Appendix C
Application for National Marine Fisheries Service Incidental Harassment Authorization

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Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with Planned Exploration Drilling Program During 2012 Near Camden Bay in the Beaufort Sea, Alaska

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List of Acronyms

°	degree
°C	degrees Celsius
4MP	Marine Mammal Monitoring and Mitigation Plan
μPa	micropascal
ADF&G	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AHD	acoustic harassment devices
ASL	above sea level
ATOC	Acoustic Thermometry of Ocean Climate
bbl/hr	barrels per hour
BCB	Bering-Chukchi-Beaufort stock (bowheads)
BOEMRE	U.S. Bureau of Ocean Energy Management, Regulation and Enforcement
BOP	blowout preventer
BOWFEST	Bowhead Whale Feeding Ecology Study
BWASP	Bowhead Whale Aerial Survey Program
CAA	Conflict Avoidance Agreement
CFR	Code of Federal Regulations
CI	Confidence Interval
Com Center	Communication and Call Center
cm^3	cubic meters
CD	cadmium
CV	Coefficient of Variation
Discoverer	*Motor Vessel Noble Discoverer*
dB	decibel(s)
DP	Dynamic Positioning
DPS	distinct population segment
EP	Exploration Plan
EPA	Environmental Protection Agency
ESA	Endangered Species Act
Exploration Drilling Program	Camden Bay 2012 Exploration Drilling Program
ft	feet
ft^2	square feet
Hz	hertz
ICAS	Inupiat Community of the Arctic Slope
IHA	Incidental Harassment Authorization
in.	inches
in^3	cubic inches
IUCN	International Union for the Conservation of Nature
kg	kilogram(s)
kHz	kiloHertz
km	kilometer(s)
km^2	kilometers squared
km/hr	kilometers per hour
Kulluk	conical drilling unit *Kulluk*
KSOP	Kuukpik Subsistence Oversight Panel

m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
m^3/hr	cubic meters per hour
MAWP	maximum anticipated wellhead pressure
mi	statute miles
mi/hr	miles per hour
Mikhail Ulyanov	Motor Vessel Mikhail Ulyanov
min	minute(s)
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MONM	Marine Operations Noise Model (JASCO)
N/A	not applicable
NMFS	National Marine Fisheries Service
Noble	Noble Drilling
Nordica	Motor Vessel Nordica
NPDES	National Pollution Discharge Elimination System
NSB	North Slope Borough
NWAB	Northwest Arctic Borough
OCS	Outer Continental Shelf
ODPCP	Oil Discharge Prevention and Contingency Plan
OSR	Oil Spill Response
OST	Oil Spill Tanker
OSV	offshore supply vessel
psi	pounds per square inch
POC	Plan of Cooperation
PTS	Permanent Threshold Shift
RL	received level
rms	root mean square
ROV	remotely operated vehicle
SA	Subsistence Advisor
SAR	Search and Rescue
SEL	sound exposure level
Shell	Shell Offshore Inc.
SIWAC	Shell Ice and Weather Advisory Center
TAH	total aromatic hydrocarbons
TK	Traditional Knowledge
TTS	temporary threshold shift
U.S.	United States
USFWS	United States Fish and Wildlife Service
VOSS	Vessel of Opportunity Skimming System
VSI	Vertical Seismic Imager
VSP	vertical seismic profile
Zn	zinc
ZVSP	zero-offset vertical seismic profile

Executive Summary

Shell Offshore Inc. (Shell) plans to drill two exploration wells at two drill sites in the eastern Beaufort Sea on Outer Continental Shelf (OCS) leases acquired from the United States (U.S.) Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) during the 2012 drilling season. Shell plans to use the conical drilling unit *Kulluk* (*Kulluk*) or the Motor Vessel (M/V) *Noble Discoverer* (*Discoverer*) drillship for exploration drilling in Camden Bay, but not both. Either drilling vessel would be attended by a minimum of 11 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 used previously in the Beaufort and Chukchi Seas, as well as elsewhere in the world's oceans. The *Kulluk* has an Arctic Class IV hull designed to maintain its location in drilling mode in moving ice with thickness up to 4 feet (ft) (1.2 meters [m]). Either drilling vessel will be accompanied by ice management vessels throughout its service during the 2012 drilling season. During exploration drilling and associated operations, either the *Kulluk* or *Discoverer* will emit near continuous non-pulse sounds that ensonify only very limited areas of the ocean bottom and intervening water column. Within the timeframe of exploration drilling operations, Shell may also conduct short-duration vertical seismic profile (VSP) surveys at the end of each drill hole. The VSPs emit pulse sounds that also ensonify very limited areas of the ocean bottom and intervening water column for only approximately 10-14 hours at the end of each drill hole. For Camden Bay exploration drilling during 2012, Shell also has committed to collect drilling mud, and drill cuttings with adhered mud, plus selected wastewater streams and not discharge these, but dispose of them at an onshore facility.

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 and impulse sounds generated during seismic surveys. 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 Shell's 2012 exploration drilling program, including VSP surveys, and related activities.

Shell has calculated the estimated take of marine mammals from both the low-level continuous sound generated during exploration drilling operations and impulse sound generated during a short-duration VSP survey likely to occur at the end of each drill hole. As detailed herein, it is assumed that any takes that might result from the proposed operations would be temporary and not be of biological significance to marine mammal populations. Any impacts from these sounds 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 sound sources.

An impact analysis of underwater sound generated by the planned exploration drilling during 2012 with either the *Kulluk* or *Discoverer* and VSP surveys (included herein; summarized in Table ES-1) determined that a maximum number of the following marine mammals may be exposed to sounds ≥120 decibels (dB) re 1 micropascal (μPa) from exploration drilling activities (or ≥160 dB from VSP surveys (see Table 4-1 for marine mammal populations and Tables 6-4 through 6-9 for estimates of marine mammals exposed to sound from the exploration drilling operations or VSPs associated with this exploration drilling program):

Table ES-1 Summary of Incidental Takes of Marine Mammals by Season (Summer and Fall)

Kulluk (summer)	*Discoverer* (summer)	*Kulluk* (fall)	*Discoverer* (fall)	VSP (summer)	VSP (fall)
23 Bowhead	1 Bowhead	5,575 Bowhead	1,387 Bowhead	2 Bowhead	N/A[a]
4 Beluga	0 Beluga	1 Beluga	0 Beluga	0 Beluga	0 Beluga
41 Bearded seals		3 Bearded seals		3 Bearded seals	
798 Ringed seals		49 Ringed seals		60 Ringed seals	

[a] Estimates for exposures to VSP activities during the fall have been included in the calculations from drilling (see Tables 6-4 and 6-5).

The same impact analysis determined that other species that may occur in the Beaufort Sea were unlikely to be exposed to industrial sounds at these levels, but minimal numbers of exposures are possible base on chance encounters.

As a consequence of Shell's planned mitigation measures for operations in the Beaufort Sea, including a commitment to halt exploration drilling during the Kaktovik and Nuiqsut bowhead whale subsistence hunts, 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 50 CFR § 216.104 (a) (1)-(14).

Shell relied on guidance in 50 CFR § 216.104, Submission of Requests, to prepare its request for this IHA:

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

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

The specific activities that can be expected to result in incidental taking of marine mammals pursuant to the requested IHA are limited to Shell's exploration drilling program and related activities, including VSP surveys. Shell has not included the potential impacts arising from a hypothetical oil spill in its consideration of "specified activity" in this IHA application for two reasons.

First, oil spill impacts would not be "substantially similar" to the primarily acoustic impacts that can be expected to result from exploration drilling and the VSP surveys. In identifying the "specified activity" at issue in this IHA, Shell has followed the instruction of the U.S. Court of Appeals for the Ninth Circuit in *Center for Biological Diversity v. Kempthorne*, 588 F.3d 701 (9th Cir. 2009). In that case, the court held that, to be consistent with the purpose of the Marine Mammal Protection Act (MMPA), "specified activities" are properly defined so that the "anticipated effects are substantially similar." *Id.* at 709. The activities specified in this IHA application – exploration drilling, VSP surveys, and related activities – all have the potential to cause primarily acoustic impacts and thus are substantially similar. In contrast the potential impacts from a spill would be substantially dissimilar from the primarily acoustic impacts for which this IHA is sought.

Second, impacts from speculative events, such as an oil spill, are not properly included in an IHA application. The Ninth Circuit instructed that when determining whether an activity will have a "negligible impact" on the affected marine mammal population, the analysis should focus on "effects that are 'reasonably expected' and 'reasonably likely,' but not those effects that are speculative or uncertain.'" *Id.* at 710-11. Oil spills are highly unlikely events and are not reasonably expected to occur during the course of exploration drilling and VSP surveys (*See* [Analysis of the Probability of an "Unspecified Activity" and Its Impacts: Oil Spill; Attachment H of this application). Thus, an analysis of whether the impacts resulting from the "specified activity" will be negligible should not include the impacts from a "speculative" oil spill.

For these reasons, Shell believes that the MMPA and NMFS's regulations implementing that statute instruct that Shell should not seek "authorization" for an action it does not intend to take, and, in fact, has expended substantial resources to prevent. Accordingly, the "specified activities" for which Shell seeks this IHA are restricted to exploration drilling, VSP surveys, and related activities.

Exploration Drilling

Shell plans to conduct an exploration drilling program on BOEMRE Alaska OCS leases located north of Point Thomson near Camden Bay in the Beaufort Sea during the 2012 drilling season (Camden Bay 2012 Exploration Drilling Program, hereinafter, the "exploration drilling program"*)* (Figure 1-1).

The leases were acquired during Beaufort Sea Oil and Gas Lease Sales 195 (March 2005) and 202 (April 2007). During the exploration drilling of 2012, Shell plans to drill two exploration wells at two drill sites, one well each on the Torpedo prospect (NR06-04 Flaxman Island lease block 6610, OCS-Y-1941 [Flaxman Island 6610 – Torpedo "H" drill site] or NR06-04 Flaxman Island lease block 6559, OCS-Y-1936 [Flaxman Island 6559 – Torpedo "J" drill site]) and the Sivulliq prospect (NR06-04 Flaxman Island lease block 6658, OCS-Y 1805 [Flaxman Island 6658 – Sivulliq "N" or "G" drill sites] Table 1-1). All drilling is planned to be vertical.

Table 1-1 Shell Lease Blocks Covered in the Camden Bay Exploration Drilling Program Starting in 2012

Drill Site	Lease File Number	NR06-04 Flaxman Island Lease Block No.	Surface Location (NAD 83)*		Distance to Mainland Shore mi (km)
			Latitude (N)	Longitude (W)	
Sivulliq G	OCS-Y 1805	6658	70° 23' 46.82"	146° 01' 03.46"	16.6 (26.7)
Sivulliq N**	OCS-Y 1805	6658	70° 23' 29.58"	145° 58' 52.53"	16.2 (26.1)
Torpedo H**	OCS-Y 1941	6610	70° 27' 01.62"	145° 49' 32.07"	20.8 (33.5)
Torpedo J	OCS-Y 1936	6559	70° 28' 56.94"	145° 53' 47.15"	23.1 (37.2)

*North American Datum 1983
**Drill sites from approved Camden Bay EP

Shell plans to drill a Torpedo prospect well (Torpedo "H" or "J") first, followed by a Sivulliq well (Sivulliq "N" or "G"), unless adverse surface conditions or other factors dictate a reversal of drilling sequence. In that case, Shell will mobilize to the Sivulliq prospect and drill there first. As with any Arctic exploration program, weather and ice conditions will dictate actual operations. As such, Shell's actual sequence for completing the identified exploration wells may vary.

One of two drilling vessels, the *Kulluk* (owned by Shell and operated by Noble Drilling [(Noble]) or *Discoverer* (owned and operated by Noble) will be used in Camden Bay during 2012 exploration drilling activities, but not both. Rig specifications for the *Kulluk and Discoverer* are located in Attachment A.

Kulluk

The *Kulluk* has an Arctic Class IV hull design, is capable of drilling in up to 600 ft (182.9 m) of water and is moored using a 12-point anchor system. The *Kulluk's* mooring system consists of 12 Hepburn winches located on the outboard side of the main deck, anchor wires lead off the bottom of each winch drum inboard for approximately 55 ft (16.8 m). The wire is then redirected by a sheave, down through a hawse pipe to an underwater, ice protected, swivel fairlead. The wire travels from the fairlead directly under the hull to the anchor system on the seafloor. The *Kulluk* would have an anchor radius maximum of 3,117 ft (950 m) for the Sivulliq and Torpedo drill sites. While on location at the drill sites, the *Kulluk* will be affixed to the seafloor using 12, 15 metric ton Stevpris anchors arranged in a radial array.

The *Kulluk* is designed to maintain its location in drilling mode in moving ice with thickness up to 4 ft (1.2 m) without the aid of any active ice management. With the aid of the ice management vessels, the *Kulluk* would be able to withstand more severe ice conditions. In more open water conditions, the *Kulluk* can maintain its drilling location during storm events with wave heights up to 18 ft (5.5 m) while drilling, and can withstand wave heights of up to 40 ft (12.2 m) when not drilling and disconnected (assuming a storm duration of 24 hours).

Discoverer

The *Discoverer* is a true drillship, and is a largely self-contained drillship that offers full accommodations for a crew of up to 140 persons. The *Discoverer* is an anchored drillship with an 8-point anchored mooring system and would likely have a maximum anchor radius of 2,969-2,986 ft (905-910 m) at either the Sivulliq or Torpedo drill sites. While on location at the drill sites, the *Discoverer* will be affixed to the seafloor using eight 7,000 kilogram (kg) Stevpris anchors arranged in a radial array. The hull has been reinforced for ice resistance.

Vessels

During 2012 exploration drilling activities, the *Kulluk* or *Discoverer* will be attended by a minimum of 11 vessels that will be used for ice management, anchor handling, oil spill response (OSR), refueling, resupply, drill mud/cuttings and wastewater transfer, equipment and waste holding, and servicing of the drilling operations (Tables 1-1a and 1-1b). A small number of workboats associated with OSR training, and stored on an oil spill response barge (OSR barge) are included in Table 1-1b, but are not counted among the 11attending vessels. All vessels will either be in transit or staged (i.e., on anchor) in the Beaufort Sea during the exploration drilling activities.

Table 1-1a Camden Bay Exploration Drilling Program – Proposed Support Vessel List

Specification	Ice Management Vessel [1]	Anchor Handler [2,7]	OSV [3]	West Dock Supply Vessel[4]	OSV[5]	Deck Barge[6]	Waste Barge
Length	380.5 ft (116 m)	360.6 ft (110 m)	280 ft (85.4 m)	134 ft (50.3 m)	280 ft (85.4 m)	360 ft (110 m)	500 ft (152.4 m)
Width	85 ft (26 m)	80 ft (24.4 m)	60 ft (18.29 m)	32 ft (11.6 m)	60 ft (18.29 m)	100 ft (30.5 m)	74 ft (22.6 m)
Draft	27.5 ft (8.4 m)	24 ft (7.3 m)	19.24 ft (5.87 m)	7 ft (2.1 m)	16.5 ft (5.0 m)	14 ft (4.3 m)	27.5 ft (8.4 m)
Accommodations (persons) (berths)	82	64	29	17	26	10	-
Maximum Speed	16 knots (30 km/hr)	15 knots (27.8 km/hr)	15 knots (27.8 km/hr)	10 knots (18.5 km/hr)	13.5 knots (25 km/hr)	10 knots (18.5 km/hr)	-
Fuel Capacity	11,070 bbl	12,575 bbl	8,411 bbl (normal) 11,905 bbl (max)	667 bbl	6,235 bbl (normal)	2,381 bbl	155,000 bbl

[1] Based on *Nordica,* or similar vessel
[2] Based on *Hull 247,* or similar vessel
[3] Based on the *Carol Chouest,* or similar vessel
[4] Based on *Arctic Seal,* or similar vessel
[5] Based on *Harvey Spirit,* or similar vessel
[6] Based on *Southeast Provider* & *Ocean Ranger*
[7] Hull 247 is under construction by Chouest Offshore. By 2012, she will be christened under a name to be determined.

The M/V *Nordica (Nordica)* or a similar vessel, will serve as the primary ice management vessel in support of the *Kulluk* or *Discoverer*. *Hull 247* will provide anchor handling duties, serve as the berthing (accommodations) vessel for the OSR crew and will also serve as a secondary ice management vessel. When managing ice, the *Nordica* (or similar vessel) and *Hull 247* will generally be confined to a 40 degree (^{o}) arc up to 3.1 statute mile (mi) (4.9 kilometers [km]) upwind originating at the drilling vessel (Figure 1-3). It is anticipated that the ice management vessels will be managing ice for up to 38 percent of the time when within 25 mi (40 km) of the *Kulluk* or *Discoverer*. Active ice management involves using the ice management vessel to steer larger floes so that their path does not intersect with the drill site. Around-the-clock ice forecasting using realtime satellite coverage (available through Shell Ice and Weather Advisory Center [SIWAC]) will support the ice management duties. When the *Nordica* and *Hull 247* are not needed for ice management, they will reside outside the 25 mi (40 km) radius from the *Kulluk* or *Discoverer* if it is safe to do so. These vessels will enter and exit the Beaufort Sea with the *Kulluk* or *Discoverer*.

As anchor handler, *Hull 247*'s duties include setting and removing anchors, berthing (accommodations) vessel for the OSR barge crew, providing supplemental oil recovery capability (Vessel of Opportunity Skimming System ([VOSS]) and managing smaller ice floes that may pose a potential safety issue to the *Kulluk* or *Discoverer* and the support vessels that will service the *Kulluk or Discoverer*.

The exploration drilling operations will require the transfer of supplies between the Deadhorse/West Dock shorebase or Dutch Harbor and the *Kulluk* or *Discoverer*. While the *Kulluk* or *Discoverer* is anchored at a drill site, Shell has allowed for 24 visits/tie-ups (if the *Kulluk* is the drilling vessel being used) or 8 visits/tie-ups (if the *Discoverer* is being used) throughout the drilling season from support vessels. The *Harvey Spirit* (or similar vessel), a 280 ft (85.3 m) offshore supply vessel (OSV) with Dynamic Positioning (DP), will shuttle supplies from the *Arctic Seal* (or similar vessel) and/or the *Southeast Provider* (aka deck barge) to the *Kulluk* or *Discoverer.* During the resupply trips, the *Harvey Spirit* will be used to remove the mud/cuttings and other. The mud/cuttings and other waste streams will be transported to the *Southeast Provider* (deck barge) or waste barge. Other waste streams (sanitary waste, domestic waste, bilge water, ballast water) will also be transferred to the deck barge, or the waste barge for temporary storage. These waste streams will also be brought south for disposal at the end of the drilling season. While the *Kulluk* or *Discoverer* leaves Camden Bay temporarily during the Kaktovik and Nuiqsut (Cross Island) subsistence whale hunts, Shell will resupply the *Kulluk* or *Discoverer* with drilling supplies and equipment brought in from Dutch Harbor and stored on the *Carol Chouest,* also an OSV, or the *Harvey Spirit*. The *Carol Chouest* will be used as a backup supply vessel and shuttle between Camden Bay and Dutch Harbor. When exploration drilling starts up again after the bowhead whaling hunts have concluded, additional resupply may be required from West Dock via the *Arctic Seal* via transfer to the *Harvey Spirit* to the drilling vessel.

Removal of waste and resupply to the drilling vessels will be conducted the same way regardless of drilling vessel.

Oil Spill Response Vessels

The OSR vessels will include a primary OSR barge (the *Arctic Endeavor* and Point Class Tug, or similar vessel), *Hull 247* will act as a berthing (quartering) vessel and a VOSS and an oil spill tanker (OST - M/V *Mikhail Ulyanov* (*Mikhail Ulyanov*) (or a similar vessel). The *Harvey Spirit* will also act as a VOSS.

The OSR barge will have associated smaller workboats called Kvichaks. There are three 34-ft (10 m) Kvichaks that will support the OSR barge by laying out booms. One 47-ft (14 m) Rozema will provide skimming services. The Berthing Vessel (*Hull 247*) will be dedicated to the revised Camden Bay EP exploration drilling program and remain in the vicinity of the *Kulluk* or *Discoverer*, with the OSR barge and the OST being staged to respond as needed to a discharge. In the unlikely event of a spill, the *Hull 247* can also be used to lighter recovered oil, emulsions and free water to the *Mikhail Ulyanov.* Specifications for these vessels are provided below in Table 1-1a and 1-1b.

An additional barge housing the oil spill containment system will be centrally located in the Beaufort Sea. The barge will be supported by an Invader Class Tug and possibly an anchor handler. The tug tending the OSR containment system barge will either drift or motor under "slow-steam" movement with the barge. An anchor handler is included in this plan only as an additional tending option for the OSR containment system barge, if Shell deems it necessary in advance of the season to anchor the OSR containment system barge. Shell does not assume the OSR containment system barge will be anchored or that the anchor handler is necessary, but includes the option of anchoring the barge and it being also tended by an anchor handler in case that option is chosen.

The *Mikhail Ulyanov* or similar vessel with similar liquid storage capacity would be staged such that it would arrive at a recovery site, if needed, within 24 hours of departure from their staging location. The purpose of the OST would be to provide a place to store large volumes of recovered crude oil, emulsion and free water in the unlikely event of a spill and OSR operations. Surplus storage capacity aboard the OST beyond what is required for response at a recovery site may be allocated to store other liquid commodities consumed by the drilling vessel and support vessels, including diesel fuel.

Table 1-1b Camden Bay Exploration Drilling Program – Proposed Oil Spill Response Vessel List

Specification	OSR Barge[1,2]		OST[1,3]	OSR Containment System[1,4]		
	Barge	Tug		Barge	Tug	Anchor Handler[5]
Length	205 ft (62.5 m)	90 ft (27.4 m)	853 ft (260 m)	400 ft (122 m)	136 ft (41.5 m)	275 ft (83.5 m)
Width	90 ft (27.4 m)	32 ft (9.8 m)	112 ft (34 m)	100 ft (30.5 m)	36 ft 11 m	59 ft (18.0 m)
Draft	8.5 ft (2.6 m)		44.6 ft (13.6 m)	12 ft (3.7 m)	20 ft (6.1 m)	20 ft (6.1 m)
Accommodations	--	8	25	--	8	23
Maximum Speed	--	7 knots (13 km/hr)	16 knots (30 km/hr)	--	8 knots (15 km/hr)	16 knots (30 km/hr)
Fuel Storage	--	1,428 bbl (227 m^3)	440,000 bbl (69,952 m^3)	--	3,690 bbl (587 m^3)	7,485 bbl (1,190 m^3)
Liquid Storage	18,636 bbl		543,000 bbl (86,328 m^3)	80,000 bbl (12,719 m^3)	NA	37,462 bbl (5,956 m^3)
Workboats	(1) 47 ft (14 m) skim boat (3) 34 ft (10 m) work boats (4) mini-barges		NA	NA	NA	

[1] Or similar vessel
[2] Based on the *Arctic Endeavor* & Point Class tug
[3] Based on the *Mikhail Ulyanov*
[4] Based on a standard deck barge, Crowley Invader class ocean going tug, and a *Tor Viking*-style anchor handler.
[5] Vessel included for planning purposes only, not assumed necessary but as an additional tending option if deemed necessary by Shell.

Aircraft

An AW139 or Sikorsky S-92 helicopter based in Deadhorse will be used for flights between the shorebase and drill sites (Table 13.a-3). It is expected that on average, up to two flights per day (approximately 12 flights per week) will be necessary to transport supplies and rotate crews. A Sikorsky S92 based in Barrow will be used for search and rescue operations.

Marine Mammal Observer (MMO) overflights will utilize a de Havilland Twin Otter aircraft. The de Havilland Twin Otter is expected to fly daily.

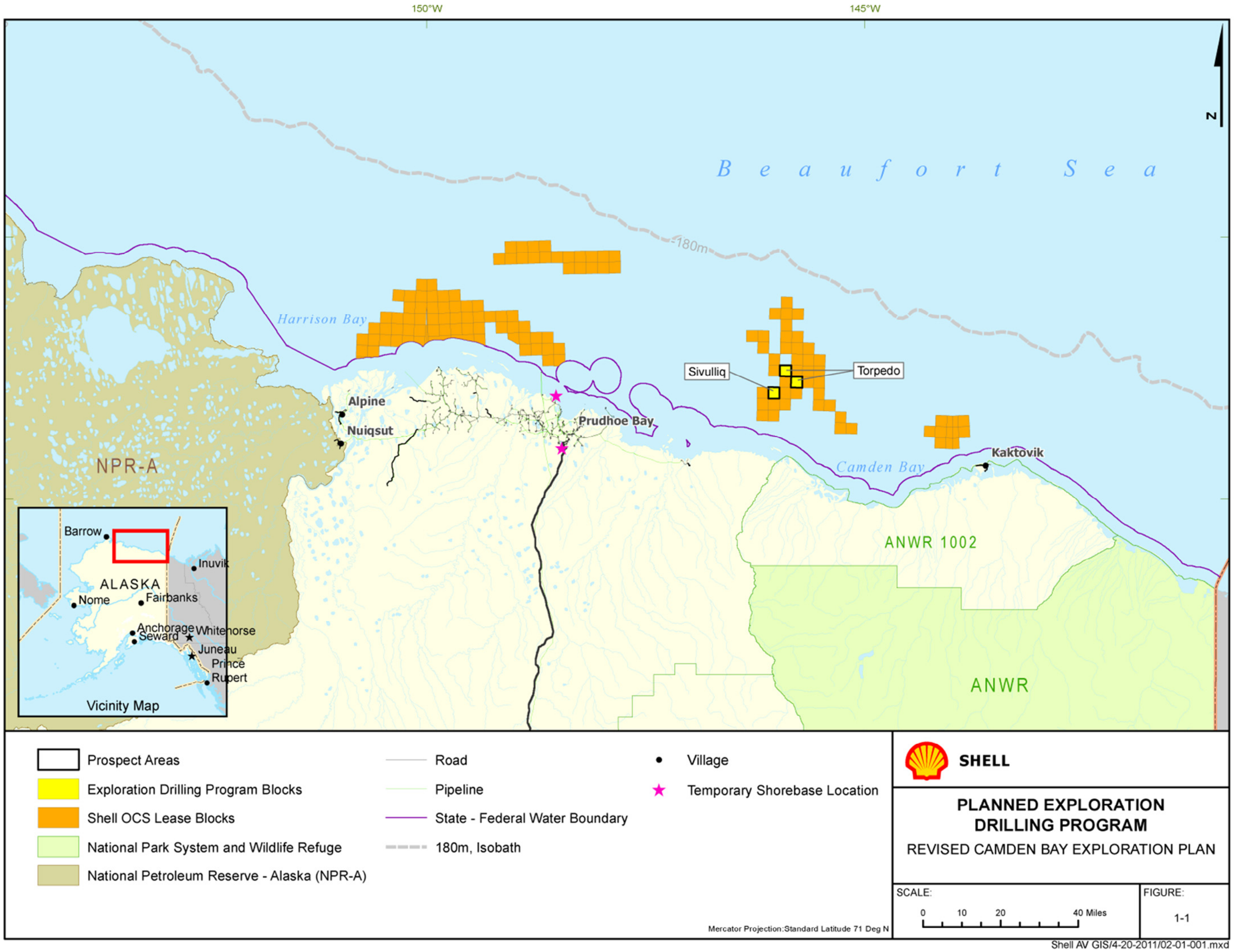
Table 1-1c presents the aircraft planned to support the exploration drilling program. This includes crew changes via helicopter and search-and-rescue via helicopter, and a fixed wing aircraft for aerial monitoring of marine mammals.

