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 in the Chukchi Sea, Alaska

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List of Acronyms

~	approximate
°	degrees Fahrenheit
°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
AISC	Alaska Ice Sea Commission
ASL	above sea level
ATOC	Acoustic Thermometry of Ocean Climate
bbl	barrels
BCB	Bering-Chukchi-Beaufort stock (bowheads)
BOEMRE	U.S. Bureau of Ocean Energy Management, Regulation and Enforcement
BOP	blowout preventer
BWASP	Bowhead Whale Aerial Survey Program
CAA	Conflict Avoidance Agreement
CFR	Code of Federal Regulations
CI	Confidence Interval
cm^3	cubic centimeters
CV	Coefficient of Variation
Com Center	Communication and Call Center
COMIDA	Chukchi Sea Offshore Monitoring in Drilling Area
dB	decibel
Discoverer	*Noble Discoverer*
DNV	Det Norske Veritas
EP	Exploration Plan
ESA	Endangered Species Act
Exploration Drilling program	Chukchi Sea Exploration Drilling Program
EWC	Eskimo Walrus Commission
Fennica	Motor Vessel *Fennica*
ft	foot/feet
hr	hour(s)
IHA	Incidental Harassment Authorization
IMP	ice management plan
in.	inch(es)
$in.^3$	cubic inch(es)
Hz	hertz
IUCN	International Union for the Conservation of Nature
km	kilometer(s)
km^2	square kilometer(s)
km/hr	kilometers per hour
LC_{50}	lethal concentration 50 percent
lb	pound(s)

m	meter(s)
mi	square miles
mi	statute mile(s)
min	minute(s)
MLC	mudline cellar
MMPA	Marine Mammal Protection Act
MMO	Marine Mammal Observer
MMS	Minerals Management Service
MONM	Marine Operations Noise Model (JASCO)
M/V	Motor Vessel
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NPDES	National Pollutant 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
POC	Plan of Cooperation
ppm	parts per million
psi	pounds per square inch
PTD	Proposed Total Depth
PTS	Permanent Threshold Shift
RL	Received Level
rms	root mean square
ROV	remotely operated vehicle
SAR	Search and Rescue
Shell	Shell Gulf of Mexico Inc.
SEL	sound exposure level
TAH	total aromatic hydrocarbons
TTS	Temporary Threshold Shift
TK	Traditional Knowledge
U.S.	United States
USFWS	United States Fish and Wildlife Service
VSI	vertical seismic imager
VSP	vertical seismic profile
ZVSP	zero-offset vertical seismic profile

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Executive Summary

As described herein, during the 2012 exploration drilling season, Shell Gulf of Mexico Inc. (Shell) plans to drill up to three exploration wells at three drill sites, and potentially a partial well at a fourth drill site in the Chukchi Sea on Outer Continental Shelf (OCS) leases acquired from the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). Shell plans to use the Motor Vessel (M/V) *Noble Discoverer (Discoverer)* drillship to drill the planned wells. The *Discoverer* will be attended by a minimum of eight support vessels for the purposes of ice management, anchor handling, oil spill response (OSR), refueling, and resupply.

The *Discoverer* is an industry-standard, ice-strengthened drillship similar to those routinely used in the Beaufort and Chukchi Seas since the 1980s. During exploration drilling and associated operations, the drillship will emit near continuous non-pulse sounds that ensonify only very limited areas of the ocean bottom and intervening water column. Within the timeframe of exploration drilling operations, Shell may also conduct a particular type of short-duration vertical seismic profile (VSP) survey known as a zero-offset VSP, or ZVSP in each well. The ZVSPs emit pulse sounds that also ensonify very limited areas of the ocean bottom and intervening water column for only approximately 10-14 hours. Typically, a single ZVSP survey will be performed when the well has reached PTD or final depth although, in some instances, a prior ZVSP will have been performed at a shallower depth.

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 the 2012 exploration drilling program, including ZVSP 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, icebreaking, and impulse sound generated during a short-duration ZVSP survey likely to occur at or near the end of each well. 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.

For example, an impact analysis of underwater sound generated by the drilling vessel and a very limited amount of icebreaking activities (see Summary Table ES-1) using the average density estimates determined that only 1 bowhead whale and 1 gray whale would be exposed to sounds ≥120 decibels (dB) re 1 micropascal (μPa) root mean square (rms) equaling <1 percent of the population. An even smaller percentage of seal populations in the Chukchi Sea would be exposed to underwater sounds in excess of 120 dB re 1 μPa rms. Marginally more numbers of marine mammals would be exposed to sounds ≥160 decibels (dB) re 1 μPa for the ZVSP surveys (see Table 4-1 for marine mammal populations and Tables 6-4 and 6-7 for estimates of marine mammals exposed to sound from the exploration drilling operations, icebreaking, or ZVSPs associated with this exploration drilling program).

Table ES-1 Summary of Incidental Takes of Marine Mammals

Drilling Vessel – *Discoverer*	Icebreaking	ZVSP
1 Bowhead whale	19 Bowhead whales	5 Bowhead whales
0 Beluga whale	4 Beluga whales	1 Beluga whale
1 Gray whale	14 Gray whales	6 Gray whales
1 Bearded seals	12 Bearded seals	5 Bearded seals
17 Ringed seals	343 Ringed seals	132 Ringed seals
0 Spotted seals	7 Spotted seals	3 Spotted seals

The small numbers of other whale species and seals that may occur in the Chukchi Sea are unlikely to be present around the planned exploration drilling activities. In regard to the subsistence harvest of bowhead whale in the Chukchi Sea, as a consequence of Shell's planned mitigation measures, any effects on the bowhead whale as a subsistence resource also will be negligible.

The organization of this request for IHA follows the organization of Chapter 50 Code of Federal Regulations (CFR) 216.104 (a). The remainder of this document is organized as to follow 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 NMFS to consider authorizing the taking by United States (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 ZVSP 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 ZVSP 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, ZVSP 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 ZVSP surveys (*See* [Analysis of the Probability of an "Unspecified Activity" and Its Impacts: Oil Spill; Attachment E 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, ZVSP surveys, and related activities.

Exploration Drilling

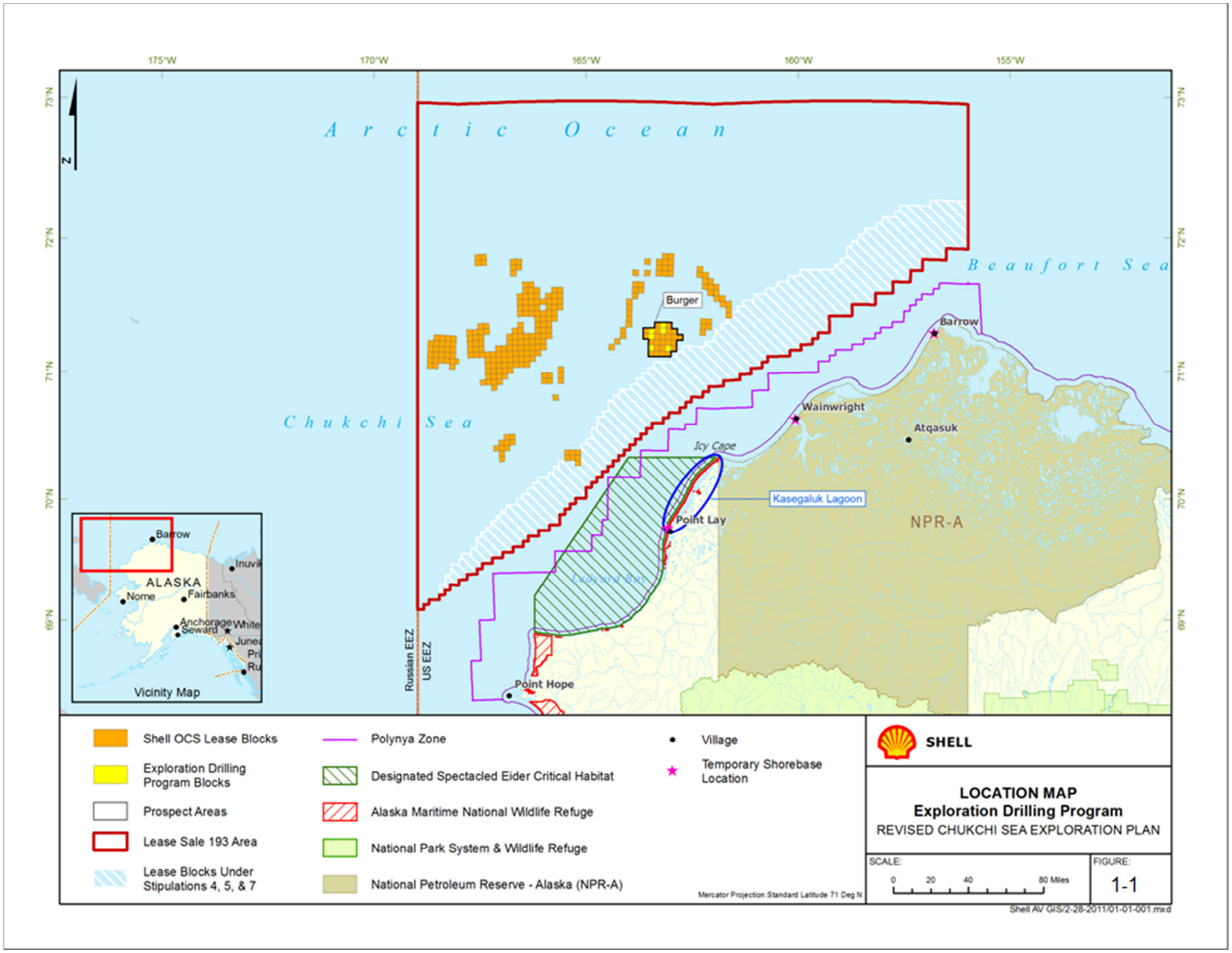
Shell plans to conduct an exploration drilling program on BOEMRE Alaska OCS leases at drill sites greater than 64 miles (mi) [103 kilometers (km)] from the Chukchi Sea coast during the 2012 exploration drilling season (Chukchi Sea Exploration Drilling Program, hereinafter, the *"exploration drilling program")* (Figure 1-1).

The leases were acquired during the Chukchi Sea Oil and Gas Lease Sale 193 held in February 2008. During 2012, the initial year of the exploration drilling program, Shell plans to drill up to three exploration wells at three drill sites, and potentially a partial well at a fourth drill site at the prospect known as Burger (Table 1-1). All wells are planned to be vertical.

Table 1-1 Shell Lease Blocks Covered in the Chukchi Sea Exploration Drilling Program Starting in 2012

Prospect	Area	Protraction	Lease Block	Shell Lease
Burger	Posey	NR03-02	6764	OCS-Y-2280
Burger	Posey	NR03-02	6714	OCS-Y-2267
Burger	Posey	NR03-02	6912	OCS-Y-2321
Burger	Posey	NR03-02	6812	OCS-Y-2294
Burger	Posey	NR03-02	6762	OCS-Y-2278
Burger	Posey	NR03-02	6915	OCS-Y-2324

Figure 1-1 Exploration Drilling Program Location Map



The ice strengthened drillship *Discoverer* will be used to drill the wells. Specifications for the *Discoverer* are included in Attachment A. While on location at the drill sites, the *Discoverer* will be affixed to the seafloor using eight 7-ton Stevpris anchors arranged in a radial array. The underwater fairleads prevent ice fouling of the anchor lines. Turret mooring allows orientation of vessel's bow into the prevailing ice drift direction to present minimum hull exposure to drifting ice. The vessel is rotated around the turret by hydraulic jacks. Rotation can be augmented by the use of the fitted bow and stern thrusters. The hull has been reinforced for ice resistance. Ice-strengthened sponsons have been retrofitted to the ship's hull.

The *Discoverer* is classed by Det Norske Veritas (DNV) as a Mobile Offshore Drilling Unit for worldwide service. It is a "1A1 Ship-Shaped Drilling Unit l" and is capable of performing exploration drilling operations offshore Alaska. The *Discoverer* has been issued with a DNV Appendix to Class stating:

"the structural strength and material quality of the 'Ice Belt' formed by the sponsons below the 8950mm A/B level, have been reviewed against the requirements for the DNV ICE-05 Additional Class Notation and found to meet those requirements (as contained in DNV Rules for Classification of Ships, Pt 5 Ch 1, July 2006) for a design temperature of -15 degrees C."

Vessels

During this exploration drilling program, the *Discoverer* will be attended by a minimum of eight vessels that will be used for ice management, anchor handling, OSR, refueling, resupply, and servicing of the exploration drilling operations (Tables 1-2a and 1-2b). In Table 1-2b, the barges include an accompanying tow/tug vessel, and in one case potentially an anchor handler that together with the barge are counted as one vessel attending the *Discoverer.*

The M/V *Fennica (Fennica)*, or a similar vessel, will serve as the ice management vessel in support of the *Discoverer*. This vessel will enter and exit the Chukchi Sea with the *Discoverer* and will remain at a location approximately 25 mi (40 km) upwind and upcurrent of the drillship when not in use. Any ice management would be expected to occur at a distance of 3-12 mi (5-19 km) upwind/upcurrent of the drillship. The M/V *Tor Viking (Tor Viking)* or a similar vessel will serve as the primary anchor handling vessel in support of the *Discoverer*. The vessel will enter and exit the Chukchi Sea with the *Discoverer* and will remain at a location approximately 25 mi (40 km) upwind and upcurrent of the drillship when not in use. Any ice management would be expected to occur within 0.6-6.0 mi (1.0-9.6 km) upwind from the *Discoverer*.

The planned exploration drilling operations will require two oil spill vessels (OSVs) to resupply the *Discoverer* with exploration drilling materials and supplies from facilities in Dutch Harbor and fuel. The vessels may be vessels such as the *Harvey Spirit*, and the *C-Leader*, or similar offshore supply boats.

Table 1-2a Chukchi Sea Exploration Drilling Program – Proposed Vessel List

Specification	Ice Management Vessel [1]	Anchor Handler [2]	OSV [3]	OSV [4]
Length	380 ft 116 m	275 ft 83.8 m	280 ft 85.3 m	280 ft 85.3 m
Width	85 ft 26 m	59 ft 18 m	60 ft 18 m	60 ft 18 m
Draft	27 ft 8.2 m	20 ft 6.1 m	15.9 ft 4.8 m	19 ft 5.8 m
Accommodations	82 berths	64 berths	37 berths	29 berths
Maximum Speed	16 knots 30 km/hr	16 knots 30 km/hr	13 knots 24 km/hr	13 knots 24 km/hr
Fuel Storage	11,070 bbl 1,760 m^3	7,484 bbl 1,190 m^3	6,233 bbl 991 m^3	7,217 bbl 1,147 m^3

[1] Based on *Fennica,* or similar vessel
[2] Based on *Tor Viking,* or similar vessel
[3] Based on the *Harvey Spirit,* or similar vessel
[4] Based on *C-Leader,* or similar vessel

Oil Spill Response Vessels

The OSR vessels supporting the exploration drilling program include a dedicated OSR barge and an OSR vessel, both of which have associated smaller workboats, an oil spill tanker (OST), and a containment barge (Table 1-2b) . An OSR vessel such as the *Nanuq* will be staged in the vicinity of the drillship when the *Discoverer* is drilling in liquid hydrocarbon bearing zones to immediately respond to a spill and provide containment, recovery, and storage for the initial operational period following a spill event. The *Nanuq* or similar vessel will be paired with an OST such as the *Mikhail Ulyanov* and used to assist refueling the *Discoverer* and support vessels, if necessary. An OSR barge, such as the *Klamath*, or similar vessel and a tug, such as the Crowley *Sea Robin*, will be staged offshore in the vicinity of the drillship. Together with the OSR vessel, it will have sufficient containment, recovery, and storage capacity for the initial operational period in the event of a spill. It will carry a 47-ft (14-m) skimming vessel, three 34-ft (10-m) workboats, four mini-barges, and boom and duplex skimming units for nearshore recovery. An OST such as the *Mikhail Ulyanov* or similar vessel with a minimum liquid storage capacity of 513,000 bbl will 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.

