Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

Issuance of Incidental Harassment Authorization under §101(a)(5)(a) of the Marine Mammal Protection Act to Shell for the Non-Lethal Taking of Whales and Seals in Conjunction with Planned Exploration Drilling Activities During 2015 Chukchi Sea, Alaska

NMFS Consultation Number: AKR-2015-9449

Action Agency: *National Marine Fisheries Service, Office of Protected Resources - Permits and Conservation Division (PR1)*

Affected Species and Determinations:

Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Balanea mysticetus (Bowhead Whale)	Endangered	Yes	No	N/A
Balaneoptera physalus (Fin Whale)	Endangered	Yes	No	N/A
Megaptera novaeangliae (Humpback Whale)	Endangered	Yes	No	N/A
Eubalaena japonica (North Pacific Right Whale)	Endangered	No	No	No
Eschrichtius robustus (Western DPS North Pacific Gray Whale)	Endangered	No	No	N/A
Physeter macroephalus (Sperm Whale)	Endangered	No	No	N/A
Phoca hispida hispida (Arctic Ringed Seal)	Threatened	Yes	No	N/A
Erignathus barbatus nauticus (Beringia DPS Bearded Seal)	Threatened	Yes	No	N/A
Eumetopias jubatus (Western DPS Steller Sea Lion)	Endangered	No	No	No

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By:

James W. Balsiger, Ph.D.
For Administrator, Alaska Region

Date: JUNE 5, 2015

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Terms and Abbreviations

ACIA	Arctic Climate Impact Assessment
ADFG	Alaska Department of Fish and Game
AGL	Above Ground Level
AKR	Alaska Region
ANWR	Arctic National Wildlife Refuge
ASL	Above Sea Level
ATOC	Acoustic Thermometry of the Ocean Climate
bbl	barrels
BCB	Bering, Chukchi, and Beaufort Seas
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BSAI	Bering Sea/Aleutian Island
BSEE	Bureau of Safety and Environmental Enforcement
BWASP	Bowhead Whale Aerial Survey Project
C	Celsius
CFR	Code of Federal Regulations
CHIRP	Compressed High Intensity Radar Pulse
CI	Confidence Interval
CNP	Central North Pacific
Com Center	Communication and Call Center
CPUE	Catch Per Unit Effort
CSEM	Controlled Source Electromagnetic
CTD	Conductivity, Temperature, Depth Meter
CTS	Compound Threshold Shift
cui	Cubic Inches
CV	Coefficient of Variation
CWA	Clean Water Act
dB	Decibels
DDT	Dichloro-Diphenyl-Trichloroethane
DEA	Draft Environmental Assessment
DP	Dynamic Positioning
DPS	Distinct Population Segment
DQA	Data Quality Act
E	East
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Median
ESA	Endangered Species Act
EZ	Exclusion Zone
F	Fahrenheit
f(0)	Detectability Bias

FR	Federal Register
ft	Feet
g	Grams
g(0)	Availability Bias
GIS	Geographic Information System
Hz	Hertz
IHA	Incidental Harassment Authorization
in	Inches
ION	ION Geophysical
IPCC	Intergovernmental Panel on Climate Change
ITA	Incidental Take Authorization
ITS	Incidental Take Statement
IUCN	International Union for Conservation of Natu
IWC	International Whaling Commission
kHz	Kilohertz
km	Kilometers
kn	Knots
L	Liter
m	Meter
mi	Mile
min	Minute
MLC	Mudline cellar
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
ms	Milliseconds
µPa	Micro Pascal
N	North
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic Atmospheric Administratio
NPDES	National Pollution Discharge Elimination System
NPRW	North Pacific Right Whale
NRC	National Research Council
NSB	North Slope Borough
NSF	National Science Foundation
NWMB	Nunavut Wildlife Management Board
NWP	Northwest Passage
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OBC	Ocean Bottom Cable
OC	Organochlorine
OCS	Outer Continental Shelf
Opinion	Biological Opinion
Pa	Pascals
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PBR	Potential Biological Removal
PCB	Polychlorinated biphenyls

