses. Below we summarize some of the relevant material reviewed by Southall et al. (2007).

LGL and Greeneridge (1986) and Finley et al. (1990) documented belugas and narwhals congregated near ice edges reacting to the approach and passage of ice-breaking ships. Beluga whales responded to oncoming vessels by (1) fleeing at speeds of up to 20 km/h from distances of 12 to 50 mi (20 to 80 km), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a "freeze" response, lying motionless or swimming slowly away (as far as 23 mi/37 km down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

The 1982 season observations by LGL & Greeneridge (1986) involved a single passage of an icebreaker with both ice-based and aerial measurements on 28 June 1982. Four groups of narwhals (n = 9 to 10, 7, 7, and 6) responded when the ship was 4.0 mi (6.4 km away) with received levels of ~100 dB re 1 μPa in the 150- to 1,150-Hz band. At a later point, observers sighted belugas moving away from the source at >12.4 mi (> 20 km) with received levels of ~90 dB re 1 μPa in the 150- to 1,150-Hz band. The total number of animals observed fleeing was about 300, suggesting approximately 100 independent groups (of three individuals each). No whales were sighted the following day, but some were sighted on 30 June, with ship noise audible at spectrum levels of approximately 55 dB re 1 μPa/Hz (up to 4 kHz).

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

The final season (1984) reported in LGL & Greeneridge (1986) involved aerial surveys before, during, and after the passage of two ice-breaking ships. During operations, no belugas and few narwhals were observed in an area approximately 17 mi (27 km) ahead of the vessels, and all whales sighted over 12-50 mi (20 to 80 km) from the ships were swimming strongly away. Additional observations confirmed the spatial extent of avoidance reactions to this sound source in this context.

Gordon et al. (1992) conducted opportunistic visual and acoustic monitoring of sperm whales in New Zealand exposed to nearby whale-watching boats (within 1,476 ft/450 m). Sperm whales respired significantly less frequently, had shorter surface intervals, and took longer to start clicking at the start of a dive descent when boats were nearby than when they were absent. Noise spectrum levels of whalewatching boats ranged from 109 to 129 dB re 1 μPa/Hz. Over a bandwidth of 100 to 6,000 Hz, equivalent broadband source levels were ~157 dB re 1 μPa-m; received levels at a range of 1,476 ft (450 m) were ~104 dB re 1 μPa.

Buckstaff (2004) reported elevated dolphin whistle rates with RLs from oncoming vessels in the 110 to < 120 dB re 1 μPa. These hearing thresholds were apparently lower than those reported by a researcher listening with towed hydrophones.

Morisaka et al. (2005) compared whistles from three populations of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*). One population was exposed to vessel noise with spectrum levels of ~85 dB re 1 μPa/Hz in the 1- to 22-kHz band (broadband received levels ~128 dB re 1 μPa) as opposed to ~65 dB re 1 μPa/Hz in the same band (broadband RL ~108 dB re 1 μPa) for the other two sites. Dolphin whistles in the noisier environment had lower fundamental frequencies and less frequency modulation, suggesting a shift in sound parameters as a result of increased ambient noise.

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

Monteiro-Neto et al. (2004) studied avoidance responses of tucuxi (*Sotalia fluviatilis*) to Dukane® Netmark acoustic deterrent devices. In a total of 30 exposure trials, ~5 groups each demonstrated significant avoidance compared to 20 pinger off and 55 no-pinger control trials over two quadrats of about 0.2 mi^2 (0.5 km^2). Estimated exposure received levels were ~115 dB re 1 μPa.

Awbrey & Stewart (1983) played back semi-submersible drillship sounds (source level: 163 dB re 1 μPa-m) to belugas in Alaska. They reported avoidance reactions at 985 ft and 4,921 ft (300 m and 1,500 m) and approach by groups at a distance of 3,927 yd (3,500 m) with received levels ~110 to 145 dB re 1 μPa over these ranges assuming a 15 log R transmission loss. Similarly, Richardson et al. (1990) played back drilling platform sounds (source level: 163 dB re 1 μPa-m) to belugas in Alaska. They conducted aerial observations of eight individuals among ~100 spread over an area several hundred meters to several kilometers from the sound source and found no obvious reactions. Moderate changes in movement were noted for three groups swimming within 656 ft (200 m) of the sound projector.

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

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

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

Blackwell et al. (2004) reported little or no reaction of ringed seals in response to pile-driving activities during construction of a man-made island in the Beaufort Sea. Ringed seals were observed swimming as close as 150 ft (46 m) from the island and may have been habituated to the sounds which were likely audible at distances <1.9 mi (<3.0 km) underwater and 0.3 mi (0.5 km) in air. Moulton et al. (2003) reported that ringed seal densities on ice in the vicinity of a man-made island in the Beaufort Sea did not change significantly before and after construction and drilling activities.

Southall et al. (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between ~90 and 140 dB re 1 μPa generally do not appear to induce strong behavioral responses in pinnipeds exposed to nonpulse sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies of pinnipeds responding to nonpulse exposures in water, there are some apparent differences in responses between field and laboratory conditions. In contrast to the mid-frequency odontocetes, captive pinnipeds responded more strongly at lower levels than did animals in the field. Again, contextual issues are the likely cause of this difference.

Jacobs & Terhune (2002) observed harbor seal reactions to AHDs (source level in this study was 172 dB re: 1 μPa-m) deployed around aquaculture sites. Seals were generally unresponsive to sounds from the AHDs. During two specific events, individuals came within 43 and 44 m of active AHDs and failed to demonstrate any measurable behavioral response; estimated received levels based on the measures given were ~120 to 130 dB re 1 μPa.

Costa et al. (2003) measured received noise levels from an Acoustic Thermometry of Ocean Climate (ATOC) program sound source off northern California using acoustic data loggers placed on translocated elephant seals. Subjects were captured on land, transported to sea, instrumented with archival acoustic tags, and released such that their transit would lead them near an active ATOC source (at 939-m depth; 75-Hz signal with 37.5- Hz bandwidth; 195 dB re 1 μPa-m max. source level, ramped up from 165 dB re 1 μPa-m over 20 min) on their return to a haulout site. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re 1 μPa (range 118 to 137) in the 60- to 90-Hz band. None of the instrumented animals terminated dives or radically altered behavior upon exposure, but some statistically significant changes in diving parameters were documented in nine individuals. Translocated northern elephant seals exposed to this particular nonpulse source began to demonstrate subtle behavioral changes at ~120 to 140 dB re 1 μPa exposure RLs.

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

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ³180 and ≥190 dB re 1 µPa (rms), respectively (NMFS 2000). Those criteria have been used in defining the safety (shut down) radii during seismic survey activities in the Arctic in recent years. However, those criteria were established before there were any data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals. In summary,

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

NMFS is presently developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS 2005b; D. Wieting in http://mmc.gov/sound/plenary2/pdf/plenary2summaryfinal.pdf).

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

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to industrial sound sources and beaked whales do not occur in the proposed study area. It is unlikely that any effects of these types would occur during the proposed project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures (see below). The following subsections discuss in somewhat more detail the possibilities of TTS, permanent threshold shift (PTS), and non-auditory physical effects.

***Temporary Threshold Shift* -** TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends.

For toothed whales exposed to single short pulses, the TTS threshold appears to be, to a first approximation, a function of the energy content of the pulse (Finneran et al. 2002, 2005). Given the available data, the received level of a single seismic pulse might need to be ~210 dB re 1 µPa rms (~221–226 dB pk–pk) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200–205 dB (rms) might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received energy. Source levels associated with drilling activities are much lower than those produced during seismic airgun activity.

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

Initial evidence from prolonged exposures to sound suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001; cf. Au et al. 2000). For harbor seal, which is closely related to the ringed seal, TTS onset apparently occurs at somewhat lower received energy levels than for odontocetes.

NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 µPa (rms). NMFS is in the process of developing an EIS to establish new sound exposure criteria for marine mammals (NMFS 2005a). New criteria are likely to include a time component in addition to sound pressure level, which has been the only metric used previously when developing mitigation measures for industrial sound exposure for marine mammals. Due to the relatively small sound radii expected to result from the proposed drilling and support activities, marine mammals would be unlikely to incur TTS without remaining very near the activities for some unknown time period. Given the proposed mitigation and the likelihood that many marine mammals are likely to avoid the proposed activities, exposure sufficient to produce TTS is unlikely to occur.

Permanent Threshold Shift **-** When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges.

There is no specific evidence that exposure to underwater industrial sound associated with oil exploration can cause PTS in any marine mammal. However, given the possibility that mammals might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to such activities might incur PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above that inducing mild TTS.

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause permanent hearing impairment during the proposed exploratory drilling program. Marine mammals are unlikely to be exposed to received levels strong enough to cause even slight TTS. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, even the levels immediately adjacent to the drillship may not be sufficient to induce PTS, even if the animals remain in the immediate vicinity of the activity. The planned monitoring and mitigation measures, including measurement of sound radii and visual monitoring when mammals are seen within “safety radii”, will minimize the already-minimal probability of exposure of marine mammals to sounds strong enough to induce PTS.

Non-auditory Physiological Effects - Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, and other types of organ or tissue damage. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for sufficiently long that significant physiological stress would develop.