Table 1-1c Camden Bay Exploration Drilling Program – Proposed Aircraft List

Aircraft	Flight Frequency
Aircraft (or similar)	
Sikorsky S-92, AW139 or similar – crew rotation	Two round trips between the shorebase and offshore vessels per day (approximately 12/week) throughout the 2012 drilling season
(1) Sikorsky S-92 or AW139 Helicopter – SAR	Trips made only in emergency; training flights
(1) deHavilland Twin Otter (DHC-6) – Used for 4MP	Daily, beginning 5-7 days before drilling and ending 5-7 days after drilling ends

The *Kulluk* or *Discoverer* and their associated support vessels will transit through the Bering Strait into the Chukchi Sea on July 1 or later, arriving on location near Camden Bay approximately July 10. Exploration drilling activities at the Sivulliq or Torpedo drill sites are planned to begin on or about 10 July and run through 31 October 2012, with a suspension of all operations beginning 25 August for the Nuiqsut (Cross Island) and Kaktovik subsistence bowhead whale hunts. During the suspension for the whale hunts the drilling vessel and support fleet will leave the Camden Bay project area and move to an area north of latitude 71° 25'N and west of longitude 146° 4'W and will return to resume activities after the Nuiqsut (Cross Island) and Kaktovik subsistence bowhead whale hunts conclude. Activities will extend through 31 October, depending on ice and weather. At the end of the drilling season, the *Kulluk* or *Discoverer*, ice management vessels, and all remaining support vessels will transit west into and through the Chukchi Sea.

Figure 1-1 Camden Bay Exploration Drilling Program Lease Block Locations



Vertical Seismic Profile

At the end of each drill hole Shell may conduct a geophysical survey referred to as VSP at each drill site where a well is drilled in 2012. During VSP surveys, an airgun array is deployed at a location near or adjacent to the drilling vessel, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically in a string, are then raised up to the next interval in the wellbore and the process is repeated until the entire wellbore has been surveyed. The purpose of the VSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell will be conducting a particular form of VSP referred to as a zero-offset vertical seismic profiling (ZVSP), in which the sound source is maintained at a constant location near the wellbore (Figure 1-2). A typical sound source that would be used by Shell in 2012 is the ITAGA eight-airgun array, which consists of four 150 cubic inches (in^3) (2,458 cubic centimeters [cm^3]) airguns and four 40 in^3 (655 cm^3) airguns. These airguns can be activated in any combination and Shell would utilize the minimum airgun volume required to obtain an acceptable signal. Current specifications of the array are provided in Table 1-2. The airgun array is depicted within its frame or sled, which is approximately 6 ft x 5 ft x 10 ft (see photograph below). Typical receivers would consist of a Schlumberger wireline four level Vertical Seismic Imager (VSI) tool, which has four receivers 50-ft (15-m) apart.

Photograph of the ITAGA 8-airgun Array in Sled

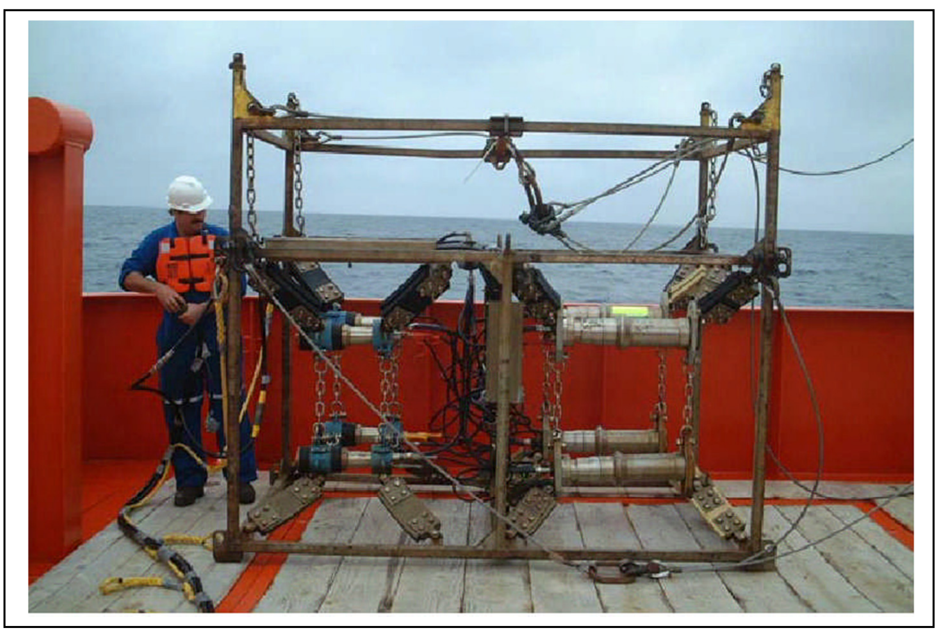


Figure 1-2 Schematic of ZVSP

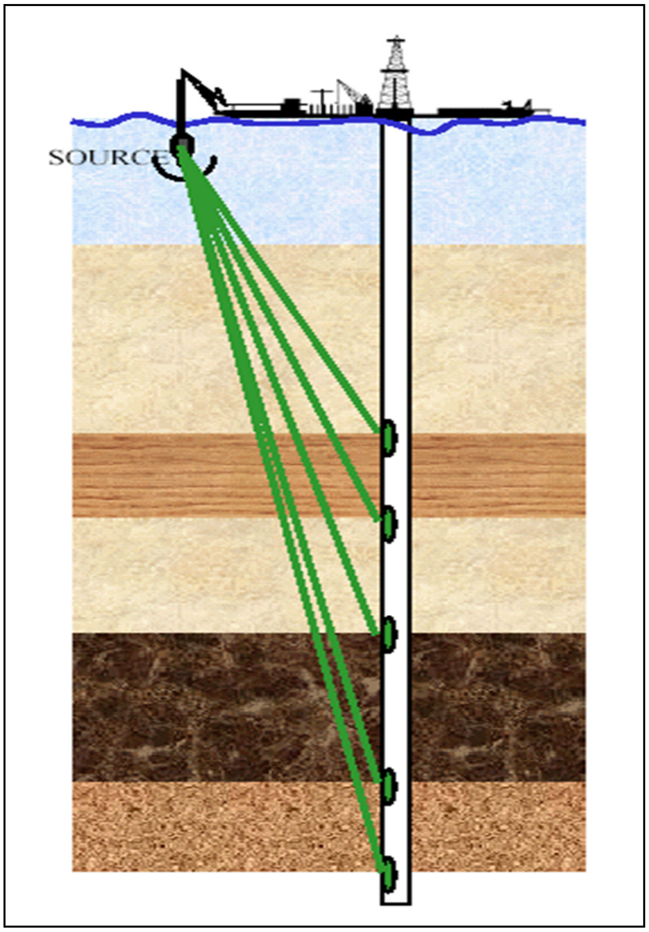


Table 1-2 Sound Source (airgun array) Specifications for ZVSP Surveys in Camden Bay in 2012

Source Type	No. Sources	Maximum Total Chamber Size	Pressure	Source Depth	Calibrated Peak-Peak Vertical Amplitude	Zero-Peak Sound Pressure Level
SLB, ITAGA Sleeve Array	8 airguns 4 X 150 in^3 (2458 cm^3) 4 X 40 in^3 (655 cm^3)	760 in^3 12,454 cm^3	2,000 psi 138 bar	9.8 ft / 3.0 m 16.4 ft / 5.0 m	16 bar @1 m 23 bar @1 m	238 dB re1µPa @1 m 241 dB re1µPa @1 m

A ZVSP survey is normally conducted at each well after total depth is reached but may be conducted at a shallower depth. For each survey, Shell would deploy the sound source (airgun array) over the side of the *Kulluk* or *Discoverer* with a crane (sound source will be 50-200 ft (15-61 m) from the wellhead depending on crane location), to a depth of approximately 10-23 ft (3-7 m) below the water surface. The VSI, with its four receivers, will be temporarily anchored in the wellbore at depth. The sound source will be pressured up to 2,000 pounds per square inch (psi), and activated 5-7 times at approximately 20-second intervals. The VSI will then be moved to the next interval of the wellbore and reanchored, after which the airgun array will again be activated 5-7 times. This process will be repeated until the entire well bore is surveyed in this manner. The interval between anchor points for the VSI usually is between 200-300 ft

(61-91 m). A normal ZVSP survey is conducted over a period of about 10-14 hours depending on the depth of the well and the number of anchoring points.

Ice Management and Forecasting

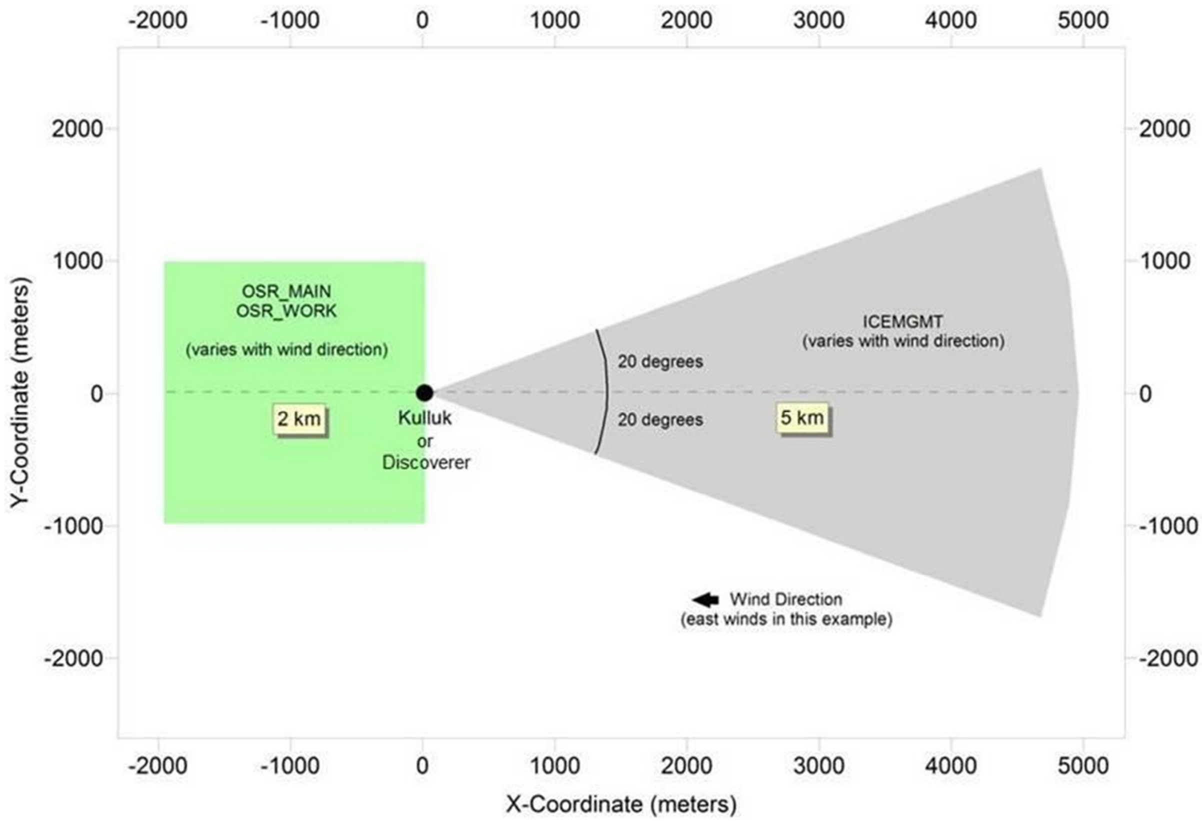
Shell recognizes the exploration drilling program is located in an area that is characterized by active sea ice movement, ice scouring, and storm surges. In anticipation of potential ice hazards that may be encountered, Shell will implement an Ice Management Plan (IMP) see Attachment B) to ensure real-time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

- Radarsat and Envisat data - satellites with Synthetic Aperture Radar providing all-weather imagery of ice conditions with very high resolution;
- Moderate Resolution Imaging Spectroradiometer - a satellite providing lower resolution visual and near infrared imagery;
- Aerial reconnaissance - provided by specially deployed fixed wing or rotary wing aircraft for confirmation of ice conditions and position;
- Reports from Ice Specialists on the ice management vessel and anchor handler and from the Ice Observer on the drillship;
- Incidental ice data provided by commercial ships transiting the area; and
- Information from the National Oceanographic and Atmospheric Administration ice centers and the University of Colorado.

Drift ice will be actively managed by ice management vessels, consisting of an ice management vessel and an anchor handling vessel. Ice management for safe operation of Shell's planned exploration drilling program will occur far out in the OCS, remote from the vicinities of any routine marine vessel traffic in the Beaufort Sea causing no threat to public safety or services that occurs near to shore. Shell vessels will also communicate movements and activities through the 2012 North Slope Communications Centers. Management of ice by ice management vessels will occur during a drilling season predominated by open water and thus will not contribute to ice hazards, such as ridging, override, or pileup in an offshore or nearshore environment.

The ice-management/anchor handling vessels would manage the ice by deflecting any ice floes that could affect the *Kulluk* or *Discoverer* when it is drilling and would also handle the *Kulluk* or *Discoverer's* anchors during connection to and separation from the seafloor. When managing ice, the *Nordica* and *Hull 247* will generally be operate a 40^o arc up to 3.1 mi (4.9 km) upwind originating at the *Kulluk* or *Discoverer* (Figure 1-3).

Figure 1-3 Ice Management Vessels Configuration for the *Kulluk* or *Discoverer*



It is anticipated that the ice management vessels will be managing ice for 38 percent of the time when within 25 mi (40 km) of the *Kulluk* or *Discoverer* (Figure 1-3). The ice floe frequency and intensity are unpredictable and could range from no ice to ice sufficiently dense that the fleet has insufficient capacity to continue operating, and the *Kulluk* or *Discoverer* would need to disconnect from its anchors and move off site. If ice is present, ice management activities may be necessary in early July and towards the end of operations in late October, but it is not expected to be needed throughout the proposed drilling season. Shell has indicated that when ice is present at the drill site, ice disturbance will be limited to the minimum needed to allow exploration drilling to continue. First-year ice will be the type most likely to be encountered. The ice-management vessels will be tasked with managing the ice so that it will flow easily around and past the *Kulluk* or *Discoverer* without building up in front of, or around it. This type of ice is managed by the ice-management vessel continually moving back and forth across the drift line, directly updrift of the *Kulluk* or *Discoverer* and making turns at both ends. During ice-management, the vessel's propeller is rotating at approximately 15–20 percent of the vessel's propeller rotation capacity. Ice management occurs with slow movements of the vessel using lower power and therefore slower propeller rotation speed (*i.e.,* lower cavitation), allowing for fewer repositions of the vessel, thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice ridges that would be managed at a much slower speed than that used to manage first-year ice. Shell does not intend to break ice with the ice-management vessels but, rather, intend to push it out of the area as described here. Shell has indicated that ice breaking could be conducted if the ice poses an immediate safety hazard at the drill sites, but is far from preferred as indicated in the IMP (see Attachment B).

Planned Mitigation

The *Kulluk* or *Discoverer* and all support vessels will operate in accordance with the provisions of a Plan of Cooperation Addendum (POC) (Attachment D), and presumed vessel operation mitigation measures included in past IHAs issued to Shell for arctic activities. Shell prepared a POC Addendum with affected North Slope subsistence communities 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 based upon Shell's experience (recent and past) since the 1980s in the Alaska OCS and in consultation with affected Beaufort and Chukchi Sea communities and marine mammal commissions. 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 POC Addendum. Shell's Chukchi Sea POC Addendum addresses transit activities for vessels that will transit through the Chukchi Sea to operate in the Beaufort Sea. For the proposed Camden Bay exploration drilling program, Shell's Beaufort Sea POC Addendum addresses the issue of vessel transit, drilling, aerial support, and onsite vessel 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 Camden Bay 2012 exploration drilling activities will be valid from the date of issuance through the conclusion of the 2012 drilling season.

Timing of Mobilization and Demobilization of the *Kulluk* or *Discoverer*

Shell's base plan is for two ice management vessels, the *Nordica* (primary ice management), the anchor handling vessel *Hull 247*(secondary ice management), the deck barge and tug, waste barge and tug, offshore supply vessels (OSVs; *Harvey Spirit* and *Carol Chouest*) and potentially some of the OSR vessels to accompany the *Kulluk* or *Discoverer* traveling north of Dutch Harbor through the Bering Strait, after 1 July 2012 then through the Chukchi Sea, around Pt. Barrow and east through the Alaskan Beaufort Sea, before arriving on location of the Torpedo H location on or about July 10, or Sivulliq N if adverse surface conditions or other factors dictate a reversal of drilling sequence. At the completion of the drilling season on or before 31 October 2012, one or two ice management vessels, along with various support vessels, such as the OSR fleet, deck and waste barges, and OSV(s) will accompany the *Kulluk* or *Discoverer* as it travels west through the Beaufort Sea, then south through the Chukchi Sea and the Bering Strait. Subject to ice conditions alternate exit routes and vessel departures may be considered.

Exploration Drilling

Shell plans to drill exploration wells at two drill sites located near Camden Bay during the 2012 drilling season: one at Torpedo H or J (lease blocks 6610 or 6559) and another at Sivulliq N or G (both on lease block 6658) (Figure 1-1 and Table 2-1). Shell will mobilize into the Beaufort Sea in early July and plans to commence drilling in Camden Bay as soon as ice, weather, and other conditions allow for safe drilling operations. Shell's plan assumes the *Kulluk* or *Discoverer* will be on location at Torpedo "H", or "J" by July 10, or Sivulliq "N" or "G" if ice or other adverse surface conditions dictate a different drilling sequence.

Table 2-1 Drill Site Locations and Water Depths

Drill Site	Distance From Shore	NR06-04 Lease Block No.	Surface Location (NAD 83)		Water Depth
	mi (km)		Latitude (north)	Longitude (west)	ft (m)
Sivulliq G	16.6 (26.7)	6658	70° 23' 46.82"	146° 01' 03.46"	110 (33.5)
Sivulliq N	16.2 (26.1)	6658	70° 23' 29.58"	145° 58' 52.53"	107 (32.6)
Torpedo H	20.8 (33.5)	6610	70° 27' 01.62"	145° 49' 32.07"	120 (36.6)
Torpedo J	23.1 (37.2)	6559	70° 28' 56.94"	145° 53' 47.15"	124 (37.8)

Activities associated with 2012 Camden Bay exploration drilling and analyzed herein include operation of the *Kulluk* or *Discoverer*, VSP survey at the completion of the drill hole, associated support vessels, crew change support and re-supply. The *Kulluk* or *Discoverer* will remain at the location of the designated exploration drill sites except when mobilizing and demobilizing to and from Camden Bay, transiting between drill sites, suspension of activities for the bowhead whale subsistence harvest described below, 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 IMP. Ice management vessels and OSR vessels will remain in close proximity to the drillship during exploration drilling operations. Crew change/re-supply vessels will transit to and from the *Kulluk* or *Discoverer* at the estimated frequency shown in Table 1-1c. Helicopter flight support from Deadhorse will provide crew changes, and fixed-wing aircraft may depart from Deadhorse also, for an aerial survey program used for marine mammal monitoring.

Exploration drilling activities at the Sivulliq or Torpedo drill sites are planned to begin on or about 10 July and run through 31 October 2012, with a suspension of all operations beginning 25 August for the Nuiqsut (Cross Island) and Kaktovik subsistence bowhead whale hunts. During the suspension for the whale hunts the drilling vessel and support fleet will leave the Camden Bay project area and move to an area north of latitude 71° 25'N and west of longitude 146° 4'W and will return to resume activities after the Nuiqsut (Cross Island) and Kaktovik subsistence bowhead whale hunts conclude. During the drilling activities suspension in the bowhead whale hunt areas, vessel and drilling vessel resupply would likely occur well away from bowhead whale hunt areas. Activities will extend through October 31, depending on ice and weather.

Shell will cease exploration drilling on or before 31 October, after which the *Kulluk* or *Discoverer* will exit the Alaskan Beaufort Sea. In total, it is anticipated by Shell that the exploration drilling program will require approximately 78 drilling days, excluding weather, whaling shut-down or other operational delays. Shell assumes approximately 11 additional days will be needed for drilling vessel mobilization, drilling vessel moves between locations, and drilling vessel demobilization.

3. Species and Numbers of Marine Mammals in Area

Marine mammals that occur in the area of the planned Camden Bay 2012 exploration drilling program belong to three taxonomic groups: odontocetes (toothed cetaceans, such as beluga whale and narwhal), mysticetes (baleen whales), and carnivora (pinnipeds and polar bears). Cetaceans and pinnipeds (except Pacific walrus) are the subject of this IHA application to NMFS. The Pacific walrus and polar bear are managed by the U.S. Fish & Wildlife Service (USFWS).

Eight cetacean and four seal species under the jurisdiction of NMFS are known to or may occur in the area of the planned exploration drilling program. Two of these species, the bowhead and humpback whales, are listed as "endangered" under the U.S. Endangered Species Act (ESA). Humpback whales normally do not occur in the Beaufort Sea; however, a single humpback sighting of a cow/calf pair was recorded in western Harrison Bay in 2007 (Green et al. 2007). Another sighting of a single humpback whale reported during the 2009 aerial survey program for the Bowhead Whale Feeding Ecology Study (BOWFEST) was also likely in the Beaufort Sea near Barrow (Goetz et al. 2010). Two species of seal (ringed seal and bearded seal) have been proposed for listing as "threatened" species under the ESA (NMFS 2010a,b). Both species are common and abundant in the Beaufort Sea during the open-water season.

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

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

Sections 3 and 4 are integrated here to minimize repetition.

Eight cetacean and four seal species could occur in the U.S. Beaufort Sea during the planned exploration drilling program (Table 4-1). Of these twelve species, two cetacean species (beluga and bowhead whales), and three seal species (ringed, bearded, and spotted seals) are likely to occur near the proposed exploration drilling operations. The marine mammal species that is likely to be encountered most widely (in space and time) throughout the period of the planned exploration drilling program is the ringed seal. Encounters with bowhead and beluga whales are expected to be limited to particular regions and seasons, as discussed below.

Table 4-1 The Habitat, Abundance (in the Beaufort Sea), and Conservation Status of Marine Mammals in Habiting the Area of the Planned Exploration Drilling Program

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	NT	–
Beluga whale (Beaufort Sea Stock)	Offshore, Coastal, Ice edges	39,257 [5]	Not Listed	NT	–
Harbor Porpoise (*Phocoena phocoena*) (Bering Sea Stock)	Coastal, inland waters, shallow offshore waters	Uncommon	Not listed	LR-lc	–
Killer whale (*Orcinus orca*)	Widely distributed	Rare	Not listed	DD	–
Narwhal (*Monodon monoceros*)	Offshore, Ice edge	Rare [6]	Not listed	NT	–
Mysticetes					
Bowhead whale (*Balaena mysticetus*)	Pack ice & Shelf	10,545 [7] 12,631 [8]	Endangered	LR-lc	I
Gray whale (*Eschrichtius robustus*) (eastern Pacific population)	Coastal, lagoons	Uncommon	Not listed	LR-lc	I
Humpback whale (*Megaptera novaeangliae*)	Shelf, coastal	Rare	Endangered	LR-lc	I
Minke whale (*Balaenoptera acutorostrata*)	Shelf, coastal	Rare	Not listed	LR-lc	I
Pinnipeds					
Bearded seal (*Erignathus barbatus*)	Pack ice, shallow offshore waters	250,000-300,000[9] 155,000 [10]	Proposed Threatened	LR-lc	–
Ribbon seal (*Histriophoca fasciata*)	Offshore, pack ice	Rare	Not Listed	DD	–
Ringed seal (*Pusa hispida*)	Landfast & pack ice, offshore	18,000 [11] 326,500 [12]	Proposed Threatened	LR-lc	–
Spotted seal (*Phoca largha*)	Pack ice, coastal haulouts	59,214 [13] 1000 [14]	Arctic pop. Segments not listed	DD	–

[1] U.S. Endangered Species Act.
[2] Red List of Threatened Species (IUCN 2010). Codes for IUCN classifications: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LR = Lower Risk (nt = Near Threatened; lc = Least Concern); DD = Data Deficient.
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2004). Appendix I = endangered/threatened; Appendix II = threatened/at risk; Appendix III = some restrictions on trade of animals/animal parts
[4] Allen and Angliss (2010)
[5] Beaufort Sea population (IWC 2000, Allen and Angliss 2010).
[6] Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO Canada 2004); very few enter the Beaufort Sea
[7] 2001 Population Estimate (Zeh and Punt 2005)
[8] 2004 Population Estimate (Koski et al. 2010)
[9] Popov (1976), Burns (1981a)
[10] Beringia Distinct Population Segment (NMFS 2010a)
[11] Beaufort Sea minimum estimate with no correction factor based on aerial surveys in 1996-1999 (Frost et al. 2002 *in* Allen and Angliss 2010)
[12] Alaskan Beaufort Sea population estimate (Amstrup 1995)
[13] Alaska stock based on aerial surveys in 1992 (Allen and Angliss 2010)
[14] Alaska Beaufort Sea population (USDI/MMS 1996)

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

4.1 Odontocetes

(a) Beluga (Delphinapterus leucas)

Beluga whales are largely absent from the coast of the Alaskan Beaufort Sea during summer. A few beluga whales could be encountered there in late summer and autumn. There is a higher probability of encountering westward-migrating belugas farther offshore in the Beaufort Sea (>37 mi (60 km), or water depths >656 ft (200 m)) during late summer and autumn than in nearshore locations where exploration drilling related activities will be focused.

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

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

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

The most recent estimate of the ***eastern Chukchi Sea*** population is 3,710 animals (Allen and Angliss 2010). This estimate was based on surveys conducted in 1989–1991. Survey effort was concentrated on the 106-mi (171-km) long Kasegaluk Lagoon where belugas are known to occur during the open-water season. The calculation was considered to be a minimum population estimate for the eastern Chukchi Sea stock because the surveys on which it was based did not include offshore areas where belugas are also likely to occur. This population is considered to be stable. It is assumed that beluga whales from the eastern Chukchi stock winter in the Bering Sea (Allen and Angliss 2010).