PCE	Primary Constituent Element
PR1	Office of Protected Resources- Permits and Conservation Division
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
R_{max}	Maximum Theoretical Net Productivity Rate
re	Relative To
RL	Received Level
rms	Root Mean Square
RPM	Reasonable and Prudent Measure
ROV	Remotely Operated Vehicle
RPA	Reasonable and Prudent Alternative
S	South
s	Second
SD	Standard Deviation
SEL	Sound Exposure Level
Shell	Shell Offshore Inc.
SONAR	SOund Navigation And Ranging
SPAWAR	Space and Naval Warfare Systems Center
SPL	Sound Pressure Level
SPLASH	Structure of Populations, Level of Abundanc and Status of Humpback Whales
SSL	Steller Sea Lion
SSV	Sound Source Verification
t	Ton
TGS	TGS-NOPEC Geophysical Company ASA
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
USCG	United States Coast Guard
USDOI	United States Department of Interior
USFWS	United States Fish and Wildlife Services
USGS	United States Geologic Survey
USSR	Union of Soviet Socialist Republics
VGP	Vessel General Permit
VMS	Vessel Monitoring System
W	West
WNP	Western North Pacific
ZOI	Zone of Influence
ZVSP	Zero-Offset Vertical Seismic Profile

1.0 Introduction

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1539(a)(2)) requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (FWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies may consult informally with NMFS or FWS if they have concluded that an action "may affect, but is not likely to adversely affect" an endangered species, threatened species, or designated critical habitat and NMFS or FWS concurs with that conclusion (50 CFR §402.14(b)).

For the actions described in this document, the action agency is NMFS's Office of Protected Resources – Permits and Conservation Division (PR1), which proposes to issue an Incidental Harassment Authorization (IHA) to take marine mammals only by harassment pursuant to the Marine Mammal Protection Act (MMPA) incidental to conducting a marine exploration drilling program in the Chukchi Sea during the 2015 Arctic open-water season. The IHA would be effective from July 1 to October 31, 2015. The consulting agency for this proposal is NMFS's Alaska Region. This document represents NMFS' biological opinion (opinion) on the effects of this proposal on endangered and threatened species and critical habitat.

The opinion is in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review.

1.1 Background

The proposed action has the potential to affect the endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered humpback whale (*Megaptera novaeangliae*), endangered right whale (*Eubalaena japonica*), endangered western Steller sea lion (*Eumatopias jubatus*) distinct population segment (DPS), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), and Beringia DPS of bearded seal (*Erignathus barbatus barbatus*)[1], as well as the designated critical habitats for North Pacific right whale and Steller sea lion. NMFS PR1 is the federal action agency that issues IHAs and is responsible for ensuring compliance with the terms and conditions of the IHA activities.

This biological opinion is based on information provided in the February 2015 Incidental Harassment Application by Shell, subsequent meetings with Shell, email and telephone conversations between NMFS Alaska Region and NMFS PR1 staff, a literature review of pertinent information, and previous biological opinions issued by NMFS on oil and gas activities in the Arctic Ocean. A complete record of this consultation is on file at NMFS's Juneau Alaska Office.

[1] On July 25, 2014, the U.S. District Court for the District of Alaska issued a decision vacating NMFS's December 28, 2012, listing of the Beringia DPS of bearded seals as a threatened species (*Alaska Oil & Gas Ass'n v. Pritzker*, Case No. 4:13-cv-00018-RPB). NMFS has appealed the district court's decision to the U.S. Court of Appeals for the Ninth Circuit. While the litigation is pending, our Biological Opinions under section 7(a)(2) of the ESA will continue to address effects to bearded seals so that action agencies have the benefit of NMFS's analysis of the consequences of proposed actions on this DPS, even though the listing of the species is not in effect.