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

Available data on the potential for underwater sounds from industrial activities to cause auditory impairment or other physical effects in marine mammals suggest that such effects, if they occur at all, would be temporary and limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of the proposed activities, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects.

Strandings and Mortality

Marine mammals close to underwater detonations of high explosive can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Underwater sound from drilling and support activities are less energetic and have slower rise times, and there is no proof that they can cause serious injury, death, or stranding. However, the association of mass strandings of beaked whales with naval exercises and, in one case, an L-DEO seismic survey, has raised the possibility that beaked whales exposed to strong pulsed sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding. The potential for stranding to result from exposure to strong pulsed sound suggests that caution be used when exposing marine mammals to pulsed or other underwater sound. Most of the stranding events associated with exposure of marine mammals to pulsed sound however, have involved beaked whales, which do not occur in the proposed area. Additionally, the sound produced from the proposed activities will be at much lower levels than those reported during stranding events.

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

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

Bowhead Whale. Most activities associated with Shell's planned exploration drilling program would have no or negligible effects on bowhead whales or on subsistence hunts for bowheads. Sound energy and general activity associated with drilling and operation of vessels and aircraft have the potential to temporarily affect the behavior of bowhead whales. However, as noted above in Section 7, though temporary diversions of the swim path of migrating whales have been documented, the whales have generally been observed to resume their initial migratory route within a distance of 6-20 mi (10-32 km) (Davis 1987; Brewer et al. 1993; Hall et al. 1994). Drilling noise has not been shown to block or impede migration even in narrow ice leads (Davis 1987; Richardson et al. 1991). Any effects on the bowhead whale as a subsistence resource would be negligible.

Observed behavioral effects from sound energy produced by drilling, such as avoidance, deflection, and changes in surface / dive ratios, have generally been restricted to the area ensonified to >160 dB or more although effects have infrequently been observed out to distance ensonified to 120 dB. As indicated above in Table 6-3, areas ensonified to >160 dB or more are limited to the areas within 0.1 km of the drillship, and areas expected to be ensonified to >120 dB would be expected to be limited to the areas within 1.47 km of the drillship. Shell's proposed drill sites are located more than 60 mi (97 km) from the Chukchi Sea coastline, whereas available mapping of subsistence use areas indicates bowhead hunts are conducted within about 30 mi (48 km) of shore. There is therefore little or no opportunity for the proposed drilling activities to affect bowhead hunts.

Vessel traffic between the drill sites and the marine support facilities in Wainwright, would traverse areas used during bowhead hunts by Wainwright crews; however whaling in Wainwright, as well as Point Hope, and Point Lay, typically takes place in the spring, and generally ends before Shell's proposed drilling program would commence.

Aircraft traffic (helicopters and small fixed wing airplanes) between the drill sites and facilities in Wainwright and Barrow would also traverse these subsistence areas. Again, flights to and from Wainwright would take place after the date on which bowhead whaling out of Point Hope, Point Lay, and Wainwright is typically finished for the year. Barrow crews hunt bowheads during the spring and the fall, although most commonly east of Barrow along the Beaufort Sea coast. Aircraft flights between Shell's drill sites and air support facilities in Barrow would traverse areas sometimes used during spring and fall whaling by Barrow crews. Spring whaling would be complete before Shell's proposed activities would commence, but aircraft flights could occur during the period when fall whaling takes place out of Barrow. The most commonly observed reactions of bowheads to aircraft traffic are hasty dives, but changes in orientation, dispersal, and changes in activity are sometimes noted. Such reactions could potentially affect subsistence hunts if the flights occurred near and at the same time as the hunt. Shell has developed and proposes to implement a number of mitigation measures to ensure that any effects on the bowhead whale as a subsistence resource, or effects on bowhead subsistence hunts would be negligible. These mitigation measures, which include minimum flight altitudes, employment of subsistence advisors in the villages, and implementation of a Communications Plan (with operation of Communications and Call Centers), are described below in Section 12.3.

Beluga. Beluga typically do not represent a large proportion of the subsistence harvests by weight in the communities of Wainwright and Barrow, the nearest communities to Shell's planned 2010 drilling program. Belugas typically represent a much greater proportion of the subsistence harvest in Point Lay and Point Hope. Beluga are harvested in coastal waters near these villages, generally within a few miles from shore. Shell's proposed drill sites are located more than 60 mi (97 km) offshore, therefore proposed drilling in these prospects would have no or negligible effect on beluga hunts. Aircraft and vessel traffic between the drill sites and support facilities in Wainwright, and aircraft traffic between the drill sites and air support facilities in Barrow would traverse areas that are sometimes used for subsistence hunting of belugas. Disturbance associated with vessel and aircraft traffic could therefore potentially affect beluga hunts. Vessel and aircraft traffic associated with Shell's proposed drilling program will be restricted under normal conditions to designated corridors that remain onshore or proceed directly offshore thereby minimizing the amount of traffic in coastal waters where beluga hunts take place. The designated traffic corridors do not traverse areas indicated in recent mapping as utilized by Barrow, Point Lay, or Point Hope for beluga hunts. The corridor avoids important beluga hunting areas in Kasegaluk Lagoon. Shell has developed and proposes to implement a number of mitigation measures to ensure that any effects on the beluga whale as a subsistence resource, or effects on beluga subsistence hunts would be negligible. These mitigation measures, which include minimum flight altitudes, employment of subsistence advisors in the villages, and implementation of a Communications Plan (with operation of Communications and Call Centers), are described below in Section 12.3. Therefore, any behavioral responses of avoidance of activity areas by beluga in the Chukchi Sea would have no or negligible effect on the subsistence resource or subsistence hunts for beluga.

Seals. Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell's exploration drilling program would commence, but some harvest continues during open water and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer. Most seals are harvested in coastal waters, with available maps of recent and past subsistence use areas indicating seal harvests have occurred only within 30-40 mi (48-64 km) of the coastline. Shell lease blocks where exploration activities would occur are located more than 60 statute mi (97 km) offshore, so activities within the prospects, such as drilling, would have no impact on subsistence hunting for seals. Helicopter traffic between land and the offshore drilling operations could potentially disturb seals and, therefore, subsistence hunts for seals, but any such effects would be minor due to the small number of flights and the altitude at which they typically fly, and the fact that most seal hunting is done during the winter and spring. Any effects on subsistence hunts for seals would be negligible and temporary lasting only minutes after the flight has passed. Any effects on the seals as a subsistence resource, or effects on subsistence hunts for seals would be negligible. These mitigation measures, which include minimum flight altitudes, employment of subsistence advisors in the villages, and implementation of a Communications Plan (with operation of Communications and Call Centers), are described below in Section 12.3.

9. Anticipated impact on habitat:

Shell's planned 2010 exploration drilling program will not result in any permanent impact on habitats used by marine mammals, or to their prey sources. With regard to migrating cetaceans and seals, any effects would be temporary and of short duration at any one place. The primary potential impacts to all marine mammals are associated with elevated sound levels from exploration drilling operations, its support vessels, and aircraft. The effects to habitat of marine mammals by sounds from the planned drilling program are expected to be negligible.

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

The level of sound at which a fish will react or alter its behavior is usually well above the detection level. Fish have been found to react to sounds when the sound level increased to about 20 dB above the detection level of 120 dB re 1 μPa (Ona 1988); however, the response threshold can depend on the time of year and the fish's physiological condition (Engas et al. 1993). In general, fish react more strongly to pulses of sound rather than a continuous signal (Blaxter et al. 1981), and a quicker alarm response is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level.

Investigations of fish behavior in relation to vessel noise (Olsen et al. 1983; Ona 1988; Ona and Godo 1990) have shown that fish react when the sound from the engines and propeller exceeds a certain level. Avoidance reactions have been observed in fish such as cod and herring when vessels approached close enough that received sound levels are 110 dB to 130 dB (Nakken 1992; Olsen 1979; Ona and Godo 1990; Ona and Toresen 1988). However, other researchers have found that fish such as polar cod, herring, and capeline are often attracted to vessels (apparently by the noise) and swim toward the vessel (Rostad et al. 2006). Typical sound source levels of vessel noise in the audible range for fish are 150 dB to 170 dB re 1 μPa/Hz (Richardson et al. 1995a). In calm weather, ambient noise levels in audible parts of the spectrum lie between 60 dB to 100 dB re 1 μPa.

Ice management would be expected to produce the most intense sounds associated with exploration drilling. Reported source levels for vessels during ice management have ranged from 175 dB to 185 dB (Brewer et al. 1993, Hall et al. 1994). Sound pressures generated while drilling have been measured during past exploration in the Beaufort and Chukchi Seas. Based on these measurements the *Discoverer* is expected to generate sound levels up to about 140 dB (Table 2.8-1; Greene 1985, 1987a). Sounds generated by drilling and ice management are generally low frequency, and within the frequency range detectable by most fish.

Based on reported source levels and ambient sound levels of 80-100 dB, there may be some avoidance by fish of the area near the drillship while drilling. Any reactions by fish to these sounds will last only minutes (Mitson and Knudsen 2003; Ona et al. 2007) longer than the vessel is operating at that location or the drillship is drilling, and would be limited to a relatively small area within about 0.9 mi (1.4 km) of the drillship during drilling based on the modeled 120dB isopleth. Avoidance by some fish could occur within portion of these areas. No important spawning habitats are known to occur at or near the drilling locations. Effects of sound generation on fish will therefore be negligible, localized, and short term. Likewise, the impact to fish as a prey species for odontocetes or seals will therefore be negligible.