An additional barge housing the oil spill containment system will be stationed offshore, where it can be mobilized to a drill site when needed. 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.

Table 1-2b Chukchi Sea Exploration Drilling Program – Proposed Oil Spill Response Vessel List

Specification	OSR Vessel [1,2]	OSR Barge [1]		OST [1,4]	Containment Barge [1,5]		
		Barge [3]	Tug [3]		Barge	Tug	Anchor Handler
Length	301 ft 91.9 m	350 ft 106.7 m	126 ft 38.4 m	853 ft 260 m	400 ft 122 m	136 ft 36.5 m	275 ft 83.7 m
Width	60 ft 18.3 m	76 ft 23.1 m	34 ft 10.4 m	112 ft 34 m	100 ft 30.5 m	36 ft 11.1 m	59 ft 18.0 m
Fuel Storage	6,867 bbl (1,092 m^3)	390 bbl (62 m^3)	1,786 bbl (284 m^3)	221,408 bbl (35,200 m^3)	--	3,690 bbl (587 m^3)	7,484 bbl (1190 m^3)
Liquid Storage	12,690 bbl (2,017 m^3)	76,900 bbl (12,226 m^3)	--	543,000 bbl (86,328 m^3)	--	--	--
Accommodations	41	--	6	25	--	10	64 berths
Maximum Speed	16 knots	--	5 knots	16 knots	--	10 knots	16 knots
Workboats	(3) 34 ft work boats	(1) skim boat 47 ft (14 m) (3) work boats 34 ft (10 m) (4) mini-barges	--	--	--	--	--

[1] Or similar vessel
[2] Based on the *Nanuq*
[3] Based on the barge *Klamath* and the tug Crowley *Sea Robin*
[4] Based on the *Mikhail Ulyanov, the* OST will have a minimum storage capacity of 513,000 bbl.
[5] Based on a standard deck barge, Crowley Invader class ocean going tug, and a *Vidar, or Tor Viking*-style anchor handler

Aircraft

Offshore operations will be serviced by helicopters operated out of onshore support base locations. The helicopters are not yet contracted. A Sikorsky S-92 or Eurocopter EC225 capable of transporting 10 to 12 persons will be used to transport crews between the onshore support base and the drillship. The helicopters will also be used to haul small amounts of food, materials, equipment, and waste between vessels and the shorebase. The helicopter will be housed at facilities at the Barrow airport. Shell will have a second helicopter for Search and Rescue (SAR). The SAR helicopter is expected to be a Sikorsky S-61, S-92, Eurocopter EC225, or similar model. This aircraft will stay grounded at the Barrow shorebase location except during training drills, emergencies, and other non-routine events.

A fixed wing propeller or turboprop aircraft, such as Saab 340-B 30-seat, Beechcraft 1900, or deHavilland Dash8 will be used to routinely transport crews, materials, and equipment between the shorebase and hub airports such as Barrow or Fairbanks. A fixed wing aircraft, deHavilland Twin Otter (DHC-6) will be used for marine mammal observer (MMO) flights.

Table 1-2c Chukchi Sea 2012 Exploration Drilling Program – Proposed Aircraft List

Aircraft	Flight Frequency
Aircraft (or similar)	
Sikorsky S-92 or Eurocopter EC225 - crew rotation	Approximately 12 round trips per week between land and offshore vessels throughout the 2012 exploration drilling season
Sikorsky S-61, S-92 or Eurocopter EC225 helicopter – SAR	Trips made only in emergency; training flights
Saab 340-B or Beechcraft 1900 or deHavilland Dash8 (Only 1) – onshore crew/supply trips	Infrequent, up to 4 trips per week from shorebase to hub airports in Barrow, Anchorage, or Fairbanks
deHavilland Twin Otter (DHC-6) – Used for 4MP	Daily, beginning 5-7 days before drilling and ending 5-7 days after drilling ends

The ice reinforced drillship *Discoverer* will move through the Bering Strait and into the Chukchi Sea on or about July 1, and then onto the Burger Prospect as soon as ice and weather conditions allow. Exploration drilling activities will be curtailed on or before 31 October, and the drillship and support vessels will exit the Chukchi Sea at the conclusion of the exploration drilling season.

Vertical Seismic Profile

Shell may conduct a geophysical survey referred to as a vertical seismic profile or ZVSP at each drill site where a well is drilled in 2012. During ZVSP surveys, an airgun array is deployed at a location near or adjacent to the drillship, 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 a string of them, 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 ZVSP 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 known as the ZVSP, in which the sound source is maintained at a constant location near the wellbore (Figure 1-2). A typical sound source that likely 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 1-3. The airgun array is depicted within its frame or sled, which is approximately 6 ft (2 m) x 5 ft (1.5 m) x 10 ft (3 m) (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

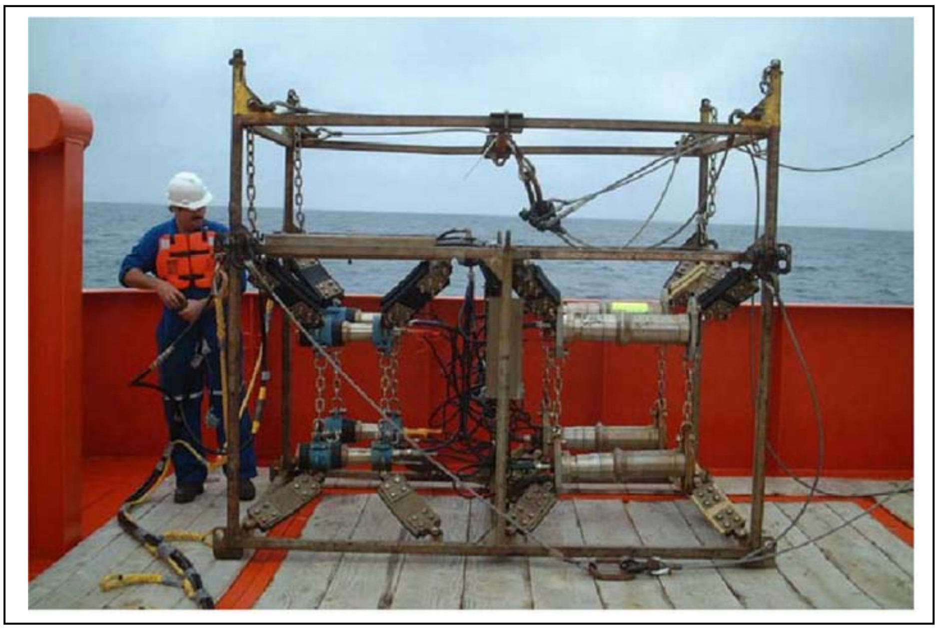


Figure 1-2 Schematic of ZVSP

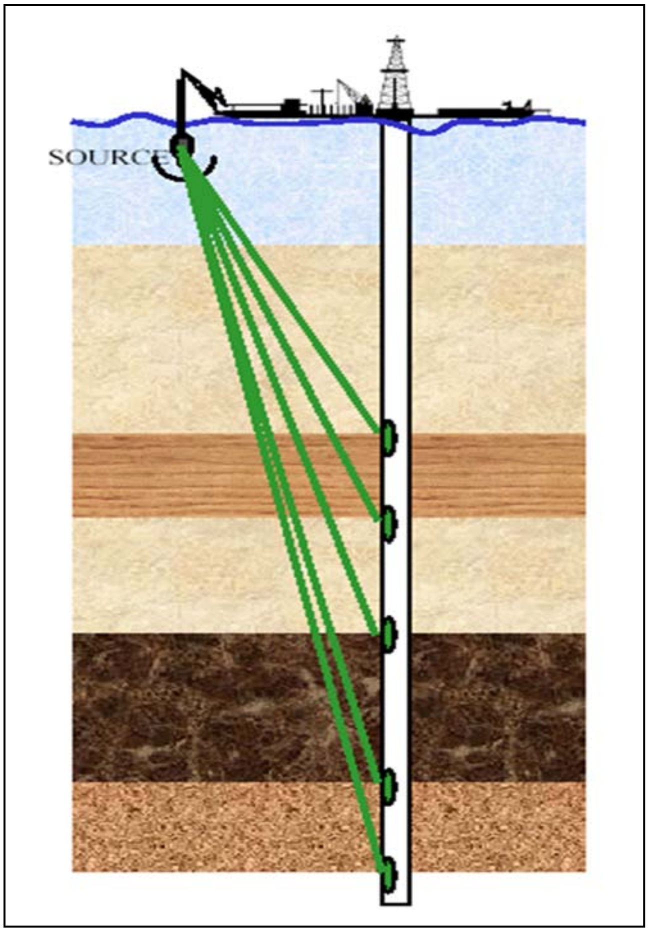


Table 1-3 Sound Source (Airgun Array) Specifications for ZVSP Surveys in the Chukchi Sea in 2012

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 @1m 23 bar @1m	238 dB re1µPa @1m 241 dB re1µPa @1m

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 *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) (138 bar), and activated 5-7 times at approximately 20-second intervals. The VSI will then be moved to the next interval of the wellbore and re-anchored, after which the airgun array will again be activated 5-7 times. This process will be repeated until the entire wellbore 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

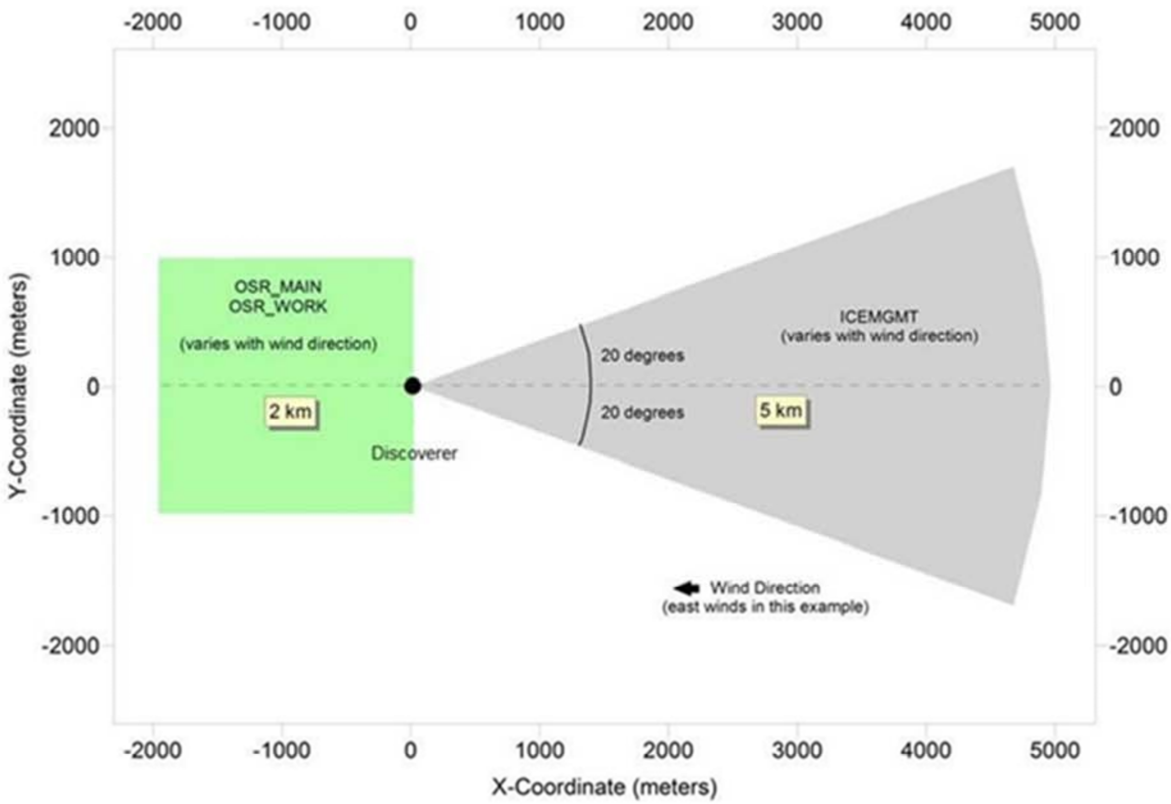
Shell recognizes the exploration drilling program is located in an area that is characterized by active sea ice movement, ice scouring, and storm surges. In anticipation of potential ice hazards that may be encountered, Shell will implement an IMP (see Attachment B) to ensure real-time ice and weather 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 Shell's Ice and Weather Advisory Center (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 Oceanic 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 Chukchi Sea, thereby resulting in no threat to public safety or services that occur 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 an exploration 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 *Discoverer* when it is drilling and would also handle the *Discoverer's* anchors during connection to and separation from the seafloor. When managing ice, the *Fennica* and *Tor Viking* will generally be operate a 40^o arc up to 3.1 mi (4.9 km) upwind originating at the *Discoverer* (Figure 1-3).

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



The ice-management/anchor handling vessels would manage any ice floes upwind of the *Discoverer* by deflecting those that could affect the *Discoverer* when it is on location conducting exploration drilling operations. The ice-management/anchor handling vessels would also manage the *Discoverer's* anchors during connection to and separation from the seafloor. The ice floe frequency and intensity are unpredictable and could range from no ice to ice densities that exceed ice-management capabilities, in which case exploration drilling operations would be stopped and the *Discoverer* disconnected from its anchors and moved 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 data regarding historic ice patterns in the area of operations indicate that it will not be required throughout the planned exploration drilling season. 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 *Discoverer* without building up in front of it. This type of ice is managed by the ice-management vessel continually moving back and forth across the drift line, directly updrift of the *Discoverer* and making turns at both ends. During ice-management, the vessel's propeller is rotating at approximately 15–20 percent of the vessel's propeller rotation capacity. Ice management occurs with slow movements of the vessel using lower power and therefore slower propeller rotation speed (*i.e.*, lower cavitation), allowing for fewer repositions of the vessel, thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice ridges that would be managed at a much slower speed than that used to manage first-year ice.

During Chukchi Sea exploration drilling operations, Shell does not plan to conduct any icebreaking activities; rather, Shell will deploy its support vessels to manage ice as described herein. As detailed in Shell's IMP (see Attachment B), actual breaking of ice will occur only in the unlikely event that ice conditions in the immediate vicinity of operations create a safety hazard for the drilling vessel. In such a circumstance, operations personnel will follow the guidelines established in the IMP to evaluate ice conditions and make the formal designation of a hazardous, ice alert condition, which would trigger the procedures that govern any actual icebreaking operations. Historical data relative to ice conditions in the Chukchi Sea in the vicinity of Shell's planned operations, and during the timeframe for those operations, establish that there is a very low probability (e.g., minimal) for the type of hazardous ice conditions that might necessitate icebreaking (e.g., records of the National Naval Ice Center archives). This probability could be greater at the shoulders of the exploration drilling season (early July or late October); therefore, for purposes of evaluating possible impacts of the planned activities, Shell has assumed limited icebreaking activities for a very limited period of time, and estimated incidental takes of marine mammals (see Section 6) from such activities.

Planned Mitigation

NMFS regulations, which require an operator to implement a Plan of Cooperation (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)). An initial POC was prepared and was submitted to NMFS (and BOEMRE) in May 2009 with an initial Chukchi Sea Exploration Plan (EP). For this IHA application and the revised Chukchi Sea EP submitted to BOEMRE in May 2011, Shell prepared a POC Addendum which updates the initial POC with information regarding proposed changes in the proposed exploration drilling program, and documentation of meetings undertaken to inform the stakeholders of the revised exploration drilling program. The POC Addendum (see Attachment D) builds upon the initial, previous POC.