Although beluga whales are known to congregate in Kasegaluk Lagoon during summer, evidence from a small number of satellite-tagged animals suggests that some of these whales may subsequently range into the Arctic Ocean north of the Beaufort Sea. Suydam et al. (2005) put satellite tags on 23 beluga whales captured in Kasegaluk Lagoon in late June and early July 1998–2002. Five of these whales moved far into the Arctic Ocean and into the pack ice to 79°–80°N. These and other whales moved to areas as far as 685 mi (1,102 km) offshore between Barrow and the Mackenzie River Delta spending time in water with 90% ice coverage.

Belugas of the eastern Chukchi Sea stock could occur in the vicinity of the planned exploration drilling activities if they were to migrate into or through the Beaufort Sea as reported by Suydam et al. (2005). However, most belugas that may occur near the activities will likely be from the Beaufort Sea stock.

The ***Beaufort Sea population*** was estimated to contain 39,258 individuals as of 1992 (DeMaster 1995; Allen and Angliss 2010). This estimate was based on the application of a sightability correction factor of 2× to the 1992 uncorrected census of 19,629 individuals made by Harwood et al. (1996). This estimate was obtained from a partial survey of the known range of the Beaufort Sea population and may be an underestimate of the true population size. This population is not considered by NMFS to be a strategic stock and is believed to be stable or increasing (Allen and Angliss 2010).

Beluga whales of the Beaufort Sea stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate through offshore waters of western and northern Alaska (Allen and Angliss 2010). The majority of belugas in the Beaufort Sea stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995a).

Much of the Beaufort Sea seasonal population enters the Mackenzie River estuary for a short period during July–August to molt their epidermis, but they spend most of the summer in offshore waters of the eastern Beaufort Sea, Amundsen Gulf and more northerly areas (Davis and Evans 1982; Harwood et al. 1996; Richard et al. 2001). Belugas are rarely seen in the central Alaskan Beaufort Sea during the early summer, but a number were reported there during early July from aerial surveys in 2008 (Christie et al. 2010). During late summer and autumn, most belugas migrate westward far offshore near the pack ice or shelf break (Frost et al. 1988; Hazard 1988; Clarke et al. 1993; Miller et al. 1999, Moore et al. 2000). During fall aerial surveys in the Alaskan Beaufort Sea, Lyons et al. (2009) reported the highest beluga sighting rates during the first two weeks of September in the northern part of their survey area.

Moore (2000) and Moore et al. (2000) suggested that beluga whales select deeper water at or beyond the shelf break independent of ice cover. However, during the westward migration in late summer and autumn, small numbers of belugas are sometimes seen near the north coast of Alaska (e.g., Johnson 1979). Christie et al. (2010) reported higher beluga sighting rates at locations >37 mi (60 km) offshore than at locations nearer shore during aerial surveys in the Alaskan Beaufort Sea in 2006-2008. The main fall migration corridor of beluga whales is typically ~62+ mi (100+ km) north of the coast. Satellite-linked telemetry data show that some belugas of this population migrate west considerably farther offshore, as far north as 76º to 78ºN latitude (Richard et al. 1997, 2001).

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

(b) Harbor Porpoise (*Phocoena phocoena*)

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

The subspecies *P. p. vomerina* ranges from the Chukchi Sea, Pribilof Islands, Unimak Island, and the southeastern shore of Bristol Bay south to San Luis Obispo, California. Point Barrow, Alaska, is the approximate northeastern extent of the regular range (Suydam and George 1992), though there are extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada and recent sightings in the Beaufort Sea in the vicinity of Prudhoe Bay during surveys in 2007 and 2008 (Christie et al. 2010). MMOs onboard industry vessels reported one harbor porpoise sighting in the Beaufort Sea in 2006 and no sightings were recorded in 2007 or 2008 (Savarese et al. 2010). Monnett and Treacy (2005) did not report any harbor porpoise sightings during aerial surveys in the Beaufort Sea from 2002 through 2004. Small numbers of harbor porpoises could occur in the general area of the planned Camden Bay exploration drilling program.

(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 (Allen and Angliss 2010).

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 (Allen and Angliss 2010). 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 (ADF&G 1994). Killer whales from either the North Pacific resident or transient stock could occur in the Chukchi or Beaufort seas during the summer or fall.

(d) Narwhal (Monodon monoceros)

Narwhals have a discontinuous arctic distribution (Hay and Mansfield 1989; Reeves et al. 2002). A large population inhabits Baffin Bay, West Greenland, and the eastern part of the Canadian Arctic archipelago, and much smaller numbers inhabit the Northeast Atlantic/East Greenland area. Population estimates for the narwhal are scarce, and the International Union for the Conservation of Nature (IUCN)-World Conservation Union lists the species as "near threatened" (IUCN 2010). Innes et al. (2002) estimated a population size of 45,358 narwhals in the Canadian

Arctic, although only part of the area was surveyed. There are scattered records of narwhal in Alaskan waters, including reports by subsistence hunters, where the species is considered extralimital (Reeves et al. 2002). Thus, it is possible, but unlikely, that individuals could be encountered in the area of the planned exploration drilling program.

4.2 Mysticetes

(a) Bowhead Whale (*Balaena mysticetus*)

Few bowhead whales are expected in the project area at the commencement of the exploration drilling program in July. Shell anticipates more bowheads to be present in the area in the fall during the whales' westward migration. Mitigation measures built into Shell's operational plans will mitigate potential impacts on local subsistence bowhead whale hunting and will minimize impacts on the species during exploration drilling activities before and after the subsistence hunt.

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunctive circumpolar distribution (Reeves 1980). The bowhead is one of only three whale species that spend their entire lives in the Arctic. Bowhead whales are found in four areas: the western Arctic (Bering, Chukchi, and Beaufort Seas) of northeastern Russia, Alaska, and northwestern Canada; the Canadian High Arctic and West Greenland (Nunavut, Baffin Bay, Davis Strait, and Hudson Bay); the Okhotsk Sea (eastern Russia); and the Northeast Atlantic from Spitzbergen westward to eastern Greenland. Those four stocks are recognized for management purposes. The largest population 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. Visual and satellite tracking data show that some bowhead whales continue migrating west past Barrow and through the Chukchi Sea to Russian waters where they may spend days to weeks apparently feeding before turning southeast toward the Bering Sea (Moore et al. 1995; Mate et al. 2000; Quakenbush et al. 2010). Some bowheads reach ~75°N latitude during the westward fall migration (Quakenbush et al. 2010).

The pre-exploitation population of bowhead whales in the Bering, Chukchi, and Beaufort Seas is estimated to have been 10,400-23,000 whales. Commercial whaling activities may have reduced this population to perhaps 3000 animals (Woodby and Botkin 1993). Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2% per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995). A census in 2001 yielded an estimated annual population growth rate of 3.4% (95% Confidence Interval [CI] 1.7–5%) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004) which was subsequently revised to 10,545 by Zeh and Punt (2005). A population estimate from photo identification data collected in 2004 was 12,631 (Koski et al. 2010) which further supports the estimated 3.4 percent population growth rate. Assuming a continuing annual population growth of 3.4%, the 2012 bowhead population may number around 15,232 animals. The large increases in population estimates that occurred from the late 1970s to the early 1990s were partly a result of actual population growth, but were also partly attributable to improved census techniques (Zeh et al. 1993). Although apparently recovering well, the BCB bowhead population is currently listed as endangered under the ESA and is classified as a strategic stock by NMFS and depleted under the MMPA (Allen and Angliss 2010).

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

Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most may remain among the offshore pack ice of the Beaufort Sea until mid-summer. After feeding primarily in the Canadian Beaufort Sea and Amundsen Gulf, bowheads migrate westward from late August through mid- or late October.

Fall migration into the Alaskan Beaufort Sea is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004, 2009a; Greene et al. 2007). Satellite tracking of bowheads has also shown that some whales move to the Chukchi Sea prior to September (ADF&G 2009). Consistent with this, Nuiqsut whalers have stated that the earliest arriving bowheads have apparently reached the Cross Island area earlier in recent years than formerly.

The BOEMRE (operating as the former Minerals Management Service [MMS]) has conducted or funded late-summer/autumn aerial surveys for bowhead whales in the Alaskan Beaufort Sea since 1979 (e.g., Ljungblad et al. 1986, 1987; Moore et al. 1989; Treacy 1988–1998, 2000, 2002a,b; Monnett and Treacy 2005; Treacy et al. 2006; Clarke et al. 2011a,b). Bowheads tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage than in years with less ice (Moore 2000; Treacy et al. 2006). In addition, the sighting rate tends to be lower in heavy ice years (Treacy 1997:67). During fall migration, most bowheads migrate west in water ranging from 49 to 656 ft (15 to 200 m) deep (Miller et al. 2002). Some individuals enter shallower water, particularly in light ice years, but very few whales are ever seen shoreward of the barrier islands in the Alaskan Beaufort Sea. Survey coverage far offshore in deep water is usually limited, and offshore movements may have been underestimated. However, the main migration corridor is over the continental shelf.

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

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

Most spring-migrating bowhead whales will pass through the Beaufort Sea prior to the start of exploration drilling operations in early July. However, a few whales that may remain in the Barrow area or other parts of the Alaskan Beaufort Sea during the summer could be encountered during project activities or by transiting vessels. More encounters with bowhead whales would occur during the westward fall migration in September and October. Shell, however, will suspend exploration drilling activities and leave the project area beginning on 25 August, before the beginning of the Kaktovik and Nuiqsut (Cross Island) fall subsistence harvest, and will not return and resume exploration drilling activities until the Kaktovik and Nuiqsut (Cross Island) hunts are concluded.

(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 that survives in the western Pacific summers near Sakhalin Island far from the planned area of the exploration drilling program. The larger eastern Pacific or California gray whale population recovered significantly from commercial whaling during its protection under the MMPA (and ESA until 1994) and numbered about 29,758 ±3122 in 1997 (Rugh et al. 2005). However, abundance estimates since 1997 indicate a consistent decline followed by stabilization or gradual recovery. Rugh et al. (2005) estimated the population to be 18,178 ±1780 in winter 2001–2002 and Rugh et al. (2008) estimated the population in winter 2006–2007 to have been 20,110 ±1766. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

Eastern Pacific gray whales calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1979; Jones and Swartz 1984). At the end of the calving season, most of these gray whales migrate about 4,971 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; Braham 1984; Nerini 1984; Moore et al. 2003; Bluhm et al. 2007). Most gray whales begin a southward migration in November with breeding and conception occurring in early December (Rice and Wolman 1971).

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

Gray whales occur regularly near Point Barrow, but historically only a small number of gray whales have been sighted in the Beaufort Sea east of Point Barrow. Hunters at Cross Island (near Prudhoe Bay) took a single gray whale in 1933 (Maher 1960). Only one gray whale was sighted in the central Alaskan Beaufort Sea during the extensive aerial survey programs funded by BOEMRE and industry from 1979 to 1997. However, during September 1998, small numbers of gray whales were sighted on several occasions in the central Alaskan Beaufort (Miller et al. 1999; Treacy 2000). More recently, a single sighting of a gray whale was made on 1 August 2001 near the Northstar production island (Williams and Coltrane 2002). Several gray whale sightings were reported during both vessel-based and aerial surveys in the Beaufort Sea in 2006-2008 (Christie et al. 2010; Saverese et al. 2010). Several single gray whales have been seen farther east in the Canadian Beaufort Sea (Rugh and Fraker 1981), indicating that small numbers must travel through the Alaskan Beaufort during some summers. In recent years, ice conditions have become reduced near Barrow, and gray whales may have become more common there and perhaps in the Beaufort Sea.

Given the infrequent occurrence and nearshore distribution of gray whales in the Beaufort Sea in summer, no more than a few gray whales are expected to be near the planned exploration drilling program in the Beaufort Sea. Beaufort Sea gray whales would be expected to remain close to shore and thus at some distance from much of the planned exploration drilling activity.

(c) Humpback Whale (*Megapter novaeangliae*)

Humpback whales are distributed in major oceans worldwide but have apparently been absent from Arctic waters of the North Pacific (Allen and Angliss 2010). In general, humpback whales spend the winter in tropical and sub-tropical waters where breeding and calving occur, and migrate to higher latitudes for feeding during the summer.

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

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

During the summer months humpback whales are common in Prince William Sound, and along the south side of the Alaska Peninsula to Unimak Pass. Humpback whales are less common in the Bering Sea and rare in the Chukchi Sea. Greene et al. (2007) reported and photographed a humpback whale cow/calf pair about 2 mi (4 km) east of Cape Simpson in western Harrison Bay in 2007, which is the first known occurrence of humpback whale in the Beaufort Sea. A second humpback whale sighting which was likely in the Beaufort Sea was reported near Barrow by Goetz et al. (2010). Humpback whales would be unlikely to occur near the planned exploration drilling program in Camden Bay.

(d) 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. Allen and Angliss (2010) recognize two minke whale stocks in U.S. waters including (1) the Alaska stock, and (2) the California/Oregon/Washington stock. There is no abundance estimate for the Alaska stock. Provisional estimates of minke whale abundance based on surveys in 1999 and 2000 are 810 and 1,003 whales in the central-eastern and southeastern Bering Sea, respectively. These estimates have not been corrected for animals that may have been submerged or otherwise missed during the surveys, and only a portion of the range of the Alaskan stock was surveyed. Minke whales range into the Chukchi Sea but are not likely to occur in the Beaufort Sea. Savarese et al. (2010) reported one minke whale sighting in the Beaufort Sea in 2007 and 2008. Minke whales would be unlikely to be observed in the Beaufort Sea near the planned exploration drilling program.

4.3 Seals

(a) Bearded Seal (*Erignathus barbatus*)

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981a). 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) (Cameron et al. 2009). During the summer period, bearded seals occur mainly in relatively shallow areas because they are predominantly benthic feeders (Burns 1981a). No reliable estimate of bearded seal abundance is available for the Beaufort Sea (Allen and Angliss 2010). The Alaska stock of bearded seals, part of the Beringia distinct population segment, has been proposed by NMFS for listing as threatened under the ESA (NMFS 2010a).

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

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

In some areas, bearded seals are associated with the ice year-round; however, they usually move shoreward into open water areas when the pack ice retreats to areas with water depths greater than 656 ft (200 m) (Cameron et al. 2009). In the Beaufort Sea, suitable habitat is limited to areas where the continental shelf is narrow because the pack ice edge frequently occurs seaward of the shelf and over water too deep for benthic feeding. The preferred habitat in the western and central Beaufort Sea during the open-water period is the continental shelf seaward of the scour zone, although a recent tagging study showed occasional movements of adult bearded seals seaward of the continental shelf (Cameron et al. 2009). WesternGeco conducted marine mammal monitoring during its open-water seismic program in the Alaskan Beaufort Sea from 1996 to 2001. Operations were conducted in nearshore waters, and of a total 454 seals that were identified to species while no airguns were operating, 4.4% were bearded seals, 94.1% were ringed seals and 1.5% were spotted seals (Moulton and Lawson 2002). Savarese et al. (2010) reported bearded seal densities in the Beaufort Sea ranging from $3.861 x 10^{-5}$ to 0.0220 seals/mi^2 (0.0001 to 0.0572 seals/km^2), during vessel-based surveys in 2006-2008.

(b) 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 1981b). 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 Beaufort Sea during recent vessel-based surveys in summer and fall of 2006-2007 with only three sightings among 997 seal sightings identified to species (Savarese et al. 2010).

Ribbon seals do not normally occur in the Beaufort Sea; however, two ribbon seal sightings were reported during vessel-based activities near Prudhoe Bay in 2008 (Savarese et al. 2010). Regardless, ribbon seals are unlikely to occur in the vicinity of the planned exploration drilling program in Camden Bay in 2012.

(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 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 (Allen and Angliss 2010). The Alaska stock, part of the Arctic subspecies of ringed seal, has been proposed for listing as threatened under the ESA (NMFS 2010b).

Ringed seals are year-round residents in the Beaufort Sea 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 (Allen and Angliss 2010). Past ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from

1–1.5 million (Frost 1985) to 3.3–3.6 million (Frost et al. 1988). Frost and Lowry (1981) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter. More recent estimates based on extrapolation from aerial surveys and on predation estimates for polar bears (Amstrup 1995) suggest an Alaskan Beaufort Sea population at ~326,500 animals.

Moulton et al. (2002) reported ringed seal densities (uncorrected) ranging from 0.17-0.24 seal/mi^2 (0.43-0.63 seal/km^2) in nearshore areas (>10 ft (3 m) deep) during aerial surveys during late spring in the central Alaskan Beaufort Sea. Ringed seal will likely be the most abundant marine mammal species encountered in the vicinity of the planned exploration drilling program in Camden Bay.

(d) 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 (Allen and Angliss 2010), but the estimate is most likely between several thousand and several tens of thousands (Rugh et al. 1997). During the summer spotted seals are found in Alaska from Bristol Bay through western Alaska to the Chukchi and Beaufort Seas. The ADF&G placed satellite transmitters on 4 spotted seals and estimated that the proportion of seals hauled out was 6.8%. Based on an actual minimum count of 4145 hauled out seals, Allen and Angliss (2010) 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 (Allen and Angliss 2010). Although the southern distinct population segment (DPS) of spotted seals was recently listed as threatened, it occurs entirely outside of U.S. waters.

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

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

5. The type of incidental taking authorization that is being requested

Shell requests an IHA pursuant to Section 101(a)(5)(D) of the MMPA for incidental take by harassment of small numbers of cetaceans and pinnipeds during the specified activities, its planned exploration drilling activities in Camden Bay during July–October, 2012.

The operations outlined in sections 1 and 2 are reasonably expected or reasonably likely to have the potential to take marine mammals by "Level B" harassment as a result of sound energy introduced into the marine environment. Sounds that may "harass" marine mammals will include near continuous, non-pulse sounds generated by the exploration drilling activities and pulsed sounds generated by the airguns used during the ZVSP activities. The effects will depend on the species of cetacean or pinniped, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see section 7). Disturbance reactions are likely to vary among some of the marine mammals in the general vicinity of the sound source. No "take" by serious injury is reasonably expected or reasonably likely, given the nature of the specified activities and the mitigation measures that are planned (see section 12). No lethal takes are expected.

6. Numbers of marine mammals that may potentially be taken

Shell seeks authorization for potential "taking" of small numbers of marine mammals under the jurisdiction of NMFS in the planned area of activity. Species for which authorization is sought are bowhead, gray, humpback, minke, and beluga whales, narwhal, harbor porpoise, and ringed, spotted, bearded, and ribbon seals. Exposure estimates and requests for takes of ribbon seal, humpback whale, minke whale, harbor porpoise and narwhal are also included, but are very minimal as sightings of these species in the Beaufort Sea are very rare.

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

The exploration drilling program in Camden Bay planned by Shell is not expected to "take" more than small numbers of marine mammals, or have more than a negligible impact on their populations. Discussions of estimated "takes by harassment" are presented below.

All anticipated takes would be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied, as described herein (see section 12), 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. The sections below 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 Camden Bay. 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 survey results or density estimates were made to account for seasonal distributions and population increases 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 exploration drilling operations by the area of water likely to be exposed to near continuous, non-pulse sounds ≥120 dB re 1 μPa root mean square (rms) during exploration drilling operations or impulse sounds ≥160 dB re 1 μPa rms created by seismic airguns during ZVSP activities. The single exception to this method is for the estimation of exposures of bowhead whales during the fall migration where more detailed data were available allowing an alternative approach to be used which is described below. 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 (2001). Any changes in behavior caused by sounds at or near the specified received levels would likely fall within the normal variation in such activities that would occur in the absence of exploration drilling operations.

To provide some allowance for the uncertainties, "maximum estimates" as well as "average estimates" of the numbers of marine mammals potentially affected have been derived. For a few marine mammal species, several density estimates were available, and in those cases the mean and maximum estimates were determined from the survey data. In other cases, no applicable estimate (or perhaps a single estimate) was available, so correction factors were used to arrive at "average" and "maximum" estimates. These are described in detail in the following sections.

During the fall, most bowhead whales will be migrating west past the exploration drilling program, so it is less accurate to assume that the number of individuals present in the area from one day to the next will be static. However, feeding, resting, and milling behaviors are not uncommon at this time and location. In order to incorporate the movement of whales past the planned operations, and because the necessary data are available, we have developed an alternative method of calculating the number of individual bowheads that may be exposed to sounds produced by the exploration drilling program (assuming no avoidance reactions).

The method is founded on estimates of the proportion of the population that would pass within the >120 dB or ≥160 dB zones on a given day during the migration while exploration drilling or ZVSP activities are occurring. Based on data in Richardson and Thomson (2002), the number of whales expected to pass each day after conclusion of the bowhead subsistence hunts (assumed to be 15 September for purposes of these calculations) was estimated as a proportion of the estimated 2012 bowhead whale population. The number of whales passing each day was based on the 10-day moving average presented by Richardson and Thomson (2002; Appendix 9.1). Richardson and Thomson (2002) also calculated the proportion of animals within water depth bins (<66 ft [20 m], 66-131 ft [20-40 m], 131-656 ft [40-200 m], >656 ft [200 m]). Using this information we multiplied the total number of whales expected to pass the exploration drilling program each day by the proportion of whales that would be in each depth category to estimate how many individuals would be within each depth bin on a given day. The proportion of each depth bin falling within the ≥120 dB zone was then multiplied by the number of whales within the respective bins to estimate the total number of individuals that would be exposed on each day of drilling or ZVSP activity, if they showed no avoidance of the operations.

Exploration drilling will be suspended on 25 August prior to the start of the bowhead subsistence hunts at Kaktovik and Nuiqsut (Cross Island) and the drilling vessel and support fleet will leave the project area. After the completion of the subsistence hunts (for purposes of these calculations this was assumed to be 15 September), the drilling vessel and support fleet will return and exploration drilling activity will resume and continue as late as 31 October. Therefore, the daily calculations described above were repeated for all days from 15 September to 31 October and the results were summed to estimate the total number of bowhead whales that might be exposed to either continuous sounds ≥120 dB rms from drilling or impulsive sounds ≥160 dB rms from ZVSP surveys during the migration period in the Beaufort Sea.

Marine Mammal Density Estimates

Marine mammal densities near the operation are likely to vary by season and habitat. However, sufficient published data allowing the estimation of separate densities during summer (July and August) and fall (September and October) are only available for beluga and bowhead whales. As noted above, exposures of bowhead whales during the fall are not calculated using densities (see detailed description below). So summer and fall densities have been estimated for beluga whales and a summer density has been estimated for bowhead whales. Densities of all other species have been estimated to represent the duration of both seasons.

Marine mammal densities are also likely to vary by habitat type. In the Alaskan Beaufort Sea, where the continental shelf break is relatively close to shore, marine mammal habitat is often defined by water depth. Bowhead and beluga occurrence within nearshore (0-131 ft [0-40 m]), outer continental shelf (131-656 ft [40-200 m]) slope (656-6,562 ft [200-2,000 m]), basin (>6,562 ft [2,000 m]), or similarly defined habitats have been described previously (Moore et al. 2000; Richardson and Thomson 2002). The presence of most other species has generally only been described relative to the entire continental shelf zone (0-656 ft [0-200 m]) or beyond. Sounds produced by the drilling vessel are expected to drop below 120 dB (continuous) and 160 dB (pulses) within the nearshore zone (0-131 ft [0-40 m] water depth).

In addition to water depth, densities of marine mammals are likely to vary with the presence or absence of sea ice (see below for descriptions by species). At times during either summer or fall, pack-ice may be present in some of the area around the exploration drilling operation. However, the retreat of sea ice in the Alaskan Beaufort Sea has been substantial in recent years so we have assumed that only 33% of the area exposed to sounds ≥120 dB rms or ≥160 dB rms by the exploration drilling program will be in ice margin habitat. Therefore ice-margin densities of marine mammals in both seasons have been multiplied by 33% of the area exposed to sounds by the exploration drilling and ZVSP activities, while open-water (nearshore) densities have been multiplied by the remaining 67% of the area.

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

Cetaceans

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

Beluga density estimates were derived from data in Moore et al. (2000). During summer, beluga whales are most likely to be encountered in offshore waters of the eastern Alaskan Beaufort Sea or areas with pack ice. The summer beluga whale nearshore density (Table 6-1) was based on 7,447 mi (11,985 km) of on-transect effort and 9 associated sightings that occurred in water ≤164 ft (50 m) in Moore et al. (2000; Table 2). A mean group size of 1.63, a f(0) value of 2.841, and a g(0) value of 0.58 from Harwood et al. (1996) were used in the density calculation. Moore et al. (2000) found that belugas were equally likely to occur in heavy ice conditions as open water or very light ice conditions in summer in the Beaufort Sea, so the same density was used for both nearshore and ice-margin estimates (Table 6-1). The fall beluga whale nearshore density was based on 45,180 mi (72,711 km) of on-transect effort and 28 associated sightings that occurred in water ≤164 ft (50 m) reported in Moore et al (2000). A mean group size of 2.9 (Coefficient of Variation [CV]=1.9), calculated from all Beaufort Sea fall beluga sightings in ≤164 ft (50 m) of water present in the BWASP database, along with the same f(0) and g(0) values from Harwood et al. (1996) were used in the density calculation. Moore et al. (2000) found that during fall in the Beaufort Sea belugas occurred in moderate to heavy ice at higher rates than in light ice, so ice-margin densities were estimated to be twice the nearshore densities (Table 6-1). Based on the CV of group size, maximum estimates in both season and habitats were estimated as four times the average estimates. Exposures of beluga whales during fall in the Beaufort Sea were not calculated in the same manner as described for bowhead whales (below) because of the relatively lower expected densities of beluga whales in nearshore habitat near the exploration drilling program and the lack of detailed data on the likely timing and rate of migration through the area.

Table 6-1 Expected Summer (July -- August) and Fall (September – October) Densities of Beluga and Bowhead Whales in the Eastern Alaskan Beaufort Sea. Densities are Corrected for f(0) and g(0) Biases. Species Listed Under the U.S. ESA as Endangered are shown in italics.