1.2 Consultation History

On January 12, 2015, NMFS PR1 submitted a request to initiate section 7 consultation with the NMFS Alaska Region. The original September 2014 IHA application was revised in December 2014, January 2015, and February 2015, based on discussions with PR1. Shell also revised the turnover rate and avoidance assumptions in the bowhead whale exposure analysis and provided updated estimates of bowhead exposure on March 22, 2015. This update did not ultimately affect the total estimated number of bowheads that would be exposed to acoustic noise, but did change the methodology used to calculate exposures. Additionally, after a review of the best available information on bowhead whale density, Shell also revised the bowhead whale density estimates used in calculating exposure to match those provided by NMFS's National Marine Mammal Lab for similar analyses. Shell provided exposure estimates calculated from the new density estimates to NMFS on May 12, 2015.

2.0 Proposed Action

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

This opinion considers the effects of the authorization of an IHA to take marine mammals by harassment under the MMPA incidental to conducting a marine exploration drilling program in the Chukchi Sea during the 2015 Arctic open-water season between July 1, 2015 and October 31, 2015.

The activities outlined in this analysis have the potential to take marine mammals by “Level B” harassment as a result of sound energy introduced to the marine environment. The ESA does not define “harassment” and NMFS has not defined this term through regulation pursuant to the ESA. The MMPA defines “harassment” as “any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild” (referred to as Level A harassment) or “has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering” (referred to as Level B harassment). For the purposes of this consultation, NMFS considers that a take by “harassment” occurs when an animal is exposed to certain sound levels described below.

NMFS Acoustic Thresholds under the MMPA

NMFS established acoustic thresholds for behavioral disturbance (Level B harassment under MMPA) for pulsed sound at 160 dB re 1 μPa (rms) based mainly on the earlier observations of mysticetes reacting to airgun pulses (e.g., Malme *et al.* 1983, 1984; Richardson *et al.* 1986). Level B behavioral harassment is set at 120 dB re 1 μPa rms for continuous sounds (such vessels in dynamic positioning). NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur (Level A harassment under the MMPA), which are 180 and 190 dB re 1 μPa (rms) for cetaceans and pinnipeds, respectively. These exposure limits were intended as precautionary estimates of exposures below which physical injury would not occur in these taxa. There was no empirical evidence as to whether exposure to higher levels of pulsed sound would or would not cause auditory or other injuries. However, given the limited data then available, it could not be guaranteed that marine mammals exposed to higher levels would not be injured. Further it was recognized that behavioral disturbance could, and in some cases likely would, occur at lower received levels (Southall *et al.* 2007). The established 180- and 190-dB re 1 μPa (rms) thresholds are used to develop exclusion zones around a sound source and trigger the necessary power-down or shut-down procedures in the event a marine mammal is observed approaching (power down) or within the exclusion zone (shut down).

Sounds that may harass marine mammals will include continuous sounds generated by drilling and related support activities, and pulsed sounds generated by airguns. The effects will depend on the species of whale or seal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level (RL) of the sound. Disturbance reactions are likely to vary among some of the marine mammals in the general vicinity of the sound source. No Level A takes, serious injury, or lethal takes are expected, given the nature of the specified activities and the mitigation measures that are planned.