The *Discoverer* and all support vessels will operate in accordance with the provisions of the POC Addendum and presumed vessel operation mitigation measures included in past IHAs issued to Shell for arctic activities. Shell's POC Addendum will 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 initial POC and POC Addendum were prepared based upon Shell's experience (recent and past) since the 1980s in the Alaska OCS and in consultation with affected 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 POC Addendum addresses the issues of vessel transit, drilling, aerial support, and associated 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

<u>Anticipated Duration of this Permit</u>

Shell anticipates that the IHA issued by NMFS for the planned Chukchi Sea exploration drilling program will be valid from the date of issuance through the conclusion of the 2012 exploration drilling season.

<u>Timing of Mobilization and Demobilization of the *Discoverer*</u>

Shell's base plan is for the ice management vessel, the *Fennica* (or similar, primary ice management), the anchor handler M/V *Tor Viking* (or similar, secondary ice management), OSVs, and potentially some of the OSR vessels to accompany the *Discoverer* traveling north from Dutch Harbor through the Bering Strait, on or about 1 July 2012, then into the Chukchi Sea, before arriving on location approximately 4 July. Exploration drilling is expected to be conducted through 31 October 2012. At the end of the exploration drilling season, these support vessels, along with various other support vessels will accompany the *Discoverer* as it travels south out of the Chukchi Sea, through the Bering Strait to Dutch Harbor, Alaska. Subject to ice conditions, alternate exit routes may be considered.

<u>Exploration Drilling</u>

All three, and potentially a forth partial well, will be at Shell's Burger Prospect (Figure 1) in the EP submitted to BOEMRE. Shell has identified a total of six Chukchi Sea EP lease blocks (Table 2-1 and Figure 1-1) on the Burger Prospect. All of the six drill sites listed on Table 2-1 are located more than 64 mi (103 km) off the coast in the Chukchi Sea. During 2012, the *Discoverer* will be used to drill up to three exploration wells and potentially a fourth partial well on four of the six possible leases (Table 2-1). For this exploration drilling program, Shell will mobilize into the Chukchi Sea on or about July 1, and commence exploration drilling at the Burger Prospect as soon as ice, weather, and other conditions allow for safe exploration drilling operations.

Activities associated with the Chukchi Sea exploration drilling program and analyzed herein include operation of the *Discoverer*, associated support vessels, crew change support and resupply. The *Discoverer* will remain at the location of the designated exploration drill sites except when mobilizing and demobilizing to and from the Chukchi Sea, transiting between drill sites, and temporarily moving off location if it is determined ice conditions require such a move to ensure the safety of personnel and/or the environment in accordance to Shell's IMP. The anchor handler and OSR vessels will remain in close proximity to the drillship during exploration drilling operations. The ice management vessel will generally be working upwind/upcurrent of the drillship from 3-12 mi (5-19 km) away. Crew change/resupply vessels will transit to and from the drillship at the estimated frequencies shown in Table 1-2c.

Helicopter flight support will provide crew changes. Fixed-wing aircraft will transport crews to regional hub airports, and to support aerial surveys for the marine mammal monitoring program.

Table 2-1 Drill Site Locations and Water Depths

Drill Site	Approximate Distance from shore (statute miles)	Lease Block No.	Surface Location (NAD 83)		Water Depth
			Latitude (north)	Longitude (west)	Feet/Meters
Burger A	75	6764	71° 18' 30.92"	163° 12' 43.17"	150/45.8
Burger F	76	6714	71° 20' 13.96"	163° 12' 21.75"	149/45.4
Burger J	69	6912	71° 10' 24.03"	163° 28' 18.52"	144/44.0
Burger R	75	6812	71° 16' 06.57"	163° 30' 39.44"	143/43.7
Burger S	78	6762	71° 19' 25.79"	163° 28' 40.84"	147/44.9
Burger V	65	6915	71° 10' 33.39"	163° 04' 21.23"	147/44.7

Shell plans to cease drilling on or before 31 October, after which the *Discoverer* will exit the Alaskan Chukchi Sea. Shell anticipates that the exploration drilling program will require approximately 32 days per well including mudline cellar (MLC) construction. These estimates exclude any downtime for weather or other operational delays. Shell also assumes approximately 10 additional days will be needed for transit, drillship mobilization and mooring, drillship moves between locations, and drillship demobilization.

3. Species and Numbers of Marine Mammals in Area

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

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

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

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

Sections 3 and 4 are integrated here to minimize repetition.

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

Table 4-1 The Habitat, Abundance, and Conservation Status of Marine Mammals Inhabiting the Area

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
Odontocetes Beluga whale (*Delphinapterus leucas*) (Eastern Chukchi Sea Stock)	Offshore, Coastal, Ice edges	3,710[4]	Not listed	NT	–
Beluga whale (Beaufort Sea Stock)	Offshore, Coastal, Ice edges	39,257[5]	Not listed	NT	–
Narwhal (*Monodon monoceros*)	Offshore, Ice edge	Rare[6]	Not listed	NT	–
Killer whale (*Orcinus orca*)	Widely distributed	Uncommon	Not listed	DD	–
Harbor Porpoise (*Phocoena phocoena*) (Bering Sea Stock)	Coastal, inland waters, shallow offshore waters	48,215[4] Common[7]	Not listed	LR-lc	–
Mysticetes Bowhead whale (*Balaena mysticetus*)	Pack ice & coastal	10,545[8] 12,631[9]	Endangered	LR-lc	I
Gray whale (*Eschrichtius robustus*) (eastern Pacific population)	Coastal, lagoons, shallow offshore waters	488[10] 17,500[11]	Not listed	LR-lc	I
Minke whale (*Balaenoptera acutorostrata*)	Shelf, coastal	Rare	Not listed	LR-lc	I
Fin whale (*Balaenoptera physalus*)	Slope, mostly pelagic	Rare	Endangered	EN	I
Humpback whale (*Megaptera novaeangliae*)	Shelf, coastal	Rare	Endangered	LR-lc	I
Pinnipeds Bearded seal (*Erignathus barbatus*)	Pack ice, shallow offshore waters	250,000- 300,000[12] 155,000[13]	Proposed Threatened	LR-lc	–
Spotted seal (*Phoca largha*)	Pack ice, coastal haulouts, offshore	59,214[14]	Arctic pop. segments not listed	DD	–
Ringed seal (*Pusa hispida*)	Landfast & pack ice, offshore	~208,000- 252,000[15]	Proposed Threatened	LR-lc	–
Ribbon seal (*Histriophoca fasciata*)	pack ice, offshore	90-100,000[16]	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)
[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 2004); very few enter the Beaufort Sea
[7] Vessel-based observations from Industry activities in 2006–2008 (Haley et al. 2010)
[8] 2001 B-C-B Bowhead population estimate (Zeh and Punt 2005)
[9] 2004 B-C-B Bowhead population estimate (Koski et al. 2010)
[10] Southern Chukchi Sea and northern Bering Sea (Clark and Moore 2002)
[11] North Pacific gray whale population (Rugh 2003 *in* Keller and Gerber 2004) ; see also Rugh et al. (2005)
[12] Alaska population (MMS 1996)
[13] Beringia Distinct Population Segment (NMFS 2010a)
[14] Alaska stock based on aerial surveys in 1992 (Allen and Angliss 2010)
[15] Eastern Chukchi Sea population (Bengtson et al. 2005)
[16] Bering Sea, (Burns 1981a)

Five additional cetacean species—the narwhal, killer whale, minke whale, humpback whale, and fin whale—could occur, but each of these species is uncommon or rare in the project area and relatively few encounters with these species are expected during the exploration drilling program. The narwhal occurs in Canadian waters and occasionally occurs in the Alaskan Beaufort Sea and the Chukchi Sea, but is considered extralimital in U.S. waters and is not expected to be encountered.

4.1 Odontocetes

(a) Beluga (Delphinapterus leucas)

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

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

In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). For the planned project, only the Beaufort Sea and eastern Chukchi Sea stocks may be encountered.

The 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 found during the open-water season. The actual number of beluga whales recorded during the surveys was much lower. Correction factors to account for animals that were underwater and for the proportion of newborns and yearlings that were not observed due to their small size and dark coloration were used to calculate the estimate. The calculation was considered to be a minimum population estimate for the eastern Chukchi Sea stock because the surveys on which it was based did not include offshore areas where belugas are also likely to occur. This population is considered to be stable. It is assumed that beluga whales from the eastern Chukchi stock winter in the Bering Sea (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. (2005a) put satellite tags on 23 beluga whales captured in Kasegaluk Lagoon in late June and early July 1998–2002. Five of these whales moved far into the Arctic Ocean and into the pack ice to 79–80°N latitude. These and other whales moved to areas as far as 685 mi (1,102 km) offshore between Barrow and the Mackenzie River Delta spending time in water with 90 percent ice coverage.

During aerial surveys in nearshore areas ~23 mi (~37 km) offshore in the Chukchi Sea in 2006 and 2007, peak beluga sighting rates were recorded in July. Lowest monthly sighting rates were recorded in September (Thomas et al. 2009). When data from the two years were pooled, beluga whale sighting rates and number of individuals were highest in the band 16-22 mi (26-35 km) offshore. However the largest single groups were sighted at locations near shore in the band within 3 mi (5 km) of the shoreline.

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

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

The ***Beaufort Sea population*** was estimated to contain 39,257 individuals as of 1992 (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 in offshore waters of western and northern Alaska (Allen and Angliss 2010). The majority of belugas in the Beaufort Sea stock migrate through the Chukchi Sea and into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late-March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995b). Beluga whales associated with the Beaufort Sea population would be most likely to occur near the planned exploration drilling activities during fall migration through the Chukchi Sea in October.

(b) Narwhal (Monodon monoceros)

Narwhals have a discontinuous Arctic distribution (Hay and Mansfield 1989; Reeves et al. 2002). A large population inhabits Baffin Bay, West Greenland, and the eastern part of the Canadian Arctic archipelago, while much smaller numbers inhabit the Northeast Atlantic/East Greenland area. The IUCN-World Conservation Union lists the species as "near threatened" (IUCN 2010). Aerial surveys of four hunting grounds off the coast of Greenland in 2006 yielded abundance estimates of between 6,024 and 8,368 individuals in each area (Heide-Jørgensen et al. 2010). Innes et al. (2002) estimated a population size of 45,358 narwhals in the Canadian Arctic although little of the area was surveyed. More recent surveys of portions of Baffin Bay in the Canadian High Arctic resulted in a total population estimate of >60,000 individuals (Richard et al. 2010). The Alaskan Beaufort Sea is not defined as a portion of a narwhal population's range and it is considered extralimital in this region (Reeves et al. 2002). However, there are scattered records of narwhal in Alaskan waters. Thus, it is possible, but very unlikely, that individuals could be encountered in the area of the planned exploration drilling activities in the Chukchi Sea.

(c) Killer Whale (*Orcinus orca*)

Killer whales are cosmopolitan and globally fairly abundant. The killer whale is very common in temperate waters, but it also frequents the tropics and waters at high latitudes. Killer whales appear to prefer coastal areas, but are also found in deep water (Dahlheim and Heyning 1999). The greatest abundance is thought to be within 497 mi (800 km) of major continents (Mitchell 1975) and the highest densities occur in areas with abundant prey. Both resident and transient stocks have been described. These are believed to differ in several aspects of morphology, ecology, and behavior including dorsal fin shape, saddle patch shape, pod size, home range size, diet, travel routes, dive duration, and social integrity of pods (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 (ADFG 1994). Killer whales from either the North Pacific resident or transient stock could occur in the Chukchi Sea during the summer or fall. The number of killer whales likely to occur in the Chukchi Sea during the planned activity is unknown. MMOs onboard industry vessels in the Chukchi Sea recorded one killer whale sighting in 2006 and two sightings in 2007 (Reiser et al. 2009a).

(d) Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise is a small odontocete that inhabits shallow, coastal waters—temperate, subarctic, and arctic—in the Northern Hemisphere (Read 1999). Harbor porpoises occur mainly in shelf areas where they can dive to depths of at least 722 ft (220 m) and stay submerged for more than 5 minutes (Harwood and Wilson 2001) feeding on small schooling fish (Read 1999). Harbor porpoises typically occur in small groups of only a few individuals and tend to avoid vessels (Richardson et al. 1995a).

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

Although separate harbor porpoise stocks for Alaska have not been identified, Alaskan harbor porpoises have been divided into three groups for management purposes. These groups include animals from southeast Alaska, Gulf of Alaska, and Bering Sea populations. Harbor porpoises present in the Chukchi Sea belong to the Bering Sea group, which includes animals from Unimak Pass northward. Based on aerial surveys in 1999, the Bering Sea population was estimated at 66,078 animals, although this estimate is likely conservative as the surveyed area did not include known harbor porpoise range near the Pribilof Islands or waters north of Cape Newenhan (~55°N latitude; Allen and Angliss 2010). Suydam and George (1992) suggested that harbor porpoises occasionally occur in the Chukchi Sea and reported nine records of harbor porpoise in the Barrow area in 1985–1991. More recent vessel-based surveys in the Chukchi Sea found that the harbor porpoise was commonly encountered during summer and fall from 2006–2008 (Haley et al. 2010).

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

4.2 Mysticetes

(a) Bowhead Whale (Balaena mysticetus)

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunct circumpolar distribution (Reeves 1980). The bowhead is one of only three whale species that spend their entire lives in the Arctic. Bowhead whales are found in 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 is the Western Arctic or Bering–Chukchi–Beaufort (BCB) stock, which includes whales that winter in the Bering Sea, and migrate through the Bering Strait, Chukchi Sea, and

Alaskan Beaufort Sea to the Canadian Beaufort Sea, where they feed during the summer. These whales migrate west through the Alaskan Beaufort Sea in the fall as they return to wintering areas in the Bering Sea. Satellite tracking data reported by the Alaska Department of Fish and Game (ADF&G) indicate that most bowhead whales continue migrating west past Barrow and through the northern Chukchi Sea to Russian waters before turning south toward the Bering Sea. Visual and satellite tracking data show that many bowhead whales continue migrating west past Barrow and through the northern Chukchi Sea to Russian waters before turning southeast toward the Bering Sea (Moore et al. 1995; Mate et al. 2000; Quakenbush et al. 2010). Some bowheads reach ~75ºN 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 in the late-1800s and early-1900s may have reduced this population to as few as 3,000 animals (Woodby and Botkin 1993). Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2 percent per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995a). A census in 2001 yielded an estimated annual population growth rate of 3.4 percent (95 percent confidence interval, 1.7–5 percent) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004, revised to 10,545 by Zeh and Punt (2005). A photo identification population estimate from data collected in 2004 estimated the population (in 2004) to be 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 percent, 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 these whales summer in the Canadian Beaufort Sea (Moore and Reeves 1993). Spring migration through the Chukchi Sea occurs through offshore ice leads, generally from March through mid-June (Braham et al. 1984; Moore and Reeves 1993), well before the onset of the planned exploration drilling activities.

Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most may remain among the offshore pack ice of the Beaufort Sea until mid- summer. After feeding primarily in the Canadian Beaufort Sea and Amundsen Gulf, bowheads migrate westward from late August through mid- or late-October. Fall migration into Alaskan waters is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004, 2009a; Greene et al. 2007). Satellite tracking of bowheads has also shown that some whales move to the Chukchi Sea prior to September (Quakenbush et al. 2010).