	Nearshore		Ice Margin	
Season Species	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**	**Average Density (# / km^2)**	**Maximum Density (# / km^2)**
Summer				
Beluga	0.0030	0.0120	0.0030	0.0120
Bowhead whale	0.0186	0.0717	0.0186	0.0717
Fall				
Beluga	0.0027	0.0108	0.0054	0.0216
Bowhead whale	*N/A*	*N/A*	*N/A*	*N/A*

Eastward migrating ***bowhead whales*** were recorded during industry aerial surveys of the continental shelf near Camden Bay in 2008 until 12 July (Lyons and Christie 2009). No bowhead sightings were recorded again, despite continued flights, until 19 August. Aerial surveys by industry operators did not begin until late August of 2006 and 2007, but in both years bowheads were also recorded in the region before the end of August (Christie et al. 2010). The late August sightings were likely of bowheads beginning their fall migration so the densities calculated from those surveys were not used to estimate summer densities in this region. The three surveys in July of 2008 resulted in density estimates of 0.0038, 0.0277, and 0.0072 bowhead whales/mi^2 (0.0099, 0.0717, and 0.0186 bowhead whales/km^2), respectively (Lyons and Christie 2009). The estimate of 0.0186 whales/km^2 was used as the average nearshore density and the estimate of 0.0277 whales/mi^2 (0.0717 whales/km^2) was used as the maximum (Table 6-1). Sea ice was not present during these surveys. Moore et al. (2000) reported that bowhead whales in the Alaskan Beaufort Sea were distributed uniformly relative to sea ice, so the same nearshore densities were used for ice-margin habitat.

During fall, most bowhead whales will be migrating west past the exploration drilling program, so it is less accurate to assume that the number of individuals present in the area from one day to the next will be static. However, feeding, resting, and milling behaviors are not uncommon at this time and location. In order to incorporate the movement of whales past the planned operations, and because the necessary data are available, we used the method described in the previous section *Basis for Estimating "Take by Harassment"*. The method was founded on estimates of the proportion of the population that would pass within the >120 dB rms or ≥160 dB rms zones on a given day during the exploration drilling or ZVSP activities. If the bowhead population has continued to grow at an annual rate of 3.4%, the 2012 population size would be ~15,232 individuals based on a 2001 population of 10,545 (Zeh and Punt 2005). The estimated population size of 15,232 was therefore used as the foundation of the calculations of exposures during the migration period. The estimate of the proportion of the population passing the exploration drilling operation on each day is based on a 10-day moving average and the calculations have been made over a substantial length of time, so it would take significant variation in the timing or nature of the migration to substantially deviate from the estimate calculated in this manner. Nonetheless, if a large portion of the migration were to be delayed or otherwise distributed closer to the area of the exploration drilling operations, more than the estimated number of whales could be exposed. Therefore, a maximum estimate of 2 times the average estimate has been calculated, although it is unlikely that a substantial enough variation in the migration timing and location would cause such an increase in the number of whales present near the operations.

For ***other cetacean species*** that may be encountered in the Beaufort Sea, densities are likely to vary somewhat by season, but differences are not expected to be great enough to require estimation of separate densities for the two seasons. Harbor porpoises and gray whales are not expected to be present in large numbers in the Beaufort Sea during the fall but small numbers may be encountered during the summer. They are most likely to be present in nearshore waters (Table 6-2). Narwhals are not expected to be encountered within the exploration drilling program area. However, there is a chance that a few individuals may be present if ice is nearby. The first record of humpback whales in the Beaufort Sea was documented in 2007 so their presence cannot be ruled out. Since these species occur so infrequently in the Beaufort Sea, little to no data are available for the calculation of densities. Minimal densities have therefore been assigned for calculation purpose and to allow for chance encounters (Table 6-2).

Seals

Extensive surveys of ringed and bearded seals have been conducted in the Beaufort Sea, but most surveys have been conducted over the landfast ice, and few seal surveys have occurred in open water or in the pack ice. Kingsley (1986) conducted ***ringed seal*** surveys of the offshore pack ice in the central and eastern Beaufort Sea during late spring (late June). These surveys provide the most relevant information on densities of ringed seals in the ice margin zone of the Beaufort Sea. The density estimate in Kingsley (1986) was used as the average density of ringed seals that may be encountered in the ice margin (Table 6-2). The average ringed seal density in the nearshore zone of the Alaskan Beaufort Sea was estimated from results of ship–based surveys at times without seismic operations reported by Moulton and Lawson (2002; Table 6-2).

Densities of ***bearded seals*** were estimated by multiplying the ringed seal densities by 0.051 based on the proportion of bearded seals to ringed seals reported in Stirling et al. (1982; Table 6-2). ***Spotted seal*** densities in the nearshore zone were estimated by summing the ringed seal and bearded seal densities and multiplying the result by 0.015 based on the proportion of spotted seals to ringed plus bearded seals reported in Moulton and Lawson (2002; Table 6-2). Minimal values were assigned as densities in the ice–margin zones (Table 6-2). Minimal values were used to estimate ***ribbon seal*** densities as their presence in the Beaufort Sea is very uncommon.

Table 6-2 Expected Densities of Cetaceans (Excluding Beluga and Bowhead Whale) and Seals in the Alaskan Beaufort Sea During Both Summer (July – August) and Fall (September – October) Seasons

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

Estimated Area Exposed to Sounds ≥120 dB or ≥160 dB re 1 µPa rms

Estimated Area Exposed to Continuous Sounds ≥120 dB re 1 µPa rms from Exploration Drilling Activities

Exploration drilling in Camden Bay will be conducted from either the *Kulluk* or the *Discoverer*. The two vessels are likely to introduce somewhat different levels of sound into the water during exploration drilling activities. Descriptions of the expected source levels and propagation distances from the two vessels are provided in this section. These distances and associated ensonified areas are then used in the following section to calculate separate estimates of potential exposures.

Sounds from the *Kulluk* were measured in the Beaufort Sea in 1986 and reported by Greene (1987a). The back propagated broadband source level from the measurements (185.5 dB re 1 µPa · m rms; calculated from the reported 1/3-octave band levels), which included sounds from a support vessel operating nearby, were used to model sound propagation at the Sivulliq prospect near Camden Bay. The model estimated that sounds would decrease to 120 dB rms at ~8.25 mi (13.27 km) from the *Kulluk* (JASCO 2007; Table 6-3). As a precautionary approach, that distance was multiplied by 1.5 and the resulting radius of 12.37 mi (19.91 km) was used to estimate the total area that may be exposed to continuous sounds ≥120 dB re 1 µPa rms by the *Kulluk* at each drill site. Assuming one well site will be drilled in each season (summer and fall), the total area of water ensonified to ≥120 dB rms in each season would be 481 mi^2 (1,245 km^2).

Table 6-3 Sound Propagation Modeling Results of Exploration Drilling and ZVSP Activities Near Camden Bay in the Beaufort Sea

Source	Received Level (dB re 1 µPa)	Modeling Results (km)	Used in Calculations (km)
Kulluk	120	13.27	19.91
Discoverer	120	3.32	4.98
ZVSP	160	3.67	5.51

Sounds from the *Discoverer* have not previously been measured in the Arctic. However, measurements of sounds produced by the *Discoverer* were made in the South China Sea in 2009 (Austin and Warner 2010). The results of those measurements were used to model the sound propagation from the *Discoverer* (including a nearby support vessel) at planned exploration drilling locations in the Chukchi and Beaufort seas (Warner and Hannay 2011). Broadband source levels of sounds produced by the *Discoverer* varied by activity and direction from the ship, but were generally between 177 and 185 dB re 1 µPa · m rms (Austin and Warner 2010). Propagation modeling at the Sivulliq and Torpedo prospects yielded somewhat different results, with sounds expected to propagate shorter distances at the Sivulliq site (Warner and Hannay 2011). As a precautionary approach, the larger distance to which sounds ≥120 dB (2.06 mi [3.32 km]) are expected to propagate at the Torpedo site have been used to estimate the area of water potentially exposed at both locations. The estimated (2.06 mi [3.32 km]) distance was multiplied by 1.5 (= 3.09 mi [4.98 km]) as a further precautionary measure before calculating the total area that may be exposed to continuous sounds ≥120 dB re 1 µPa rms by the *Discoverer* at each drill site (Table 6-3). Assuming one well will be drilled in each season (summer and fall), the total area of water ensonified to ≥120 dB rms in each season would be 30 mi^2 (78 km^2).

The acoustic propagation model used to estimate the sound propagation from both vessels in Camden Bay is JASCO'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).

For analysis of the potential effects on migrating bowhead whales we calculated the total distance perpendicular to the east-west migration corridor ensonified to ≥120 dB rms in order to determine the number of migrating whales passing the activities that might be exposed to that sound level. For the *Kulluk*, that distance is two times 12.4 mi (19.9 km) (the estimated radius of the 120 dB rms zone), or 24.7 mi (39.8 km) (i.e. 12.4 mi [19.9 km] north and 12.4 mi [19.9 km] south of the drill site); for the *Discoverer*, that distance is two times 3.09 mi, or 6.19 mi, (4.98 km, or 9.96 km). At the two Sivulliq sites (G and N, which are located close together and positioned similarly relative to the 131 and 656 ft [40 and 200 m] bathymetric contours), the 24.7 mi (39.8 km) distance from the *Kulluk* covers all of the 23 mi (37 km) wide 0-131 ft (0-40 m) water depth category, and ~11% of the 22.1 mi (35.5 km) wide 131-656 ft (40-200 m) water depth category. The 9.96 km distance from the *Discoverer* covers 27% of the 0-131 ft (0-40 m) category and none of the 131-656 ft (40-200 m) category at the Sivulliq sites.

The two drill sites on the Torpedo prospect (designated as H and J) are not as close together as the Sivulliq sites, but their position relative to the 131 ft (40 m) and 656 ft (200 m) bathymetric contours are similar. For simplicity, only the slightly greater estimates resulting from calculations at the Torpedo "H" site are provided here and are used to represent activities at either of the two Torpedo sites. At the Torpedo "H" site, the 24.7 mi (39.8 km) distance from the *Kulluk* covers ~74% of the 37 km wide 0-131 ft (0-40 m) water depth category and ~35% of the 22.1 mi (35.5 km) wide 131-656 ft (40-200 m) water depth category. The 6.19mi (9.96 km) distance from the *Discoverer* covers 27% of the 0-131 ft (0-40 m) category and none of the 131-656 ft (40-200 m) category at either of the Torpedo sites.

As described above in the section *Basis for Estimating "Take by Harassment"*, the percentages of water depth categories described in the previous two paragraphs were multiplied by the estimated proportion of the whales passing within those categories on each day to estimate the number of bowheads that may be exposed to sounds ≥120 dB if they showed no avoidance of the exploration drilling operations.

Estimated Area Exposed to Impulse Sounds ≥160 dB re 1µPa rms from ZVSP Activities

A typical sound source that would be used by Shell for the ZVSP survey in 2012 is the ITAGA eight-airgun array, which consists of four 150-in^3 (2,458-cm^3) airguns and four 40-in^3 (655-cm^3) airguns. The ≥160 dB re 1 µPa rms radius for this source was estimated from measurements of a similar seismic source used during the 2008 BP Liberty seismic survey (Aerts et al. 2008). The BP liberty source was also an eight-airgun array, but had a slightly larger total volume of 880 in^3. Because the number of airguns is the same, and the difference in total volume only results in an estimated 0.4 dB decrease in the source level of the ZVSP source, the 100th percentile propagation model from the measurements of the BP Liberty source is almost directly applicable. However, the BP Liberty source was towed at a depth of 5.9 ft (1.8 m), while the ZVSP source will be lowered to a target depth of 13 ft (4 m) (from 10-23 ft [3-7 m]). The deeper depth of the ZVSP source has the potential to increase the source strength by as much as 6 dB. Thus, the constant term in the propagation equation from the BP Liberty source was increased from 235.4 to 241.4 while the remainder of the equation (–18*LogR – 0.0047*R) was left unchanged. This equation results in the following estimated distances to maximum received levels: 190 dB = 524 m; 180 dB = 1,240 m; 160 dB = 3,670 m; 120 dB = 10,500 m. The ≥160 dB distance was multiplied by 1.5 (Table 6-4) for use in estimating the area ensonified to ≥160 dB rms around the drilling vessel during VSP activities. Therefore, the total area of water potentially exposed to received sound levels ≥160 dB rms by ZVSP operations at one exploration well sites during each season is estimated to be 73.7 mi^2 (190.8 km^2).

For analysis of potential effects on migrating bowhead whales, the ≥120 dB distance for exploration drilling activities was used on all days during the bowhead migration as described above. This is a precautionary approach in the case of the *Kulluk* since the ≥160 dB zone for the relatively brief ZVSP surveys is expected to be less than the ≥120 dB distance from the *Kulluk*. If the *Discoverer* were to be used, the slightly greater distance to the ≥160 dB threshold from the ZVSP airguns than the ≥120 dB distance from the *Discoverer* (Table 6-3) would result in only 3% more of the 0-131 ft (0-40 m) depth category being ensonified on up to 2 days. This would result in an estimated increase of ~10 bowhead whales compared to the estimates shown in (Table 6-7).

Sound propagation measurements will be performed on the *Kulluk* or *Discoverer* (whichever is used), and the ZVSP airgun source in 2012, once they are on location near Camden Bay. The results of those measurements will be used during the season to implement mitigation measures as required by the permit.

Potential Number of "Takes by Harassment"

This subsection provides estimates of the number of individuals potentially exposed to continuous sound levels ≥120 dB re 1 μPa rms from exploration drilling activities and pulsed sound levels ≥160 dB re 1 μPa rms by ZVSP activities. The estimates are based on a consideration of the number of marine mammals that might be disturbed appreciably by operations in Camden Bay and the anticipated area exposed to those sound levels.

The number of different individuals of each species potentially exposed to received levels of continuous drilling related sounds ≥120 dB re 1 μPa (rms) or to pulsed airgun sounds ≥160 dB re 1 μPa (rms) within each season and habitat zone was estimated by multiplying:

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

The estimate for bowhead whales during the migration period was calculated differently as described in the previous sections. The numbers of exposures were then summed for each species across the seasons and habitat zones.

Numbers of marine mammals that might be present and potentially disturbed are estimated below based on available data about mammal distribution and densities at different locations and times of the year as described above. Exposure estimates are based on a single drilling vessel (*Kulluk* or *Discoverer*) operating in Camden Bay beginning in July. Shell will not operate the drilling vessel (*Kulluk* or *Discoverer*) and associated vessels in Camden Bay during the 2012 Kaktovik and Nuiqsut (Cross Island) fall bowhead whale subsistence hunts. Shell will suspend exploration activities on 25 August and leave the project area prior to the beginning of the hunts, and will return and resume activities in Camden Bay after conclusion of the subsistence hunts. Shell expects exploration drilling activities to be completed on or before 31 October 2012.

At times during either summer (July-August) or fall (September-October), pack-ice may be present in some of the area around the exploration drilling operation. However, the retreat of sea ice in the Alaskan Beaufort Sea has been substantial in recent years so we have assumed that only 33% of the area exposed to sounds ≥120 dB or ≥160 dB by the exploration drilling program will be in ice margin habitat. Therefore ice-margin densities of marine mammals in both seasons have been multiplied by 33% of the area exposed to sounds by the drilling and ZVSP activities, while open-water (nearshore) densities have been multiplied by the remaining 67% of the area.

Many of the animals exposed to sound levels near 120 dB rms would not react to those sound levels, particularly seals, and exposures to drilling sounds at this level should not be considered "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" is likely less than the number estimated herein to potentially be exposed to ≥120 dB (or ≥160 dB from the ZVSP activities).

Cetaceans

Cetacean species potentially exposed to exploration drilling program sounds with received levels ≥120 dB rms or airgun sounds ≥160 dB rms may include both mysticetes (bowhead, gray, humpback, and minke whales), and odontocetes (beluga, narwhal, harbor porpoise, and killer whale. Species with an estimated average number of individuals exposed equal to zero are included here for completeness, but are not likely to be encountered.

Separate estimates for beluga and bowhead whales are provided based on whether the *Kulluk* (Table 6-4) or the *Discoverer* (Table 6-5) is used as the drilling vessel in 2012. The results presented in these two tables should not be summed, as the operations will only be conducted from one of the drilling vessels. Estimates of exposure to airgun pulses from ZVSP activities are provided in Table 6-6.

If the *Kulluk* is used, the best (average) estimates of the number of individual belugas and bowheads exposed to continuous sounds ≥120 dB during both summer and fall are 8 and 5,598, respectively (Table 6-4). The smaller size of the expected ≥120 dB zone around the *Discoverer* resulted in an estimated 0 and 1,388 beluga and bowhead whales potentially being exposed to sounds ≥120 dB during summer and fall, respectively (Table 6-5). Because of the short duration of the ZVSP surveys, they are not expected to contribute substantially to the estimated number of beluga and bowheads exposed by the activities (Table 6-6). The estimated exposure of bowheads to these sounds during the migration has already been included in the estimates for the *Kulluk* (Table 6-4). The slightly greater distance to the ≥160 dB threshold from the ZVSP airguns than the ≥120 dB distance from the *Discoverer* (Table 6-3) would result in only 3% more of the 0-131 ft (0-40 m) depth category being ensonified on up to 2 days. This would result in an estimated increase of ~10 bowhead whales compared to the estimate shown in (Table 6-5).

Few other cetaceans are likely to be present in the area of the planned operations and the very small estimated densities for those species were not large enough for the calculations to result in estimates >1% from the *Kulluk* (Table 6-7), *Discoverer* (Table 6-8), or ZVSP activities (Table 6-9).

Table 6-4 Estimates of the Numbers of Beluga and Bowhead Whales in Areas Where Maximum Received Sound Levels in the Water Would Be ≥120 dB from operations conducted by *Kulluk* During Shell's Planned Exploration Drilling Program in Summer (July – August) and Fall (September – October) near Camden Bay in the Beaufort Sea, Alaska, 2012. Not All Marine Mammals Will Change Their Behavior When Exposed to these Sound Levels.

Season	Number of Exposure to Sound Levels ≥120 dB from *Kulluk*					
	Nearshore		Ice Margin		Total	
Species	Avg.	Max.	Avg.	Max.	Avg.	Max.
Summer						
Beluga	3	10	1	5	4	15
Bowhead whale	16	60	8	29	23	89
Fall						
Beluga	2	9	2	9	4	18
Bowhead whale [a]	5,575	11,150	*N/A*	*N/A*	5,575	11,150

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

Table 6-5 Estimates of the Numbers of Beluga and Bowhead Whales in Areas Where Maximum Received Sound Levels in the Water Would Be ≥120 dB from operations conducted by *Discoverer* During Shell's Planned Exploration Drilling Program in Summer (July – August) and Fall (September – October) near Camden Bay in the Beaufort Sea, Alaska, 2012. Not All Marine Mammals Will Change Their Behavior When Exposed to these Sound Levels.

Season	Number of Exposure to Sound Levels ≥120 dB from *Discoverer*					
	Nearshore		Ice Margin		Total	
Species	Avg.	Max.	Avg.	Max.	Avg.	Max.
Summer						
Beluga	0	1	0	0	0	5
Bowhead whale	1	4	0	2	1	6
Fall						
Beluga	0	1	0	1	0	5
Bowhead whale [a]	1,387	2,774	*N/A*	*N/A*	1,387	2,774

[a] See text for description of bow head w hale estimates for the Fall in the Beaufort Sea

Table 6-6 Estimates of the Numbers of Beluga and Bowhead Whales in Areas Where Maximum Received Sound Levels in the Water Would Be ≥160 dB from ZVSP Activities During Shell's Planned Exploration Drilling Program in Summer (July – August) and Fall (September – October) near Camden Bay in the Beaufort Sea, Alaska, 2012. Not All Marine Mammals Will Change Their Behavior When Exposed to these Sound Levels.

	Number of Exposure to Sound Levels ≥160 dB from VSP					
Season	**Nearshore**		**Ice Margin**		**Total**	
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Summer						
Beluga	0	1	0	0	0	5
Bowhead whale	1	4	1	2	2	7
Fall						
Beluga	0	1	0	1	0	5
Bowhead whale [a]	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

[a] See text for description of bowhead whale estimates for the Fall in the Beaufort Sea. Estimates for VSP activities have been included in the calculations from drilling (Table 6-4 or 6-5)

Table 6-7 Estimates of the Numbers of Marine Mammals (Excluding Beluga and Bowhead Whales, Which are Shown in Tables 6-6) in Each Offshore area where maximum received sound levels in the water would be ≥120 dB from the *Kulluk* during Shell's Planned Exploration Drilling Program near Camden Bay in the Beaufort Sea, Alaska, July – October 31, 2012. Not All Marine Mammals Will Change Their Behavior When Exposed to these Sound Levels.

	Number of Exposure to Sound Levels ≥120 dB from *Kulluk*					
	Nearshore		**Ice Margin**		**Total**	
Species	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Odontocetes						
Monodontidae						
Narwhal	0	0	0	0	0	5
Phocoenidae						
Harbor porpoise	0	1	0	0	0	5
Mysticetes						
Gray whale	0	1	0	0	0	5
Pinnipeds						
Bearded seal	30	121	11	42	41	163
Ribbon seal	0	1	0	0	0	5
Ringed seal	592	2367	206	825	798	3192
Spotted seal	6	25	0	0	6	25

Table 6-8 Estimates of the Numbers of Marine Mammals (Excluding Beluga and Bowhead Whales, Which are Shown in Tables 6-7) in Each Offshore area where maximum received sound levels in the water would be ≥120 dB from the *Discoverer* during Shell's Planned Exploration Drilling Program near Camden Bay in the Beaufort Sea, Alaska, July – October 31, 2012. Not All Marine Mammals Will Change Their Behavior When Exposed to these Sound Levels.

	Number of Exposure to Sound Levels ≥120 dB from *Discoverer*					
	Nearshore		Ice Margin		Total	
Species	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Odontocetes						
Monodontidae						
Narwhal	0	0	0	0	0	5
Phocoenidae						
Harbor porpoise	0	0	0	0	0	5
Mysticetes						
Gray whale	0	0	0	0	0	5
Pinnipeds						
Bearded seal	2	7	1	3	3	10
Ribbon seal	0	0	0	0	0	5
Ringed seal	37	146	13	52	49	198
Spotted seal	0	2	0	0	0	5

Table 6-9 Estimates of the Numbers of Marine Mammals (Excluding Beluga and Bowhead Whales, Which are Shown in Tables 6-8) in Each Offshore area where maximum received sound levels in the water would be ≥160 dB from ZVSP Activities during Shell's Planned Exploration Drilling Program near Camden Bay in the Beaufort Sea, Alaska, July – October 31, 2012. Not All Marine Mammals Will Change Their Behavior When Exposed to these Sound Levels.

	Number of Exposure to Sound Levels ≥160 dB from VSP					
	Nearshore		Ice Margin		Total	
Species	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Odontocetes						
Monodontidae						
Narwhal	0	0	0	0	0	5
Phocoenidae						
Harbor porpoise	0	0	0	0	0	5
Mysticetes						
Gray whale	0	0	0	0	0	5
Pinnipeds						
Bearded seal	2	9	1	3	3	12
Ribbon seal	0	0	0	0	0	5
Ringed seal	44	178	16	63	60	241
Spotted seal	0	2	0	0	0	5

Seals

The ringed seal is the most widespread and abundant pinniped in ice-covered arctic waters, and there appears to be a great deal of year-to-year variation in abundance and distribution of these marine mammals. As a result of their high abundance, ringed seals account for a large number of marine mammals expected to be encountered during the exploration drilling program, and hence exposed to sounds with received levels ≥120 dB or ≥160 dB rms. If the *Kulluk* is used, calculations based on the average density result in an estimate of 798 ringed seals that might be exposed during summer and fall to sounds with received levels ≥120 dB from the exploration drilling program (Table 6-9). Should the *Discoverer* be used, the estimated number of ringed seals exposed to ≥120 dB during summer and fall is 49 (Table 6-8). The ZVSP activities are estimated to expose 60 ringed seals to pulsed airgun sounds ≥160 dB (Table 6-9).

Two additional seal species are expected to be encountered with lower frequency than ringed seals. Estimates based on average densities of bearded seals and spotted seals are 41 and 6, respectively, during summer and fall if the exploration drilling program is conducted by the *Kulluk* (Table 6-7). If the *Discoverer* is used, the estimates are reduced to 3 and 0 for bearded and spotted seals, respectively (Table 6-8). Exposures of individuals from either species to sound levels ≥160 dB from the ZVSP activities are expected to be quite low due to the relative small area expected to be exposed to those sounds (Table 6-9). The ribbon seal is unlikely to be encountered, but the presence of a few individuals cannot be ruled out.

Conclusions

Effects on marine mammals are generally expected to be restricted to avoidance of the area around the planned activities and short-term changes in behavior, falling within the MMPA definition of "Level B harassment". The planned exploration drilling program in Camden Bay will involve one drilling vessel that will introduce continuous sounds into the ocean and up to two brief periods of airgun activity during ZVSP surveys. Other routine vessel operations are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

Cetaceans

Using the 120 dB criterion for continuous sounds from the exploration drilling operations and the 160 dB criterion for pulsed airgun sounds from the ZVSP activities, the best (average) estimates of the numbers of individual cetaceans potentially exposed represent varying proportions of the populations of each species in the Beaufort Sea and adjacent waters. If the *Kulluk* is used for the exploration drilling operation the calculations suggest ~5,600 bowheads may be exposed to sounds at the specified levels, nearly all of which would occur during the fall migration. This number is ~37% of the estimated 2012 BCB population of >15,232 assuming 3.4% annual population growth from the 2001 estimate of >10,545 animals (Zeh and Punt 2005). If the *Discoverer* were to be used, the estimate falls to ~1,390 bowheads, or ~9.1% of the 2012 population estimate. The small numbers of other mysticetes whales that may occur in the Beaufort Sea are unlikely to be present around the planned operations. The few that might occur would represent a very small proportion of their respective populations.

Some monodontids may be exposed to sounds produced by the exploration drilling program, and the numbers potentially affected are small relative to the population sizes. The best estimate of the number of belugas that might be exposed to continuous drilling sounds ≥120 dB or pulsed airgun sounds ≥160 dB rms from ZVSP surveys is <5, which represents <1% of the Beaufort Sea stock. Narwhals are extremely rare in the U.S. Beaufort Sea and few, if any, are expected to be encountered during the survey.

Seals

Several seal species could be encountered in the study area, but ringed seal is by far the most abundant in this area. Assuming the *Kulluk* is used to conduct the exploration drilling program, the estimates calculated using average densities suggest the numbers of individuals exposed to sounds at received levels ≥120 dB during the exploration drilling program or ≥160 dB during ZVSP surveys are as follows: ringed seals (858), bearded seals (44), and spotted seals (6), (representing <1% of their respective Beaufort Sea populations). If the *Discoverer* is used, the estimates decrease to 109 ringed seals, 6 bearded seals, and a minimal number of spotted seals. Most seals are unlikely to react to continuous sounds until they are much stronger than 120 dB, so it is probable that only a small percentage of these animals would actually be disturbed.

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

The reasonably expected or reasonably likely impacts of the specified activities (planned offshore exploration drilling program and brief ZVSP surveys) 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 exploration drilling activity, vessels and aircraft.