Shell Gulf of Mexico Inc. (Shell) is proposing to drill at up to four exploration drill sites on the Chukchi Sea Outer Continental Shelf (OCS) leases acquired from the United States (U.S.) Department of Interior, Bureau of Ocean Energy Management (BOEM). The exploration drilling planned for the 2015 season is a continuation of the Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Exploration Drilling Program) that began in 2012, and resulted in the completion of a partial well at the location known as Burger A. Exploration drilling will be done pursuant to Shell's Chukchi Sea Exploration Plan, Revision 2 (EP). Shell plans to continue its drilling operations over multiple seasons, according to the National Environmental Policy Act (NEPA) analysis associated with this action (Shell 2015b). This biological opinion analyzes effects to ESA-listed species from Shell's 2015 drilling activities, and in determining whether the action is likely to jeopardize listed species or adversely modify or destroy critical habitat, anticipates that 2016 and 2017 drilling activities would be very similar, causing similar effects to ESA-listed species. Any take of listed species in connection with future drilling activities will be subject to future consultations and be authorized at that time. The incidental take statement attached to this opinion is therefore limited to the takes proposed in the incidental harassment authorization. Moreover, these potential future drilling activities were considered in NMFS's Lease Sale 193 biological opinion, which concluded that such activities are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat (NMFS 2015).

In 2015, Shell plans to use two drilling units, the drillship *Noble Discoverer (Discoverer)* and semi-submersible *Transocean Polar Pioneer (Polar Pioneer)* to drill at up to four locations on the Burger Prospect. Both drilling units will be attended to by support vessels for the purposes of ice management, anchor handling, oil spill response (OSR), refueling, support to drilling units, and resupply. The drilling units will be accompanied by support vessels, aircraft, and oil spill response vessels (OSRV).

The *Discoverer* and *Polar Pioneer* are industry standard drilling units which will execute drilling in all manners similar to that conducted in the Beaufort and Chukchi Seas since the 1980s. During exploration drilling activities, the drilling units will emit near continuous non-pulse sounds that ensonify limited areas of the ocean bottom and intervening water column. Within the timeframe of exploration drilling activities, Shell may also conduct a particular type of short-duration Vertical Seismic Profile (VSP) survey known as a zero-offset VSP (ZVSP) at each drill site in the fall. The ZVSPs emit pulse sounds that also ensonify very limited areas of the ocean bottom and intervening water column. The entire process lasts for approximately 10-14 hours. Typically, a single ZVSP survey will be performed after drilling has reached a proposed total depth (PTD) or final depth. ZVSP was not conducted in 2012 since drilling at the Burger A drill site was stopped at the bottom of the top hole section.

NMFS expects disturbance from this action to be primarily acoustic in nature. The specific activities that may result in incidental taking of marine mammals pursuant to the requested IHA include exploration drilling, icebreaking, ZVSP, as well as three new sound categories that have been added to analyze acoustic impacts related to the 2015 exploration program: sound generated while constructing the mudline cellar (MLC), sound due to anchor handling while mooring a drilling unit at a drill site, and sound made by support vessels while on dynamic positioning (DP) when tending to the drilling units at drill sites. Other stressors associated with this action are analyzed in Section 5.0 and include exposure to vessel strike and oil and gas spills. None of these exposures are expected to rise to the level of take.

Exploration Drilling

Shell plans to continue its exploration drilling program on BOEM Alaska OCS leases at drill sites greater than 64 miles (mi) (103 kilometers [km]) from the Chukchi Sea coast during the 2015 drilling season and likely also in 2016 and 2017. Shell plans to conduct exploration drilling activities at up to four drill sites at the Burger Prospect (Table 5) utilizing two drilling units, the drillship *Discoverer* and the semi-submersible *Polar Pioneer*.

During 2012, Shell drilled a partial well at the Burger A drill site. Burger A did not reach a depth at which a ZVSP survey would be conducted, consequently one was not performed. In 2015, Shells hopes to perform a single ZVSP survey at each site when drilling has reached a PTD or final depth.

A MLC will be constructed at each drill site. The MLCs will be constructed in the seafloor using a large diameter bit operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer*.

Support Vessels

During this exploration drilling program, the *Discoverer and Polar Pioneer* will be supported by the types of vessels listed in Table 1. These drilling units will also be accompanied by oil spill response vessels (Table 2).