Bowheads commonly interrupt their migration to feed along the Alaskan Beaufort Sea coast (Ljungblad et al. 1986; Lowry 1993; Landino et al. 1994; Würsig et al. 2002; Lowry et al. 2004) and their stop-overs vary in duration from a few hours to a few weeks (Koski et al. 2002). The nearest of these known feeding areas to the proposed operations in the Chukchi Sea is just east of Pt. Barrow, which is approximately 156 mi (250 km) from the Burger prospect. This location is currently under intensive study as part of the BOWFEST program (BOWFEST 2011).

Westbound bowheads typically reach the Barrow area in mid-September, and remain there until late October (e.g., Brower 1996). However, over the years, local residents report having seen a small number of bowhead whales feeding off Barrow or in the pack ice off Barrow during the summer. Bowhead whales that are thought to be part of the Western Arctic stock may also occur in small numbers in the Bering and Chukchi seas during the summer (Rugh et al. 2003). Thomas et al. (2009) also reported bowhead sightings in 2006 and 2007 during summer aerial surveys in the Chukchi Sea. All sightings were recorded in the northern portion of the study area, north of 70ºN latitude. Autumn bowhead whaling near Barrow normally begins in mid-September to early October, but may begin as early as August if whales are observed and ice conditions are favorable (USDI/BLM 2005). Whaling near Barrow can continue into October, depending on the quota and conditions.

Most spring-migrating bowhead whales would likely pass through the Chukchi Sea prior to the start of the planned exploration drilling activities. However, a few whales that may remain in the Chukchi Sea during the summer could be encountered during the exploration drilling activities or by transiting vessels. More encounters with bowhead whales would be likely to occur during the westward fall migration in late September through October. An ongoing GPS tagging study (Quakenbush et al. 2010) has provided information on fall bowhead movements across the Chukchi Sea. Most bowheads migrating in September and October appear to transit across the northern portion of the Chukchi Sea to the Chukotka coast before heading south toward the Bering Sea (Quakenbush et al. 2009). Some of these whales have traveled well north of the planned operations, but others have passed near to, or through, the proposed project area. In addition to other planned mitigation, Shell will operate in consultation with stakeholders to avoid disturbance to subsistence bowhead whaling activities in the Chukchi Sea, should such a subsistence bowhead hunt occur during the period of Shell's planned 2012 exploration drilling activities.

(b) Gray Whale (Eschrichtius robustus)

Gray whales originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic populations are believed to have become extinct by the early 1700s. There are two populations in the North Pacific. A relic population, which survives in the Western Pacific, summers near Sakhalin Island far from the area of the planned exploration drilling activities. The larger eastern Pacific or California gray whale population recovered significantly from commercial whaling during its protection under the MMPA (and ESA until 1994) and numbered about 29,758 ±3,122 in 1997 (Rugh et al. 2005). However, abundance estimates since 1997 indicate a consistent decline followed by the population stabilizing or gradually recovering. Rugh et al. (2005) estimated the population to be 18,178 ±1,780 in winter 2001-2002 and Rugh et al. (2008) estimated the population in winter 2006-2007 to have been 20,110 ±1,766. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

Eastern Pacific gray whales calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the calving season, most of these gray whales migrate about 5,000 mi (8,000 km), generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (Tomilin 1957, Rice and Wolman 1971, Nerini 1984, Moore et al. 2003, Bluhm et al. 2007). Most gray whales begin the southward migration in November with breeding and conception occurring in early December (Rice and Wolman 1971).

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

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

Although they are most common in portions of the Chukchi Sea close to shore, gray whales may also occur in offshore areas of the Chukchi Sea, particularly over offshore shoals. Gray whales are likely to be in the vicinity of the planned exploration drilling activities in the Chukchi Sea and are likely to be one of the most commonly encountered cetacean species, along with the harbor porpoise (Reiser et al. 2011).

(c) Minke Whale (Balaenoptera acutorostrata)

Minke whales have a cosmopolitan distribution at ice-free latitudes (Stewart and Leatherwood 1985), and also occur in some marginal ice areas. Allen and Angliss (2010) recognize two minke whale stocks in U.S. waters: (1) the Alaska stock, and (2) the California/Oregon/ Washington stock. There is no abundance estimate for the Alaska stock. Provisional estimates of minke whale abundance based on surveys in 1999 and 2000 are 810 and 1003 whales in the central-eastern and south-eastern Bering Sea, respectively. These estimates have not been corrected for animals that may have been submerged or otherwise missed during the surveys, and only a portion of the range of the Alaskan stock was surveyed. Minke whales range into the Chukchi Sea, but the level of minke whale use of the Chukchi Sea is unknown. Minke whales have been observed from vessels during previous industry activities in the Chukchi Sea (Haley et al. 2010) and during aerial surveys conducted by the National Marine Mammal Laboratory (NMML) (COMIDA 2011).

(d) Fin Whale (Balaenoptera physalus)

Fin whales are widely distributed in all the world's oceans (Gambell 1985), but typically occur in temperate and polar regions. Fin whales feed in northern latitudes during the summer where their prey include plankton, as well as shoaling pelagic fish, such as capelin *Mallotus villosus* (Jonsgård 1966a,b). The North Pacific population's summering grounds span from the Chukchi Sea to California (Gambell 1985). Three fin whale sightings were made in 2008 from industry vessels and NMFS/NMML survey aircraft in the northern Chukchi Sea off of Ledyard Bay indicating that the range of fin whales may be expanding. Population estimates for the entire North Pacific region range from 14,620 to 18,630, however, reliable estimates are not available (Allen and Angliss 2010). Provisional estimates of fin whale abundance in the central-eastern and southeastern Bering Sea are 3,368 and 683, respectively. No estimates for fin whale abundance during the summer in the Chukchi Sea are available. Reiser et al. (2009a) reported a fin whale sighting during vessel-based surveys in the Chukchi Sea in 2006. Fin whale is listed as "endangered" under the ESA and by the IUCN (2010), and in the North Pacific is classified as a strategic stock by NMFS. Fin whales could be encountered in very low numbers during the exploration drilling activities in the Chukchi Sea.

(e) Humpback Whale (Megaptera novaeangliae)

Humpback whales are distributed in major oceans worldwide but are apparently absent from Arctic waters of the North Pacific (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 percent of their original numbers. The International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean in 1965 and humpbacks were listed as "endangered" under the ESA and depleted under the MMPA in 1973. Most humpback whale populations appear to be recovering well.

Humpbacks feed on euphausiids, copepods, and small schooling fish, notably herring, capelin, and sandlance (Reeves et al. 2002). As with other baleen whales, the food is trapped or filtered when large amounts of water are taken into the mouth and forced out through the baleen plates. Individual humpback whales can often be identified by distinctive patterns on the tail flukes. They are frequently observed breaching or engaged in other surface activities. Adult male and female humpback whales average 46 and 49 ft (14 and 15 m) in length, respectively (Wynne 1997). Humpbacks have large, robust bodies and long pectoral flippers, which may reach ⅓ of their body length. The dorsal fin is variable in shape and located well back toward the posterior ⅓ of the body on a hump which is particularly noticeable when the back is arched during a dive (Reeves et al. 2002).

Allen and Angliss (2010) reported that at least three humpback whale populations have been identified in the North Pacific. Two of these stocks may be relevant to the planned exploration drilling activities in the Chukchi Sea. The Central North Pacific stock winters in waters near Hawaii and migrates to British Columbia, Southeast Alaska, and Prince William Sound to Unimak Pass to feed during the summer. The Western North Pacific stock winters off the coast of Japan and probably migrates to the Bering Sea to feed during the summer. There may be some overlap between the Central and Western North Pacific stocks.

Humpback whale sightings in the Bering Sea have been recorded southwest of St. Lawrence Island, the southeastern Bering Sea, and north of the central Aleutian Islands (Moore et al. 2002, Allen and Angliss 2010). Recently there have been sightings of humpback whales in the Chukchi Sea and a single sighting in the Beaufort Sea (Green et al. 2007). Reiser et al. (2009a) reported four humpback whales during vessel-based surveys in the Chukchi Sea in 2007 and Haley et al. (2009) reported one humpback whale sighting during 2008 operations. Green et al. (2007) reported and photographed a humpback whale cow/calf pair east of Barrow near Smith Bay in 2007. Small numbers of humpback whales could occur within or near the exploration drilling activities in the Chukchi Sea.

4.3 Pinnipeds

(a) Bearded Seal (*Erignathus barbatus*)

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981b). They have occasionally been reported to maintain breathing holes in sea ice and broken areas within the pack ice, particularly if the water depth is <656 ft (<200 m) (e.g., Harwood et al. 2005). Bearded seals apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas where water depth is considerably greater than 656 ft (200 m) (Cameron et al. 2009). During the summer period, bearded seals occur mainly in relatively shallow areas because they are predominantly benthic feeders (Burns 1981b). No reliable estimate of bearded seal abundance is available for the Chukchi Sea (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).

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

In Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort Seas (Burns 1981b). The Alaska stock of bearded seals may consist of 300,000–450,000 individuals (MMS 1996). Bengtson et al. (2005) reported bearded seal densities in the Chukchi Sea ranging from 0.18 to 0.36 seals/square miles (mi^2) (0.07 to 0.14 seals/square kilometers [km^2]) in 1999 and 2000, respectively. No population estimates could be calculated since these densities were not adjusted for haulout behavior. Bearded seals are common in offshore pack ice, but there have been high bearded seal numbers observed near the shore south of the project area near Kivalina. Haley et al. (2010) reported bearded seal densities ranging from 0.03 to 0.23 seals/mi^2 (0.01 to 0.09 seals/km^2) in the summer and fall, respectively, during vessel-based surveys in the Chukchi Sea. These densities were lower than those reported by Bengtson et al. (2005) but are not directly comparable since the latter densities were based on aerial surveys of seals on sea ice in late May and early June. Bearded seals are likely to be encountered during exploration drilling operations, and greater numbers of bearded seals are likely to be encountered if the ice edge occurs nearby.

(b) Spotted Seal (*Phoca largha*)

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

An early estimate of the size of the world population of spotted seals was 370,000–420,000, and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000–250,000 animals (Bigg 1981). The total number of spotted seals in Alaskan waters is not known (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 four spotted seals in Kasegaluk Lagoon and estimated that the proportion of seals hauled out was 6.8 percent. Based on an actual minimum count of 4,145 hauled out seals, 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 of spotted seals was recently listed as a threatened species, 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 200 animals. During the summer, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July until

September. At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. Spotted seals are commonly seen in bays, lagoons and estuaries, but also range far offshore as far north as 69–72ºN latitude. In summer, they are rarely seen on the pack ice, except when the ice is very near shore. As the ice cover thickens with the onset of winter, spotted seals leave the northern portions of their range and move into the Bering Sea (Lowry et al. 1998).

In the Chukchi Sea, Kasegaluk Lagoon and Icy Cape are important areas for spotted seals. Spotted seals haul out in this region from mid-July until freeze-up in late October or November. Lowry et al. (1998) reported a maximum count of about 2,200 spotted seals in the lagoon during aerial surveys. No spotted seals were recorded along the shore south of Pt. Lay. Based on satellite tracking data, Frost and Lowry (1993) reported that spotted seals tagged at Kasegaluk Lagoon spent 94 percent of the time at sea. Extrapolating the count of hauled-out seals to account for seals at sea would suggest a Chukchi Sea population of about 36,000 animals. Few spotted seals are expected to occur near the planned exploration drilling activities in the Chukchi Sea.

(c) Ringed Seal (*Phoca hispida*)

Ringed seals have a circumpolar distribution and occur in all seas of the Arctic Ocean (King 1983). They are closely associated with ice and, in the summer, they often occur along the receding ice edges or farther north in the pack ice. In the North Pacific, they occur in the southern Bering Sea and range south to the seas of Okhotsk and Japan. They are found throughout the Beaufort, Chukchi, and Bering seas (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 Chukchi and Beaufort seas and the ringed seal is the most frequently encountered seal species in the area. During winter, ringed seals occupy landfast ice and offshore pack ice of the Bering, Chukchi and Beaufort seas. In winter and spring, the highest densities of ringed seals are found on stable shorefast ice. However, in some areas where there is limited fast ice but wide expanses of pack ice, including the Beaufort Sea, Chukchi Sea and Baffin Bay, total numbers of ringed seals on pack ice may exceed those on shorefast ice (Burns 1970, Stirling et al. 1982, Finley et al. 1983). Ringed seals maintain breathing holes in the ice and occupy lairs in accumulated snow (Smith and Stirling 1975). They give birth in lairs from mid-March through April, nurse their pups in the lairs for 5–8 weeks, and mate in late April and May (Smith 1973, Hammill et al. 1991, Lydersen and Hammill 1993).

No estimate for the size of the Alaska ringed seal stock is currently available (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). During aerial surveys in 1999, Bengtson et al. (2005) reported ringed seal densities offshore from Shishmaref to Barrow ranging from 1.0 to 9.6 seals/mi^2 (0.4 to 3.7 seals/km^2) and estimated the total Chukchi Sea population at 245,048 animals in 1999. Densities were higher in nearshore than offshore locations. During vessel-based observations from industry activities in the Chukchi Sea, Haley et al. (2010) reported seal densities (assumed to be almost entirely ringed seals) from 0.18 to 1.92 seals/mi^2

(0.07 to 0.74 seals/km^2) in summer and fall, respectively. Ringed seal will likely be the most abundant marine mammal species encountered in the Chukchi Sea during exploration drilling operations.

(d) Ribbon Seal (Histriophoca fasciata)

Ribbon seals are found along the pack-ice margin in the southern Bering Sea during late winter and early spring and they move north as the pack ice recedes during late spring to early summer (Burns 1970, Burns et al. 1981a). Little is known about their summer and fall distribution, but Kelly (1988) suggested that they move into the southern Chukchi Sea, based on a review of sightings during the summer. However, ribbon seals appeared to be relatively rare in the northern Chukchi Sea. During recent vessel-based surveys in 2006-2008 there were only two ribbon seal sightings among the total of 1,390 seal sightings identified to species (Haley et al. 2010). Ribbon seals are expected to be rare in the planned project area.

5. Type of Incidental Take Authorization Requested

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

The operations outlined in sections 1 and 2 have the potential to take marine mammals by "Level B" harassment as a result of sound energy introduced to the marine environment. Sounds that may "harass" marine mammals will include continuous 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 11). No lethal takes are expected.

6. Numbers of Marine Mammals That May be Taken

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

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

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

All anticipated takes would be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied will minimize the possibility of injurious takes. However, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures. In the sections below, we describe methods to estimate "take by harassment" and present estimates of the numbers of marine mammals that might be affected during the planned exploration drilling program in the Chukchi Sea. The estimates are based on data obtained during marine mammal surveys in and near the planned exploration drilling sites and on estimates of the sizes of the areas where effects could potentially occur. Adjustments to reported population or density estimates were made to account for seasonal distributions and population increases or declines insofar as possible.

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

Basis for Estimating "Take by Harassment"

"Take by Harassment" is calculated in this section by multiplying the expected densities of marine mammals that may occur near the exploration drilling operations by the area of water likely to be exposed to continuous sounds ≥120 dB re 1 μPa rms during exploration drilling operations or icebreaking activities, and impulsive sounds ≥160 dB re 1 μPa rms created by seismic airguns during ZVSP surveys.