10. Anticipated impact of habitat loss or modification:

The effects of the planned exploration drilling program are expected to be negligible. It is estimated that only a small portion of the animals utilizing the areas of the planned program would be temporarily displaced. During the period of the exploration drilling program (July 4-October 31st), most marine mammals would be dispersed throughout the area. The peak of the bowhead whale migration through the Chukchi Sea typically occurs in September and October. Again, some bowheads might be temporarily displaced around the drilling operation during this time. The numbers of cetaceans and seals subject to displacement, if any, would be extremely few 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 Chukchi Sea in most years. 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 planned drilling program is 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 program.

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:

Details of the planned mitigations are discussed in the Marine Mammal Monitoring and Mitigation Plan (4MP; Attachment B).

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

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

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

The POC identifies the measures that Shell has developed in consultation with North Slope subsistence communities and will implement during its planned 2010 Beaufort Sea and Chukchi Sea exploration drilling programs to minimize any adverse effects on the availability of marine mammals for subsistence uses. In addition, the POC details Shell's communications and consultations with local subsistence communities concerning its planned 2010 exploration drilling program, potential conflicts with subsistence activities, and means of resolving any such conflicts (50 CFR § 18.128(d) and 50 CFR § 216.104(a) (12) (i), (ii), (iv)). Shell has documented its contacts with the North Slope subsistence communities, as well as the substance of its communications with subsistence stakeholder groups.

The leases within the Burger, SW Shoebill and Crackerjack Prospects were acquired during the Chukchi Sea Oil and Gas Lease Sales 193 held in February 2008. During the 2010 drilling program Shell plans to drill up to three exploration wells on three of seven leases (Table 1-1). All drilling is planned to be near vertical.

Shell's 2010 Chukchi Sea exploration drilling program, which is planned for the Burger, Crackerjack, and SW Shoebill prospects in the Chukchi Sea (Figure 1-1), is set-out in detail in the Chukchi Sea EP and the impacts of the project, as well as the measures Shell will implement to mitigate those impacts, are analyzed in the Chukchi Sea EIA. Shell will implement this POC, and the mitigation measures set-forth herein, for both its Beaufort and Chukchi exploration programs.

The affected subsistence communities that were consulted regarding Shell's 2010 activities include: Barrow, Wainwright, Kotzebue, Kivalina, Point Lay and Point Hope. Several one-on-one meetings were also held throughout the villages.

Beginning in early January 2009, Shell held one-on-one meetings with representatives from the North Slope Borough (NSB) and Northwest Arctic Borough (NWAB), subsistence-user group leadership, and Village Whaling Captain Association representatives. These meetings took place at the convenience of the community leaders and in various venues. Meetings were held starting on the 12th of January 2009 and continuing through April of 2009. Shell's primary purpose in holding individual meetings was to inform key leaders, prior to the public meetings, so that they would be prepared to give appropriate feedback on planned activities.

Due to a death in the community, the scheduled meeting in Point Lay had to be postponed after receipt of a request by the Mayor. A meeting with the Point Lay community leadership did occur on June 2, 2009 during which the Chukchi Sea 2010 exploration plan was discussed. Shell also presented the proposed project to NWAB Assembly on January 27, to the NSB Assembly on February 2 and to the NSB and NWAB Joint Planning Commission Meeting on March 25. Since this IHA application submission, Shell has successfully completed POC meeting with several communities. The meetings include:

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

All engagements were directed towards discussing Shell's planned 2010 drilling activities in the Chukchi Sea.

Shell will meet at least twice each year with the commissioners and committee heads of ABC, the Nanuuq Commission, Eskimo Walrus Commission (EWC), and Alaska Ice Seal Commission (AISC) jointly in co-management meetings. Following the drilling season, Shell will have a post-season co-management meeting with the commissioners and committee heads to discuss results of mitigation measures and outcomes of the preceding season. The goal of the post-season meeting is to build upon the knowledge base, discuss successful or unsuccessful outcomes of mitigation measures, and possibly refine plans or mitigation measures if necessary.

Shell also attended the 2009 Conflict Avoidance Agreement (CAA) negotiation meetings in support of its 2009 Shallow Hazards surveys taking place in the Chukchi Sea. Shell is committed to a CAA process and will demonstrate this by making a good-faith effort to negotiate an agreement every year it has planned activities. Shell will also hold an additional round of POC meetings prior to drilling in 2010, reflecting the mitigation measures developed as a result of the first round of POC meetings.

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

Beginning in early January 2009, Shell held one-on-one meetings with representatives from NSB and NWAB, subsistence-user group leadership, and Village Whaling Captain Association representatives. These meetings took place at the convenience of the community leaders and in various venues. Meetings were held starting on the 12th of January 2009 and continuing through April of 2009. Shell's primary purpose in holding individual meetings was to inform key leaders, prior to the public meetings, so that they would be prepared to give appropriate feedback on planned activities.

The affected subsistence communities that were consulted regarding Shell's 2010 activities include: Barrow, Wainwright, Kotzebue, Kivalina, Point Lay and Point Hope. Several one-on-one meetings were also held throughout the villages.

Shell conducted POC community meetings in the Chukchi Sea villages of Wainwright, Point Hope, and Point Lay, Kivalina, and Kotzebue regarding its Chukchi Sea 2010 exploration drilling program. During these meetings, Shell focused on lessons learned from prior years activities and presented mitigation measures for avoiding potential conflicts, which are outlined in the 2010 POC.

Shell has facilitated quarterly meetings with the co-management groups including the Alaska Eskimo Whaling Commission (AEWC), Alaska Beluga Whale Committee, the EWC, the AISC, and the Alaska Nanuuq Commission beginning in June 2006, continuing in June, September, and December 2007, and February, March, May, June, and November 2008. Shell plans to meet with these co-management groups before the end of 2009 to discuss potential conflicts that could arise with the siting, timing, and method of planned operations and mitigation measures regarding the planned 2010 exploration drilling activities.

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

The following mitigation measures, plans and programs, are integral to this POC and were developed during consultation with potentially affected subsistence groups and communities. These measures, plans, and programs will be implemented by Shell during its 2010 exploration drilling operations in both the Beaufort and Chukchi Seas to monitor and mitigate potential impacts to subsistence users and resources. The mitigation measures Shell has adopted and will implement during its 2010 Camden Bay and Chukchi Sea exploration drilling operations are listed and discussed below. These mitigation measures reflect Shell's experience conducting exploration activities in Alaska over the last three years and its ongoing efforts to engage with local subsistence communities to better understand their concerns and develop appropriate and effective mitigation measures to address those concerns. This most recent version of Shell's planned mitigation measures was presented to community leaders and subsistence user groups starting in January of 2009 and has evolved since in response to information learned during the consultation process.

Subsistence Mitigation Measures

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

- The drillship and associated support vessels will not enter the Chukchi Sea before July 1 unless authorized by the USFWS based upon a review of seasonal ice conditions and other factors [see 50 CFR 18.118 (a)(3)(i)] to minimize effects on marine mammals and birds that frequent open leads and to minimize effects on spring bowhead whale or beluga hunting.
- To minimize impacts on marine mammals and subsistence hunting activities, vessels that can safely travel outside of the polynya zone will do so, unless it is necessary to break ice (as opposed to managing ice by pushing it out of the way) or if sea state conditions require an alternative route. Shell will notify the local communities of any change in the transit route through the Com Centers. In all cases, vessel transits will follow a route that allows for the highest degree of safety regarding ice conditions and sea states.
- Shell has developed a Communication Plan and will implement the plan before initiating exploration drilling operations to coordinate activities with local subsistence users as well as Village Whaling Associations in order to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale migration, as well as the timing and status of other subsistence hunts. The Communication Plan includes

procedures for coordination with Communication and Call Centers to be located in coastal villages along the Chukchi and Beaufort Seas during Shell's proposed activities in 2010.

- Shell will employ local Subsistence Advisors from the Beaufort and Chukchi Sea villages to provide consultation and guidance regarding the whale migration and subsistence hunts. A total of nine subsistence advisor-liaisons (one per village) will be hired to work approximately 8-hours per day and 40-hour weeks through Shell's 2010 exploration project. The subsistence advisor will use Traditional Knowledge (TK) to gather data on subsistence lifestyle within the community and advise as to ways to minimize and mitigate potential impacts to subsistence resources during the drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; and advising how to avoid subsistence conflicts. A subsistence advisor handbook will be developed prior to the operational season to specify position work tasks in more detail.
- Shell will recycle drilling muds (e.g., use those muds on multiple wells), to the extent practicable based on operational considerations (e.g., whether mud properties have deteriorated to the point where they cannot be used further), to reduce discharges from its operations. At the end of the season excess water base fluid, approximately 1,500 barrels will be pre-diluted to a 30:1 ratio with seawater and then discharged.

Shell will also implement flight restrictions prohibiting aircraft from flying within 1,000 ft (300 m) of marine mammals or below 1,500 ft (457 m) altitude (except during takeoffs and landings, in emergency situations, or for MMO overflights) while over land or sea.

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 planned marine mammal monitoring and mitigation program for the exploration drilling program for 2010 is included as Attachment B and this document addresses the issues in item 13.