7.1 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. However, some data are now available for two species of odontocetes exposed to a single strong noise pulse lasting 1 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 there to be any temporary threshold shift (TTS). 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).

Exploration Drilling Sounds

Exploration drilling will be conducted from the *Kulluk* or *Discoverer,* vessels specifically prepared 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. Underwater sound levels may also depend on the specific equipment in operation. Lower sound levels have been reported during well logging than during exploration 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 Hertz (Hz) although tones up to 1,850 Hz were recorded by Greene (1987a) during exploration drilling operations in the Beaufort Sea. At a range of 0.11 mi (0.17 km) the 20-1,000 Hz band level was 122-125 dB for the drillship *Explorer I*. Underwater sound levels were slightly higher (134 dB) during drilling activity from the *Explorer II* at a range of 0.12 mi (0.20 km) 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) than from the other two vessels.

Vertical Seismic Profile Sounds

A typical eight airgun array (4×40 in^3 [655 cm^3] airguns and 4×150 in^3 [2,458 cm^3] airguns) would be used to perform ZVSP surveys, if conducted after the completion of each exploratory well. A typical survey will last 10–14 hours, depending on the depth of the well and the number of anchoring points, and include firings of the full array, plus additional firing of a single 40-in^3 (655 cm^3) airgun to be used as a "mitigation airgun" while the geophones are relocated within the wellbore. The estimated source level used to model sound propagation from the airgun array is ~241 dB re 1µPa · m rms, with most energy between 20 and 140 Hz.

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle. A typical high-energy airgun arrays emit most energy at 10–120 Hz. However, the pulses contain significant energy up to 500–1,000 Hz and some energy at higher frequencies (Goold and Fish 1998; Potter et al. 2007).

Aircraft Noise

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

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

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

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drilling vessel will generally maintain straight-line routes at altitudes of 1,500 ft (457 m) above sea level (ASL) or greater, 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 handler, OSV(s), barges and tugs, 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 at distances ranging from ~1.5-2.3 mi (2.4-3.7 km) from various types of barges. MacDonald et al. (2008) estimated higher underwater sound pressure levels from the seismic vessel *Gilavar* of 120 dB 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.

7.2 Summary of Potential Effects of Exposure to Underwater Sounds from Exploration Drilling

The potential effects of sounds from the proposed exploration 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.

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, it is meant "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**—**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 exploration drilling activities. These subtle behavioral effects were temporary and localized, and occurred at distances up to 1-2 mi (2-4 km). Safety radii for the proposed exploration 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 exploration 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 may have been closer to industrial activities than was suggested by results of aerial observations.

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

Patenaude et al. (2002) reported fewer behavioral responses to aircraft overflights by bowhead compared to beluga whales. Behaviors classified as reactions consisted of short surfacings, immediate dives or turns, changes in behavior state, vigorous swimming, and breaching. Most bowhead reaction resulted from exposure to helicopter activity and little response to fixed-wing aircraft was observed. Most reactions occurred when the helicopter was at altitudes ≤492 ft (150 m) and lateral distances ≤820 ft (250 m). Restriction on aircraft altitude will be part of the mitigation measures during the proposed exploration 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. Probability of avoidance and other behavioral effects increased when received levels were 120-160 dB. 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, 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). In two cases for received levels of 100 to 110 dB, no behavioral reaction was observed. Avoidance behavior was observed in two cases where received levels were 110 to 120 dB.

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

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

Palka and Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of minke whales. Minor changes in locomotion speed, direction, and/or diving profile were reported at ranges from 1,847-2,352 ft (563-717 m) at received levels (RLs) of 110 to 120 dB.

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 at 3 ft (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 (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 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 22-31 mi (35-50 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 90-120 dB, while others failed to exhibit such responses for exposure to received levels from 120-150 dB. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating noise exposure, may also explain why there was great disparity in results from field and laboratory conditions—exposures in captive settings generally exceeded 170 dB before inducing behavioral responses. 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 12 miles per hour (mi/hr) (20 kilometers per hour [km/hr]) from distances of 12-50 mi (20-80 km), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a "freeze" response, lying motionless or swimming slowly away (as far as 23 mi (37 km) down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

The 1982 season observations by LGL & 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 6.4 km away (received levels of ~100 dB in the 150- to 1,150-Hz band). At a later point, observers sighted belugas moving away from the source at > 12 mi (20 km) (received levels of ~90 dB in the 150- to 1,150-Hz band). The total number of animals observed fleeing was about 300, suggesting approximately 100 independent groups (of three individuals each). No whales were sighted the following day, but some were sighted on 30 June, with ship noise audible at spectrum levels of approximately 55 dB/Hz (up to 4 kiloHertz [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 in the 20- to 1,000-Hz band and at a distance of up to 40 mi (65 km). Large numbers (100s) of beluga whales moved out of the area at higher received levels. As noise levels from icebreaking operations diminished, a total of 45 narwhals returned to the area and engaged in diving and foraging behavior. During the final sampling period, following an 8-hour quiet interval, no reactions were seen from 28 narwhals and 17 belugas (at received levels ranging up to 115 dB).

The final season (1984) reported in LGL & 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 approximately17 mi (27 km) ahead of the vessels, and all whales sighted over 12-50 mi (20-80 km) from the ships were swimming strongly away. Additional observations confirmed the spatial extent of avoidance reactions to this sound source in this context.

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 whale watching boats ranged from 109-129 dB/Hz. Over a bandwidth of 100-6,000 Hz, equivalent broadband source levels were ~157 dB; received levels at a range of 1,476 ft (450 m) were ~104 dB.

Buckstaff (2004) reported elevated dolphin whistle rates with RLs from oncoming vessels in the 110 to < 120 dB. 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/Hz in the 1- to 22-kHz band (broadband received levels ~128 dB) as opposed to ~65 dB/Hz in the same band (broadband RL ~108 dB) for the other two sites. Dolphin whistles in the noisier environment had lower fundamental frequencies and less frequency modulation, suggesting a shift in sound parameters as a result of increased ambient noise.

Morton and Symonds (2002) used census data on killer whales in British Columbia to evaluate avoidance of nonpulse acoustic harassment devices (AHDs). Avoidance ranges were about 2 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 0.19 mi^2 (0.5 km^2). Estimated exposure received levels were ~115 dB.

Awbrey and Stewart (1983) played back semi-submersible drillship sounds (source level: 163 dB) to belugas in Alaska. They reported avoidance reactions at 984 and 4,921 ft (300 and 1,500 m) and approach by groups at a distance of 11,482 ft (3,500 m) (received levels ~110 to 145 dB over these ranges assuming a 15 log R transmission loss). Similarly, Richardson et al. (1990) played back drilling platform sounds (source level: 163 dB) to belugas in Alaska. They conducted aerial observations of eight individuals among ~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 and 55-min duration affected the trained behaviors of a bottlenose dolphin participating in a TTS experiment. Finneran and Schlundt (2004) provided a detailed, comprehensive analysis of the behavioral responses of belugas and bottlenose dolphins to 1-s tones (received levels 160 to 202 dB) in the context of TTS experiments. Romano et al. (2004) investigated the physiological responses of a bottlenose dolphin and a beluga exposed to these tonal exposures and demonstrated a decrease in blood cortisol levels during a series of exposures between 130 and 201 dB. Collectively, the laboratory observations suggested the onset of behavioral response at higher received levels than did field studies. The differences were likely related to the very different conditions and contextual variables between untrained, free-ranging individuals vs. laboratory subjects that were rewarded with food for tolerating noise exposure.

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

Blackwell et al. (2004) reported little or no reaction of ringed seals in response to pile-driving activities during construction of a man-made island in the Beaufort Sea. Ringed seals were observed swimming as close as 151 ft (46 m) from the island and may have been habituated to the sounds which were likely audible at distances <9,842 ft (3,000 m) underwater and 0.3 mi (0.5 km) in air. Moulton et al. (2003) reported that ringed seal densities on ice in the vicinity of a man-made island in the Beaufort Sea did not change significantly before and after construction and drilling activities.

Southall et al. (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between ~90 and 140 dB 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 and Terhune (2002) observed harbor seal reactions to AHDs (source level in this study was 172 dB) deployed around aquaculture sites. Seals were generally unresponsive to sounds from the AHDs. During two specific events, individuals came within 141 and 144 ft (43 and 44 m) of active AHDs and failed to demonstrate any measurable behavioral response; estimated received levels based on the measures given were ~120 to 130 dB.

Costa et al. (2003) measured received noise levels from an Acoustic Thermometry of Ocean Climate (ATOC) program sound source off northern California using acoustic data loggers placed on translocated elephant seals. Subjects were captured on land, transported to sea, instrumented with archival acoustic tags, and released such that their transit would lead them near an active ATOC source (at 3,081-ft [939-m] depth; 75-Hz signal with 37.5-Hz bandwidth; 195 dB max. source level, ramped up from 165 dB over 20 min) on their return to a haulout site. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB (range 118-137) 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 ~120-140 dB exposure RLs.

Kastelein et al. (2006) exposed nine captive harbor seals in a ~25 × 98 ft (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 source levels; 1- to 2-second 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, avoiding it by ~16 ft (5 m), although they did not haul out of the water or change surfacing behavior. Seal reactions did not appear to wane over repeated exposure (i.e., there was no obvious habituation), and the colony of seals generally returned to baseline conditions following exposure. The seals were not reinforced with food for remaining in the sound field.

7.3 Summary of Potential Effects of Exposure to Underwater Sounds from Airguns

Tolerance

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

Masking

Masking effects of underwater sounds on marine mammal calls and other natural sounds are expected to be limited. Some whales however, 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 reported that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen et al. 2002). Similar results were also reported during 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. 2009a). Bowhead whales in the Beaufort Sea may decrease their call rates in response to seismic operations, although movement out of the area might also have contributed to the lower call detection rate (Blackwell et al. 2009a,b). Additionally, there is increasing evidence that, at times, there is enough reverberation between airgun pulses such that detection range of calls may be significantly reduced. In contrast, Di Iorio and Clark (2009) found evidence of increased calling by blue whales during operations by a lower-energy seismic source, a sparker. Masking effects of seismic pulses are expected to be negligible in the case of the smaller odontocete, given the intermittent nature of seismic pulses. Also, the sounds important to small odontocetes for communication are predominantly at much higher frequencies than are airgun sounds.

Disturbance Reactions

***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; Christie et al. 2010).

Results of studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 µPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 2.8-9.0 mi (4.5-14.5 km) from the source. For the much smaller airgun array used during the ZVSP survey, distances to received levels in the 160–170 dB re 1 µPa rms range are estimated to be 2.28-1.44 mi (3.67–2.31 km). Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and recent studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 µPa rms. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with avoidance occurring out to distances of 12-19 mi (20-30 km) from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). However, more recent research on bowhead whales (Miller et al. 2005) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 µPa rms (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 2005).

Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 in^3 (1,639 cm^3) airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 µPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and on observations of the distribution of feeding Western Pacific gray whales off Sakhalin Island, Russia during a seismic survey (Yazvenko et al. 2007).

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

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

Seismic operators and marine mammal observers sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of seismic vessels operating large airgun systems. However, some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003). The beluga may be a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 6-12 mi (10–20 km) of an active seismic vessel. These results were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel, suggesting that some belugas might be avoiding the seismic operations at distances of 6-12 mi (10–20 km) (Miller et al. 2005).

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

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

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

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 ≥180 and ≥190 dB, 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/plenary2summary-final.pdf; Scholik-Schlomer *in press*). New science-based noise exposure criteria are also proposed by a group of experts in this field, based on an extensive review and syntheses of available data on the effect of noise on marine mammals (Southall et al., 2007) and this review seems to confirm that the current 180 dB and 190 dB are conservative.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the 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. Beaked whales seem 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 Section 12). The following subsections discuss in somewhat more detail the possibilities of TTS, permanent threshold shift (PTS), and non-auditory physical effects.

Temporary Threshold Shift (TTS) — TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple impulses of sound. [There are, however, recent data on TTS in dolphins caused by multiple pulses of sonar sound—Mooney et al. (2009).]

The distinction between TTS and PTS is not absolute. Although mild TTS is fully reversible and is not considered to be injury, exposure to considerably higher levels of sound causes more "robust" TTS, involving a more pronounced temporary impairment of sensitivity that takes longer to recover. There are very few data on recovery of marine mammals from substantial degrees of TTS, but in terrestrial mammals there is evidence that "robust" TTS may not be fully recoverable, i.e., TTS can grade into PTS (Le Prell *in press*).

The received energy level of a single seismic pulse that caused the onset of mild TTS in the beluga, as measured without frequency weighting, was ~186 dB re 1 $\mu Pa^2 \cdot s$ or 186 dB sound exposure level (SEL) (Finneran et al. 2002).[1] The rms level of an airgun pulse (in dB re 1 µPa measured over the duration of the pulse) is typically 10–15 dB higher than the SEL for the same pulse when received within a few kilometers of the airguns. Thus, a single airgun pulse might need to have a received level of ~196–201 dB re 1 µPa rms in order to produce brief, mild TTS. Exposure to several strong seismic pulses that each has a flat-weighted received level near 190 dB rms (175–180 dB SEL) could result in cumulative exposure of ~186 dB SEL (flat-weighted) or ~183 dB SEL (M_{mf}-weighted), and thus slight TTS in a small odontocete. That assumes that the TTS threshold upon exposure to multiple pulses is (to a first approximation) a function of the total received pulse energy, without allowance for any recovery between pulses.

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.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures 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 2005). 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 exploration 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

[1] If the low-frequency components of the watergun sound used in the experiments of Finneran et al. (2002) are downweighted as recommended by Southall et al. (2007) using their M_{mf}-weighting curve, the effective exposure level for onset of mild TTS was 183 dB re 1 $\mu Pa^2 \cdot s$ (Southall et al. 2007).

mammals are likely to avoid the proposed activities, exposure sufficient to produce TTS is unlikely to occur.

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

There is no specific evidence that exposure to 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 (Southall et al. 2007, Le Prell *in press*). PTS might occur at a received sound level at least several decibels above that inducing mild TTS.

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 exploration 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 have been in beaked whales, which do not occur in the proposed project 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 academic 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 Beaufort 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% 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 exploration 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. Activities associated with Shell's planned exploration drilling program would have no or negligible effects on bowhead whales. Noise and general activity associated with exploration drilling and operation of vessels and aircraft have the potential to impact 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 or 10-30 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.

Exploration drilling operations could in some circumstances affect subsistence hunts by placing the animals further offshore or otherwise at a greater distance from villages thereby increasing the difficulty of the hunt or retrieval of the harvest, or creating a safety risk to the whalers. Residents of Kaktovik and Nuiqsut hunt bowheads during the fall migration. In 2012, Shell's operations will commence in July before the fall hunt begins, cease during these bowhead subsistence hunts, and resume after they are completed so the exploration program would have no direct impact on these subsistence activities. Any effects on bowhead behavior or movements would therefore have no impact on the Kaktovik or Nuiqsut (Cross Island) fall whaling as Shell's exploration drilling program will cease on August 25, prior to the start of the hunts, and will not resume until the hunts have concluded.

Helicopters (~2-trips/day, approximately 12/week) servicing the offshore operations could traverse areas utilized by Kaktovik or Nuiqsut (Cross Island) whalers for fall whaling from a Deadhorse shorebase location, but not while the hunts are ongoing. Helicopters traffic often evokes no response from bowheads, but the whales sometimes engage in hasty dives or abrupt turns (Richardson et al. 1985, 1995a). Bowhead whales tend to be more sensitive in shallow water (Richardson et al 1985). Any such behavioral responses would be momentary and have negligible effect on the subsistence resource and no effect on the subsistence activity. Aircraft shall not operate below 1,500 ft (457 m) unless the aircraft is engaged in marine mammal monitoring, approaching, landing or taking off, or unless engaged in providing assistance to a whaler or in poor weather (low ceilings) or any other emergency situations. Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft (457 m) in areas of active whaling; such areas to be identified through communications with the Com-Centers. Except for airplanes engaged in marine mammal monitoring, aircraft shall use a flight path that keeps the aircraft at least 5 mi (8 km) inland until the aircraft is directly south of its offshore destination, then at that point it shall fly directly north to its destination. In addition, aircraft will not get closer than 1,500 ft (457 m) of groups of whales.

No routine vessel traffic will traverse this subsistence area. Vessels within 900 ft (274 m) of marine mammals will reduce speed, avoid separating members from a group and will avoid multiple changes in direction. Vessel speeds will be reduced during inclement weather to avoid collisions with marine mammals.

The planned period of the exploration drilling program begins in July 2012, ceases on August 25 for the bowhead whale subsistence hunts by Kaktovik and Nuiqsut (Cross Island) hunters, and then restarts after the hunts have concluded. During this period most marine mammals are expected to be dispersed throughout the area, except during the peak of the bowhead whale migration in the Beaufort Sea, which occurs from late August into October. Bowhead whales are expected to be in the Canadian Beaufort Sea during much of the time prior to the subsistence whaling shutdown that occurs on August 25 and, therefore, are not expected to be affected by the exploration drilling program prior to that date. After the conclusion of the bowhead whale subsistence hunt, bowheads may travel in proximity to the exploration drilling program area and hear sounds from exploration drilling and associated vessel and aircraft traffic, and may be displaced by these activities. The potential impacts of exploration drilling to the fall bowhead whale migration during the subsistence hunts is eliminated by Shell's commitment to shutdown the exploration drilling program during the Kaktovik and Nuiqsut (Cross Island) hunts.

Beluga. Beluga are not a prevailing subsistence resource in the communities of Kaktovik and Nuiqsut, the nearest communities to Shell's planned 2012 exploration drilling program. Therefore, any such behavioral responses of avoidance of activity areas by beluga in the Beaufort Sea would have a no effect on the subsistence resource.

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 into the drilling season period and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer. Shell lease blocks where exploration activities would occur are located more than 16 mi (26 km) offshore, so activities within the prospects would have no impact on subsistence hunting for seals. Helicopter traffic between the shorebase and the offshore exploration 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.

9. The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat

Shell's planned 2012 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 that are reasonably expected or reasonably likely 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 exploration drilling program are expected to be negligible.

Although evaluation of speculative events such as oil spills is not properly included in the "negligible impacts" analysis, Shell recognizes the agency's interest in these remote risks. Therefore, [as a courtesy] Shell includes with this IHA application an analysis of the highly unlikely, unanticipated impact of a crude oil spill event during this exploration drilling program (Attachment E). This is an analysis of the impacts from a site-specific, very large oil spill scenario created for Shell's regional oil spill response plan (*Beaufort Sea Regional Oil Discharge Prevention and Contingency Plan* [ODPCP] – revised April 2011) which was submitted to BOEMRE contemporaneously with Shell's Camden Bay Exploration Plan (EP). Under 30 CFR 254.26(d) (1), Shell's oil spill response plan must envision a crude oil spill scenario from a worst case discharge lasting 30 days. Attachment E analyzes the impacts from such a site-specific scenario, and presents this analysis in light of the very large crude oil spill impact analyses already conducted for oil and gas exploration activities in the arctic by NMFS

(NMFS 2008) and BOEMRE (MMS 2003). Given that a very large oil spill is a highly unlikely, and an unanticipated result of Shell's planned exploration drilling program, the analysis is not included within Section 9 of this IHA application which assesses the anticipated impacts of Shell's exploration drilling activity, but provided separately as Attachment E.

9.1 Potential Impacts from Seafloor Disturbance (Mooring and Mudline Cellar (MLC) Construction)

There will be some seafloor disturbance or temporary increased turbidity in the seabed sediments during anchoring and emplacement of the MLCs. The amount and duration of disturbed or turbid conditions will depend on sediment material and consolidation and specific activity. The *Kulluk* would be anchored using a 12-point anchor system held in place with 12, 15 metric ton Stevpris anchors and the *Discoverer* would be stabilized and held in place with a system of eight 7,000 kg Stevpris anchors during operations. The anchors from either drilling vessel are designed to embed into the seafloor. Prior to setting, the anchors will penetrate the seafloor and drag two or three times their length. Both the anchor and anchor chain will disturb sediments and create an "anchor scar" which is a depression in the seafloor caused by the anchor embedding. Anchor depressions commonly exceed the dimensions of the anchor itself.

For the *Kulluk,* each Stevpris anchor may impact an area of 2,928 square feet (ft^2) (272 m^2) whereas each Stevpris anchor from the *Discoverer* may impact an area of 2,027 ft^2 (188 m^2) of the seafloor. Minimum impact estimates of the seafloor from each well or mooring with the 12 anchors of the *Kulluk* is 35,136 ft^2 (3,264 m^2) or with the eight anchors of the *Discoverer* is 16,216 ft^2 (1,507 m^2). This estimate assumes that the anchors are set only once and not moved by outside forces such as sea current.

Once the *Kulluk* or *Discoverer* ends operation at a drill site, the anchors will be retrieved. Over time the anchor scars will be filled through natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type. Anchor scars were visible under low energy conditions in the North Sea for five to ten years after retrieval. Scars typically do not form or persist in sandy mud or sand sediments but may last for nine years in hard clays (Centaur Associates, Inc. 1984). The energy regime, plus possible effects of ice gouge in the Beaufort Sea suggests that anchor scars would be refilled faster than in the North Sea.

Excavation of each MLC by the *Kulluk* will displace about 24,579 ft^3 (696 m^3) of seafloor sediments and directly disturb approximately 452 ft^2 (42m^2) of seafloor. Excavation of each MLC by the *Discoverer* will displace about 17,128 ft^3 (485 m^3) of seafloor sediments and directly disturb approximately 314 ft^2 (29 m^2) of seafloor. The MLC excavation amounts range in volume because the MLC bits for the *Kulluk* and *Discoverer* differ in size and hence excavate different diameter MLCs. Material will be excavated from the MLCs using a large diameter drillbit. Pressurized air and water (no drilling mud used) will be used to assist in the removal of the excavated materials from the MLC. Some of the excavated sediments will be displaced to adjacent seafloor areas and some will be removed via the air lift system and discharged on the seafloor away from the MLC. These excavated materials will also have some indirect effects as they are deposited on the seafloor in the vicinity of the MLCs. Direct and indirect effects would include slight changes in seafloor relief and sediment consistency.

9.2 Potential Impacts on Habitat due to Sound Generation

Marine Mammals

Shell does not expect any significant or lasting impacts to marine mammals from sound energy created by exploration drilling activities in Camden Bay. Sound is crucial to marine mammals because they use it to navigate, communicate, find open water, avoid predators, and find food. There are a variety of sounds in the Beaufort Sea, especially during the drilling season, when the area is exposed to the peak level of man-made sound from oil and gas exploration activities and biological research surveys. Sound sources from Shell's exploration activities that could be heard by marine mammals include the drilling vessel, marine vessels, and support vessels. Sounds that are natural in the marine environment of the Beaufort Sea include sound from ice, surf, subsea landslides, and other animals. Concern has been expressed regarding the presence and intensity of impacts from sound energy on marine mammals. Concerns are mainly aimed at deflection of whales from hunting and migration areas, masking of natural sounds, and physiological damage to marine mammals' hearing. Based on previous studies regarding sound energy and effects on marine mammals, as well as the preventive mitigation measures planned for the project, Shell does not expect any significant or lasting impacts to marine mammals from sound energy resulting from exploration drilling activities in Camden Bay.

Avoidance behavior in response to sound energy by marine mammals, such as temporary deflection, is the most likely behavioral response expected as a result of Shell's exploration activities in Camden Bay. Depending upon the sound source, different mitigation measures will be implemented. Mitigation measures have been included in the 4MP that is included as Attachment C to this IHA application. That discussion and analysis of Shell's sound energy mitigation measures is incorporated here by reference.

MMOs will be stationed on all drilling and support vessels to survey inside the exclusion zone (areas within isopleths of certain sound levels for different species) for marine mammals. For support vessels in transit, if a marine mammal is sighted from a vessel within its respective safety radius, the Shell vessel will reduce activity (e.g. reduce speed) and sound energy level to ensure that the animal(s) are not exposed to sound above their respective safety level. Full activity will not be resumed until all marine mammals are outside of the vessel's exclusion zone and there are no other marine mammals likely to enter the exclusion zone. Regular overflight surveys and support vessel surveys for marine mammals will be conducted to further monitor drilling areas.

Anchored vessels, including the drilling vessel, will remain at anchor and continue ongoing operations if approached by a marine mammal. An approaching animal, not exhibiting avoidance behavior, is likely curious and not regarded as harassed. The anchored vessel will remain in place and continue ongoing operations to avoid possibly causing avoidance behavior by suddenly changing sound conditions. Moving vessels will avoid groups of whales by a distance of 1,500 ft (457 m), and will reduce speed if within 900 ft (274 m) of other marine mammals. MMOs use distance as an indicator of the safety radii, which is anticipated to be much smaller than 900 ft (274 m). These measures will reduce the sound energy received by the mammals. Shell will not be operating during the sensitive times such as pupping and molting. These important activities will be over by the time Shell activities start. If seals are hauled out on ice in the vicinity of operations temporary deflection is expected.

While observing the response of beluga whales to icebreakers, Finley and Davis (1984) reported avoidance behavior when ice breaker vessels approached at distances of 22-31 mi (35-50 km). Belugas are thought to have poor hearing below one Hz, the range of most drilling activities, but have shown some behavioral reactions to the sounds. Brewer et al. (1993) observed belugas within 2.3 mi (3.7 km) of the drilling vessel *Kulluk* during drilling.

Seals are not expected to be impacted by sound energy from Shell vessel traffic or exploration drilling. This was demonstrated during a study designed to assess ringed seals' reactions to drilling activity (Brewer et al. 1993). After observing the seals approach within 33 ft (10 m) of the drilling vessel *Kulluk*, the scientists concluded that they are not disturbed by drilling activity. The same conclusion was reached concerning bearded seals that approached within 656 ft (200 m) of ice breakers (Brewer et al. 1993). In another study involving the drillship *Explorer II,* seals were observed within 115 ft (35 m) of the ship during drilling (Gallagher et al. 1992).

Sound energy introduced into the environment of marine mammals could cause masking (the covering of sound that would otherwise have been heard). Masking can interfere with the detection of important natural sources. Underwater sound could possibly mask environmental sounds (Terhune 1981) or communication between marine mammals (Perry and Renouf 1987). However, in a study conducted by Cummings et al. (1984) in which breeding ringed seals were subjected to recordings of industrial sounds and there were no documented effects on ringed seal vocalizations.

Belugas primarily use high-frequency sounds to communicate and locate prey; therefore, masking by low-frequency sounds associated with drilling activities is not expected to occur (Gales 1982). If the distance between communicating whales does not exceed their distance from the drilling activity, the likelihood of potential impacts from masking would be low (Gales 1982). At distances greater than 660-1,300 ft (200-400 m), recorded sounds from drilling activities did not affect behavior of beluga whales even though the sound energy level and frequency were such that it could be heard several kilometers away (Richardson et al. 1995b). This exposure resulted in whales being deflected from the sound energy and changing behavior. These brief changes are expected to be temporary and are not expected to affect whale population (Richardson et al. 1991; Richard et al. 1998).