Two ice management vessels will support the drilling units. These vessels will enter and exit the Chukchi Sea with or ahead of the drilling units, and will generally remain in the vicinity of the drilling units during the drilling season. Ice management and ice scouting is expected to occur at distances of 20 mi (32 km) and 30 mi (48 km) respectively from the drilling units. However, these vessels may have to expand beyond these ranges depending on ice conditions.

Up to three anchor handlers will support the drilling units. These vessels will enter and exit the Chukchi Sea with or ahead of the drilling units, and will generally remain in the vicinity of the drilling units during the drilling season. When the vessels are not anchor handling, they will be available to provide other general support. Two of the three anchor handlers may be used to perform secondary ice management tasks if needed.

The planned exploration drilling activities will use three offshore supply vessels (OSV) for resupply of the drilling units and support vessels. Drilling materials, food, fuel, and other supplies will be picked up in Dutch Harbor (with possible minor resupply coming out of Kotzebue) and transported to the drilling units and support vessels.

Shell plans to use up to two science vessels; one for each drilling unit, from which sampling of drilling discharges would be conducted. The science vessel specifications are based on larger OSVs, but smaller vessels may be used.

Two tugs will tow the *Polar Pioneer* from Dutch Harbor to the Burger Prospect. After the *Polar Pioneer* is moored, the tugs will remain in the vicinity of the drilling units to help move either drilling unit in the event they need to be moved off of a drilling site due to ice or any other event. The *Discoverer* is self-propelled.

Table 1. Chukchi Sea Exploration Drilling Program – Proposed Vessel Types

Specification	**Ice Managemen Vessel (x2)**[1]	**Anchor Handler (x3)**[2]	**OSV (x3)**[3]	**Drilling Discharge Monitoring Science Vessel (x2)**[4]	**Shallow Water Vessel (x2)**[5]	**Support Tugs (x2)**[6]	**Resupply Tug and Barges (x2)**[7]	
							Tug	**Barge**
Length	380 ft. (116 m)	361 ft. (110.1 m)	300 ft. (91.5 m)	300 ft. (91.5 m)	134 ft. (40.8 m)	146 ft. (44.5 m)	150 ft. (45.7 m)	400 ft. (122 m)
Width	85 ft. (26 m)	80 ft. (24.4 m)	60 ft. (18.3 m)	60 ft. (18.3 m)	32 ft. (9.7 m)	46 ft. (14 m)	40 ft. (12.2 m)	99.5 ft. (30.3m)
Draft	27 ft. (8.4 m)	28 ft. (8.5 m)	15.9 ft. (4.9 m)	15.9 ft. (4.9 m)	6 ft. (1.8 m)	21 ft. (6.4 m)	19.5 ft. (5.9 m)	25 ft. (7.6 m)
Accommodations	82	64	50	50	22	13	11	--
Maximum Speed	16 knots (30 km/hr.)	15 knots (28 km/hr.)	13 knots (24 km/hr.)	13 knots (24 km/hr.)	10 knots (18 km/hr.)	16 knots (30 km/hr.)	12 knots (22 km/hr.)	--
Available Fuel Sto	14,192 bbl. (2,256m^3)	11,318 bbl. (1,799 m^3)	5,786 bbl. (920 m^3)	5,786 bbl. (920 m^3)	667 bbl. (106 m^3)	5,585 bbl. (888 m^3)	4,800 bbl. (774 m^3)	--

[1] **Based on Nordica or similar vessel**

[2] **Based on Aiviq or similar vessel**

[3] **Based on the Harvey Champion or similar vessel**

[4] **Based on the Harvey Champion or similar vessel**

[5] **Based on the Arctic Seal; Vessels will be located in Kotzebue Sound and not transiting to a drill site**

[6] **Based on the tug Ocean Wave; Tugs will be located in Kotzebue Sound and not transiting to a drill site**

[7] **Based on the Lauren Foss (tug) and Tuuq (barge)**

Oil Spill Response Vessels

The OSR vessel types supporting the exploration drilling program are listed in Table 2.