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

Marine Mammal Density Estimates

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

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

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

Cetaceans

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

Summer densities of ***belugas*** in offshore waters are expected to be low, with somewhat higher densities in ice-margin and nearshore areas. Aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore et al. 2000). Aerial surveys of the Chukchi Sea in 2008-2009 flown by the NMML as part of the Chukchi Offshore Monitoring in Drilling Area (COMIDA) project have only reported 5 beluga sightings during >8,700 mi (>14,000 km) of on-transect effort, only 2 of which were offshore (COMIDA 2009). One of the three nearshore sightings was of a large group (~275 individuals on July 12, 2009) of migrating belguas along the coastline just north of Peard Bay. Additionally, only one beluga sighting was recorded during >37,900 mi (>61,000 km) of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September-October of 2006-2008 (Haley et al. 2010). If belugas are present during the summer, they are more likely to occur in or near the ice edge or close to shore during their northward migration. Expected densities have previously been calculated from data in Moore et al. (2000b). However, more recent data from COMIDA aerial surveys during 2008-2010 are now available (Clarke and Ferguson *in prep.*). Effort and sightings reported by Clarke and Ferguson (*in prep.*) were used to calculate the average open-water density estimate. Clarke and Ferguson (*in prep*) reported two on-transect beluga sightings (5 individuals) during 11,985 km of on-transect effort in waters 36-50 m deep in the Chukchi Sea during July and August. The mean group size of these two sightings is 2.5. A *f(0)* value of 2.841 and *g(0)* value of 0.58 from Harwood et al. (1996) were also used in the density calculation. The CV associated with group size was used to select an inflation factor of 2 to estimate the maximum density that may occur in both open-water and ice-margin habitats. Specific data on the relative abundance of beluga in open-water versus ice-margin habitat during the summer in the Chukchi Sea is not available. However, belugas are commonly associated with ice, so an inflation factor of 4 was used to estimate the average ice-margin density from the open-water density. Very low densities observed from vessels operating in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (0.0-0.0003/mi^2, 0.0-0.0001/km^2; Haley et al. 2010), also suggest the number of beluga whales likely to be present near the planned activities will not be large.

In the fall, beluga whale densities in the Chukchi Sea are expected to be somewhat higher than in the summer because individuals of the eastern Chukchi Sea stock and the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Allen and Angliss 2010). However, there were no beluga sightings reported during >11,200 mi (>18,000 km) of vessel based effort in good visibility conditions during 2006-2008 industry operations in the Chukchi Sea (Haley et al. 2010). Densities derived from survey results in the northern Chukchi Sea in Clarke and Ferguson (*in prep*) were used as the average density for open-water fall season estimates (see Table 6-2). Clarke and Ferguson (*in prep*) reported 3 beluga sightings (6 individuals) during 10,036 km of on-transect effort in water depths 36–50 m. The mean group size of those three sightings is 2. A *f(0)* value of 2.841 and *g(0)* value of 0.58 from Harwood et al. (1996) were used in the calculation. The same inflation factor of 2 used for summer densities was used to estimate the maximum density that may occur in both open-water and ice-margin habitats in the fall. Moore et al. (2000) reported lower than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas, so an inflation value of 4 was used to estimate the average ice-margin density from the open-water density. Based on the lack of any beluga sightings from vessels operating in the Chukchi Sea during non-seismic periods and locations in September-October of 2006-2008 (Haley et al. 2010), the relatively low densities shown in Table 6-2 are consistent with what is likely to be observed form vessels during the planned operations.

By July, most ***bowhead whales*** are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea. No bowheads were reported during 6,640 mi (10,686 km) of on-transect effort in the Chukchi Sea by Moore et al. (2000). Aerial surveys in 2008-2010 by the NMML as part of the COMIDA project reported only 6 sightings during >16,020 mi (>25,781 km) of on-transect effort (Clarke and Ferguson *in prep*). Two of the six sightings were in waters ≤35 m deep and the remaining four sightings were in waters 51-200 m deep. Bowhead whales were also rarely sighted in July-August of 2006-2008 during aerial surveys of the Chukchi Sea coast (Thomas et al. 2010). This is consistent with movements of tagged whales (see ADFG 2010), all of which moved through the Chukchi Sea by early May

2009, and tended to travel relatively close to shore, especially in the northern Chukchi Sea. The estimate of bowhead whale density in the Chukchi Sea was calculated by assuming there was one bowhead sighting during the 7,447 mi (11,985 km) of survey effort in waters 36-50 m deep in the Chukchi Sea during July-August reported in Clarke and Ferguson (*in prep*), although no bowheads were actually observed during those surveys. The mean group size from September–October sightings reported in Clarke and Ferguson (*in prep*) is 1.1, and this was also used in the calculation of summer densities. The group size value, along with a *f(0)* value of 2 and a *g(0)* value of 0.07, both from Thomas et al. (2002) were used to estimate a summer density of bowhead whales (Table 6-1). The CV of group size and standard errors reported in Thomas et al (2002) for *f(0)* and *g(0)* correction factors suggest that an inflation factor of 2 is appropriate for estimating the maximum density from the average density. Bowheads are not expected to be encountered in higher densities near ice in the summer (Moore et al. 2000), so the same density estimates are used for open-water and ice-margin habitats. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2010) ranged from 0.0003-0.0018/mi^2 (0.0001-0.0007/km^2) with a maximum 95 percent confidence interval (CI) of 0.0075/mi^2 (0.0029/km^2). This suggests the densities used in the calculations and shown in Table 6-1 are somewhat higher than are likely to be observed from vessels near the area of planned operations.

During the fall, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf migrate west and south to their wintering grounds in the Bering Sea making it more likely that bowheads will be encountered in the Chukchi Sea at this time of year. Moore et al. (2002; Table 8) reported 34 bowhead sightings during 27,560 mi (44,354 km) of on-transect survey effort in the Chukchi Sea during September-October. Thomas et al. (2010) also reported increased sightings on coastal surveys of the Chukchi Sea during September and October of 2006-2008. GPS tagging of bowheads appear to show that migration routes through Chukchi Sea are more variable than through the Beaufort Sea (Quakenbush et al. 2010). Some of the routes taken by bowheads remain well north of the planned exploration drilling activities while others have passed near to or through the area. Kernel densities estimated from GPS locations of whales suggest that bowheads do not spend much time (e.g. feeding or resting) in the north-central Chukchi Sea near the area of planned activities (Quakenbush et al. 2010). Clarke and Ferguson (*in prep*) reported 14 sightings (15 individuals) during 10,036 km of on transect aerial survey effort in 2008-2010. The mean group size of those sightings is 1.1. The same *f(0)* and *g(0)* values that were used for the summer estimates above were used for the fall estimates (Table 6-2). As with the summer estimates, an inflation factor of 2 was used to estimate the maximum density from the average density in both habitat types. Moore et al. (2000) found that bowheads were detected more often than expected in association with ice in the Chukchi Sea in September-October, so a density of twice the average open-water density was used as the average ice-margin density. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2010) ranged from 0.0008 to 0.0114/mi^2 (0.0003-0.0044/km^2) with a maximum 95 percent confidence interval (CI) of 0.1089/mi^2 (0.0419/km^2). This suggests the densities used in the calculations and shown in Table 6-2 are somewhat higher than are likely to be observed from vessels near the area of planned operations.

Table 6-1 Expected Densities of Cetaceans and Seals in Areas of the Chukchi Sea, Alaska, for the Planned Summer (July–August) Period. Species listed under the U.S. ESA as Endangered are in italics.

	Open Water		Ice Margin	
Species	**Average Density (# / km²)**	**Maximum Density (# / km²)**	**Average Density (# / km²)**	**Maximum Density (# / km²)**
Odontocetes				
Monodontidae				
Beluga	0.0010	0.0020	0.0040	0.0080
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0011	0.0015	0.0011	0.0015
Mysticetes				
Bowhead whale	0.0013	0.0026	0.0013	0.0026
Fin whale	0.0001	0.0004	0.0001	0.0004
Gray whale	0.0258	0.0516	0.0258	0.0516
Humpback whale	0.0001	0.0004	0.0001	0.0004
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ribbon seal	0.0005	0.0020	0.0005	0.0020
Ringed seal	0.3668	0.6075	0.4891	0.8100
Spotted seal	0.0073	0.0122	0.0098	0.0162

Gray whale densities are expected to be much higher in the summer months than during the fall. Moore et al. (2000) found the distribution of gray whales in the planned operational area was scattered and limited to nearshore areas where most whales were observed in water less than 114 ft (35 m) deep. Thomas et al. (2010) also reported substantial declines in the sighting rates of gray whales in the fall. The average open-water summer density (Table 6-1) was calculated from 2008–2010 aerial survey effort and sightings in Clarke and Ferguson (*in prep*) for water depths 118-164 ft (36-50 m) including 54 sightings (73 individuals) during 7,447 mi (11,985 km) of on-transect effort. The average group size of those sightings is 1.35. Correction factors $f(0)$ = 2.49 (Forney and Barlow 1998) and $g(0)$ = 0.30 (Forney and Barlow 1998, Mallonee 1991) were also used in the density calculation. Similar to beluga and bowhead whales, an inflation factor of 2 was used to estimate the maximum densities from average densities in both habitat types and seasons. Gray whales are not commonly associated with sea ice, but may be present near it, so the same densities were used for ice-margin habitat as were derived for open-water habitat during both seasons. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2010) ranged from 0.0055/mi^2 to 0.0208/mi^2 (0.0021/km^2 to 0.0080/km^2) with a maximum 95 percent CI of 0.0874 mi^2 (0.0336 km^2).

In the fall, gray whales may be dispersed more widely through the northern Chukchi Sea (Moore et al. 2000), but overall densities are likely to be decreasing as the whales begin migrating south. A density calculated from effort and sightings (15 sightings [19 individuals] during 6,236 mi (10,036 km) of on-transect effort) in water 118-164 ft (36-50 m) deep during September–October reported by Clarke and Ferguson (*in prep*) was used as the average estimate for the Chukchi Sea during the fall period. The corresponding group size value of 1.26, along with the same *f(0)* and *g(0)* values described above were used in the calculation. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2008 (Haley et al. 2010) ranged from $0.0068/mi^2$ to $0.0109/mi^2$ ($0.0026/km^2$ to $0.0042/km^2$) with a maximum 95 percent CI of 0.0720 mi^2 (0.0277 km^2).

Harbor Porpoise densities were estimated from industry data collected during 2006-2008 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006–2008, however, recorded sightings throughout the Chukchi Sea during the summer and early fall months. Density estimates from 2006-2008 observations during non-seismic periods and locations in July-August ranged from $0.0021/mi^2$ to $0.0039/mi^2$ ($0.0008/km^2$ to $0.0015/km^2$) with a maximum 95 percent CI of $0.0205/mi^2$ ($0.0079/km^2$) (Haley et al. 2010). The average density from the summer season of those three years ($0.0029/mi^2$, $0.0011/km^2$) was used as the average open-water density estimate while the high value ($0.0039/mi^2$, $0.0015/km^2$) was used as the maximum estimate (Table 6-1). Harbor porpoise are not expected to be present in higher numbers near ice, so the open-water densities were used for ice-margin habitat in both seasons. Harbor porpoise densities recorded during industry operations in the fall months of 2006-2008 were slightly lower and ranged from $0.0075/mi^2$ to $0.0029/mi^2$ ($0.0029/km^2$ to $0.0011/km^2$) with a maximum 95 percent CI of $0.0242/mi^2$ ($0.0093/km^2$). The average of those three years ($0.0018/mi^2$, $0.0007/km^2$) was again used as the average density estimate and the high value $0.0029/mi^2$ ($0.0011/km^2$) was used as the maximum estimate (Table 6-2).

Table 6-2 Expected Densities of Cetaceans and Seals in Areas of the Chukchi Sea, Alaska, for the Fall (September–October) Period. Species listed under the U.S. ESA as Endangered are in italics.

	Open Water		Ice Margin	
Species	Average Density (# / km^2)	Maximum Density (# / km^2)	Average Density (# / km^2)	Maximum Density (# / km^2)
Odontocetes				
Monodontidae				
Beluga	0.0015	0.0030	0.0060	0.0120
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0007	0.0011	0.0007	0.0011
Mysticetes				
Bowhead whale	0.0219	0.0438	0.0438	0.0876
Fin whale	0.0001	0.0004	0.0001	0.0004
Gray whale	0.0080	0.0160	0.0080	0.0160
Humpback whale	0.0001	0.0004	0.0001	0.0004
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ribbon seal	0.0005	0.0020	0.0005	0.0020
Ringed seal	0.2458	0.4070	0.3277	0.5427
Spotted seal	0.0049	0.0081	0.0065	0.0108

The remaining five cetacean species that could be encountered in the Chukchi Sea during Shell's planned exploration drilling program include the humpback whale, killer whale, minke whale, fin whale, and narwhal. Although there is evidence of the occasional occurrence of these animals in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned exploration drilling program. Clarke et al. (2011) and Haley et al. (2010) reported humpback whale sightings; George and Suydam (1998) reported killer whales; Brueggeman et al. (1990), Haley et al. (2010) and COMIDA (2011) reported minke whales; and Clarke et al. (2011) and Haley et al. (2010) reported fin whales. Narwhal sightings in the Chukchi Sea have not been reported in recent literature, but subsistence hunters occasionally report observations near Barrow, and Reeves et al. (2002) indicated a small number of extralimital sightings in the Chukchi Sea.

Pinnipeds

Three species of pinnipeds under NMFS jurisdiction are likely to be encountered in the Chukchi Sea during Shell's planned exploration drilling program: ringed seal, bearded seal, and spotted seal. Each of these species, except for the spotted seal, is associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) for ringed and bearded seals during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be found in the southern margin of the retreating sea ice. However, satellite tagging has shown that they sometimes undertake long excursions into offshore waters during summer (Lowry et al. 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Patterson et al. 2007, Haley et al. 2010).

Ringed seal and ***bearded seals*** "average" and "maximum" summer ice-margin densities (Table 6-1) were available in Bengtson et al. (2005) from spring surveys in the offshore pack ice zone (zone 12P) of the northern Chukchi Sea. However, corrections for bearded seal availability, *g(0)*, based on haulout and diving patterns were not available. Densities of ringed and bearded seals in open water are expected to be somewhat lower in the summer when preferred pack ice habitat may still be present in the Chukchi Sea. Average and maximum open-water densities have been estimated as 3/4 of the ice margin densities during both seasons for both species. The fall density of ringed seals in the offshore Chukchi Sea has been estimated as 2/3 the summer densities because ringed seals begin to reoccupy nearshore fast ice areas as it forms in the fall. Bearded seals may also begin to leave the Chukchi Sea in the fall, but less is known about their movement patterns so fall densities were left unchanged from summer densities. For comparison, the ringed seal density estimates calculated from data collected during summer 2006-2008 industry operations ranged from 0.0411/mi^2 to 0.1786/mi^2 (0.0158/km^2 to 0.0687/km^2) with a maximum 95 percent CI of 0.3936/mi^2 (0.1514/km^2) (Haley et al. 2010). These estimates are lower than those made by Bengtson et al. (2005) which is not surprising given the different survey methods and timing.

Little information on ***spotted seal*** densities in offshore areas of the Chukchi Sea is available. Spotted seal densities in the summer were estimated by multiplying the ringed seal densities by 0.02. This was based on the ratio of the estimated Chukchi populations of the two species (Table 4-1). Chukchi Sea spotted seal abundance was estimated by assuming that 8 percent of the Alaskan population of spotted seals is present in the Chukchi Sea during the summer and fall (Rugh et al. 1997), the Alaskan population of spotted seals is 59,214 (Allen and Angliss 2010), and that the population of ringed seals in the Alaskan Chukchi Sea is ~208,000 animals (Bengtson et al. 2005). In the fall, spotted seals show increased use of coastal haulouts so densities were estimated to be 2/3 of the summer densities.

Two ***ribbon seal*** sightings were reported during industry vessel operations in the Chukchi Sea in 2006-2008 (Haley et al. 2010). The resulting density estimate of 0.0013/mi^2 (0.0005/km^2) was used as the average density and 4 times that was used as the maximum for both seasons and habitat zones.