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 Chukchi Sea during the course of the 2010 drilling season. It is unclear if these studies might be relevant to Shell's planned exploration drilling program. Shell is prepared to share information obtained during implementation of our marine mammal monitoring and mitigation program with a variety of groups who may find the data useful in their research. A suggested list of recipients includes:

- The NSB Department of Wildlife Management (T. Hepa)

- The USFWS Office of Marine Mammal Management (C. Perham and J. Garlic-Miller)
- The MMS's Bowhead Whale Aerial Survey Program (C. Monnett)
- The Kuukpik Subsistence Oversight Panel
- Alaska Eskimo Whaling Commission (H. Brower -Barrow)
- Beluga Whale Committee (W. Goodwin -Kotzebue)
- Inupiat Community of the Arctic Slope (Martha Ipalook Faulk -Barrow)
- North Slope Science Initiative (J. Payne)
- MMS Field Supervisor (Jeff Walker)
- National Marine Mammal Laboratory (R. Angliss)
- Alaska Department of Natural Resources (D. Perrin)
- Alaska Department of Fish and Game

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Attachment A
Equipment Specifications

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FRONTIER DISCOVERER SPECIFICATIONS

TYPE-DESIGN	Drillship - Sonat Offshore Drilling Discoverer Class
SHAPE	Monohull with sponsons added for ice resistance
SHIP BUILDERS & YEAR	Namura Zonshno Shipyard, Osaka, Japan - hull number 355
YEAR OF HULL CONSTRUCTION	1965
YEAR OF CONVERSION	1976
DATE OF LAST DRY-DOCKING	2007

FRONTIER DISCOVERER DIMENSIONS

LENGTH	514 ft	156.7 meters (m)
LBP	486 ft	148.2 m
MAX HEIGHT (ABOVE KEEL)	274 ft	83.7 m
HEIGHT OF DERRICK ABOVE RIG FLOOR	175 ft	53.3 m

FRONTIER DISCOVERER MOORING EQUIPMENT

Anchor pattern symmetric 8 points system. The unit is fitted with Sonat Offshore Drilling patented roller turret mooring system giving the unit the ability to maintain favorable heading without an interruption of the drilling operations

ANCHORS	Stevpris New Generation 7,000 kilograms (kg) ea; 15,400 pounds (lb) ea
ANCHOR LINES	Chain Wire Combination
SIZE/GRADE	2-3/4" wire 3" ORQ Chain
LENGTH	2,450 ft (747 m) wire, 1,150 ft (351 m) chain (useable) per anchor

FRONTIER DISCOVERER OPERATING WATER DEPTH

MAX WATER DEPTH	1,000 ft with present equipment (can be outfitted to 2,500 ft)
MAX DRILLING DEPTH	20,000 ft

FRONTIER DISCOVERER DRILLING PACKAGE

DRAW WORKS	Ideco E-2,100, 1,600 hp
ROTARY	National C-495 with 49-1/2" opening
MUD PUMPS	2 x Continental Emsco Model FB-1600 Triple Mud Pumps
DERRICK	Pyramid 170 ft. with 1,300,000 lbs nominal capacity
PIPE RACKING	BJ 3 arm system
DRILL STING COMPENSATOR	Shaffer 400 K x 18 ft stroke
RISER TENSIONS	8 x 80k Shaffer 50 ft stroke tensioners
CROWN BLOCK	Pyramid with 9 each 60" diameter sheaves rated at 1,330,000 lbs
TRAVELING BLOCK	Continental - Emsco RA60-6
BOP	Cameron 18-3/4" x 10,000 psi
RISER	Cameron RCK type
TOP DRIVE	Varco TDS-3S, with GE-752 motor, 500 ton
BOP HANDLING	Hydraulic skid based system, drill floor

FRONTIER DISCOVERER DISPLACEMENT

FULL LOAD	20,253 Metric Tons (mt)
DRILLING	18,780 mt (Drilling, max load, deep hole, deep water)

FRONTIER DISCOVERER DRAUGHT

DRAFT AT LOAD LINE	27 ft	8.20 m
TRANSIT	(fully loaded, operating , departure)	8.02 m
DRILLING		7.67 m

FRONTIER DISCOVERER HELIDECK

MAXIMUM HELICOPTER SIZE	Sikorsky 61N & 92N
FUEL STORAGE	2 ea 720 gallon tanks

FRONTIER DISCOVERER ACCOMODATIONS

NUMBER OF BEDS	124
SEWAGE TREATMENT UNIT	Hamworthy ST-10

FRONTIER DISCOVERER PROPULSION EQUIPMENT

PROPELLER	1 ea 15' 7" diameter, fixed blade
PROPULSION DRIVE UNIT	Marine Diesel, 6 cylinder, 2 cycle, Crosshead type
HORSEPOWER	7,200 hp @ 135 RPM

GENERAL STORAGE CAPACITIES

SACK STORAGE AREA	934 cubic meters (m^3)
BULK STORAGE BENTONITE/BARITE	180 m^3 - 4 tanks
BULK CEMENT	180 m^3 - 4 tanks
LIQUID MUD	
Active	1,200 Barrels (bbls)
Reserve	1,200 bbls
Total	2,400 bbls
POTABLE WATER	1,670 bbls / 265.5 m^3 (aft peak can be used as add. pot water tank)
DRILL WATER	5,798 bbls / 921.7 m^3
FUEL OIL	6,497 bbls / 1,033 m^3 (2S, 2P, 3S, 3P, 4S and 4P upper wings can be used as additional fuel storage or well test crude tankage)

TRANSIT SPEED	8 knots

Attachment B
Marine Mammal Monitoring and Mitigation Plan (4MP)

MARINE MAMMAL MONITORING AND MITIGATION PLAN

for

Exploration Drilling of Selected Lease Areas in the Alaskan Chukchi Sea

Shell Gulf of Mexico Inc.

Original Submission May 2009
Revised Submission December 2009
Second Revised Submission April 2010

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ACRONYMS

4MP	Marine Mammal Monitoring and Mitigation Plan
AEWC	Alaska Eskimo Whaling Commission
dB	decibel
CD	Compact Disc
GPS	Global Positioning System
ft	feet
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
km	kilometer
LOA	Letter of Authorization
m	meter(s)
mi	mile(s)
MMO	Marine Mammal Observer
MMS	Minerals Management Service
NMFS	National Marine Fisheries Service
NSB	North Slope Borough
NVD	Night-vision Device
rms	Root Mean Square
Scripps	Scripps Institute of Oceanography
Shell	Shell Gulf of Mexico Inc.
SPL	Sound Pressure Level
USFWS	U.S. Fish and Wildlife Service

INTRODUCTION

Shell Gulf of Mexico Inc. (Shell) will conduct a Marine Mammal Monitoring and Mitigation Plan (4MP) for exploration drilling activities in the Chukchi Sea during the 2010 drilling season. The 4MP developed for Shell's 2010 exploration drilling program 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 establishes a means for gathering additional baseline data on marine mammals for future operations planning.

Shell plans to conduct exploration drilling within existing lease holdings in the Chukchi Sea. Drilling will be conducted from the M/V *Discoverer* drillship owned by Frontier Drilling. The drillship is an ice-class drilling vessel designed, engineered and constructed to safely operate in the Chukchi Sea. The support vessels will include tugs and barges, an ice management vessel, an anchor handler/ice management vessel, and oil spill response vessels.

Shell's 4MP is a combination of active monitoring of the area of operations and the implementation of mitigation measures designed to minimizing project impacts to marine mammal resources. Monitoring will provide information on the numbers of marine mammals potentially affected by the exploration operations and facilitate real time mitigation to prevent injury of marine mammals by industrial sounds or activities. These goals will be accomplished by conducting vessel-based, aerial, and acoustic monitoring programs to characterize the sounds produced by the drilling activities and support vessels, and to document the potential reactions of marine mammals in the area to those sounds and activities.

Aerial monitoring and reconnaissance of marine mammals in coastal areas of the Chukchi Sea and recordings of ambient sound levels and vocalizations of marine mammals along the Chukchi Sea coast will be used to interpret potential impacts to marine mammals in subsistence use areas. Acoustic measurements will be made to establish safety radii for real time mitigation, if necessary, around the activities. These measurements will be used to determine the sound levels produced by various equipment and to establish any safety and disturbance radii if necessary. An initial sound source analysis will be supplied to NMFS within 120 hours of completion of the measurements, if possible. A detailed report will be issued to NMFS as part of the 90-day report following the end of the drilling season. Shell will continue to measure the sound propagation of the drillship at various times or throughout the drilling program. Sound energy from support vessels will also be measured. Bottom-founded hydrophones will also be placed in a large array across the Chukchi Sea to collect information on the use of the region by marine mammals and additional information on the propagation of sounds from human activities.

VESSEL-BASED MARINE MAMMAL MONITORING PROGRAM

Introduction

The vessel-based operations of Shell's 4MP are designed to meet the requirements of the IHA and the LOA which Shell expects to be issued by the NMFS and the USFWS, respectively, and to meet any other agreements between Shell and other agencies or groups. The objectives of the program will be to ensure that disturbance to marine mammals and subsistence hunts is minimized, that effects on marine mammals are documented, and to collect baseline data on the occurrence and distribution of marine mammals in the project area.