Threatened and Endangered Species

Sound is important to bowhead whales because they use it to navigate, communicate, find open water, avoid predators, and find areas of food abundance. Bowhead whales, along with being endangered, are a key subsistence resource of the Inupiat Eskimos of the North Slope. There is concern regarding potential impacts on the whales due to sound energy produced by exploration drilling activities. Potentially, sounds created by drilling activities could affect behavior, mask whale communication and other environmental sounds, or damage hearing mechanisms. There have been no conclusive studies on the sensitivity of bowhead whale hearing (Richardson et al.

1995b). It is likely that the range of hearing includes the frequency range used in their calls. Most frequencies used by bowhead whales are low (less than 1,000 Hz) (Richardson et al. 1995b). Mitigation measures are in place to minimize or eliminate impacts to the whales and, by extension, subsistence uses of the whales. Shell does not expect any lasting impacts on marine mammals from sound energy created during drilling activities in Camden Bay.

In order to limit the whales' close contact with ice management and other support vessels, MMOs will be stationed on all support vessels to survey inside the exclusion zone (areas within isopleths of certain sound levels for different species) for marine mammals. If a marine mammal is sighted from a vessel in transit within its respective safety radius, the Shell vessel will reduce activity (e.g. reduce speed) and sound energy level to ensure that the animal is not exposed to sound above its respective safety levels. Full activity will not be resumed until all marine mammals are outside of the exclusion zone and there are no other marine mammals likely to enter the exclusion zone before the next overflight survey. Regular overflight surveys and support vessel surveys for marine mammals will be conducted to further monitor drilling areas. Anchored vessels, including the drilling vessel, will remain at anchor and continue ongoing operations if approached by a marine mammal. An approaching animal, not exhibiting avoidance behavior, is likely curious and not regarded as harassed. The anchored vessel will remain in place and continue ongoing operations to avoid possibly causing avoidance behavior by suddenly changing sound energy conditions.

Avoidance behavior in response to sound by marine mammals such as temporary deflection from hunting and migration corridors is the most likely behavioral response expected as a result of Shell's exploration activities in Camden Bay. Bowhead whales, likely due to their hearing range, have been reported to react more to low frequency sounds than higher frequency sounds (Richardson et al. 1995b). Davis (1987) studied the responses exhibited by bowhead whales to drilling sound. The only response he saw was avoidance behavior in some whales. Davis (1987) concluded that avoidance behavior was temporary and sound energy from drilling did not impede migration of the whales. Recordings from the drilling ship *Explorer II* were projected in the Canadian Beaufort Sea during the drilling season (Richardson et al. 1985). Changes in behavior in response to the sounds were observed. Some whales showed avoidance behavior, but the deflection away from the sound was considered weak (Richardson et al. 1985). During the same study, Richardson et al. (1985) observed whales between 2.5 mi and 12.4 mi (4 and 20 km) while drilling activity was occurring, and he concluded that the whales were undisturbed. In a similar study where recordings from the drilling vessel *Kulluk* were projected, no deflection was seen until sound pressure levels reached 120 dB or higher (Wartzok et al. 1989).

Concern has been expressed that sound energy levels produced by drilling and ice management could cause masking. Masking can interfere with the detection of important natural sound sources. Underwater sound could possibly mask environmental sounds (Terhune 1981) or communication between marine mammals (Perry and Renouf 1987). Effects of sound energy from drilling and ice management will be temporary and localized, and are not expected to significantly impact marine mammals.

Loud sound (higher than 180 dB) could cause temporary (the duration would depend upon the level and duration of noise exposure) or permanent damage to hearing ability (Kryter 1985;

Richardson and Malme 1993). Since bowhead whales have been shown to exhibit avoidance behaviors in the presence of lower level sound (115 dB) (Richardson et al. 1990), it is unlikely that they would approach such sound sources close enough to be exposed to sound levels that could be injurious (Richardson and Malme 1993).

Zooplankton

Sound energy generated by drilling activities will not negatively impact the diversity and abundance of zooplankton. The primary generators of sound energy are the drilling vessel and marine vessels. Ice management vessels are likely to be the most intense sources of sound associated with the exploration drilling program (Richardson et al. 1995a). It is expected that the lower level of sound produced by the drillship and other vessels would have less impact on zooplankton than seismic (survey) sound.

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

Benthos

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

Sound energy generated by drilling activities will not appreciably affect diversity and abundance of plants or animals on the seafloor. The primary generators of sound energy are the drilling vessel and marine vessels. Ice management vessels are likely to be the most intense sources of sound associated with the exploration drilling program (Richardson et al. 1995a). The lower level of sound produced by either drilling vessel or other vessels will have less impact on bottom-dwelling organisms than seismic (survey) sound.

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

Fish

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

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

Drilling vessel sound source levels during drilling can range from 90 dB within 31 mi (50 km) of the drilling vessel to 138 dB within a distance of 0.06 mi (0.1 km) from the drilling vessel (Greene 1985,1987b). These are predicted sound levels at various distances based on modeled transmission loss equations in the literature (Greene 1987b). Ice management vessel sound source levels can range from 174-184dB. At these intensity levels, fish may avoid the drilling vessel, ice management vessels, or other large support vessels. This avoidance behavior is temporary and limited to periods when a vessel is underway or drilling.

There have been no studies of the direct effects of ice management vessel sounds on fish. However, it is known that the ice management vessels produce sounds generally 10-15 dB higher when moving through ice rather than open water (Richardson et al. 1995b). In general, fish show greater reactions to a spike in sound energy levels, or impulse sounds, rather than a continuous high intensity signal (Blaxter et al. 1981).

Fish sensitivity to impulse sound varies depending on the species of fish. Fish such as mackerel, flatfish and other bottom-living species lack a swim bladder and are not capable of hearing sounds, unlike species such as cod and herring. Cod and herring have a well-developed swim bladder and therefore are sensitive to sound. An alarm response in these fish is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level (Blaxter et al. 1981).

9.3 Potential Impacts on Habitat from Drill Cuttings

General

For the Camden Bay exploration drilling program, Shell has committed to not discharge various waste streams during routine drilling operations, even though the waste streams are allowable discharges under the current U.S. Environmental Protection Agency (EPA) administered Arctic National Pollutant Discharge Elimination System (NPDES) General Permit AKG-28-0000 (GP

AKG-28-0000). Shell will not discharge any of the following liquid waste streams; treated sanitary waste (black water), domestic waste (gray water), bilge water or ballast water, that are generated by the drilling vessel. Shell will not discharge drilling mud or cuttings that are generated below the depth at which the 20-in. (51-cm) diameter casing is set in each well. The mud and cuttings collected will be transferred to an OSV then to the deck or waste barge. Either barge will hold collected mud and cuttings, and collected wastewater for transport and disposal at an approved and licensed, onshore facility.

Cuttings generated while drilling the MLC, the 36- and 26-in. (91- and 66-cm) hole sections (all drilled with seawater and viscous sweeps only) plus cement discharged while cementing the 30- and 20-in. (76- and 51-cm) casing strings will be discharged on the surface of the seafloor under provisions of the previously mentioned NPDES GP.

The NPDES GP establishes discharge limits for drilling fluids (at the end of a discharge pipe) to a minimum 96-hr LC50 of 30,000 ppm. Both modeling and field studies have shown that discharged drilling fluids are diluted rapidly in receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; NRC 1983; O'Reilly et al. 1989; Nedwed et al. 2004; Smith et al. 2004; Neff 2005). The dilution rate is strongly affected by the discharge rate; the NPDES GP limits the discharge of cuttings and fluids to 750 bbl/hr (89 m^3/hr). For example, the EPA modeled hypothetical 750 bbl/hr (89 m^3/hr) discharges of drilling fluids in water depths of 66 ft (20 m) in the Beaufort and Chukchi Sea and predicted a minimum dilution of 1,326:1 at 330 ft (100 m).

Modeling of similar discharges offshore of Sakhalin Island predicted a 1,000-fold dilution within 10 minutes and 330 ft (100 m) of the discharge. In a field study (O'Reilly et al. 1989) of a drilling waste discharge offshore of California, a 270 bbl (43 m^3) discharge of drilling fluids was found to be diluted 183-fold at 33 ft (10 m) and 1,049-fold at 330 ft (100 m). Neff (2005) concluded that concentrations of discharged drilling fluids drop to levels that would have no effect within about two minutes of discharge and within 16 ft (5 m) of the discharge location.

Marine Mammals

The levels of drill cuttings and drilling mud discharges are regulated by the EPA's NPDES GP. The impact of the limited amount of drill cutting discharges would be localized to the drill sites and temporary. Drill cutting discharges could displace marine mammals a short distance from a drilling location. As noted above, drilling mud will not be discharged from the wells proposed under this exploration program in Camden Bay.

Gray whales will more than likely avoid drilling activities and not come into close contact with drill cuttings. However, gray whales are benthic feeders and the area of seafloor that will be covered by discharge will be unavailable to the whales for foraging purposes. This is not expected to impact individual whales or the population, because the areas of disturbance are insignificant compared to the area covered by the whales for foraging. Impacts on beluga whales from the discharge of drill cuttings are not likely.

It is anticipated that drill cuttings will only dispense up to 330 ft (100 m) from the drilling vessel. Therefore, it is highly unlikely that beluga whales will come into contact with any drilling discharge and impacts are not expected.

Seals are not expected to be impacted by drill cuttings. If seals remain within 330 ft (100 m) of the discharge source for an extended period of time, it is possible that physiological effects due to toxins could impact the animal. However, it is highly unlikely that a seal would remain within 330 ft (100 m) of the discharge source for any extended period of time.

Threatened and Endangered Species

Negative effects on endangered whales from drilling discharges are not expected. Baleen whales, such as bowheads, tend to avoid drilling rigs at distances up to 12 mi (20 km). Therefore, it is highly unlikely that the whales will swim or feed in close enough proximity of discharges to be affected.

The levels of drill cutting discharges are regulated by the EPA's NPDES GP. The impact of drill cutting discharges would be localized and temporary. Drill cutting discharges could displace endangered whales (bowhead and humpback whales) a short distance from a drilling location. Effects on the whales present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, endangered whales are not likely to have long-term exposures to drill cuttings because of the episodic nature of discharges (typically only a few hours in duration).

Seals, including the proposed for threatened listing ringed and bearded seals, are not expected to be impacted by drill cuttings. If seals remain within 330 ft (100 m) of the discharge source for an extended period of time, it is possible that physiological effects due to toxins could impact the animal. However, it is highly unlikely that a seal would remain within 330 ft (100 m) of the discharge source for any extended period of time.

It is expected that any toxic effects on fish and fish larvae present within a few feet of the discharge point would be negligible and ephemeral.

Zooplankton

Studies by the EPA (2006) and Neff (2005) indicate that though planktonic organisms are extremely sensitive to environmental conditions (e.g., temperature, light, availability of nutrients, and water quality), there is little or no evidence of effects from drill cuttings discharges on plankton.

More than 30 OCS well sites have been drilled in the Beaufort Sea. The Warthog well was drilled in Camden Bay in 35 ft (11 m) of water (Thurston et al. 1999). The BOEMRE routinely monitored that well site for contaminants and found that it had no accumulated petroleum hydrocarbons or heavy metals (Brown et al. 2001).

The levels of drill cutting discharges are regulated by the EPA's NPDES GP. The impact by drill cuttings discharges would be localized and temporary. Effects on zooplankton present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, zooplankton are not likely to have long-term exposures to drill cuttings because of the episodic nature of discharges (typically only a few hours in duration). Results of a recent study on a historical drill site in Camden Bay (HH-2) showed that movement of drilling mud and cuttings were restricted to within 330 ft (100 m) of the discharge site (Trefry and Trocine 2009).

Fine-grained particulates and other solids in drilling mud and cuttings could cause sublethal effects to organisms in the water column. However as noted above, Shell will not discharge drilling muds from the wells proposed under this exploration drilling program in Camden Bay. The responses observed following exposure to drilling mud include alteration of respiration and filtration rates and altered behavior. Zooplankton in the immediate area of discharge from exploration drilling operations could potentially be adversely impacted by sediments in the water column, which could clog respiratory and feeding structures, and they could suffer abrasions. This impact would likely not have more than a short-term impact and not affect population levels of zooplankton.

Benthos

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

Significant heavy metal contamination of sediments and resulting effects on benthic organisms is not expected. The NPDES GP contains stringent limitations on the concentrations of mercury, cadmium, chromium, silver, and thallium allowed in discharged drilling fluids and cuttings. Additional limitations are placed on free oil, diesel oil, and total aromatic hydrocarbons (TAH) allowed in discharged drilling fluids and cuttings. Discharge rates are also controlled by the permit. Baseline studies at the 1985 Hammerhead drill site (Trefry and Trocine 2009) detected background levels aluminum, iron, zinc (Zn), cadmium (Cd) and mercury in all surface and subsurface sediment samples. Considering that drilling mud will not be discharged and the relatively small area that drill cutting sediment will be deposited, no significant impacts on sediment are expected to occur. The expected increased concentrations of Zn, Cd, and chromium (Table 4.1-2) in sediments near the drill site due to the discharge are in the range where no or low effects would result.

Studies in the 1980s, 1999, 2000, and 2002 (Brown et al. 2001 in USDI/MMS 2003) also found that benthic organism near drilling sites in the Beaufort have accumulated neither petroleum hydrocarbon nor heavy metals. In 2008 Shell investigated the benthic communities (Dunton et al. 2008) and sediments (Trefry and Trocine 2009) around the Sivulliq Prospect including the location of the historical Hammerhead drill site that was drilled in 1985. Benthic communities at the historical Hammerhead drill site were found not to differ statistically in abundance, community structure, or diversity, from benthic communities elsewhere in this portion of the Beaufort Sea, indicating that there was no long term effect. Because discharges from drill cuttings are composed of seawater, impacts to benthic organisms will be negligible and restricted to a very small area of the seafloor.

Fish

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

Although unlikely at deeper offshore drilling locations, demersal fish eggs could be smothered if discharges occur in a spawning area during the period of egg production. No specific demersal fish spawning locations have been identified at the Sivulliq or Torpedo well locations. The most abundant and trophically important marine fish, the Arctic cod, spawns with planktonic eggs and larvae under the sea ice during winter and will therefore have little exposure to discharges.

Habitat alteration concerns apply to special or relatively uncommon habitats, such as those important for spawning, nursery, or overwintering. Important fish overwintering habitats are located in coastal rivers and nearshore coastal waters, but are not found in the proposed exploration drilling areas. Important spawning areas have not been identified in the Beaufort Sea, although gravelly areas along the coast are thought to be herring spawning areas. Kelp beds such as the Stefansson Sound boulder batch are important habitat for many species and are found in shallower and more coastal waters along Camden Bay. The known occurrences of kelp beds are more than 5 mi (8 km) from Shell's proposed drill sites.

9.4 Potential Impacts from Ice Management

Ice-management activities include the physical pushing or moving of ice in the proposed exploration drilling area and to prevent ice floes from striking the drilling vessel. Ringed, bearded, and spotted seals (along with the ribbon seal and walrus) are dependent on sea ice for at least part of their life history. Sea ice is important for life functions such as resting, breeding, and molting. These species are dependent on two different types of ice: pack ice and landfast ice. Shell does not expect to have to manage pack ice during the majority of the drilling season. The majority of the pack ice management should occur in the early and latter portions of the drilling season. Landfast ice would not be present during Shell's proposed operations.

The ringed seal is the most common pinniped species in the Camden Bay project area. While ringed seals use ice year-round, they do not construct lairs for pupping until late winter/early spring on the landfast ice. Therefore, since Shell plans to conclude exploration drilling on or before October 31, Shell's activities would not impact ringed seal lairs or habitat needed for breeding and pupping in the Camden Bay area. Ringed seals can be found on the pack ice surface in the late spring and early summer in the Beaufort Sea, the latter part of which may overlap with the start of Shell's planned exploration drilling activities. If an ice floe is managed into one that contains hauled out seals, the animals may become startled and enter the water when the two ice floes meet.

Bearded seals breed in the Bering and Chukchi Seas, as the Beaufort Sea provides less suitable habitat for the species.

Spotted seals are even less common in the Camden Bay area. This species does not breed in the Beaufort Sea. Therefore, ice used by bearded and spotted seals needed for life functions such as breeding and molting would not be impacted as a result of Shell's exploration drilling program since these life functions do not occur in the proposed project area.

For ringed seals, ice-management would occur during a time when life functions such as breeding, pupping, and molting do not occur in the proposed activity area. Additionally, these life functions normally occur on landfast ice, which will not be impacted by Shell's activity.

Therefore, it is determined that Shell's planned exploration drilling program in the Camden Bay area is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or on the food sources that they utilize.

9.5 Potential Impacts from Drilling Vessel Presence

The size of the *Kulluk*, (266 ft [81.0 m]) in diameter or length of the *Discoverer* (514 ft [156.7 m] long) are not significant enough to cause large-scale diversions from the animals' normal swim and migratory paths. Either drilling vessel's physical footprint is small relative to the size of the geographic region either would occupy, and will likely not cause marine mammals to deflect greatly from their typical migratory route. First, the eastward spring bowhead whale migration will occur prior to the beginning of Shell's proposed exploration drilling program. Second, the westward fall bowhead whale migration begins in late August/early September and lasts through October. Shell plans to suspend all operations on 25 August for the Kaktovik and Nuiqsut (Cross Island) bowhead subsistence hunts. During the suspension for the whale hunts, the drilling vessel and support fleet will leave the Camden Bay project area and move to an area north of latitude 71^{o} 25'N and west of longitude 146^{o} 4'W, and will not resume exploration drilling activities until the close of the Kaktovik and Nuiqsut (Cross Island) bowhead subsistence hunts. This will reduce the amount of time that the *Kulluk* or *Discoverer* spends in the bowheads' normal swim and migratory paths as they move through Camden Bay.

Any deflection of bowhead whales or other marine mammal species due to the physical presence of the *Kulluk* or *Discoverer* or its support vessels would be very minor. Even if animals may deflect because of the presence of either drilling vessel, the Beaufort Sea's migratory corridor is much larger in size than the diameter or length of either drilling vessel, and animals would have other means of passage around either drilling vessel.

In sum, the physical presence of either drilling vessel is not likely to cause a significant deflection to migrating marine mammals.

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 10-August 25, and the again from the end of Kaktovik and Nuiqsut (Cross Island) bowhead whale subsistence hunts to on or about October 31), most marine mammals would be dispersed throughout the area. The peak of the bowhead whale migration through the Beaufort Sea typically occurs in late August and October. Again, some bowheads might be temporarily displaced seaward during this time. The numbers of cetaceans and seals subject to displacement are small in relation to abundance estimates for the mammals addressed under this IHA application.

In addition, feeding does not appear to be an important activity by bowheads migrating through the eastern and central part of the Alaskan Beaufort 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, nor are any seals predicted to be excluded from any habitat by the exploration drilling program.

The planned exploration 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 C).

12. 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

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 POC pursuant to BOEMRE Lease Sale Stipulation No. 5, which requires that all exploration operations be conducted in a manner that prevents unreasonable conflicts between oil and gas activities and the subsistence activities and resources of residents of the North Slope. This stipulation also requires adherence to, and USFWS and NMFS regulations, which require an operator to implement a POC to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR § 18.124(c)(4) and 50 CFR § 216.104(a)(12)). A POC was prepared and submitted with the initial Camden Bay EP that was submitted to BOEMRE in May 2009, and approved on 19 October 2009. Shell has prepared a POC Addendum (Attachment D) which updates the POC with information regarding proposed changes to the proposed exploration drilling program as compared to the initial Camden Bay EP. The POC Addendum includes documentation of meetings undertaken to specifically to inform the stakeholders of the revised exploration drilling program and obtain their input. The POC Addendum builds upon the previous POC.

The POC Addendum identifies the measures that Shell has developed in consultation with North Slope subsistence communities to minimize any adverse effects on the availability of marine mammals for subsistence uses and will implement during its Camden Bay and Chukchi Sea exploration drilling programs planned to begin in the summer of 2012. In addition, the POC Addendum details Shell's communications and consultations with local subsistence communities concerning its planned exploration drilling program, potential conflicts with subsistence activities, and means of resolving any such conflicts (50 CFR § 18.128(d) and 50 CFR § 216.104(a) (12) (i), (ii), (iv)). Shell has documented its contacts with the North Slope subsistence communities, as well as the substance of its communications with subsistence stakeholder groups.

Shell's revised Camden Bay exploration drilling program is planned for the Sivulliq and Torpedo prospects in Camden Bay (Figure 1-1). This program is set-out in detail in a revised Camden Bay EP submitted to BOEMRE in May 2011 and the impacts of the project, as well as the measures Shell will implement to mitigate those impacts, are analyzed in the Camden Bay Environmental Impact Analysis Shell submitted to BOEMRE (Appendix F to the revised Camden Bay EP). Shell will implement this POC Addendum, and the mitigation measures set-forth herein, for its Camden Bay exploration program.

The potentially affected subsistence communities, identified in BOEMRE Lease Sale Stipulation No. 5, that were consulted regarding Shell's exploration drilling activities include: Barrow, Kaktovik, Nuiqsut, Wainwright, Point Lay and Point Hope. Shell presented its POC for the Camden Bay exploration drilling program to these potentially affected subsistence communities during these consultations. Shell also conducted POC meetings in the Chukchi Sea communities of Wainwright, Point Lay and Point Hope to discuss a planned Chukchi Sea exploration drilling program, while also describing the of mobilization Camden Bay exploration drilling program vessels through the Chukchi Sea to and from the Beaufort Sea. Additionally, Shell met with subsistence groups including the AEWC, Inupiat Community of the Arctic Slope (ICAS), and the Native Village of Barrow, and presented information regarding the proposed activities to the North Slope Borough (NSB) and Northwest Arctic Borough (NWAB) Assemblies, and NSB and NWAB Planning Commissions. Several one-on-one meetings were also held throughout the villages.

Beginning in early January 2009 and continuing into 2011, the one-on-one meetings Shell held included 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 12 January 2009 and have continued to date. Shell's primary purpose in holding individual meetings was to inform and prepare key leaders, prior to the public meetings, so that they would be prepared to give appropriate feedback on planned activities.

Shell attended the 2011 Conflict Avoidance Agreement (CAA) negotiation meetings in support of a limited program of marine environmental baseline activities in 2011 taking place in the Beaufort and Chukchi seas. 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 held individual consultation meetings with representatives from the various marine mammal commissions to discuss the proposed 2012 exploration drilling program. Prior to exploration drilling in 2012, Shell has attended meetings with members of the marine mammal commissions and plans to hold additional consultation meetings with the affected communities and subsistence user groups, NSB, and NWAB to discuss the mitigation measures included in the EP and POC.

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.

In the POC Addendum report (Attachment D), Table 4.2-1 provides a list of public meetings attended by Shell since January 2009 to develop the POC and the POC Addendum. Attachment D, updated to April 2011, also includes sign-in sheets and presentation materials used at the POC meetings held in 2011 to present the revised Camden Bay EP. Comment analysis tables for numerous meetings held during 2011 summarize feedback from the communities on Shell planned activities beginning in the summer of 2012. These comments analysis tables, with responses from Shell and corresponding mitigation measures pertinent to the comment are included in Attachment D.

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

Subsistence Mitigation Measures

To minimize any cultural or resource impacts to subsistence whaling activities from its exploration operations, Shell will suspend exploration drilling activities on 25 August 2012 prior to the start of the Kaktovik and Cross Island bowhead whale hunting season. The drilling vessel, either the *Kulluk* or *Discoverer* and associated vessels will remain outside of the Camden Bay area during the hunt. Shell will resume exploration drilling operations after the conclusion of the hunt and, depending on ice and weather conditions, continue its exploration drilling activities through 31 October 2012. In addition to the adoption of this project timing restriction, 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:

Communications

- Shell has developed a Communication Plan and will implement this plan before initiating exploration drilling operations to coordinate activities with local subsistence users, as well as Village Whaling Captains' Associations, to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Com Centers to be located in coastal villages along the Chukchi and Beaufort Seas during Shell's proposed exploration drilling activities.
- Shell will employ local SAs from the Beaufort and Chukchi Sea villages that are potentially impacted by Shell's exploration drilling activities. The SAs will provide consultation and guidance regarding the whale migration and subsistence activities. There will be one per village, working approximately 8-hr per day and 40-hr weeks during the drilling seasons. The subsistence advisor will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and to advise in ways to minimize and mitigate potential negative 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; coordinating with the Com and Call Center personnel; and advising how to avoid subsistence conflicts. Subsistence advisors will have a handbook that will specify work tasks in more detail.

Aircraft Travel

- Aircraft shall not operate below 1,500 ft (457 m) unless the aircraft is engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings) in an emergency situation. Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers. Except for airplanes engaged in marine mammal monitoring, aircraft shall use a flight path that keeps the aircraft at least 5 mi (8 km) inland until the aircraft is south of its offshore destination, then at that point it shall fly directly north through the Mary Sachs Entrance to its destination. Shell reserves the option to use an alternative flight route in the event that transit through the Mary Sachs Entrance is unsafe due to weather, other environmental conditions, or in the event of an emergency.
- Aircraft and vessels will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice.
- Shell will also implement non-MMO 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 or in emergency situations) while over land or sea. This flight will also help avoid disturbance of and collisions with birds.

Vessel Travel

- The *Kulluk* or *Discoverer* and support vessels will enter the Chukchi Sea through the Bering Strait on or after 1 July, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- Exploration drilling activities at the Sivulliq or Torpedo drill sites are planned to begin on or about 10 July following transit into the Beaufort Sea and run through October 31, with a suspension of all operations beginning 25 August for the Nuiqsut (Cross Island) and Kaktovik subsistence bowhead whale hunts. During the suspension for the whale hunts, the drilling vessel and support fleet will leave the Camden Bay project area and move to an area north of latitude 71^{o} 25'N and west of longitude 146^{o} 4'W. Should the drilling vessel or support vessels anchor during the suspension, none will anchor in known environmentally, or archaeologically sensitive areas. Shell will return to resume activities after the subsistence bowhead whale hunts conclude. Exploration drilling activities will be completed by 31 October, depending on ice and weather.
- The drilling fleet transit route will avoid known fragile ecosystems, including the Ledyard Bay Critical Habitat Unit, and will include coordination through Com Centers.
- To minimize impacts on marine mammals and subsistence hunting activities, the drilling vessel and support fleet will transit through the Chukchi Sea along a route that lies offshore of the polynya zone. In the event the transit outside of the polynya zone results in Shell having to break ice (as opposed to managing ice by pushing it out of the way), the drilling vessel and support vessels will enter into the polynya zone far enough so that ice breaking is not necessary. If it is necessary to move into the polynya zone, Shell will notify the local communities of the change in the transit route through the Com Centers. As soon as the fleet transits past the ice, it will exit the polynya zone and continue a path in the open sea toward the Camden Bay drill sites.
- MMOs will be aboard the *Kulluk* or *Discoverer* and all support vessels (see the 4MP in Appendix D of the revised Camden Bay EP).
- When within 900 ft (274 m) of marine mammals, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.
- Vessel speed is to be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- All vessels must maintain cruising speed not to exceed 9 knots while transiting the Beaufort Sea. This measure would reduce the risk of ship-whale collisions.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.