As described in earlier sections, the assumed start date of exploration drilling in the Chukchi Sea using the drillship *Discoverer* and associated support vessels is 4 July. Up to four wells (three wells, and one partial well) may be drilled in a drilling season, with an assumed average of 32 days at each drill site (including the partial well drill site, including 7.5 days of MLC excavation at all four drill sites. All four drill sites will be at the Burger Prospect. Exploration drilling operations are expected to be conducted through 31 October 2012.

<u>Area Potentially Exposed to Sounds ≥120 dB or ≥160 dB re 1µPa rms</u>

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

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 1 m (rms) (Austin and Warner 2010). Propagation modeling at the Burger Prospect resulted in an estimated distance of 0.814 mi (1.31 km) to the point at which exploration drilling sounds would likely fall below 120 dB. The estimated 1.31 km distance was multiplied by 1.5 (= 1.22 mi [1.97 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 on the Burger Prospect (Table 6-3). Given this distance or radius, he total area of water ensonified to ≥120 dB rms during exploration drilling at each drill site was estimated to be 4.6 mi^2 (12 km^2).

The acoustic propagation model used to estimate the sound propagation from *Discoverer* in the Chukchi Sea is JASCO Research's Marine Operations Noise Model (MONM). MONM computes received sound levels in rms units when source levels are specified also in those units. MONM treats sound propagation in range-varying acoustic environments through a wide-angled parabolic equation solution to the acoustic wave equation. The specific parabolic equation code in MONM is based on the Naval Research Laboratory's Range-dependent Acoustic Model. This code has been extensively benchmarked for accuracy and is widely employed in the underwater acoustics community (Collins 1993).

Changes in the water column of the Chukchi Sea through the course of the exploration drilling season will likely affect the propagation of sounds produced by exploration drilling activities, so the modeling of exploration drilling sounds was run using expected oceanographic conditions in October which are expected to support greater sound propagation (Warner and Hannay 2011). Results of sound propagation modeling that were used in the calculations of areas exposed to various levels of received sounds are summarized in Table 6-3.

Distances shown in Table 6-3 were used to estimate the area ensonified to ≥120 dB rms around the drillship. As noted above, all exploration drilling activities will occur at the Burger Prospect. The exploration drill sites assumed for the summer of 2012 at the Burger Prospect (Burger A, F, J, and V) are 3.4 to 13 mi (5.5 km to 21 km) from each other and wells will not be drilled simultaneously. Therefore, the area exposed to continuous sounds ≥120 dB at each drill site is not expected to overlap with any other drill site. The total area of water potentially exposed to received sound levels ≥120 dB rms by exploration drilling operations during July–August at two locations is therefore estimated to be 9.42 mi^2 (24.4 km^2). Activities at two additional locations in September–October may expose an additional 9.42 mi^2 (24.4 km^2) to continuous sounds ≥120 dB rms.

Sound propagation measurements will be performed on the *Discoverer* and support vessels in 2012, once these are on location in Chukchi Sea. The results of those measurements will be used during the season to implement mitigation measures as required by the IHA.

Table 6-3 Sound Propagation Modeling Results of Exploration Drilling, Icebreaking, and ZVSP Activities at the Burger Prospect in the Chukchi Sea

Source	Received Level (dB re 1 µPa)	Modeling Results (km)	Used in Calculations (km)
Discoverer	120	1.31	1.97
Icebreaking	120	7.63	9.50
ZVSP	160	3.67	5.51

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

Measurements of the icebreaking supply ship *Robert Lemeur* pushing and breaking ice during exploration drilling operations in the Beaufort Sea in 1986 resulted in an estimated broadband source level of 193 dB re 1 µPa · m (Greene 1987a; Richardson et al. 1995a). Measurements of the icebreaking sounds were made at 5 different distances and those were used to generate a propagation loss equation [RL=141.4–1.65R–10Log(R) where R is range in kilometers (Greene 1987a); converting R to meters results in the following equation: R=171.4–10log(R)–0.00165R]. Using that equation, the estimated distance to the 120 dB threshold level for continuous sounds from icebreaking is 4.74 mi (7.63 km). Since the measurements of the *Robert Lemeur* were taken in the Beaufort Sea under presumably similar conditions as would be encountered in the Chukchi Sea in 2012, an inflation factor of 1.25 was selected to arrive at a precautionary 120 dB distance of 5.9 mi (9.5 km) for icebreaking sounds. Additionally, measurements of identical sound sources at the Burger and Camden Bay prospects in 2008 yielded similar results, suggestion that sound propagation at the two locations is likely to be similar (Hannay and Warner 2009).

If ice is present, icebreaking 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 exploration drilling season. Icebreaking activities would likely occur in a 40^{o} arc up to 3.1 mi (5 km) upwind of the drilling vessel (see Section 1, Figure 1-3 and Attachment B of this application for additional details). This activity area plus a 5.9 mi (9.5 km) buffer around it results in an estimated total area of 162 mi^2 (420 km^2) that may be exposed to sounds ≥120 dB from icebreaking activities in each season.

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

A typical sound source that would be used by Shell in 2012 is an 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 airgun source used in the region in 2008 during the BP Liberty seismic survey in the Beaufort Sea.

Preseason estimates of the propagation of airgun sounds from the ITAGA VSP sound source have therefore been estimated based on the measurements of the seismic source reported in BP's 90-day report (Aerts et al. 2008). The BP liberty source was also an eight-airgun array, but had a slightly larger total volume of 880 $in.^3$ (14,421 cm^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 airgun source has been increased from 235.4 to 241.4 while the remainder of the equation (–18*LogR – 0.0047*R) has been left unchanged. This equation results in the following estimated distances to maximum received levels: 190 dB = 1719 ft (524 m); 180 dB = 4068 ft (1240 m); 160 dB = 12,041 ft (3670 m); 120 dB = 34,449 ft (10,500 m). The ≥160 dB distance was multiplied by 1.5 (Table 6-3) for use in estimating the area ensonified to ≥160 dB rms around the drillship during ZVSP activities. Therefore, the total area of water potentially exposed to received sound levels ≥160 dB rms by ZVSP operations at two exploration drill sites during each season (summer and fall) is estimated to be 73.67 mi^2 (190.8 km^2).

<u>Potential Number of "Takes by Harassment"</u>

This subsection provides estimates of the number of individuals potentially exposed to continuous sound levels ≥120 dB re 1 μPa rms from exploration drilling and icebreaking 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 the Chukchi Sea and the anticipated area exposed to those sound levels.

The number of individuals of each species potentially exposed to received levels of continuous drilling related sounds ≥120 dB or to pulsed airguns sounds ≥160 dB within each season (summer and fall) and habitat zone was estimated by multiplying

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

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

The exploration drilling program is planned to occur from July 4 through October 31 as described in the previous section. We have assumed that ZVSP activities may occur at each well drilled. Additionally, we have assumed that more ice is likely to be present in the area of operations during the July–August period, so summer ice-margin densities have been applied to 50 percent of the area that may be exposed to sounds from exploration drilling and ZVSP activities in those months. Open water densities in the summer were applied to the remaining 50 percent of the area. Less ice is likely to be present during the September–October period, so fall ice-margin densities have been applied to only 20 percent of the area that may be exposed to sounds from exploration drilling and ZVSP activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since icebreaking activities would only occur within ice-margin habitat, the entire area potentially ensonified by icebreaking activities has been multiplied by the ice-margin densities in both seasons.

Species with an estimated average number of individuals exposed equal to zero are included below for completeness, but are not likely to be encountered.

Exploration Drilling Activities

Estimates of the average and maximum number of individual marine mammals that may be exposed to continuous sound levels ≥120 dB by exploration drilling activities are shown by season and habitat in Table 6-4. Due to the relatively small estimated ≥120 dB radius around the exploration drilling activities, only a few individuals of any species are estimated to be exposed based on average densities. However, chance encounters with individuals of any species are possible as all listed species are known to occur in the Chukchi Sea. Minimal estimates have therefore been included in the Total (Max) column to account for chance encounters or where greater numbers may be encountered than calculations suggested.

Icebreaking Activities

Estimates of the average and maximum number of individual marine mammals that may be exposed to continuous sound levels ≥120 dB by exploration drilling activities are shown by season and habitat in Table 6-5. Should icebreaking be necessary, it would ensonify a larger area of water to ≥120 dB than the exploration drilling activities or to ≥160 dB by ZVSP surveys and therefore results in the highest number of potential estimated individual exposed to such sounds.

The average and maximum estimates of the number of individual bowhead whales exposed to received sound levels ≥120 dB are 19 and 38, respectively. The average estimates for beluga and gray whales are 4 and 14, respectively (Table 6-5). Few other cetaceans are likely to be exposed to icebreaking sounds ≥120 dB, but maximum estimates have been included to account for chance encounters.

Ringed seals are expected to be the most abundant animal in the Chukchi Sea and the average and maximum estimates of the number exposed to ≥120 dB by potential icebreaking activities are 343 and 568, respectively (Table 6-5). Estimated exposures of other seal species are substantially less than those for ringed seals (Table 6-5).

ZVSP Activities

Estimates of the average and maximum number of individual marine mammals that may be exposed to pulsed airgun sounds at received levels ≥160 dB during ZVSP activities are shown by season and habitat in Tables 6-6. The estimates are somewhat greater than for exploration drilling activities because of the larger ≥160 dB radius around the airguns compared to the estimated ≥120 dB radius around exploration drilling activities (Table 6-3).

The average and maximum estimates of the number of individual bowhead whales potentially exposed to received sound levels ≥160 dB are 5 and 11, respectively. The average estimates for beluga and gray whales are 1 and 6, respectively (Table 6-6). Few other cetaceans are likely to be exposed to airgun sounds ≥160 dB, but maximum estimates have been included to account for chance encounters.

The average and maximum estimated number of ringed seals potentially exposed to ≥160 dB by ZVSP activities are 132 and 218, respectively (Table 6-6). Estimated exposures of other seal species are substantially below those for ringed seals (Table 6-6).

Table 6-4 The number of potential exposures of marine mammals to received sound levels in the water of ≥120 dB rms during planned exploration drilling activities in Summer (July–August) and Fall (September–October) in the Chukchi Sea, Alaska, 2012.

	Number of Individuals Potentially Exposed to Drilling Sounds ≥ 120 dB													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phocoenidae														
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Mysticetes														
Bowhead whale	0	0	0	0	0	0	0	1	0	0	1	1	1	5
Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Gray whale	0	1	0	1	1	1	0	0	0	0	0	0	1	5
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinnipeds														
Bearded seal	0	0	0	0	0	1	0	0	0	0	0	1	1	5
Ribbon seal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ringed seal	4	7	6	10	10	17	5	8	2	3	6	11	17	28
Spotted seal	0	0	0	0	0	0	0	0	0	0	0	0	0	5

Table 6-5 The number of potential exposures of marine mammals to received sound levels in the water of ≥120 dB rms during potential icebreaking activities in Summer (July–August) and Fall (September–October) in the Chukchi Sea, Alaska, 2012.

	Number of Individuals Potentially Exposed to Icebreaking Sounds ≥120 dB													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	0	0	2	3	2	3	0	0	3	5	3	5	4	5
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phocoenidae														
Harbor porpoise	0	0	0	1	0	1	0	0	0	0	0	0	1	5
Mysticetes														
Bowhead whale	0	0	1	1	1	1	0	0	18	37	18	37	19	38
Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Gray whale	0	0	11	22	11	22	0	0	3	7	3	7	14	28
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinnipeds														
Bearded seal	0	0	6	11	6	11	0	0	6	11	6	11	12	23
Ribbon seal	0	0	0	1	0	1	0	0	0	1	0	1	0	5
Ringed seal	0	0	205	340	205	340	0	0	138	228	138	228	343	568
Spotted seal	0	0	4	7	4	7	0	0	3	5	3	5	7	11

Table 6-6 The number of potential exposures of marine mammals to received sound levels in the water of ≥160 dB rms during planned ZVSP activities in Summer (July–August) and Fall (September–October) in the Chukchi Sea, Alaska, 2012.

	Number of Individuals Potentially Exposed to VSP Sounds ≥160 dB													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	0	0	0	1	0	1	0	0	0	0	0	1	1	5
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Phocoenidae														
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Mysticetes														
Bowhead whale	0	0	0	0	0	0	3	7	2	3	5	10	5	11
Fin whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Gray whale	2	5	2	5	5	10	1	2	0	1	2	3	6	13
Humpback Whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Minke whale	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinnipeds														
Bearded seal	1	2	1	3	2	5	2	3	1	1	2	4	5	9
Ribbon seal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ringed seal	35	58	47	77	82	135	38	62	13	21	50	83	132	218
Spotted seal	1	1	1	2	2	3	1	1	0	0	1	2	3	5

Table 6-7 The total number of potential exposures of marine mammals to received sound levels in the water of ≥120 dB or ≥160 dB rms during proposed exploration drilling, icebreaking, and ZVSP activities in the Chukchi Sea, Alaska, 2012.

Species	Total Number of Individuals Potentially Exposed to Sounds ≥120 dB or ≥160 dB	
	Average	Maximum
Odontocetes		
Monodontidae		
Beluga	5	15
Narwhal	0	15
Delphinidae		
Killer whale	0	15
Phocoenidae		
Harbor porpoise	1	15
Mysticetes		
Bowhead whale	25	53
Fin whale	0	15
Gray whale	21	46
Humpback Whale	0	15
Minke whale	0	15
Pinnipeds		
Bearded seal	17	36
Ribbon seal	1	15
Ringed seal	492	814
Spotted seal	10	21

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".

Cetaceans

Overall, few cetaceans are expected to be exposed to continuous sounds ≥120 dB rms or impulse sounds ≥160 dB rms in the Chukchi Sea during the exploration drilling program, should they show no avoidance of the activities. This is largely a result of the relatively small area expected to be exposed to sounds at these levels. The average estimates suggest 25 bowhead whales may be exposed to sounds at or above the specified levels (Table 6-7). This number is <1 percent of the BCB population of >15,232 assuming 3.4 percent annual population growth from the 2001 estimate of >10,545 animals (Zeh and Punt 2005) which is supported by a 2004 population estimate of 12,631 by Koski et al. (2010). Similarly small numbers of beluga and gray whales may also be exposed to sounds from the exploration drilling program if they do not avoid the area of operations. The small numbers of other whales that may occur in the Chukchi Sea are unlikely to be present around the planned operations but chance encounters may occur. The few individuals would represent a very small proportion of their respective populations.

Pinnipeds

Ringed seal is by far the most abundant species expected to be encountered during the planned operations. The best (average) estimate of the numbers of ringed seals exposed to sounds at the specified received levels during the exploration drilling program is 492 ringed seals which represents <1 percent of the estimated Chukchi Sea population. Fewer individuals of other pinniped species are estimated to be exposed to sounds at the specified received levels, also representing small proportions of their populations. Pinnipeds are unlikely to react to continuous sounds or impulsive sounds until received levels are much stronger than 120 dB rms and 160 dB, respectively. So it is probable that a smaller number 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. Data are available for two species of odontocetes exposed to a single strong noise pulse lasting one second (Ridgway et al. 1997 and pers. comm.) and for three species of pinnipeds exposed to moderately strong sound for 20-22 minutes (Kastak et al. 1999). Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift (TTS) to occur. The TTS threshold depends on duration of exposure; the sound level necessary to cause TTS is higher for short sound exposures than for long sound exposures. Received levels must be even higher to risk permanent hearing impairment (probably at least 10 dB above the TTS threshold).

Exploration Drilling Sounds

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

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

Airgun Sounds

A typical eight airgun array used to perform ZVSP surveys in each exploration well would consist of 4×40 $in.^3$ (655 cm^3) airguns and 4×150 $in.^3$ (2,458 cm^3) airguns. Typically, a single ZVSP survey will be performed when the well has reached PTD or final depth although, in some instances, a prior ZVSP will have been performed at a shallower depth. A typical survey, would last 10–14 hours, depending on the depth of the well and the number of anchoring points, and include firings of up to 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.