The 4MP will be implemented by a team of experienced marine mammal observers (MMOs). These MMOs will be trained, experienced field observers, including both biologists and Inupiat personnel. The MMOs will be stationed aboard the drillship and associated support vessels throughout the drilling period. The duties of the MMOs will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the drilling operations; initiating mitigation measures when appropriate; and reporting the results. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of marine mammal "takes" as defined by the NMFS and stipulated in the IHA.

The vessel-based operations of Shell's 4MP will be required to support the vessel based drilling activities in the Chukchi Sea. The dates and operating areas will depend upon ice and weather conditions, along with Shell's arrangements with agencies and stakeholders. Drilling activities are expected to occur from July through October 2010, or intermittently during that time. Vessel-based monitoring for marine mammals will be done throughout the period of drilling operations to comply with provisions in the anticipated IHA and LOA from NMFS and USFWS, respectively.

The vessel-based work will provide:

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

The 4MP will be operated and administered consistent with monitoring programs conducted during seismic and shallow hazards surveys in 2006–2008 or such alternative requirements as may be specified in the permits issued to Shell for this project. Any other agreements between Shell and agencies or groups such as MMS, USFWS, the North Slope Borough (NSB), and the Alaska Eskimo Whaling Commission (AEWC) will also be fully incorporated. All MMOs will be provided training through a program approved by NMFS and Shell, as described later. At least one observer on each vessel will be an Inupiat who will have the additional responsibility of communicating with the Inupiat community and (during the various subsistence harvests) directly with Inupiat hunters and whalers. Details of the vessel-based marine mammal monitoring program are described below.

Mitigation Measures during Drilling Activities

Shell's planned exploration drilling program incorporates both design features and operational procedures for minimizing potential impacts on marine mammals and on subsistence hunts. The design features and operational procedures have been described in the IHA and LOA applications submitted to NMFS and USFWS, respectively and are summarized below. Survey design features are

- timing and locating drilling and support activities to avoid interference with the annual subsistence hunting by the peoples of the Chukchi villages,
- conducting pre-season acoustic modeling to establish the appropriate safety zones and behavioral or disturbance radii,
- vessel-based monitoring to implement appropriate mitigation if necessary, and to determine the effects of project activities on marine mammals,
- acoustic monitoring of drilling and vessel sounds and marine mammal vocalizations.

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

Safety and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around industrial sound sources are customarily defined as the distances within which received pulse levels are ≥180 dB re 1 µPa (rms) for cetaceans and ≥190 dB re 1 µPa (rms) for pinnipeds. These safety criteria are based on an assumption that sound energy received at lower levels will not injure these animals or impair their hearing abilities, but that higher received levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the safety radii (Richardson et al. 1995). NMFS assumes that marine mammals exposed to underwater continuous sound levels ≥120 dB rms have the potential to be disturbed behaviorally.

Expected safety and disturbance radii based on sound propagation from the drillship *Discoverer* were modeled by JASCO Applied Sciences at the three potential well locations (JASCO, 2009). Changes in the water column of the Chukchi Sea through the course of the open-water season will likely affect the propagation of sounds produced by drilling activities, so models were run for expected oceanographic conditions in July and October to bracket the seasonal variability. These radii will be used for mitigation purposes, should they be necessary, until direct measurements are available early during the exploration drilling activities. Shell will measure the received levels of underwater sound versus distance and direction from the sound sources 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 and disturbance radii.

Sounds from the *Discoverer* have not previously been measured in the Arctic or elsewhere, but sounds from a similar drillship, *Explorer II*, were measured in the Beaufort Sea (Greene 1987; Miles et al. 1987). The underwater received sound pressure level in the 20 to 1000 Hz band for drilling activity by the *Explorer II*, including a nearby support vessel, was 134 dB re 1 µPa at 0.2 km (Greene 1987). The estimated source level from this measurement is 175 dB re 1 µPa (rms) for drilling. The source level from this measurement was used as a proxy for modeling the sounds likely to be produced by drilling activities from the *Discoverer* at the three potential well locations in the Chukchi Sea. Based on the models, source levels are expected to fall below 180 dB rms within tens of meters and below 160 dB rms within 100 m.

The source levels noted above for exploration drilling activities are not high enough to cause a temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals. Consequently, mitigation as described for seismic activities including ramp ups, power downs, and shut downs should not be necessary for drilling activities. However, Shell plans to use MMOs onboard the drillship and the various support vessels to monitor marine mammals and their responses to industry activities and to initiate mitigation measures should in-field measurements of the operations indicate conditions represent a threat to the health and well-being of marine mammals.

Marine Mammal Observers

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

Number of observers

A sufficient number of MMOs will be onboard each vessel to meet the following criteria

- 100 percent monitoring coverage during all periods of drilling operations in daylight
- maximum of four consecutive hours on watch per MMO
- maximum of approximately 12 hours on watch per day per MMO

MMO teams will consist of trained Inupiat and field biologist observers. An experienced field crew leader will be a member of every MMO team aboard the drillship and each support vessel during the drilling program. The total number of MMOs aboard may decrease later in the season as the duration of daylight decreases assuming NMFS does not require continuous nighttime monitoring. Inupiat MMOs will also function as Native language communicators with hunters and whaling crews and with the Communications and Call Centers (Com Centers) in Native villages along the Chukchi Sea coast.

Crew Rotation

Shell anticipates that there will be provision for crew rotation at least every three to six weeks to avoid observer fatigue. During crew rotations detailed hand-over notes will be provided to the incoming crew leader by the outgoing leader. Other communications such as email, fax, and/or phone communication between the current and oncoming crew leaders during each rotation will also occur when possible.[0] In the event of an unexpected crew change Shell will facilitate such communications to insure monitoring consistency among shifts.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers in 2010 will be individuals with experience as observers during one or more of the 2006–2009 monitoring projects for Shell or recent experience with other operators in Alaska or the Canadian Beaufort.

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

Most observers will also complete a two-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2010 drilling 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 seismic monitoring programs.

Primary objectives of the training include:

- review of the marine mammal monitoring plan for this project, including any amendments adopted, or specified by NMFS or USFWS in the IHA or LOA, by MMS, or other agreements in which Shell may elect to participate,
- review of marine mammal sighting, identification, and distance estimation methods, including any amendments specified by NMFS or USFWS in the 2010 IHA or LOA,
- review of operation of specialized equipment (reticle binoculars, night vision devices, and GPS system),
- review of, and classroom practice with, data recording and data entry systems, including procedures for recording data on mammal sightings, drilling 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 will be prepared for Shells's monitoring program. Handbooks contain maps, illustrations, and photographs as well as text and are intended to provide guidance and reference information to trained individuals who will participate as MMOs. The following topics will be covered in the MMO Handbook:

- summary overview descriptions of the project, marine mammals and underwater sound energy, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements, special studies), the NMFS IHA and USFWS LOA and other regulations/permits/agencies, the Marine Mammal Protection Act,
- monitoring and mitigation objectives and procedures, including initial safety radii,
- responsibilities of staff and crew regarding the marine mammal monitoring plan,
- instructions for ship crew regarding the marine mammal monitoring plan,

- data recording procedures: codes and coding instructions, common coding mistakes, electronic database; navigational, marine physical, and drilling 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 provided,
- suggested list of personal items to pack,
- suggested literature, or literature cited,
- copies of the NMFS IHA and USFWS LOA will be made available.

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the drillship and support vessels. The observer(s) will scan systematically with the naked eye and 7×50 reticle binoculars, supplemented with Big-eye binoculars and night-vision equipment when needed (see below). Personnel on the bridge will assist the marine mammal observer(s) in watching for pinnipeds and whales.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during previous monitoring projects (e.g., Moulton and Lawson 2002). When a mammal sighting is made, the following information about the sighting will be recorded:

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

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

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7×50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.

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

Monitoring At Night and In Poor Visibility

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

Specialized Field Equipment

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

Field Data-Recording, Verification, Handling, and Security

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

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

Field Reports

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

Reporting

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

The technical report(s) will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through study period for sea state, and other factors affecting visibility and detectability of marine mammals,
- analyses of the effects of various factors influencing detectability of marine mammals: 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 drilling operations:
    - sighting rates of marine mammals versus drilling activities (and other variables that could affect detectability),
    - initial sighting distances versus drilling state,
    - closest point of approach versus drilling state,
    - observed behaviors and types of movements versus drilling state,
    - numbers of sightings/individuals seen versus drilling state,
    - distribution around the drillship and support vessels versus drilling state,
    - estimates of "take by harassment".

ACOUSTIC MONITORING PLAN

Drilling Sound Measurements

Objectives

Drilling sounds are expected to vary significantly with time due to variations in the level of operations and the different types of equipment used at different times onboard the drillship. The goals of these measurements are (1) to quantify the absolute sound levels produced by drilling and to monitor their variations with time, distance and direction from the drillship, and (2) to measure the sound levels produced by vessels operating in support of drilling operations. These vessels will include crew change vessels, tugs, ice-management vessels, and spill response vessels.