Drilling Operations

- Shell will collect all drilling mud and cuttings with adhered mud from all well sections below the 26-in. (20-in. casing) hole section, as well as treated sanitary waste water, domestic wastes, bilge water and ballast water, and transport them outside the Arctic for proper disposal in an EPA-licensed TDS. These waste streams will not be discharged to the ocean.

- Drilling mud will be cooled to mitigate any potential permafrost thawing or thermal dissociation of any methane hydrates encountered during exploration drilling, if such materials are present at the drill site.
- Drilling muds will be recycled to the extent practicable based on operational considerations (e.g., whether mud properties have deteriorated to the point where they cannot be used further) so that the volume of the spent mud is reduced.
- Critical operations will not be started if potential hazards (ice floe, inclement weather, etc.) are in the vicinity and there is not sufficient time to complete the critical operation before the arrival of the hazard at the drill site (see COCP in Appendix J of the revised Camden Bay EP).
- All casing and cementing programs will be certified by a registered professional engineer.
- Airguns will be ramped up slowly during ZVSPs to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by MMOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB radius for cetaceans and 190 dB for pinnipeds. The entire safety zone must be visible during the 30-min lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 min: 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.
- The blowout prevention program will be enhanced through the use of two sets of blind/shear rams, increased frequency of BOP performance tests from 14 days to 7 days, a remotely operated vehicle (ROV) control panel on the seafloor with sufficient pressured water-based fluid to operate the BOP, a containment system that includes treatment and flaring capabilities, capping stack equipment located on one of the ice management vessels and a fully-designed relief well drilling plan and provisions for a second relief well drilling vessel (*Discoverer* or *Kulluk*) to be available to drill the relief well if the primary drilling vessel is disabled and not capable of drilling its own relief well.
- Lighting on the drilling vessel will be shaded and has been replaced with ClearSky lighting. ClearSky lighting is designed to minimize the disorientation and attraction of birds to the lighted drilling vessel to reduce the possibility of a bird collision (see the Bird Strike Avoidance and Lighting Plan in Appendix I of the revised Camden Bay EP).

Ice Management

- Ice management will involve preferentially redirecting, rather than breaking, ice floes while the floes are well away from the drill site (see the Ice Management Plan Attachment B).
- Real time ice and weather forecasting will be from the SIWAC.

Oil Spill Response

- The primary OSR vessel will be on standby at all times when drilling into zones containing oil to ensure that oil spill response capability is available within one hour, if needed.
- Shell will deploy an OSR fleet that is capable of collecting oil on the water up to the calculated Worst Case Discharge flowrate of a blowout in the unlikely event that one should occur. The primary OSR vessel will be on standby when drilling into zones containing oil to ensure that oil spill response capability is available within one hour, if needed. The remainder of the OSR fleet will be fully engaged within 72 hours.
- In addition to the OSR fleet, oil spill containment equipment will be available for use in the unlikely event of a blowout. The barge will be centrally located in the Beaufort Sea and supported by an Invader Class Tug and possibly an anchor handler. The containment equipment will be designed for conditions found in the Arctic including ice and cold temperatures. This equipment will also be designed for maximum reliability, ease of operation, flexibility and robustness so it could be used for a variety of blowout situations.
- Capping stack equipment will be stored aboard one of the ice management vessels and will be available for immediate deployment in the unlikely event of a blowout. Capping stack equipment consist of subsea devices assembled to provide direct surface intervention capability with the following priorities:

    1. Attaching a device or series of devices to the well to affect a seal capable of withstanding the maximum anticipated wellhead pressure (MAWP) and closing the assembly to completely seal the well against further flows (commonly called “capping and killing”)
    2. Attaching a device or series of devices to the well and diverting flow to surface vessel(s) equipped for separation and disposal of hydrocarbons (commonly called “capping and diverting”)

- A polar bear culvert trap has been constructed in anticipation of OSR needs and will be deployed near Point Thomson or Kaktovik prior to drilling.
- Pre-booming is required for all fuel transfers between vessels.

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

The planned marine mammal monitoring program for the Camden Bay exploration drilling program is included as Attachment C to 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 Beaufort Sea during the course of the 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 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 BOEMRE's Bowhead Whale Aerial Survey Program (C. Monnett)
- National Oceanic and Atmospheric Association, National Marine Mammal Laboratory (Robyn Angliss)
- The Kuukpik Subsistence Oversight Panel (KSOP)
- Alaska Eskimo Whaling Commission (H. Brower -Barrow)
- Beluga Whale Committee (W. Goodwin -Kotzebue)
- Inupiat Community of the Arctic Slope (Martha Ipalook Faulk -Barrow)
- North Slope Science Initiative (J. Payne)
- BOEMRE Field Supervisor (Jeff Walker)
- Alaska Department of Natural Resources (D. Perrin)
- Alaska Department of Fish and Game

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Attachment A
Specifications for *Kulluk* and *Noble Discoverer*

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***Kulluk* Specifications**

Kulluk

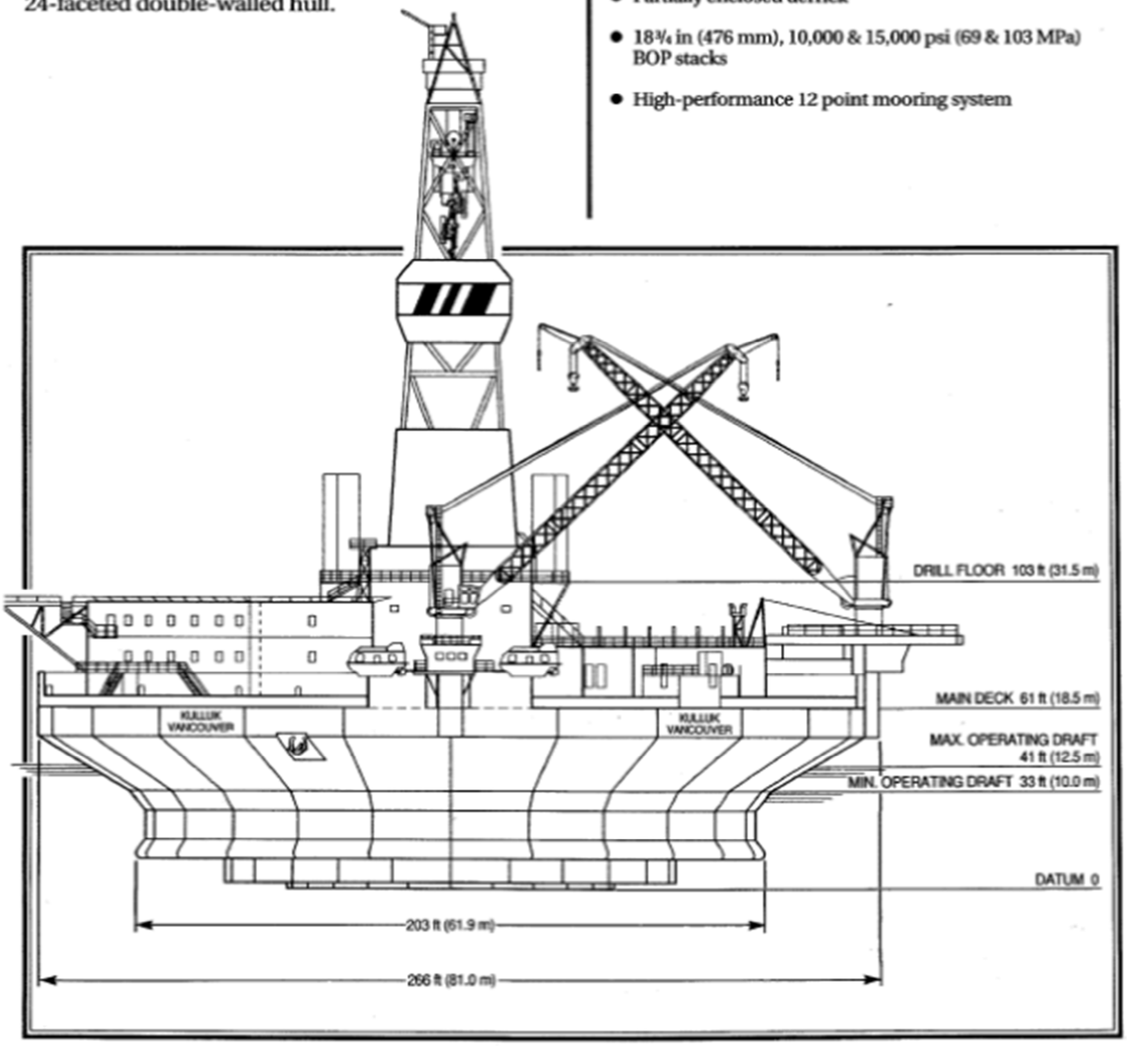
BeauDril

Kulluk is the first floating drilling vessel designed and constructed for extended season drilling operations in deep Arctic waters.

An improvement on the floating drillship concept, Kulluk is a conically shaped, ice strengthened floating drilling unit with a 24-faceted double-walled hull.

Key Features

- Unique, purpose-built conical Arctic Class IV hull design
- Operating water depth 60 to 600 ft (18.3 to 183 m), drilling depth up to 20,000 ft (6 096 m)
- Electrically driven Varco top drive drilling system
- 24 ft (7.3 m) diameter glory hole bit capable of drilling and setting a steel caisson 40 ft (12.2 m) into the seabed for ice scour protection
- Partially enclosed derrick
- 18¾ in (476 mm), 10,000 & 15,000 psi (69 & 103 MPa) BOP stacks
- High-performance 12 point mooring system



Classification

The unit has been designated as Arctic Class IV (by the Canadian Coast Guard) under Canadian Arctic Shipping Pollution Prevention Regulations, and as Ice Class 1AA by the American Bureau of Shipping.

Specifications

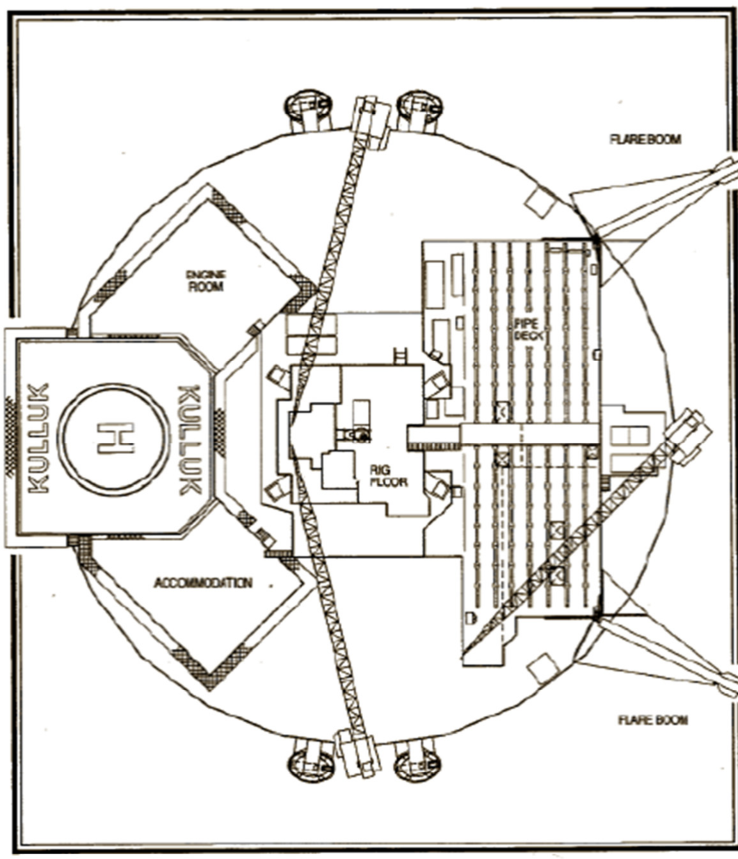
Owner:	BeauDril Limited
Flag:	Canadian
Rig Type:	Conical Drilling Unit (CDU)
Delivered:	1983
Rig Design:	Earl & Wright - Lavalin
Built By:	Mitsui Engineering and Shipbuilding, Japan

Dimensions

Diameter at main deck:	266 ft (81.0 m)
Diameter at pump deck:	196 ft (59.7 m)
Hull Depth:	61 ft (18.5 m)

Operations

Draft (max. operating):	41 ft (12.5 m)
Draft (min. operating):	33 ft (10.0 m)
Draft (light ship):	26 ft (8.0 m)
Light Ship Displacement:	19,300 tons (17 510 tonnes)
Maximum Drilling Depth:	20,000 ft (6 096 m)
Operating Water Depth:	60 to 600 ft (18.3 to 183 m)



Variable Load

7,717 tons (7 000 tonnes)

Storage Capacities

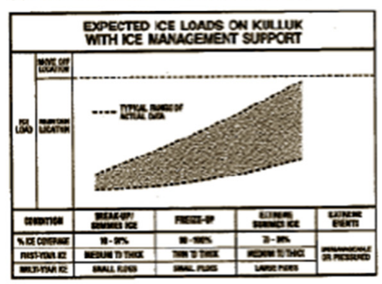
Barite & cement bulk:	21,471 cf (608 m³)
Liquid mud:	2,605 bbl (414 m³)
Drill water:	4,227 bbl (672 m³)
Fuel:	10,085 bbl (1 603 m³)
Potable water:	1,961 bbl (312 m³)
Ballast:	35,928 bbl (5 712 m³)
Pipe & casing (pipe deck):	1,543 tons (1 400 tonnes)
Brine:	2,010 bbl (320 m³)

Operational Limits

Stationkeeping Conditions

Kulluk was built to operate in the ice infested waters of the Arctic offshore. The unit was developed to extend the drilling season available to more conventional floating vessels by enabling operations to be carried out through spring breakup conditions, the summer months, and well into the early winter period.

Kulluk was designed to maintain location in a drilling mode in moving first-year ice of 4 ft (1.2 m) thickness. With ice management support provided by BeauDril's Arctic Class IV icebreakers, the unit can maintain location in more severe conditions as shown below.



In terms of Kulluk's open water performance, the drilling unit was designed to maintain location in storm conditions associated with maximum wave heights of 18 ft (5.5 m) while drilling and 40 ft (12.2 m) while disconnected (assumed storm duration of 24 hrs).

If ice or open water storm conditions become more severe than those indicated, the unit's mooring system, which incorporates acoustic release devices, is disconnected from the anchors and the unit moves off location.

Equipment

Drilling Equipment

Derrick
160 ft (44.8 m) Dreco dynamic with a 40 ft x 40 ft (12.2 m x 12.2 m) base, rated at 1,400,000 lb (623 000 daN) with 14 lines

Racking platform has capacity to hold 23,340 ft (7 115 m) of 5 in (127 mm) drill pipe plus bottom hole assembly

Drawworks
Ideco E-3000 electric drawworks complete with sand reel, Elmago model 7838 Baylor auxiliary brake, spinning and breakout catheads and three GE model 752 motors each rated at 1,000 hp (746 kW) continuous

Travelling Block
McKissick model 686, 650 ton (590 tonne) capacity with 7 sheaves grooved for 1 5/8 in (41.3 mm) drilling line

Swivel
Ideco TL-500, 500 ton (454 tonne) capacity

Drill Pipe
20,000 ft (6 096 m) x 5 in (127 mm), 19.5 lb/ft (29 kg/m) with 4 1/2 IF connections

Top Drive
Varco TDS-3 with one GE model 752 motor rated at 1,000 hp (746 kW) continuous and a 500 ton (454 tonne) hoisting capacity

Rotary Table
Ideco LR-495, 49.5 in (1 257 mm) driven by one GE model 752 motor, rated at 1,000 hp (746 kW) continuous, coupled to a two speed transmission

Drill String Compensator
NL Shaffer 18 ft (5.5 m) stroke 400,000 lb (178 000 daN) compensating capacity or a 1,000,000 lb (444 800 daN) locked capacity

Tensioner System
4 x 80,000 lb (35 600 daN) Western Gear riser tensioners, 48 ft (14.6 m) wireline travel with 1 3/4 in (44.5 mm) wire rope

6 x 16,000 lb (7 100 daN) Western Gear guideline/pod tensioners, 40 ft (12.2 m) wireline travel with 3/4 in (19.1 mm) wire rope

Mud Pumps
2 x Ideco T1600 triplex, each driven by two GE model 752 motors rated at 1,000 hp (746 kW) continuous

Cementing Unit
Dowell owned R717 twin triplex powered by two GE model 752 motors each rated at 1,000 hp (746 kW) continuous, with 7,500 psi (52 MPa) and 10,500 psi (72 MPa) fluid ends

Rig Floor Pipe Handling System
Varco Iron Roughneck model IR-2000
Range: 2 7/8 to 8 in (73 to 203 mm)

Mud Logging Room

Designed to accommodate equipment from any of the major mud logging companies. This room is an integral part of the rig and contains complete lab facilities

Testing Equipment

Complete testing system with a 10,000 BOPD (1 590 m³/day) capacity consisting of: data header, choke manifold, steam heater, 3-phase separator, surge tank, water degasser, transfer pumps, and flare booms

Mud Conditioning Equipment

4 x Thule United VSM-120 shale shakers
1 x Brandt SR-3 desander
1 x Brandt SE-24 desilter
1 x Thule VSM-200 mud cleaner
1 x Wagner Sigma-100 centrifuge
1 x Sharples DM 40 000 centrifuge
2 x Burgess Magna-Vac vacuum degassers
2 x Alfa-Laval AX30 mud coolers

Subsea Equipment

BOP System
1 x NL Shaffer 18 3/4 in (476 mm), 10,000 psi (69 MPa) BOP stack with annular, 4 ram type preventors, and Vetco H-4 E connector

1 x NL Shaffer 18 3/4 in (476 mm), 15,000 psi (103 MPa) BOP stack with annular rated at 10,000 psi (69 MPa), 4 ram type preventors, and Vetco H-4 E x F connector

Lower Marine Riser Packages
2 x 18 3/4 in (476 mm) with 10,000 psi (69 MPa) Shaffer annular, Regan 24 in (610 mm) CR-1 pressure compensated lower ball joint and Vetco H-4E connector

BOP Cranes
2 x Hepburn main bridge cranes, 85 ton (77 tonne) capacity each with 10 ton (9.1 tonne) auxiliary hoists

30 in (762 mm) Marine Riser System
3 x hydraulic pin connectors; 2 x 36 in (914 mm) Cameron and 1 x 30 in (762 mm) Dril-Quip

1 x Regan 28 in (711 mm) CR-1 pressure compensated lower ball joint

30 in (762 mm) riser consisting of 1 in (25.4 mm) wall casing with Hunting Lynx 52S connectors

1 x Regan 28 in (711 mm) telescoping riser joint with 45 ft (13.7 m) stroke

1 x Regan 28 in (711 mm) DR-1 upper ball joint

1 x Regan KFDS 28 in (711 mm) diverter

21 1/4 in (540 mm) Marine Riser System
21 1/4 in (540 mm) Cameron RCK riser with 10,000 psi (69 MPa) choke and kill lines

2 x Cameron telescoping riser joints, 1 x 40 ft (12.2 m), and 1 x 50 ft (15.2 m) stroke

1 x Regan 24 in (610 mm) DR-1 upper ball joint

1 x Regan KFDS 24 in (610 mm) diverter

Glory Hole Bit
1 x Brown Tornado, 24 ft (7.3 m) diameter hydraulically operated with airlift discharge. Capable of drilling a glory hole 40 ft (12.2 m) into the seabed for ice scour protection

Power Generation

Prime Movers:
3 x Electro-Motive Diesel rated at 2,817 hp (2 100 kW) each

Emergency Power:
1 x GM Detroit diesel rated 873 hp (651 kW)

Cranes

3 x Liebherr, BOS 65/850, rated at 72 ton (65 tonne) at 30 ft (9.1 m)

Safety Equipment

4 x Whittaker 54-person survival craft; two on port, two on starboard

1 x Hurricane Model 700-D emergency rescue boat

2 x RFD inflatable escape slides

Helideck

Capacity for Sikorsky 61 or similar with fueling station

Accommodation

Bunks for 108 people, recreation room, sauna, galley with seating for 36, offices, and hospital

Kulluk Mooring System

The Kulluk's mooring system consists of twelve Hepburn winches located on the outboard side of the main deck. Anchor wires lead off the bottom of each winch drum inboard for approximately 55 ft (17 m). The wire is then redirected by a sheave, down through a hawse pipe to an underwater, ice protected, swivel fairlead. The wire travels from the fairlead directly under the hull to the anchor system on the seafloor.

Specifications

Anchor Winch
12 x Hepburn single-drum winches with a 287 ton (260 tonne) operating tension

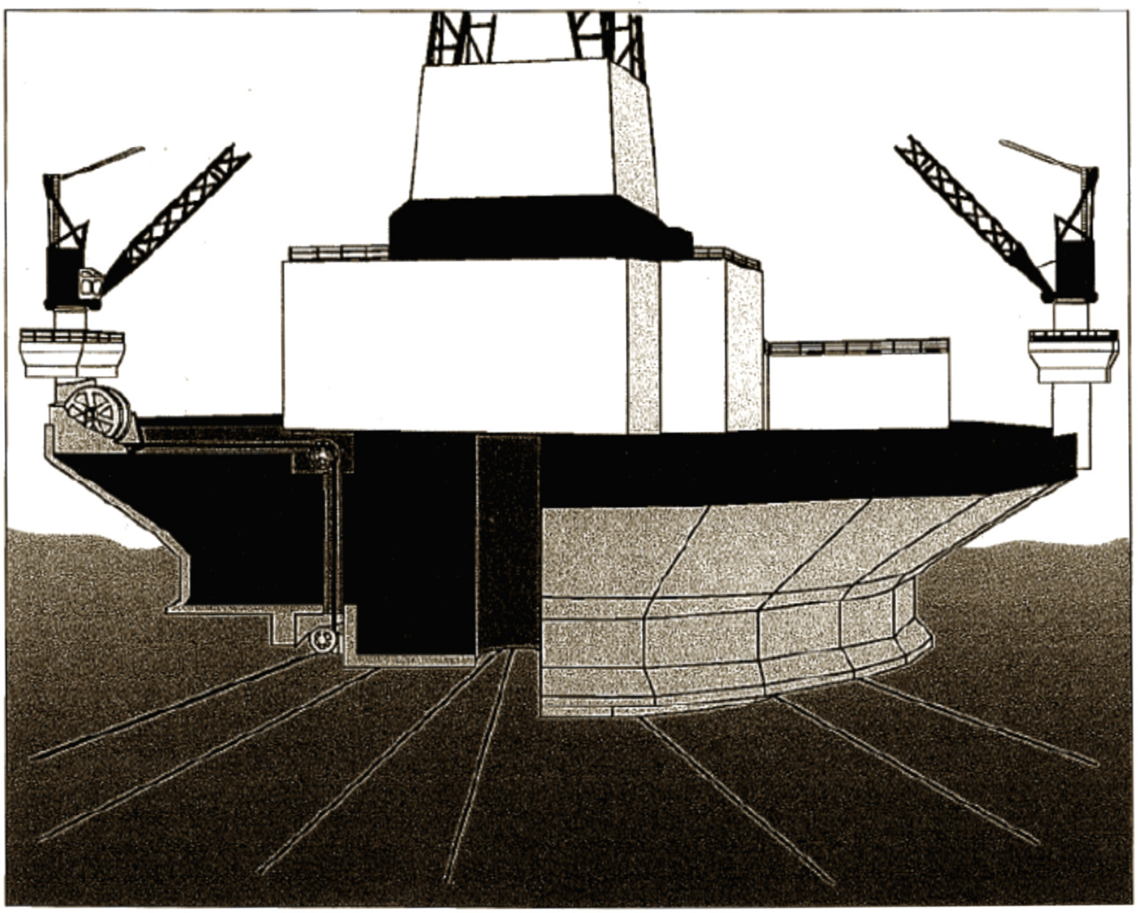
Mooring Wires and Anchors

Anchors:
Various sizes & quantities of anchors are available for use. Exact anchor configuration to be provided once location and seafloor conditions are specified

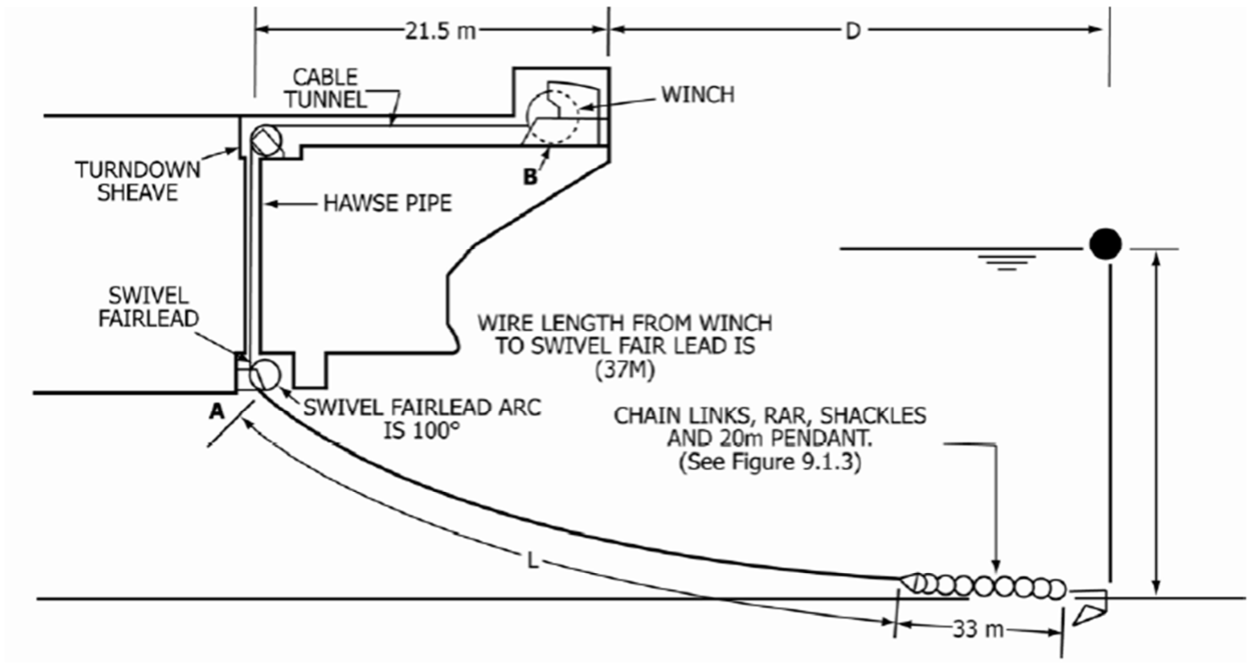
Wire ropes:
Each winch drum has capacity for 3,763 ft (1 147 m) of 3½ in (88.9 mm), 573 ton (520 tonne) breaking strength wireline

Anchor Release:
Each anchor wire contains a remote acoustic release (RAR) unit

FOR MORE INFORMATION ABOUT KULLUK, CONTACT MANAGER, BEAUDRILL AT (403) 233-3030.