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 500–1000 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 drillship. Under calm conditions, rotor and engine sounds are coupled into the water within a 26°(degree) cone beneath the aircraft. Some of the sound will transmit beyond the immediate area, and some sound will enter the water outside the 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 drillship will generally maintain straight-line routes at altitudes of 1,500 ft (457 m) above sea level (ASL), thereby limiting the received levels at and below the surface.

<u>Vessel Noise</u>

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

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

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.

<u>Tolerance</u>

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, we mean "in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations".

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

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

Baleen Whales**—**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 1.2-2.5 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 ~400 m of a drilling vessel although most other bowhead sightings were at much greater distances. Few bowheads were recorded near industrial activities by aerial observers. After controlling for spatial autocorrelation in aerial survey data from Hall et al. (1994) using a Mantel test, Schick and Urban (2000) found that the variable describing straight line distance between the rig and bowhead whale sightings was not significant, but that a variable describing threshold distances between sightings and the rig was significant. Thus, although the aerial survey results suggested substantial avoidance of the operations by bowhead whales, observations by vessel-based observers indicate that at least some bowheads may have been closer to industrial activities than was suggested by results of aerial observations.

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

Patenaude et al. (2002) reported fewer behavioral responses to aircraft overflights by bowhead compared to beluga whales. Behaviors classified as reactions consisted of short surfacings, immediate dives or turns, changes in behavior state, vigorous swimming, and breaching. Most bowhead 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 rms. Probability of avoidance and other behavioral effects increased when received levels were 120-160 dB rms. Some of the relevant reviews of Southall et al. (2007) are summarized below.

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

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

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

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

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

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

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

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

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

At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson et al. 1995b). Received levels from the icebreaker playback were estimated at 78-84 dB re 1 µPa in the 1/3-octave band centered at 5,000 Hz, or 8-14 dB above ambient. If beluga whales reacted to an actual icebreaker at received levels of 80 dB, reactions would be expected to occur at distances on the order of 6 mi (10 km). Finley et al. (1990) also reported beluga avoidance of icebreaker activities in the Canadian High Arctic at distances of 22 to 31 mi (35 to 50 km). In addition to avoidance, changes in dive behavior and pod integrity were also noted. Beluga whales have also been report to avoid active seismic vessels at distances of 6-12 mi (10-19 km) (Miller et al. 2005). It is likely that at least some beluga whales may avoid the vicinity of the proposed activities thus reducing the potential for exposure to high levels of underwater sound.

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

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

LGL and Greeneridge (1986) and Finley et al. (1990) documented belugas and narwhals congregated near ice edges reacting to the approach and passage of icebreaking ships. Beluga whales responded to oncoming vessels by (1) fleeing at speeds of up to 20 kilometers per hour (km/hr) from distances of 12 to 50 mi (19 to 80 km), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a "freeze" response, lying motionless or swimming slowly away (as far as 23 mi/37 km down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

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

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

The final season (1984) reported in LGL & Greeneridge (1986) involved aerial surveys before, during, and after the passage of two icebreaking ships. During operations, no belugas and few narwhals were observed in an area approximately 17 mi (27 km) ahead of the vessels, and all whales sighted over 12-50 mi (19 to 80 km) from the ships were swimming strongly away. Additional observations confirmed the spatial extent of avoidance reactions to this sound source in this context.

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

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

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

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

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

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

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

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

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

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

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

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

Costa et al. (2003) measured received noise levels from an Acoustic Thermometry of Ocean Climate (ATOC) program sound source off northern California using acoustic data loggers placed on translocated elephant seals. Subjects were captured on land, transported to sea, instrumented with archival acoustic tags, and released such that their transit would lead them near an active ATOC source (at 3,081 ft [939-m] depth; 75-Hz signal with 37.5- Hz bandwidth; 195 dB re 1 μPa-m max. source level, ramped up from 165 dB re 1 μPa-m over 20 min) on their return to a haulout site. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re 1 μPa (range 118 to 137) in the 60- to 90-Hz band. None of the instrumented animals terminated dives or radically altered behavior upon exposure, but some statistically significant changes in diving parameters were documented in nine individuals. Translocated northern elephant seals exposed to this particular nonpulse source began to demonstrate subtle behavioral changes at ~120 to 140 dB re 1 μPa exposure RLs.

Kastelein et al. (2006) exposed nine captive harbor seals in a ~80 x 100 ft (~24 × 30 m) enclosure to nonpulse sounds used in underwater data communication systems (similar to acoustic modems). Test signals were frequency modulated tones, sweeps, and bands of noise with fundamental frequencies between 8 and 16 kHz; 128 to 130 [± 3] dB re 1 μPa-m source levels; 1- to 2-s duration (60-80% duty cycle); or 100% duty cycle. They recorded seal positions and the mean number of individual surfacing behaviors during control periods (no exposure), before exposure, and in 15-min experimental sessions (n = 7 exposures for each sound type). Seals generally swam away from each source at received levels of ~107 dB re 1 μPa, avoiding it by ~5 m, although they did not haul out of the water or change surfacing behavior. Seal reactions did not appear to wane over repeated exposure (i.e., there was no obvious habituation), and the colony of seals generally returned to baseline conditions following exposure. The seals were not reinforced with food for remaining in the sound field.

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

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 longer distances. However, baleen whales exposed to strong noise pulses from airguns may react by deviating from their normal migration route. In the case of the 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).

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 to 9.0 mi (4.5 to 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 1.44-2.28 mi (2.31-3.67 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 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. 1999).

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

Seismic operators and marine mammal observers sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of seismic vessels operating large airgun systems. However, some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003). The beluga may be a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 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. As for delphinids, a ≥170 dB disturbance criterion is considered appropriate for pinnipeds, which tend to be less responsive than many cetaceans.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds 180 and ≥190 dB re 1 μPa (rms), respectively (NMFS 2000). Those criteria have been used in defining the safety (shut down) radii 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 Orenstein et al. 2004). 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 exploration drilling activities to avoid exposing them to underwater sound levels that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the proposed activities. In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid any possibility of hearing impairment.

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

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

[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).

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 2005b). 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 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. 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 62 mi (100 km) north of the Canaries in 2004 during naval exercises. Examinations of several other stranded species have also revealed evidence of gas and fat embolisms (e.g., Arbelo et al. 2005; Jepson et al. 2005a; Méndez et al. 2005). Most of the afflicted species were deep divers. There is speculation that gas and fat embolisms may occur if cetaceans ascend unusually quickly when exposed to aversive sounds, or if sound in the environment causes the destabilization of existing bubble nuclei (Potter 2004; Arbelo et al. 2005; Fernández et al. 2005a; Jepson et al. 2005b). Even if gas and fat embolisms can occur during exposure to mid-frequency sonar, there is no evidence that that type of effect occurs in response to the types of sound produced during the proposed exploratory activities. Also, most evidence for such effects has been in beaked whales, which do not occur in the proposed survey area.

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

Strandings and Mortality

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

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

Subsistence hunting continues to be an essential aspect of Inupiat Native life, especially in rural coastal villages. The Inupiat participate in subsistence hunting activities in and around the Chukchi Sea. The animals taken for subsistence provide a significant portion of the food that will last the community through the year. Marine mammals represent on the order of 60-80 percent of the total subsistence harvest. Along with the nourishment necessary for survival, the subsistence activities strengthen bonds within the culture, provide a means for educating the young, provide supplies for artistic expression, and allow for important celebratory events. In this IHA application, Shell specifically discusses the potential impact from the 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. Most activities associated with Shell's planned exploration drilling program would have no or negligible effects on bowhead whales or on subsistence hunts for bowheads. Sound energy and general activity associated with exploration drilling and operation of vessels and aircraft have the potential to temporarily affect the behavior of bowhead whales. However, as noted above in Section 7, though temporary diversions of the swim path of migrating whales have been documented, the whales have generally been observed to resume their initial migratory route within a distance of 6-20 mi (10-32 km) (Davis 1987; Brewer et al. 1993; Hall et al. 1994). Drilling noise has not been shown to block or impede migration even in narrow ice leads (Davis 1987; Richardson et al. 1991). Any effects on the bowhead whale as a subsistence resource would be negligible.

Observed behavioral effects from sound energy produced by drilling, such as avoidance, deflection, and changes in surface/dive ratios, have generally been restricted to the area ensonified to >160 dB or more although effects have infrequently been observed out to distance ensonified to 120 dB. As indicated above in Table 6-3, areas ensonified to >160 dB or more are limited to the areas within 0.06 mi (0.1 km) of the drillship, and areas expected to be ensonified to >120 dB would be expected to be limited to the areas within 0.913 mi (1.47 km) of the drillship. Shell's proposed drill sites are located more than 64 mi (103 km) from the Chukchi Sea coastline, whereas available mapping of subsistence use areas indicates bowhead hunts are conducted within about 30 mi (48 km) of shore. There is therefore little or no opportunity for the proposed exploration drilling activities to affect bowhead hunts.

Planned vessel traffic between the drill sites and marine support facilities in Wainwright would traverse areas used during bowhead harvests by Wainwright crews. However, bowhead hunts by residents of Wainwright, Point Hope and Point Lay takes place almost exclusively in the spring and are typically curtailed prior to the date Shell would commence the proposed exploration drilling program. From 1984 through 2009, bowhead harvests by these Chukchi Sea villages occurred only between April 14 and June 24 (George and Tarpley 1986; George et al. 1987, 1988 1990, 1992, 1995, 1998, 1999, 2000; Philo et al. 1994; Suydam et al. 1995b, 1996, 1997, 2001b, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010), while Shell will not enter the Chukchi Sea prior to July 1. Fall whaling by Chukchi Sea villages may occur in the future, particularly if bowhead quotas are not completely filled during the spring hunt, and fall weather is accommodating. A Wainwright whaling crew harvested the first fall bowhead in 90 years or more on October 8, 2010. Shell's mitigation measures, which include a system of subsistence advisors, community liaisons, and Communication and Call Centers (Com Centers), will be implemented to avoid any effects from vessel traffic on fall whaling in the Chukchi.

Aircraft traffic (helicopters and small fixed wing airplanes) between the drill sites and facilities in Wainwright and Barrow would also traverse these subsistence areas. Again, flights to and from Wainwright would take place after the date on which bowhead whaling out of Point Hope, Point Lay, and Wainwright is typically finished for the year. Barrow crews hunt bowheads during the spring and the fall, although most commonly east of Barrow along the Beaufort Sea coast. Aircraft flights between the Barrow air support facilities and Shell's drill sites located approximately 140 mi (227 km) to the west/southwest would traverse areas sometimes used during spring and fall whaling by Barrow crews. Spring whaling by Barrow crews is normally finished before the date that such flights would commence. From 1984 through 2009 whales were harvested in the spring by Barrow crews only between April 23 and June 15 (George and Tarpley 1986; George et al. 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo et al. 1994; Suydam et al. 1995b, 1996, 1997, 2001b, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010), while Shell operations would not commence until early July. During these same years fall bowheads were harvested between August 31 and October 29, so some flights could traverse areas hunted in the fall. However, in the past 35 years, Barrow whaling crews have harvested almost all whales in the Beaufort Sea to the east of Point Barrow (Suydam et al. 2008), indicating that relatively little fall hunting occurs to the west where the flight corridor is located. The most commonly observed reactions of bowheads to aircraft traffic are hasty dives, but changes in orientation, dispersal, and changes in activity are sometimes noted. Such reactions could potentially affect subsistence hunts if the flights occurred near and at the same time as the hunt. Shell has developed and proposes to implement a number of mitigation measures to ensure that any effects on the bowhead whale as a subsistence resource, or effects on bowhead subsistence hunts would be negligible. These mitigation measures, which include minimum flight altitudes, employment of subsistence advisors in the villages, and implementation of a Communications Plan (with operation of Com Centers), are described below in Section 12.3.

Beluga. Beluga typically do not represent a large proportion of the subsistence harvests by weight in the communities of Wainwright and Barrow, the nearest communities to Shell’s planned exploration drilling program. Barrow residents hunt beluga in the spring (normally after the bowhead hunt) in leads between Point Barrow and Skull Cliffs in the Chukchi Sea – primarily in April-June, and later in the summer (July-August) on both sides of the barrier island in Elson Lagoon / Beaufort Sea (MMS 2008), but harvest rates indicate the hunts are not frequent. Wainwright residents hunt beluga in April-June in the spring lead system, but this hunt typically occurs only if there are no bowheads in the area. Communal hunts for beluga are conducted along the coastal lagoon system later in July-August.

Belugas typically represent a much greater proportion of the subsistence harvest in Point Lay and Point Hope. Point Lay’s primary beluga hunt occurs from mi-June through mid-July, but can sometimes continue into August if early success is not sufficient. Point Hope residents hunt beluga primarily in the lead system during the spring (late March to early June) bowhead hunt, but also in open water along the coastline in July and August. Beluga are harvested in coastal waters near these villages, generally within a few miles from shore. Shell's proposed drill sites are located more than 60 mi (97 km) offshore, therefore proposed exploration drilling in the Burger Prospect would have no or negligible effect on beluga hunts. Aircraft and vessel traffic between the drill sites and support facilities in Wainwright, and aircraft traffic between the drill sites and air support facilities in Barrow would traverse areas that are sometimes used for subsistence hunting of belugas.

Disturbance associated with vessel and aircraft traffic could therefore potentially affect beluga hunts. However, all of the beluga hunt by Barrow residents in the Chukchi Sea, and much of the hunt by Wainwright residents would likely be completed before Shell activities would commence. Additionally, vessel and aircraft traffic associated with Shell's planned exploration drilling program will be restricted under normal conditions to designated corridors that remain onshore or proceed directly offshore thereby minimizing the amount of traffic in coastal waters where beluga hunts take place. The designated traffic corridors do not traverse areas indicated in recent mapping as utilized by Point Lay, or Point Hope for beluga hunts, and avoids important beluga hunting areas in Kasegaluk Lagoon. Shell has developed and proposes to implement a number of mitigation measures to ensure that any effects on the beluga whale as a subsistence resource, or effects on beluga subsistence hunts would be negligible. These mitigation measures, which include minimum flight altitudes, employment of subsistence advisors in the villages, and implementation of a Communications Plan (with operation of Com Centers), are described below in Section 12.3. Therefore, any behavioral responses of avoidance of activity areas by beluga in the Chukchi Sea would have no or negligible effect on the subsistence resource or subsistence hunts for beluga.

Seals. Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell's exploration drilling program would commence, but some harvest continues during open water and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer. Most seals are harvested in coastal waters, with available maps of recent and past subsistence use areas indicating seal harvests have occurred only within 30-40 mi (48-64 km) of the coastline. Shell planned drill sites where exploration activities would occur are located more than 64 statute mi (103 km) offshore, so activities within the Burger Prospect, such as drilling, would have no impact on subsistence hunting for seals. Helicopter traffic between land 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. Any effects on the seals as a subsistence resource, or effects on subsistence hunts for seals would be negligible. These mitigation measures, which include minimum flight altitudes, employment of subsistence advisors in the villages, and implementation of a Communications Plan (with operation of Com Centers), are described below in Section 12.3.

9. Anticipated impact on habitat

Shell's planned 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 hypothetical, site-specific, very large oil spill scenario created for Shell's regional oil spill response plan (*Chukchi Sea Regional Oil Discharge Prevention and Contingency Plan* [ODPCP] – revised April 2011) which was submitted to BOEMRE contemporaneously with Shell's Chukchi Sea Exploration Plan. 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's on-going effort in the Supplemental Environmental Impact Statement for Chukchi Sea Lease Sale 193 (BOEMRE in print). Given that a very large oil spill is a highly unlikely and 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 this activity, but provided separately as Attachment E.