Equipment

The drilling and support vessel sound measurements will be performed using one of two methods, both of which involve real-time monitoring. The first method would involve use of bottom-founded hydrophones cabled back to the drillship (Fig. 2). These hydrophones weigh approximately 88 lbs (40 kilograms) with a footprint of approximately 2.7 square feet (0.5 square meters) and would be positioned between 500 m and 1000 m from the drillship, depending on the final positions of the anchors used to hold the drillship in place. Hydrophone cables would be fed to real-time digitization systems on board. In addition to the cabled system, a separate set of bottom-founded hydrophones (Fig. 3) may be deployed at various distances from the drilling operation for storage of acoustic data to be retrieved and processed at a later date.

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

Sound level monitoring with either method will occur on a continuous basis throughout all drilling activities. Both types of systems will be set to record digital acoustic data at sample rate 32 kHz, providing useful acoustic bandwidth to at least 15 kHz. Both the hydrophone systems use Reson TC4032 hydrophones with sensitivity -170 dB re V/μPa. These systems are capable of measuring absolute broadband sound levels between 90 and 180 dB re μPa. The long duration recordings will capture many different operations performed at the drillship. Retrieval of these systems will occur following completion of the drilling activities.

The deployment of drilling sound monitoring equipment will occur as soon as possible once the drillship is on site at any of the prospects where Shell intends to drill an exploration well. Retrieval of these systems will occur following completion of the drilling activities. The long duration recordings will capture many different operations performed at the drillship. Accurate activity logs of drilling operations and nearby vessel activities will be maintained to correlate with these acoustic measurements.

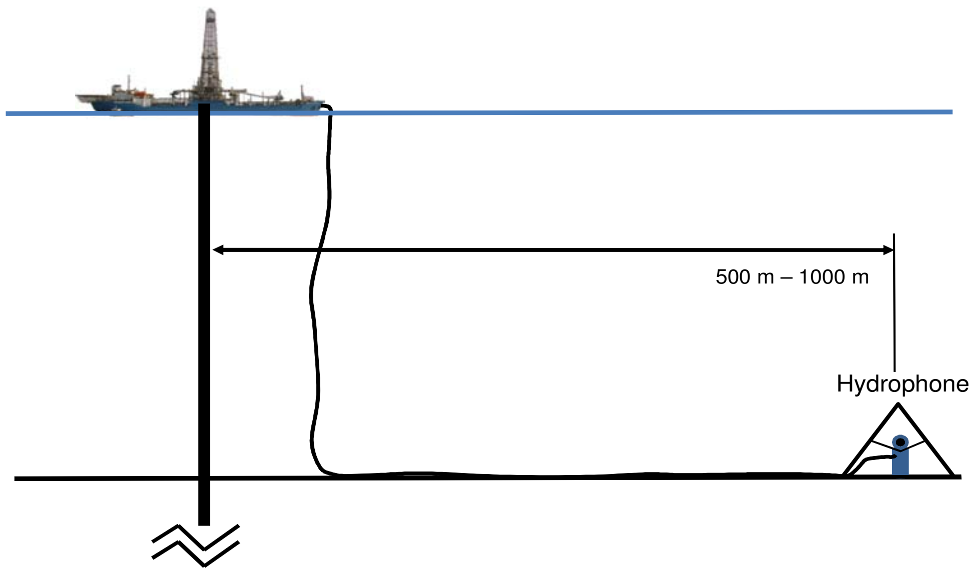

Figure 2: Cabled hydrophone method for real time monitoring of drilling sound energy.

Figure 3: Hydrophone recording system being deployed at sea. The hydrophone system is an autonomous recorder with very high recording resolution. Acoustic data is stored internally on a hard-drive.

Vessel Sounds Monitoring

Sound produced by the vessels supporting drilling operations will be recorded by the drilling sounds monitoring equipment. Logs of vessel position and activity will be used to determine the time varying contribution of each vessel to the overall sound level measurements. Additional dedicated measurements of vessel source levels will be obtained by having the vessels perform sail-pasts of the monitoring locations. These dedicated measurements will provide sound level versus distance from the respective vessels and will also be processed to compute source levels in 1/3-octave bands referenced to 1m range.

Acoustic Data Analyses

Drilling sound data will be analyzed to extract a record of the frequency-dependent sound levels as a function of time. Figure 4 shows the results of this type of analysis. These results are useful also for correlating measured sound energy events with specific survey operations and capturing marine mammal vocalizations. The analysis provides absolute sound levels in finite frequency bands that can be tailored to match the highest-sensitivity hearing ranges for species of interest. For example, bowhead hearing is thought to be most acute in the 100 Hz - 1000 Hz frequency range that corresponds with the blue dotted line in the upper plot of Figure 4.

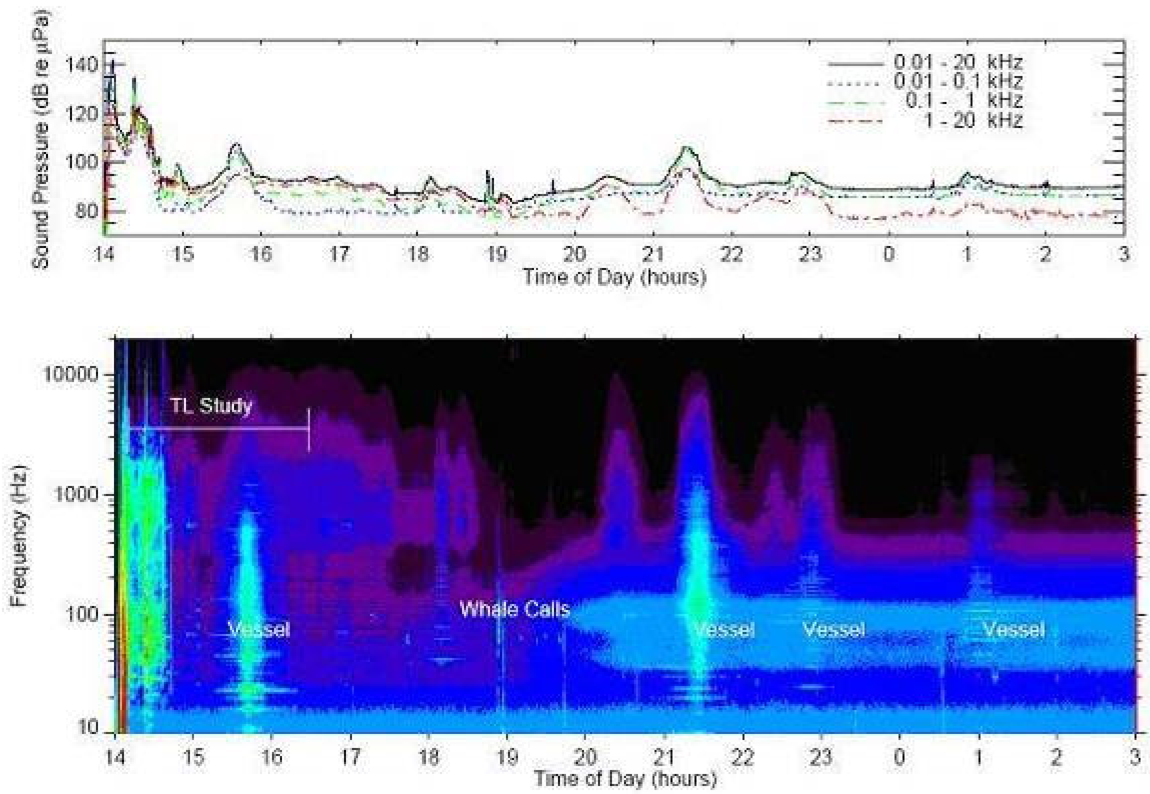

Figure 4: Lower: spectrogram of sound level measurements obtained from a hydrophone recording system. Upper: broadband and selected band level variation with time.

The analyses will also consider sound level integrated through 1-hour durations (referred to as sound energy equivalent level Leq (1-hour). Figure 5 (upper) shows an example of a Leq analysis of hydrophone data. Similar graphs for long time periods will be generated as part of the data analysis performed for indicating drilling sound variation with time in selected frequency bands.

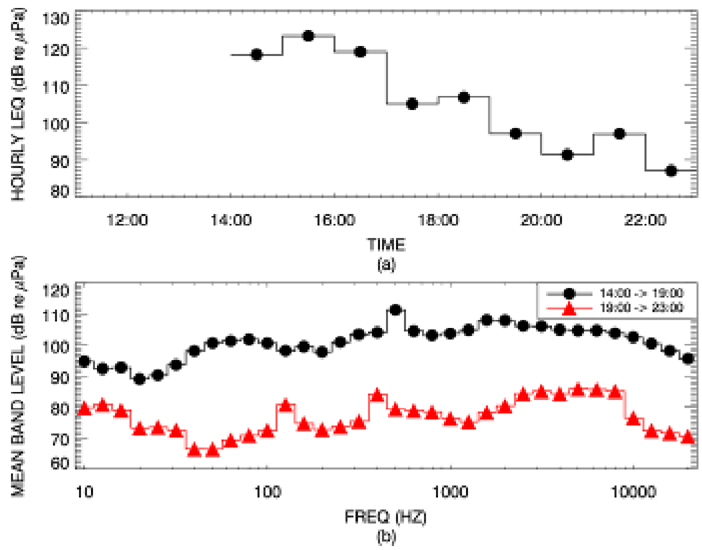

Figure 5: Upper: 1-hour Leq levels that will be calculated from acoustic measurements for use in correlating with bowhead whale deflection data.