One dedicated OSR barge and on-site OSRV will be staged in the vicinity of the drilling unit(s) when drilling into potential liquid hydrocarbon bearing zones. This will enable the OSRV to respond to a spill and provide containment, recovery, and storage for the initial response period in the unlikely event of a well control incident.

The OSR barge, associated tug, and OSRV possess sufficient storage capacity to provide containment, recovery, and storage for the initial response period. Shell plans to use two oil storage tankers (OST). An OST will be staged at the Burger Prospect. The OST will hold fuel for Shell's drilling units, support vessels, and have space for storage of recovered liquids in the unlikely event of a well control incident. A second OST will be stationed outside the Chukchi Sea lease sale planning area and will be sited such that it will be able to respond to a well control event before the first tanker reaches its recovered liquid capacity.

The tug and barge will be used for nearshore OSR. The nearshore tug and barge will be moored near Goodhope Bay, Kotzebue Sound. The nearshore tug and barge will also carry response equipment, including one 47 ft. (14 m) skimming vessel, 34 ft. (10 m) workboats, mini-barges, boom and duplex skimming units for nearshore recovery and possibly support nearshore protection. The nearshore tug and barge will also carry designated response personnel and will mobilize to recovery areas, deploy equipment and begin response operations.

Table 2. Chukchi Sea Exploration Drilling Program – Proposed Oil Spill Response Vessel Types

Specification	OSR Vessel [1,2]	Offshore OSR [1,3]		Nearshore OSR[1,4,9]		OST [1,5]	OST [1,6,9]	Containment Barge [1,7,9]	
		Tug	Barge	Tug	Barge			Tug	Barge
Length	301 ft. (91.9 m)	126 ft. (38.4 m)	333 ft. (101.5 m)	90 ft. (27.4 m)	205 ft. (62.5 m)	748 ft. (228 m)	813 ft. (248 m)	150 ft. (45.7 m)	316.5 ft. (96.5 m)
Width	60 ft. (18.3 m)	34 ft. (10.4 m)	76 ft. (23.1 m)	32 ft. (9.8 m)	90 ft. (27.4 m)	105 ft. (32 m)	141 ft. (48 m)	40 ft. (12.2 m)	105 ft. (32 m)
Draft	19 ft. (5.8 m)	17 ft. (5.2 m)	22 ft. (6.7 m)	10 ft. (3 m)	15 ft. (4.6 m)	66 ft. (20 m)	69 ft. (21 m)	19.5 ft. (5.9 m)	12.5 ft. (3.8 m)
Accommodations	41	15	--	8	25	25	25	11	72
Maximum Speed	16 knots (30 km/hr.)	12 knots (22 km/hr.)	--	12 knots (22 km/hr.)	--	15 knots (28 km/hr.)	15 knots (28 km/hr.)	10 knots (19 km/hr.)	--
Available Fuel Storage	7,692 bbl. (1,223 m^3)	1,786 bbl. (284 m^3)	390 bbl. (62 m^3)	1,286 bbl. (204.5 m^3)	--	16,121 bbl. (2,563m^3)	20,241 bbl. (3,218 m^3)	4,800 bbl. (763 m^3)	6,630 bbl. (1,054 m^3)
Available Liquid Storage	12,245 bbl. (1,947 m^3)	--	76,900 bbl. (12,226 m^3)	--	17,000 bbl. (5,183 m^3)	106,000 bbl[8] (16,852 m^3)	670,000bbl (106,518m^3)	--	--
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 tug *Guardsman* (tug) and *Klamath* (barge)

4 based on the *Point Oliktok* (tug) and Endeavor (barge)

5 Based on a Panamax type tanker

6 Based on an Aframax type tanker

7 Based on the *Corbin Foss* (tug), *Arctic Challenger* (barge) and the *Ross Chouest* (anchor handler)

8 Total available storage is 350,000 bbl.; however, 244,000 bbl. of ULSD or a fuel with equal or lower sulfur content (used to refuel the drilling units and support vessels) will take up storage space, leaving 106,000 bbl. for recovered liquids. Storage space for recovered liquids will increase as fuel is dispensed for refueling.