9.1 Potential Impacts from Seafloor Disturbance (Mooring and 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 *Discoverer* would be stabilized and held in place with a system of eight 15,400 pounds (lb) (7,000 kg) Stevpris anchors during operations. The anchors from the *Discoverer* 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.

Each Stevpris anchor may impact an area of 2,027 ft^2 (188 m^2) of the seafloor. Minimum impact estimates from each well or mooring the *Discoverer* by its eight anchors is 16,216 ft^2 (1,507 m^2) of seafloor. This estimate assumes that the anchors are set only once. Shell plans to pre-set anchors at each drill site for whichever drillship is used for exploration drilling. Unless moved by an outside force such as sea current, anchors should only need to be set once per drill site.

Once the *Discoverer* ends operation, the anchors will be retrieved. Over time the anchor scars will be filled through natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type. Anchor scars were visible under low energy conditions in the North Sea for 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). Surficial sediments in Shell's Burger Prospect consist of soft sandy mud (silt and clay) with lesser amounts of gravel (Battelle Memorial Institute 2010; Blanchard et al. 2010a,b). The energy regime, plus possible effects of ice gouge in the Chukchi Sea suggests that anchor scars would be refilled faster than in the North Sea.

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. Material will be excavated from the MLCs using a large diameter drillbit. Pressurized air and seawater (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 the Chukchi Sea. 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 Chukchi Sea, especially during the “open water” exploration 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 drillship, marine vessels, and support vessels. Sounds that are natural in the marine environment of the Chukchi 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 the Chukchi Sea.

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 drilling activities in the Chukchi Sea. Depending upon the sound source, different mitigation measures will be implemented. Mitigation measures have been included in the 4MP that is included as an appendix of 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 exploration drilling areas.

Anchored vessels, including the drillship, 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 exploration 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 unit *Kulluk* during exploration 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 unit *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 exploration 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 exploration drilling activities in the Chukchi Sea.

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 exploration drilling areas. Anchored vessels, including the drilling unit, 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 migration corridors is the most likely behavioral response expected as a result of Shell's exploration activities in the Chukchi Sea. 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 unit *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 exploration 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 exploration 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 exploration drilling activities will not negatively impact the diversity and abundance of zooplankton. The primary generators of sound energy are the drillship 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). Ice management vessels, during active ice management, may have to adjust course forward and astern while moving ice and thereby create greater variability in propeller cavitation than other vessels that maintain course with less adjustment. The drillship maintains station during exploration drilling without activation of propulsion propellers. Richardson (et al.1995a) reported that the noise generated by an icebreaker pushing ice was 10-15 dB greater than the noise produced by the ship underway in open water. It is expected that the lower level of sound produced by the drillship, ice management vessels conducting icebreaking, or other vessels would have less impact on zooplankton than would 3D 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 units 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 exploration 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 drilling activities in the Chukchi Sea.

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 exploration drilling activities will not appreciably affect diversity and abundance of plants or animals on the seafloor. The primary generators of sound energy are the drillship 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). Ice management vessels, during active ice management, may have to adjust course forward and astern while moving ice and thereby create greater variability in propeller cavitation than other vessels that maintain course with less adjustment. The drillship maintains station during exploration drilling without activation of propulsion propellers. Richardson et al.(1995a) reported that the noise generated by an icebreaker pushing ice was 10-15 dB greater than the noise produced by the ship underway in open water. The lower level of sound produced by the drillship, ice management vessels conducting icebreaking, or other vessels will have less impact on bottom-dwelling organisms than would 3D 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 drillship 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 exploration 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).

Drillship sound source levels during drilling can range from 90 dB within 31 mi (50 km) of the drillship to 138 dB within a distance of 0.06 mi (0.01 km) from the drillship (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 174-184 dB. At these intensity levels, fish may avoid the drilling unit, 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. Cod, herring and other species of fish with swim bladders have been found to be relatively sensitive to sound, while mackerel, flatfish, and many other species that lack swim bladders have been found to have poor hearing (Hawkins 1981, Hastings and Popper 2005). 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 Drilling Muds and Cuttings Waste

General

The National Pollutant Discharge Elimination System (NPDES) General Permit establishes discharge limits for drilling fluids (at the end of a discharge pipe) to a minimum 96-hr Lethal Concentration 50 percent (LC_{50}) of 30,000 parts per million (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 General Permit 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 General Permit. The impact of the limited amount of drilling mud and cuttings discharges would be localized to the drill sites and temporary. Drilling mud and cuttings discharges could displace marine mammals a short distance from an exploration drilling location.

Gray whales will more than likely avoid exploration drilling activities and not come into close contact with drilling mud or 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 drilling mud and cuttings are not likely.

It is anticipated that drilling mud and cuttings will only dispense up to 330 ft (100 m) from the drillship in beluga feeding areas. 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 drilling mud or 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 drilling mud and cuttings discharges are regulated by the EPA's NPDES General Permit. The impact of drilling mud and cuttings discharges would be localized and temporary. Drilling mud and cuttings discharges could displace endangered whales (bowhead and humpback whales) a short distance from an exploration 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 drilling mud and 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 drilling mud and 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 drilling mud and 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 drilling mud and cuttings discharges are regulated by the EPA's NPDES General Permit. The impact by drilling mud and 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 drilling mud and 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. 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

Drilling mud and cuttings discharges are regulated by the EPA's NPDES General Permit. The impact of drilling mud and 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 drilling mud and 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 general NPDES permit 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 Al, Fe, Zn, Cd and Hg in all surface and subsurface sediment samples. Considering the relatively small area that drilling mud and cuttings sediment will be deposited, no significant impacts on sediment are expected to occur. The expected increased concentrations of Zn, Cd, and Cr 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 drilling mud and cuttings are composed of seawater, impacts to benthic organisms will be negligible and restricted to a very small area of the seafloor in the Chukchi Sea.

Fish

The levels of drilling mud and cuttings discharges are regulated by the EPA's NPDES General Permit. The impact of drilling mud and cuttings discharges would be localized and temporary. Drilling mud and cuttings discharges could displace fish a short distance from an exploration 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 drilling mud and cuttings because of the episodic nature of discharges (typically only a few hours in duration).

Although unlikely at deeper offshore exploration 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 Burger 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 Chukchi Sea.

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 unit. 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 exploration drilling season. The majority of the pack ice management should occur in the early and latter portions of the exploration drilling season. Landfast ice would not be present during Shell's proposed operations.

The ringed seal is the most common pinniped species in the Chukchi Sea 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 Chukchi Sea. Ringed seals can be found on the pack ice surface in the late spring and early summer in the Chukchi 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, but would not be plentiful in the area of the Chukchi Sea exploration drilling program.

Spotted seals are even less common in the Chukchi Sea project area. The 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 it is unlikely these life functions would occur in the proposed project area, during the time in which drilling activities will take place.

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 Chukchi Sea 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 Discoverer Presence

The length of the *Discoverer* (514 ft [156.7 m]) is not significant enough to cause large-scale diversions from the animals' normal swim and migratory paths. The *Discoverer'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 routes.

Any deflection of bowhead whales or other marine mammal species due to the physical presence of the *Discoverer* or its support vessels would be very minor. Even if animals may deflect because of the presence of the drillship, the Chukchi Sea's migratory corridor is much larger in size than the length of the drillship and animals would have other means of passage around the drillship. In sum, the physical presence of the drillship is not likely to cause a significant deflection to migrating marine mammals.

10. Anticipated impact of habitat loss or modification

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

In addition, feeding does not appear to be an important activity by bowheads migrating through the Chukchi Sea in most years. In the absence of important feeding areas, the potential diversion of a small number of bowheads is not expected to have any significant or long-term consequences for individual bowheads or their population. Bowheads, gray, or beluga whales are not predicted to be excluded from any habitat, nor are any seals predicted to be excluded from any habitat by the offshore 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. Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following

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

Shell has prepared and will implement a 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 Chukchi Sea EP that was submitted to BOEMRE in May 2009, and approved on 7 December 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 Chukchi Sea 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 planned 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.

The leases within the Burger Prospect were acquired during the Chukchi Sea Oil and Gas Lease Sales 193 held in February 2008. During the 2012 exploration drilling program Shell plans to drill up to three exploration wells, and potentially a fourth partial well, on four leases (Table 1-1).

Shell's Chukchi Sea exploration drilling program is planned for the Burger Prospect in the Chukchi Sea (Figure 1-1). This program is set-out in detail in a revised Chukchi Sea 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 Chukchi Sea Environmental Impact Analysis Shell submitted to BOEMRE (Appendix F to the revised Chukchi Sea EP). Shell will implement this POC Addendum, and the mitigation measures set-forth herein, for its Chukchi Sea exploration drilling 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, Wainwright, Point Lay and Point Hope. Shell presented its POC for the Chukchi Sea exploration drilling program to these potentially affected subsistence communities during these consultations. 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 the NSB and NWAB, subsistence-user group leadership, and

Village Whaling Captain Association representatives. These meetings took place at the convenience of the community leaders and in various venues. Meetings were held starting on the 12 January 2009 and have continued to date. Shell's primary purpose in holding individual meetings was to inform key leaders, prior to the public meetings, so that they would be prepared to give appropriate feedback on planned activities.

Shell continues to meet each year with the commissioners and committee heads of Alaska Beluga Whale Committee, the Nanuuq Commission, Eskimo Walrus Commission (EWC), and Alaska Ice Seal Commission (AISC) jointly in co-management meetings. Shell held individual consultation meetings with representatives from the various marine mammal commissions to discuss the planned Chukchi exploration drilling program. Following the exploration drilling season, Shell will have a post-season co-management meeting with the commissioners and committee heads to discuss results of mitigation measures and outcomes of the preceding season. The goal of the post-season meeting is to build upon the knowledge base, discuss successful or unsuccessful outcomes of mitigation measures, and possibly refine plans or mitigation measures if necessary.

Shell also attended the 2011 Conflict Avoidance Agreement (CAA) negotiation meetings in support of a limited program of marine environmental baseline activities in 2011 surveys 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.

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 Chukchi Sea 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 the Chukchi Sea. The mitigation measures Shell has adopted and will implement during its Chukchi Sea 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 from its exploration operations, Shell will implement the following additional measures to ensure coordination of its activities with local subsistence users to minimize further the risk of impacting marine mammals and interfering with the subsistence hunt:

Communication

- 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-hours per day and 40-hours per week during the exploration drilling season. 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 exploration 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 Center personnel; and advising how to avoid subsistence conflicts. SAs 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), or in an emergency situation, while over land or sea to minimize disturbance to mammals and birds. 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.
- Aircraft 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 *Discoverer* and support vessels will enter the Chukchi Sea through the Bering Strait on or after July 1, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- All vessels transit routes 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 drillship 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 drillship and support vessels will enter into the polynya zone far enough so that ice breaking is not necessary. If it is necessary to move into the polynya zone, Shell will notify the local communities of the change in the transit route through the 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 drill sites.
- MMOs will be aboard the *Discoverer* and all support vessels.
- Vessels will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice.
- 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.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.
- 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 Bird Strike Avoidance and Lighting Plan, Appendix I, revised Chukchi Sea EP).

Exploration Drilling Operations

- 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.
- All casing and cementing programs will be certified by a registered professional engineer.
- 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 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 both capping stack equipment and, treatment and flaring capabilities, a fully-designed relief well drilling plan and provisions for a second relief well drilling vessel (*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.

ZVSPs

- Airgun arrays will be ramped up slowly to the required level 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 level will not begin until there has been a minimum of 30 minutes 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-minute lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-minute watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

Ice Management

- Ice management will involve preferentially redirecting, rather than breaking, ice floes while the floes are well away from the drill site.
- Real time ice and weather forecasting will be from the Shell Ice and Weather Advisory Center (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 planning scenario which is greater than the calculated WCD 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 containment 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 as equipment 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 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 available prior to exploration 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. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding

The planned marine mammal monitoring and mitigation program for the Chukchi Sea exploration drilling program is included as Attachment C and this document addresses the issues in item 13.

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

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

- The NSB Department of Wildlife Management (T. Hepa)
- The USFWS Office of Marine Mammal Management (C. Perham and J. Garlic-Miller)
- The BOEMRE's Bowhead Whale Aerial Survey Program (C. Monnett)
- National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory (Robyn Angliss)
- The Kuukpik Subsistence Oversight Panel
- Alaska Eskimo Whaling Commission (H. Brower -Barrow)
- Beluga Whale Committee (W. Goodwin -Kotzebue)
- Inupiat Community of the Arctic Slope (Martha Ipalook Faulk -Barrow)
- North Slope Science Initiative (J. Payne)
- BOEMRE Field Supervisor (J. Walker)
- Alaska Department of Natural Resources (S. Longan)
- Alaska Department of Fish and Game

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Attachment A
Equipment Specifications for *Discoverer*

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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 PERPENDICULARS (LBP)	486 ft	148.2 m
BREADTH (MOULDED) OVER SPONSONS	85.3 ft	26.0 m
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 7,000 kilograms (kg) each (ea) 15,400 pounds (lb) 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 with present equipment (can be outfitted to 2,500 ft)
MAX DRILLING DEPTH	20,000 ft

***DISCOVERER* DRILLING PACKAGE**	
DRAW WORKS	EMSCO E-2,100 - 1,600 horsepower (hp)
ROTARY	National C-495 with 49-$^{1}/_{2}$-in. opening
MUD PUMPS	2 ea Continental Emsco Model FB-1600 Triplex Mud Pumps
DERRICK	Pyramid 170 ft with 1,300,000 lb nominal capacity
PIPE RACKING	BJ 3-arm system
DRILL STING COMPENSATOR	Shaffer 400,000 lb with 18-ft stroke
RISER TENSIONS	8 ea 80,000 lb Shaffer 50-ft stroke tensioners
CROWN BLOCK	Pyramid with 9 ea 60-in. diameter sheaves rated at 1,330,000 lb
TRAVELING BLOCK	Continental - Emsco RA60-6
BOP	Cameron Type U 18.75-in. x 10,000 pounds per square inch (psi)
RISER	Cameron RCK type
TOP DRIVE	Varco TDS-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* DRAFT**		
DRAFT AT LOAD LINE	27 ft	8.20 m
TRANSIT	27 ft (fully loaded, operating , departure)	8.20 m
DRILLING	25.16 ft	7.67 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 each 15 ft 7-in. (4.75 m) diameter, fixed blade
PROPULSION DRIVE UNIT	Marine Diesel, 6 cylinder, 2 cycle, Crosshead type
HORSEPOWER	7,200 hp @ 135 RPM
TRANSIT SPEED	8 knots max

GENERAL STORAGE CAPACITIES	
SACK STORAGE AREA	33,000 ft^3 (934 m^3)
BULK STORAGE	
Bentonite / Barite	1,132 bbl (180 m^3) - 4 tanks
Bulk Cement	1,132 bbl (180 m^3) - 4 tanks
LIQUID MUD	
Active	1,200 bbl (191 m^3)
Reserve	1,200 bbl (191 m^3)
Total	2,400 bbl (382 m^3)
POTABLE WATER	1,670 bbl / 265.5 m^3 (aft peak can be used as additional pot water tank)
DRILL WATER	5,798 bbl / 921.7 m^3
FUEL OIL	6,497 bbl / 1,033 m^3

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

Attachment B
Ice Management Plan

(Refer to Appendix K of the Revised Chukchi Sea EP)

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

(Refer to Appendix D of the Revised Chukchi Sea EP)

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Attachment D
Plan of Cooperation (POC) Addendum

(Refer to Appendix 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

(Refer to Section 4.3 of Appendix F of the Revised Chukchi Sea EP)

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