Reporting of Results

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

- sound source levels for the drillship and all drilling support vessels,
- spectrogram and band level versus time plots computed from the continuous recordings obtained from the hydrophone systems,
- hourly Leq levels at the hydrophone locations,
- correlation of drilling source levels with the type of drilling operation being performed. These results will be obtained by observing differences in drilling sound associated with differences in the drill rig activity as indicated in detailed drillship logs.

JOINT INDUSTRY STUDIES PROGRAM

This section describes studies that were undertaken from 2006 through 2008 in the Chukchi Sea that will be continued during drilling operations in 2010. Shell plans to conduct aerial surveys consistent with the previous 2006–2008 programs along the Chukchi Sea coast. Additionally, the acoustic net array similar to the one deployed in 2008 will be used to monitor industry sounds and marine mammals across the Chukchi Sea and along coast. Additional recorders will be deployed in the area around any of the prospects where Shell intends to drill.

Chukchi Sea Coastal Aerial Survey

Recent aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 miles (mi) [37 kilometers (km)] offshore in 2006–2008 in support of Shell's summer seismic exploration. These surveys provided data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell plans to conduct an aerial survey program in the Chukchi Sea in 2010 that will be similar to the 2006–2008 programs.

Alaskan Natives from several villages along the east coast of the Chukchi Sea hunt marine mammals during the summer and Native communities are concerned that offshore oil and gas exploration activities may negatively impact their ability to harvest marine mammals. Of particular concern are potential impacts on the beluga harvest at Point Lay and on future bowhead harvests at Point Hope, Point Lay, Wainwright and Barrow. Other species of concern in the Chukchi Sea include the gray whale, bearded, ringed, and spotted seals, and walrus. Gray whale and harbor porpoise are expected to be the most numerous cetacean species encountered during the proposed aerial survey, although harbor porpoise are difficult to detect from aircraft. Beluga whales may occur in high numbers early in the season. The ringed seal is likely to be the most abundant pinniped species. The current aerial survey program will be designed to collect distribution data on cetaceans but will be limited in its ability to collect similar data on pinnipeds.

Objectives

The aerial survey program will be conducted in support of the Shell drilling program in the Chukchi Sea during summer and fall of 2010. The objectives of the aerial survey are:

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

Survey Considerations

With agreement from hunters in the coastal villages, aerial surveys of coastal areas to approximately 23 mi (37 km) offshore between Point Hope and Point Barrow will begin in early to mid-July and will continue until drilling operations in the Chukchi Sea are completed. Weather and equipment permitting, surveys will be conducted twice per week during this time period. In addition, during the 2010 drilling season, aerial surveys will be coordinated in cooperation with the aerial surveys funded by MMS and conducted by NMFS and any other groups conducting surveys in the region.

Survey Procedures

Transects will be flown in a saw-toothed pattern between the shore and 23 mi (37 km) offshore as well as along the coast from Point Barrow to Point Hope (Fig. 6). This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore region. The surveyed area will include waters where belugas are normally available to subsistence hunters. Survey altitude will be at least 1,000 ft (305 m) with an average survey speed of 110–120 knots. Sawtooth transects were designed by placing transect start/end points every 34 mi (55 km) along the offshore boundary of this 23 mi (37 km) wide nearshore zone, and at midpoints between those points along the coast. The transect line start/end points will be shifted along both the coast and the offshore boundary for each survey based upon a randomized starting location, but overall survey distance will not vary substantially. The coastline transect will simply follow the coastline or barrier islands. As with past surveys of the Chukchi Sea coast, coordination with coastal villages to avoid disturbance of the beluga whale subsistence hunt will be extremely important. “No-fly” zones around coastal villages or other hunting areas established during communications with village representatives will be in place until the end of the hunting season.

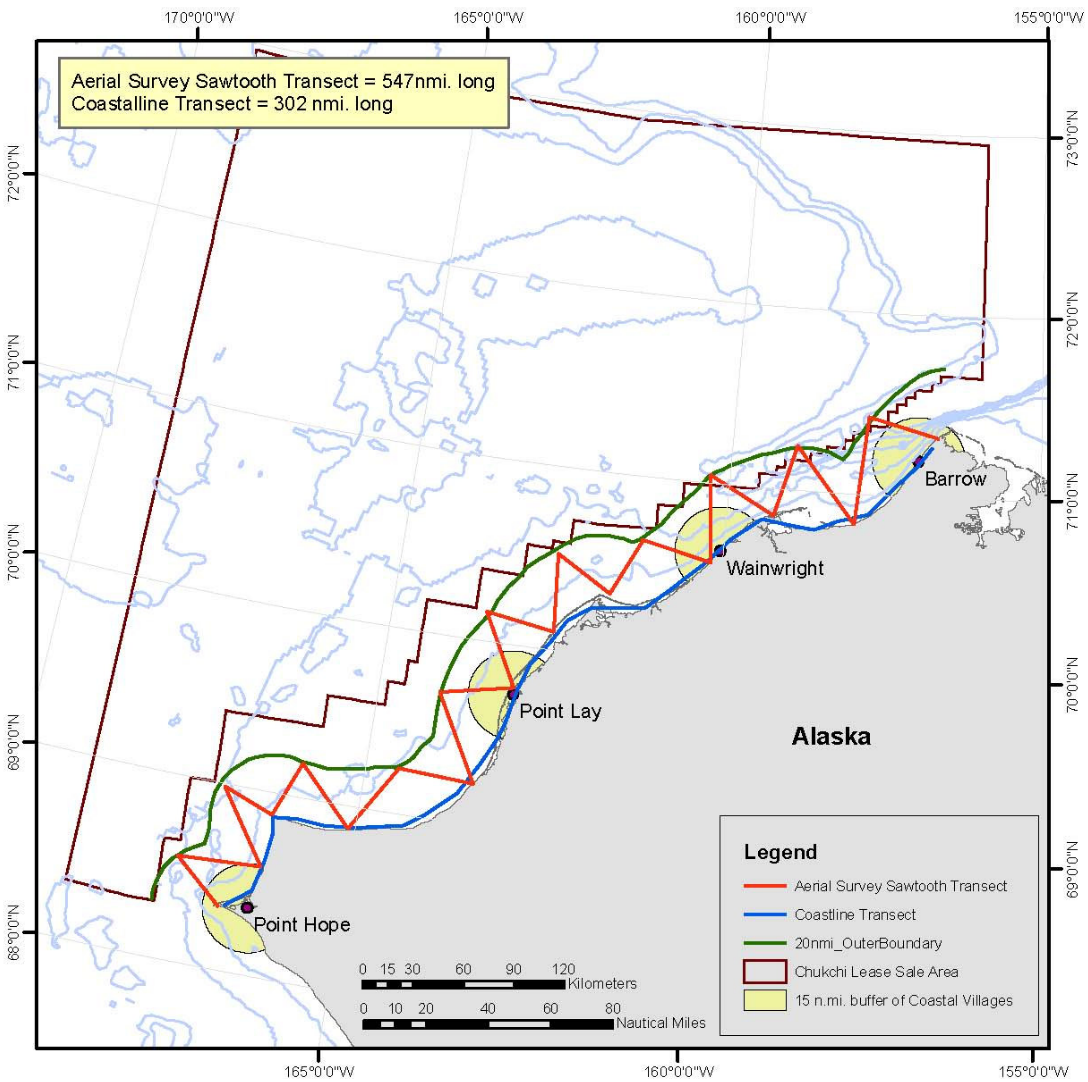

Figure 6. Aerial survey transects location and general pattern for the eastern Chukchi Sea, 2010. Specific transect start-/end-points will be altered randomly from survey to survey, and hunting areas will be avoided when hunting is occurring.

Standard aerial survey procedures used in previous marine mammal projects (by Shell as well as by others) will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize controversy about the chosen survey procedures. The aircraft will be flown at 110–120 knots ground speed and usually at an altitude of 1,000 ft (305 m). In accordance with anticipated stipulations in the LOA, survey aircraft will be flown at 1500 ft (457 m) over the Ledyard Bay spectacled eider habitat after 1 July. Aerial surveys at an altitude of 1,000 ft (305 m) do not provide much information about seals but are suitable for bowhead, beluga, and gray whales. The need for a 1,000+ ft (305+ m) cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher altitude for surveys would result in a significant reduction in the number of days during which surveys would be possible, impairing the ability of the aerial program to meet its objectives.

If large concentrations of belugas are encountered during the survey, the survey may be interrupted to photograph the groups to obtain better counts of the number of animals present. If whales are photographed in lagoons or other shallow-water concentration areas, the aircraft will climb to ~10,000 ft (3,050 m) altitude to avoid disturbing the whales and cause them to leave the area. If whales are in offshore areas, the aircraft will climb high enough to include all whales within a single photograph; typically about 3,000 ft (914 m) altitude. When in shallow water, belugas and other marine mammals are more sensitive to aircraft over flights and other forms of disturbance than when they are offshore (see Richardson et al. 1995 for a review). They frequently leave shallow estuaries when over flown at altitudes of 2,000–3,000 ft (610-904 m), whereas they rarely react to aircraft at 1,500 ft (457 m) when offshore in deeper water. Additionally, if large groups of other marine mammals are encountered on the surveys, such as the large aggregations of walruses seen in 2007, we will attempt to photograph the animals and provide location information to interested stakeholders.