9 These vessels will be moored in Kotzebue Sound; however the OST may be moored elsewhere. The remaining vessels will be stationed in the vicinity of the drilling units.

Aircraft

Offshore operations will be serviced by up to three helicopters operated out of an onshore support base in Barrow. The helicopters are not yet contracted. Sikorsky S-92s (or similar) will be used to transport crews between the onshore support base, the drilling units and support vessels with helidecks. The helicopters will also be used to haul small amounts of food, materials, equipment, samples and waste between vessels and the shorebase. Approximately 40 Barrow to Burger Prospect round trip flights will occur each week to support the additional crew change necessities for an additional drilling unit, support vessels, required sampling and analytical requirements under the National Pollutant Discharge Elimination System (NPDES) exploration facilities General Permit (GP).

The route chosen will depend on weather conditions and whether subsistence users are active on land or at sea. These routes may be modified depending on weather and subsistence uses.

Shell will also have a dedicated helicopter for Search and Rescue (SAR). The SAR helicopter is expected to be a Sikorsky S-92 (or similar). This aircraft will stay grounded at the Barrow shorebase location except during training drills, emergencies, and other non-routine events. The SAR helicopter and crew plan training flights for approximately 40 hours per month.

A fixed wing propeller or turboprop aircraft, such as the Saab 340-B, Beechcraft 1900, or De Havilland Dash 8, will be used to transport crews, materials, and equipment between Wainwright and hub airports such as Barrow or Fairbanks. It is anticipated that there will be one round trip flight every three weeks.

A fixed wing aircraft, Gulfstream Aero-Commander (or similar), will be used for photographic surveys of marine mammals. These flights will take place daily depending on weather conditions. Protected Species Observer (PSO) flight paths are located in the Marine Mammal Monitoring and Mitigation Plan (4MP) (Attachment B).

An additional Gulfstream Aero Commander may be used to provide ice reconnaissance flights to monitor ice conditions around the Burger Prospect. Typically, the flights will focus on the ice conditions within 50 mi (80 km) of the drill sites, but more extensive ice reconnaissance may occur beyond 50 mi (80 km). These flights will occur at an altitude of approximately 3,000 ft. (915 m).

Table 3. Trip Information for Support Aircraft

Aircraft Type [1] / Purpose	Trip Frequency or Duration
(1) Saab 340 B, Beechcraft 1900, Dash 8, or similar fixed-wing aircraft for transport from shorebase to regional jet service in Deadhorse or Barrow	1 trip every 3 weeks between Wainwright and Barrow or Anchorage
(3) S-92, EC225, or similar helicopters for crew rotation & groceries/supply	Approximately 40 round trips/week between shorebase & prospect – approx. 3 hr./trip
(1)S-61, S-92, EC225, or similar helicopter for search-and-rescue	Stationed in Barrow – 40 hr./month for proficiency training & trips made in emergency
(2) Gulfstream 690 Aero Commander (or similar)	Photographic marine mammal surveys and ice reconnaissance; both to occur daily when possible

[1] Similar model of aircraft may be contracted for these purposes

Vertical Seismic Profile

Shell may conduct a geophysical VSP survey at each drill site where a well is drilled in 2015. During VSP surveys, an airgun array is deployed at a location near or adjacent to the drilling units, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired, 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 VSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell will be conducting a particular form of VSP referred to as a ZVSP, in which the sound source is maintained at a constant location near the wellbore (Figure 2). Shell may use one of two typical sound sources: 1) a three-airgun array consisting of three150 cubic inch (in^3) (2,458 cubic centimeter [cm^3]) airguns, or 2) a two-airgun array consisting of two, 250 in^3 (4,097 cm^3) airguns. Specifications for the maximum volume of the array are provided in Table 4. An airgun array is depicted within its frame or sled in the photograph below. Typical receivers would consist of a standard wireline four-level Vertical Seismic Imager (VSI) tool, which has four receivers 50 ft. (15.2 m) apart.