Kulluk Anchoring Detail



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***Discoverer* Specifications**

***DISCOVERER* SPECIFICATIONS**	
TYPE-DESIGN	Drillship - Sonat Offshore Drilling *Discoverer* Class
SHAPE	Monohull with sponsons added for ice-resistance[1]
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	2010

***DISCOVERER* DIMENSIONS**		
LENGTH	514 ft	156.7 m
LENGTH BETWEEN PERPINDICULARS (LBP)	486 ft	148.2 m
WIDTH	85 ft	26 m
MAXIMUM (MAX) HEIGHT (ABOVE KEEL)	274 ft	83.7 m
HEIGHT OF DERRICK ABOVE RIG FLOOR	175 ft	53.3 m

***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 15,400 lb each; 7,000 kilograms (kg) each (ea)
ANCHOR LINES	Chain Wire Combination
SIZE/GRADE	2.75 inch (in.) wire 3 in. ORQ Chain
LENGTH	2,750 ft (838 m) wire + 1,150 ft (351 m) chain (useable) per anchor

***DISCOVERER* OPERATING WATER DEPTH**		
MAX WATER DEPTH	1,000 ft (305 m) with present equipment (can be outfitted to 2,500 ft [762 m])	
MAX DRILLING DEPTH	20,000 ft	6,098 m

Table 1.c-2 *Discoverer* Specifications (continued)	
DRAW WORKS	EMSCO E-2,100 - 1,600 horsepower (hp)
ROTARY	National C-495 with 49-1/2 in. (1.3 m) opening
MUD PUMPS	2 ea. Continental Emsco Model FB-1600 Triplex Mud Pumps
DERRICK	Pyramid 170 ft. (51.8 m) with 1,300,000 lb nominal capacity
PIPE RACKING	BJ 3-arm system
DRILL STING COMPENSATOR	Shaffer 400,000 lb with 18-ft (5.5-m) stroke
RISER TENSIONS	8 ea. 80,000 lb Shaffer 50-ft (15.2-m) stroke tensioners
CROWN BLOCK	Pyramid with 9 ea. 60-in. (1.5 m) diameter sheaves rated at 1,330,000 lb
TRAVELING BLOCK	Continental - Emsco RA60-6
BLOWOUT PREVENTOR (BOP)	Cameron Type U 18. 3/4-in. x 10,000 pounds per square inch (psi)
RISER	Cameron RCK type (21-in.)
TOP DRIVE	Varco TSD-3S, with GE-752 motor, 500 ton
BOP HANDLING	Hydraulic skid based system, drill floor

***DISCOVERER* DISPLACEMENT**	
FULL LOAD	20,253 metric tons (mt)
DRILLING	18,780 mt (Drilling, max load, deep hole, deep water)

***DISCOVERER* DRAUGHT**	
DRAFT AT LOAD LINE	27 ft (8.2 m)
TRANSIT	27 ft (8.2 m) (fully loaded, operating , departure)
DRILLING	25.16 ft (7.7 m)

***DISCOVERER* HELIDECK**	
MAXIMUM HELICOPTER SIZE	Sikorsky S-92N
FUEL STORAGE	2 ea. 720-gallon (gal) tanks
***DISCOVERER* ACCOMODATIONS**	
NUMBER OF BEDS	140
SEWAGE TREATMENT UNIT	Hamworthy ST-10
***DISCOVERER* PROPULSION EQUIPMENT**	
PROPELLER	1 ea 15 ft 6 in. (4.8 m) diameter, fixed blade
PROPULSION DRIVE UNIT	Marine Diesel, 6 cylinder, 2 cycle, Crosshead type
HORSEPOWER	7,200 hp @ 135 revolutions per minute (RPM)
TRANSIT SPEED	8 knots

GENERAL STORAGE CAPACITIES	
SACK STORAGE AREA	934 cubic meters (m³)
BULK STORAGE	
Bentonite / Barite	1.,132 bbl - 4 tanks
Bulk Cement	1.132 bbl - 4 tanks
LIQUID MUD	
Active	1,200 barrels (bbl)
Reserve	1,200 bbl
Total	2,400 bbl
POTABLE WATER	1,670 bbl (aft peak can be used as add. pot water tank)
DRILL WATER	5,798 bbl
FUEL OIL	6,497 bbl

[1] Sponsons designed and constructed to meet requirements of Det Norske Veritas (DNV) Additional Class Notation ICE-05.

Attachment B
Ice Management Plan

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

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Attachment D
Plan of Cooperation Addendum

(Refer to Appenedix H of the Revised Camden Bay EP)

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Attachment E
Analysis of the Probability of an "Unspecified Activity" and Its Impacts: Oil Spill

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Analysis of the Probability of an "Unspecified Activity" and Its Impacts: Oil Spill

Shell analyzed the likelihood of an accidental oil spill and its possible impacts in its revised Camden Bay Exploration Plan (EP) and Environmental Impact Assessment (EIA). The following analysis is excerpted from that document.

Probability Analysis of an Oil Spill

While a well blowout (loss of well control) is potentially the most significant concern for generating a large hydrocarbon spill because of the associated spill volume, Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) has estimated the risk that a blowout event would impact the Beaufort Sea as a result of exploration drilling is low. A total of thirty-five (35) exploration wells have been drilled between 1982 to 2003 in the Chukchi and Beaufort Seas and there have been no blowouts. In addition, none have occurred from the approximately 98 exploration wells drilled within the Alaskan Outer Continental Shelf (OCS) (MMS 2007a).

The BOEMRE Environmental Assessment (EA) prepared for the Beaufort Sea (MMS 2007b) reported that from 1971 through 2005 approximately 13,463 exploration wells were drilled (172 in the Pacific OCS, 51 in the Atlantic OCS, and 98 in the Alaska OCS). Sixty-six blowouts were identified for all exploration drilling from 1971 to 2005. No large spills (greater than 1,000 barrels [bbl; greater than or equal to 159 m^3]) occurred during exploration drilling well blowouts from 1971 to 2005. Of the approximately 13,000 wells that were drilled, four spills resulted in crude reaching the environment from blowouts with volumes of 200, 100, 11, and 0.8 bbl (31.8 m^3, 16 m^3, 1.8 m^3, and 0.13 m^3), respectively. Another BOEMRE study affirmed that no crude oil spills greater than 100 bbl (16 m^3) resulting from blowouts occurred from 1985 to 1999 (Hart Crowser, Inc 2000). A 2007 report by BOEMRE (Izon et al. 2007) reviewed blowout statistics for the U.S. from 1992 through 2006. This paper did not distinguish between exploration and development wells but reported that the overall frequency of blowouts has diminished since their previous review for the period of 1971 through 1972.

Holand (1997) reported the U.S. Gulf of Mexico OCS exploration blowout frequencies as 0.0059 per well drilled, based on worldwide historical data available from the SINTEF Offshore Blowout Database. As Holand's exploration blowout frequencies included blowouts of all types, the frequencies for a blowout resulting in oil reaching the environment are significantly less. Of the total blowouts reported by Holand (1997), gas releases accounted for 77 percent of the total blowouts, gas/liquid mixtures 14 percent, and uncontrolled liquid flows involved only three percent.

BOEMRE recently analyzed how the *Deepwater Horizon* event affected prior analysis about the likelihood of an oil spill.[2] It explained that, when preparing such predictive analyses, it used data from past OCS spills. However, from 1985-1999 (the time period used when preparing the Gulf of Mexico analysis), there were no platform or blowout spills greater than 1,000 barrels. Thus, "to allow for conservative future predictions of spill occurrence, a spill number of one was 'assigned' to provide a non-zero spill rate for blowouts. Therefore, this spill rate already included the occurrence of the Macondo Event."[3]

Scandpower (2001) used statistical blowout frequencies modified to reflect specific field conditions and operative systems at the Northstar Development in the Beaufort. The report concluded that the predicted frequency of blowouts when drilling into the oil-bearing zone is 0.000015 per well drilled. This same report estimates that the frequency of oil quantities per well drilled for Northstar for a spill greater than 130,000 bbl (20,668 m^3) is 0.00000094 per well. This compares to a statistical blowout frequency of 0.000074 per well for an average development well.

Bercha (2006, 2008) developed a fault tree model to estimate oil spill occurrence rates associated with Arctic OCS locations. Since limited historical spill data for the Arctic exists, Bercha modified the existing base data using fault trees to arrive at oil spill frequencies for future development and production scenarios. For offshore exploration drilling, Bercha (2008) used statistics derived from Holand (1997) for non-Arctic drilling operations and Scandpower's (2001) blowout frequency assessment for Northstar to estimate the anticipated size and frequency of spills. Based on this historical data, Bercha reported the spill frequency for non-Arctic exploration well drilling as 0.000342 per well for a blowout equal to or in excess of 150,000 bbl (23,848 m^3).

In order to model the data variability for Arctic exploration, Bercha applied a numerical simulation approach to develop the probability distribution of 150,000 bbl (23,848 m^3) or greater, and arrived at a frequency ranging from a low of 0.00015 per well to a high of 0.000697 per well. The expected value for a blowout of this size was computed to be 0.000394 per well (Bercha 2008). To address causal factors associated with blowouts, Bercha applied adjustments for improvements to logistics support and drilling contractor qualifications that resulted in lower predicted frequencies for Arctic drilling operations. No fault tree analyses or unique Arctic effects were applied as a modification to existing spill causes for exploration, development, or production drilling frequency distributions. For exploration wells drilled in analogous water depths to planned Beaufort Sea wells at 98-197 ft (30-60 m), Bercha (2008), the predicted,

[2] BOEMRE, Site Specific Environmental Assessment of Exploration Plan No. S-7445 for Shell Offshore Inc. (March 21, 2011), Appendix A: Accidental Oil Spill Discussion, at A-4. This technical analysis builds on and is consistent with BOEMRE's findings related to the Deepwater Horizon incident. *See* BOEMRE, Modifications to Suspension of Deepwater Drilling Operations Environmental Assessment and Finding of No Significant Impact (October 12, 2010) at 35 ("The probability of a catastrophic spill from drilling deepwater exploration and development well[s] remains very low, even remote. The knowledge gained and proactive steps taken since the Macondo well blowout further reduces that probability, the degree to which is still unknown."); BOEMRE ESA Section 7(d) Determination Relating to Gulf of Mexico Leasing, Drilling and Production Activities (October 7, 2010) at 5 ("The potential impact of these activities on listed species and their designated critical habitat remains low because it is very unlikely that another high impact oil spill would occur in the [Gulf of Mexico] and because BOEMRE is taking steps to reduce the likelihood of such a spill and to protect listed species and their habitat, including new measures devised in light of the [Deepwater Horizon] incident.").

[3] *Id.*

adjusted frequency is 0.000612 per well for a blowout sized between 10,000 bbl (1,590 m^3) to 149,000 bbl (23,689 m^3) and 0.000354 per well for a blowout greater than 150,000 bbl (23,848 m^3).

The best available information on blowouts associated with oil and gas operations on Alaska's North Slope identifies 11 blowouts between 1977 and 2001. These blowouts released either dry gas or gas condensate only; resulting in minimum environmental impact (NRC 2003).

Impact Analysis of an Oil Spill

Oil and gas exploration activities, such as those proposed in Shell's Revised Outer Continental Shelf Lease Exploration Plan, Camden Bay, Beaufort Sea, Alaska for Flaxman Island Blocks 6559, 6610 and 6658 and Beaufort Sea Lease Sales 195 and 202 ("revised Camden Bay EP") carry a risk of an oil spill. Various events could cause a spill, ranging from a hose rupture to the extreme example of a loss of well control (blowout). However, the most likely spill to occur during the activities in the revised Camden Bay EP would be a spill of approximately 48 bbl resulting from a refueling operation.[4] This conclusion is consistent with BOEMRE's prior findings when analyzing the likelihood of various kinds of spill impacts.[5] Accordingly, this EIA evaluates the impacts of a 48 bbl spill on existing environmental resources.[6] These impacts will not be significant. As discussed *infra*, the impacts of a 48 bbl spill resulting from a refueling operation are expected to be localized and fleeting.

While not a reasonably expected impact of this exploration project, BOEMRE has analyzed the impacts of a very large oil spill ("VLOS") in the Beaufort Sea, defined by BOEMRE as a spill of 150,000 or more bbl. BOEMRE analyzed the impacts of a 180,000 bbl spill in the 2003 Final Environmental Impact Statement for the Beaufort Sea Planning Area Oil and Gas Lease Sales 186, 195, and 202 ("2003 Multi-Sale Environmental Impact Statement (EIS)"). As discussed below, BOEMRE concluded that such a spill would be rare, but that, if it occurred, it could have significant impacts on certain environmental resources. As part of that analysis, BOEMRE analyzed potential trajectories of a spill and considered the impacts of a spill in various ice conditions.

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[4] *See* infra (EIA) at [*Environmental Impact Analysis, Revised Outer Continental Shelf Exploration Plan, Camden Bay, Beaufort Sea, Alaska*]

[5] 2010 Camden Bay EP/EA at Appendix A.

[6] This approach is consistent with the approach approved by the Ninth Circuit in *Edwardsen v. U.S. Dep't of the Interior*, in which the agency did not include a worst case scenario analysis regarding oil spill trajectories. 268 F.3d 781, 785 (9th Cir. 2001) ("Moreover, an EIS need not include a worst-case scenario. *See Robertson v. Methow Valley Citizen's Council*, 490 U.S. 332, 354 (1989). *See also* Mandelker, *NEPA Law and Litigation* § 10.07[3] at 10-39.").

The VLOS analysis in the 2003 Multi-Sale EIS properly informs the analysis of the revised Camden Bay EP. The Ninth Circuit has approved of the use of existing NEPA analyses on spill impacts when the analysis covers the area at issue.[7] Applying the impacts analysis in the 2003 Multi-Sale EIS to the activities in the revised Camden Bay EP provides a site-specific analysis of the potential impacts of a VLOS resulting from the revised Camden Bay EP. Although the oil spill resulting from the *Deepwater Horizon* incident has brought heightened attention to oil spill – and especially VLOS – issues, there is no new information related to the site-specific impacts of this project that requires additional analysis. The existing analysis of VLOS impacts in the Beaufort Sea in the 2003 Multi-Sea EIS, as properly applied to the revised Camden Bay EP, evaluates the reasonably foreseeable impacts from a VLOS resulting from this operation.

Impacts Of A Very Large Oil Spill

In its 2003 Multi-Sale EIS, BOEMRE analyzed the likelihood of a spill, the fate of spilled oil without cleanup and the most likely trajectories of spills of various sizes that could result from oil exploration and development on the proposed leased areas.[8] This analysis included an evaluation of the impacts of a VLOS, which BOEMRE defined as greater than 150,000 barrels of oil.[9] For the purposes of the analysis, the agency evaluated the impacts of a hypothetical 180,000 barrel spill in a nearshore area on areas identified by the agency as sensitive resources.[10] BOEMRE analyzed the behavior of spilled crude oil in open water, solid ice, and broken ice. For each scenario, BOEMRE evaluated the impacts of the spill on environmental resources.[11] The agency concluded that impacts to some resources were likely to be significant in the unlikely event of a very large oil spill. However, the agency also noted the mitigating role that oil spill response activities could have on these potential impacts.

In its 2003 Multi-Sale EIS BOEMRE noted the following impacts resulting from a very large 180,000 barrel oil spill. BOEMRE considered the impact of a VLOS on threatened and endangered species, including bowhead whales. BOEMRE estimated a VLOS during summer had a 35 percent chance of contacting important bowhead whale habitat within 30 days. The probability of oil contacting whales, however, is likely to be considerably less than the probability of it contacting bowhead whale habitat. If bowhead whales were contacted, available data shows baleen whales are unlikely to experience serious direct effects from oil exposure. While lethal effects for some individuals are possible, most individuals exposed to spilled oil are expected to experience temporary nonlethal effects from, for example, oiling of the skin and inhalation of hydrocarbon vapors.[12]

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[7] *Id.* at 785-86 (upholding the approval of the BP Northstar project which relied on analysis of oil spill impacts in the NEPA documents related to Lease Sale 170, which covered the same area as the project).

[8] 2003 Multi-Sale EIS at Section IV-1.

[9] *Id.* at IV-227.

[10] *Id.* at IV-228.

[11] *See id.* at IV-230 to IV-247.

[12] *Id.* at IV-233 to IV-234. BOEMRE's analysis also considered the impacts of a VLOS on spectacled and Steller's eiders, which are potentially significant for these small populations. *See id.* at IV-234 to IV-236. BOEMRE also analyzed the potential impacts on other marine and coastal birds. Depending on season and distribution, a VLOS could cause the loss of potentially thousands of waterfowl. *Id.* at IV-236 to IV-238.

A VLOS could have potentially lethal impacts on marine mammals, including pinnipeds, polar bears and beluga whales, because of absorption, inhalation or ingestion of toxic hydrocarbons. About 67 percent of the oil likely would contact offshore seal and polar bear ice-front habitat. Several thousand walrus and seals and as many as 128 polar bears (assuming a high population density) could be exposed to oil. Assuming all contacted individuals died, this loss could take these marine mammal populations more than one or two generations to recover (up to approximately 15 years). Beluga whales might encounter spilled oil during the spring migration and summer, but few if any whales are likely to be adversely affected, with fewer than 20 individuals lost (population recovery in 1 year).[13]

BOEMRE found that a VLOS would impact water quality by increasing the concentration of hydrocarbons in the water column in a large area greatly above background levels. For example, a very large spill to open water during summer could increase concentrations above the 1.5 parts/million acute toxic criterion during the first several days in an area of a hundred square miles (mi^2). Oil could exceed the 0.015 parts/million chronic criterion for several months or more in an area of approximately 5,000 mi^2, before dispersion and dilution reduced oil concentrations below the chronic criterion.[14] BOEMRE estimated only limited affects on lower trophic-level organisms given their distribution and seasonal factors. For example, BOEMRE estimated there would be no impacts on subtidal marine plants because they live below the zone where toxic concentrations of oil are expected to occur. Lethal and sublethal effects are expected on marine invertebrates in the intertidal and subtidal zones. Plankton species would also be impacted by a spill, but because of their wide distribution, large numbers and rapid rate of regeneration, there would be only a temporary, local effect on the plankton community resulting from a very large oil spill.[15] BOEMRE estimated a very large oil spill would have no measurable effects on fishes in winter, due to their low numbers and wide distribution. A VLOS during summer could affect fishes in nearshore waters, although BOEMRE estimated the likelihood of a VLOS occurring and contacting nearshore areas as very low (< 0.5%). If such a spill did occur, some marine and migratory fishes could be harmed or killed, but mortality due to oil exposure is seldom observed outside the laboratory because the zone of lethal toxicity is very small and short lived, and fishes in the immediate area typically avoid that zone.[16]

Finally, BOEMRE analyzed the impact of a VLOS on air quality. BOEMRE concluded a spill's effects on air quality would be low. A VLOS could cause an increase in gaseous hydrocarbon concentrations, which could affect onshore air quality. Any effects would be localized and temporary, and concentrations of criteria pollutants would likely remain well within Federal air-quality standards.[17]

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[13] *Id.* at IV-238 to IV-239.

[14] *Id.* at IV-230 to IV-231.

[15] *Id.* at IV-231 to IV-232.

[16] *Id.* at IV-232.

[17] *Id.* at IV-245. The 2003 Multi-Sale EIS also analyzed the impacts of a VLOS on terrestrial mammals, vegetation and wetland habitats as well as socio-economic impacts, particularly the impacts on subsistence activities and resources. *See id.* at IV-239 to IV-245.

BOEMRE continued to refine its impacts analysis in subsequent EAs it prepared in advance of lease sales held pursuant to the 2003 Multi-Sale EIS. For example, by the time it prepared its EA of Proposed OCS Lease Sale 202 Beaufort Sea Planning Area ("Lease Sale 202 EA") in 2006, BOEMRE had updated its analysis with refined information to estimate that the likelihood of one or more large spills (defined by BOEMRE to mean > 1,000 bbl) had increased from the 8-10 percent likelihood estimated in the 2003 Multi-Sale EIS to 20 percent in the Lease Sale 202 EA.[18] The EA further stated that in the absence of any clean-up activities, it assumed that after 30 days in open water or broken ice, 27-29 percent of oil evaporates, 4-32 percent disperses, and 28-65 percent remained. After 30 days under landfast ice, the EA assumed that nearly 100 percent of oil remains in place and unweathered.[19]

The VLOS Impacts Analysis Of The 2003 Multi-Sale EIS Is Applicable To Shell's Current EP.

The detailed impacts analysis of the 2003 Multi-Sale EIS provides decision-makers with useful information on the anticipated impacts of a VLOS from a given project. For example, when BOEMRE prepared its EA of the Shell Offshore Inc. 2010 Outer Continental Shelf Lease Exploration Plan for Camden Bay, Alaska ("2010 Camden EA"), the agency referred back to the overall analysis prepared in the 2003 Multi-Sale EIS and determined that the potential impacts from a very large spill in the vicinity of Shell's proposed operations were "statistically similar" to the impacts and contacts modeled in the 2003 Multi-Sale EIS.[20] BOEMRE then applied the previous analysis to determine the likelihood of spilled oil reaching various key environmental areas from the proposed activity site in various time windows, both in the summer and winter.[21] In this way, BOEMRE was able to narrow the range of possible impacts from those identified in the 2003 Multi-Sale EIS to the more likely impacts if a spill were to occur from the proposed activities.

This analysis remains applicable for the revised Camden Bay EP. OCSLA anticipates and instructs that BOEMRE evaluate exploration and development in the OCS in a staged manner, building its analysis over the course of the lease sale, exploration, and development. The statute's limited time period in which to approve or deny EPs indicates Congress's intent that the agency use the environmental analysis underlying the lease sale to the extent appropriate. There is no reason not to use this approach here. The revised Camden Bay EP proposes activities that will take place within the area analyzed in the 2003 Multi-Sale EIS. Thus, any analysis of potential VLOS impacts arising from the revised Camden Bay EP properly should look to the analysis in the 2003 Multi-Sale EIS. Further, the revised Camden Bay EP proposes drill sites in the vicinity as those proposed in the 2010 Camden Bay EP approved by BOEMRE and upheld by the Ninth Circuit. Having once analyzed the VLOS impacts related to wells in these locations by using the 2003 Multi-Sale EIS framework, it is reasonable to take the same approach for the revised Camden Bay EP. There is no new information indicating that this approach, and the analytical framework created by the 2003 Multi-Sale EIS, is incomplete, dated or otherwise insufficient. To the contrary, additional information regarding the potential size of a "worst

[18] Lease Sale 202 EA at 15.

[19] *Id.* at 14-15.

[20] Camden EA at A-2.

[21] Camden EA at A11 through A-12.

case" spill arising from the proposed activities, developed using new guidance from the agency in response to the *Deepwater Horizon* incident, indicate that such a spill would be well within the range of spills analyzed by the agency in the 2003 Multi-Sale EIS.

The drill sites proposed have worst case discharge scenarios comparable to, albeit notably lower than, the scenarios used in the 2003 Multi-Sale EIS. For example, using BOEMRE's revised "Worst Case Scenario" guidelines, Shell calculated and reported in response to NTL-06 that, if a well control event occurred at the Sivulliq N exploration well, the most oil that would be released in a single day would be 860 bbl, on the first day.[22] Modeling indicates that oil released from the well would decrease steadily to 556 bbl/day on the 38th day (when the relief well, if necessary, would be completed). This modeling assumes no bridging over of the well, although the wet sands formations above the oil-bearing zone and prior experiments with Hammerhead wells in the area indicate that bridging over would likely occur.[23] If the well did bridge over the worst case discharge would fall to approximately 20 percent of the modeled amounts.[24]

Shell has continued to refine its analysis since that submission and has determined that the worst case discharge scenarios for the proposed drill sites are as follows: Sivulliq G (594 bbl/day), Sivulliq N (918 bbl/day), Torpedo H (9,648 bbl/day), Torpedo J (5,824 bbl/day).

<u>Shell's Oil Spill Response Strategies Will Mitigate The Impacts Of A Spill</u>.

Shell has an extensive response system in place that would minimize the amount of oil reaching the environment.[25] Shell will deploy state-of-the art subsea blow-out preventer devices to stop all flow from the well immediately upon a well control event occurring. If that system fails, Shell will have a secondary system which will be capable of either (i) stopping the flow from the well, or (ii) capturing the flow from the well and diverting it to the surface for proper disposal. Shell anticipates that it can stop the flow from the well within 15 days of deploying this secondary system. Shell is also ready to intervene with containment devices as necessary to capture the oil below the surface to prevent interference with sea ice. If subsurface efforts are not successful at capturing and containing all oil, Shell has surface response vessels that will conduct clean-up operations. Shell also is prepared to drill a relief well, if necessary, with its primary drilling vessel (whether that be the *Kulluk* or *Discoverer)*, but if the primary drilling vessel is disabled, Shell will have the other drilling vessel on standby to complete the relief well. In the event the primary drilling vessel is not available to complete the relief well, Shell anticipates that it would take a maximum of 43 days from the time the secondary drilling vessel is mobilized for it to complete a relief well at the Torpedo Prospect where the wells will be drilled slightly deeper than Sivulliq where the maximum number of days for a relief well is 38. The time to drill a relief well would be substantially shorter if the primary drilling vessel is able to complete it. Thus, even if a large spill were to occur, the impacts identified in the 2003 Multi-

[22] *Id.* at 1, 21. A bridge over refers to the collapse of a well bore during a loss of well control, in which rock, sand, clay and other materials obstruct the well and stop the blow out.

[23] *Id.* at 2, 23-24.

[24] *Id.* at 23.

[25] *See* Shell's [*Beaufort Sea Regional Oil Discharge Prevention and Contingency Plan*] for a full description and timeline of Shell's response capabilities.

Sale EIS would not necessarily follow because Shell's spill response capabilities would minimize the amount of oil reaching the environment.

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Appendix D
Marine Mammal Monitoring and Mitigation Plan