Three MMOs will be aboard the aircraft during surveys. Two observers will be looking for marine mammals within 2.5 km of the survey track line; one each at bubble windows on either side of the aircraft. The third person will record data. When sightings are made, observers will notify the data recorder of the species or species class of the animal(s) sighted, the number of animals present, and the lateral distance (inclinometer angle) of the animals from the flight path of the aircraft. This information, along with time and location data from an onboard GPS, will be entered into a database.

At the start of each transect, the primary observer will record the transect start time and position, ceiling height (ft), cloud cover (in 10ths), wind speed (knots), wind direction (°T) and outside air temperature (°C). In addition, each observer will record the time, visibility (subjectively classified as excellent, good, moderately impaired, seriously impaired or impossible), sea state (Beaufort wind force), ice cover (in 10ths) and sun glare (none, moderate, severe) at the start and end of each transect, and at 2-min intervals along the transect. This will provide data in units suitable for statistical summaries and analyses of effects of these variables on the probability of detecting animals (see Davis et al. 1982; Miller et al. 1999; Thomas et al. 2002, Manly et al. 2004).

The data logger will automatically record time and aircraft position (latitude and longitude) for sightings and transect waypoints, and at pre-selected intervals along the transects. The primary data logger will be a laptop computer with Garmin Mapsource (ver 6.9) GPS software. Mapsource automatically stores the time and aircraft position at pre-selected intervals (typically at 6 seconds for straight-line transect surveys) and stores the records to a file as they are obtained.

Coordination with Other Aerial Surveys

The MMS, the NMFS, the NSB, or other organizations may conduct aerial surveys in the Chukchi Sea during the drilling season. Shell will consult with any groups or organizations conducting aerial surveys along the eastern Chukchi Sea coast regarding coordination during the drilling season. The objectives will be:

- to ensure aircraft separation when both crews conduct surveys in the same general region,
- to coordinate the 2010 aerial survey projects in order to maximize consistency and minimize duplication,
- to maximize consistency with previous years' efforts insofar as feasible.

Analysis of Aerial Survey Data

During the field program, preliminary maps and summaries of the daily surveys will be provided to NMFS as normally required by the terms of the IHA. While in the field data will be checked for entry errors and files will be backed up to CDs or portable memory drives. Reporting of results will focus on the distribution of the observed species along the coast and the seasonal timing (if any) of the observed species.

Acoustic "Net" Array in Chukchi Sea

Background and Objectives

The acoustic "net" array used during the 2006–2009 field seasons in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of marine mammals (including beluga whale, bowhead whale, and walrus) that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns. The second objective was to measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

Technical Approach

The net array configuration used in 2007–2009 is again proposed for 2010. The basic components of this effort consist of 30 hydrophone systems placed widely across the US Chukchi Sea and a prospect specific array of 12 hydrophones capable of localization of mammal calls. The net array configuration will include hydrophone systems distributed at each of the four primary transect locations: Cape Lisburne, Point Hope, Wainwright and Barrow. The systems comprising the regional array will be placed at locations shown in Figure 7. These offshore systems will capture exploration drilling sounds, if present, over large distances to help characterize the sound transmission properties in the Chukchi Sea. They will also provide a large amount of information related to marine mammals in the Chukchi Sea.

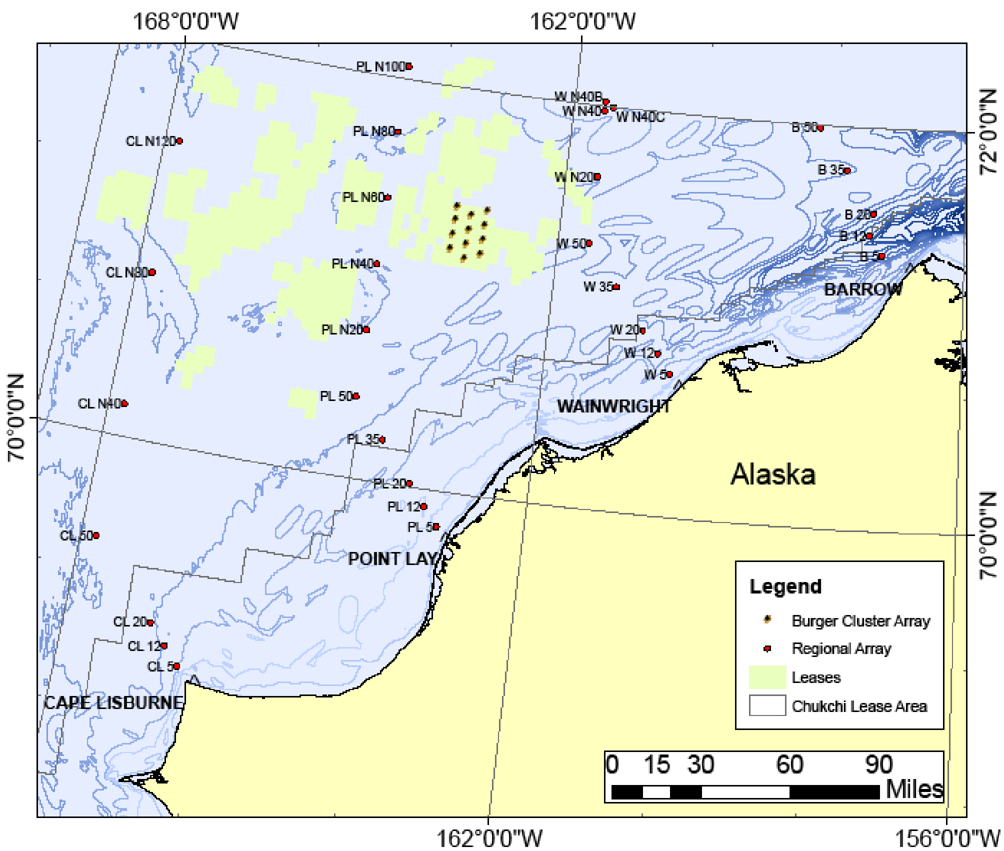

Figure 7. Deployment locations of Hydrophones in acoustic arrays in the eastern Chukchi Sea, Alaska 2010. Depiction of hydrophone array at Burger is not scaled correctly based on description below (12 km by 18 km)

The regional acoustic monitoring program, will be augmented in 2010 by an array of twelve additional acoustic recorders to be deployed on a grid pattern over a 7.2 mi (12 km) by 10.8 mi (18 km) area extending over several of Shell's lease blocks near locations of highest interest for drilling in 2010. The cluster array will operate at a sampling frequency of 16 kHz, which is sufficient to capture vocalizations from bowhead, beluga, walrus, gray whale, fin whale, humpback, killer whale and most other marine mammals known to be present in the Chukchi Sea. The cluster deployment configuration was defined to allow tracking of vocalizing animals that pass through the immediate area of these lease blocks. Maximum separation between adjacent recorders is 3.6 mi (5.8 km). At this spacing we expect that individual whale calls will be detected on at least 3 different recorders when the calling animals are within the boundary of the deployment pattern. Bowhead and other mysticete calls should be detectable simultaneously on more than 3 recorders due to their relatively higher sound source levels compared to other marine mammals. In calm weather conditions, when ambient underwater sound levels are low, we expect to have detection of most other marine mammal calls on more than 3 recorders. The goal of simultaneous detection on multiple recorders is to allow for triangulation of the call positions, which also requires accurate time synchronization of the recorders. When small numbers of whales are vocalizing Shell hopes to be able to identify and track the movements of specific individuals within the deployment area. It will not be possible to track individual whales if many whales are calling due to abundant overlapping calls. In this case analyses will show the general distribution of calls in the vicinity of the recorders.

Analysis and Reporting

The Chukchi Net Arrays of 30 recorders and Cluster Array, deployed for up to 3 months, will produce an extremely large dataset comprising several Terabytes of acoustic data. The analyses of these data require identification of marine mammal vocalizations. Because of the very large amount of data to be processed, the analysis methods will incorporate the automated vocalization detection algorithms developed at Scripps Institute of Oceanography (Scripps). Scripps personnel will be assigned to assist in application of these algorithms for this analysis. While the hydrophones used in the net array are not directional, and therefore not capable of accurate localization of detections, the number of vocalizations detected on each of the sensors may provide a measure of the relative spatial distribution of some marine mammal species, assuming that vocalization patterns are consistent within a species across the spatial and geographic distribution of the hydrophone array. These results may therefore provide information such as timing of migrations and routes of migration for belugas and bowheads.

A second purpose of the Chukchi net array is to monitor the amplitude of drilling sounds reaching the near-shore region. It is expected that sounds from drilling activities will be detectable on hydrophone systems when ambient sound energy conditions are low. The drilling sound levels at recorder locations will be quantified and reported.

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

COMPREHENSIVE REPORT ON INDUSTRY ACTIVITIES AND MARINE MAMMAL MONITORING EFFORTS IN THE BEAUFORT AND CHUKCHI SEAS

Following the 2010 drilling season a comprehensive report describing the acoustic, vessel-based, and aerial monitoring programs will be prepared. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of industry activities and their impacts on marine mammals in the Chukchi Sea during 2010. 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.

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Attachment C
Plan of Cooperation (POC) (Previously Provided)

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