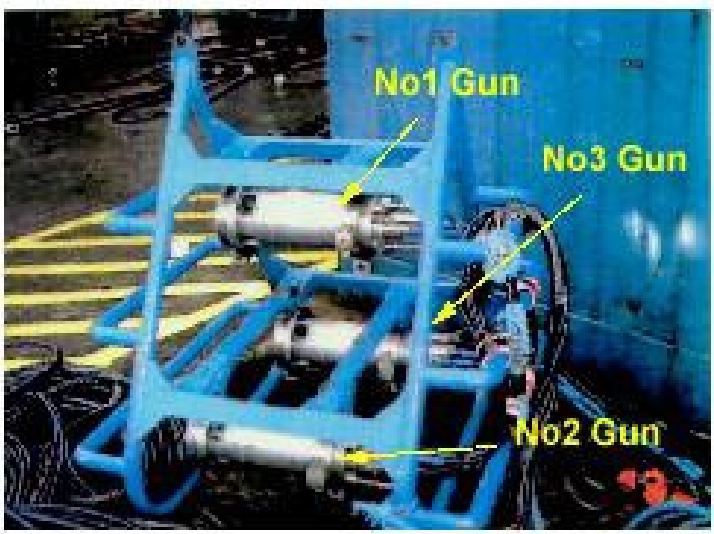

Figure 1. Photograph of the 3-airgun array in sled

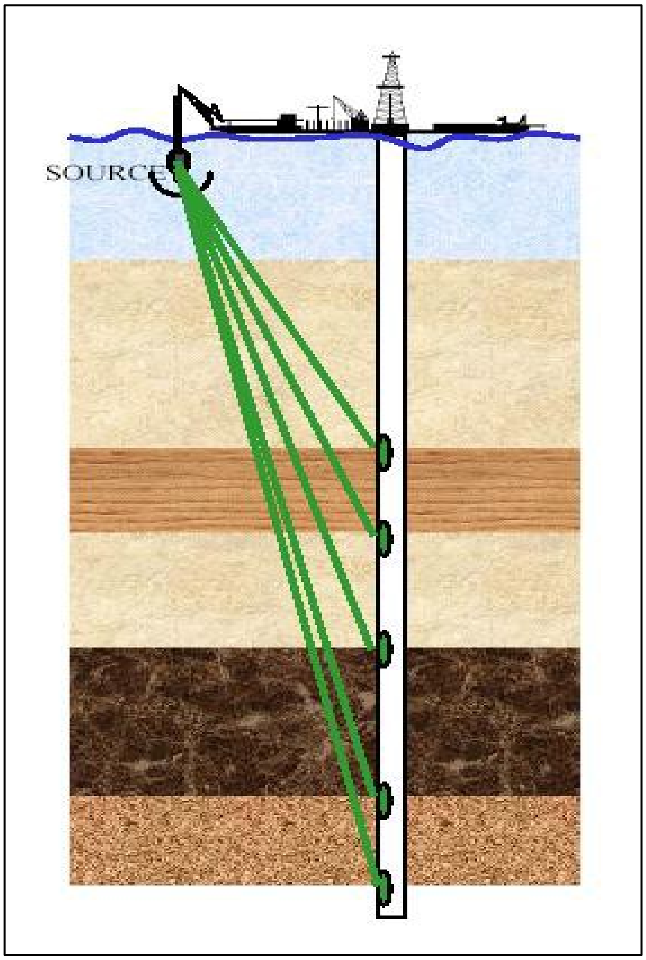

Figure 2. Schematic of ZVSP.

Table 4. Sound source (airgun array) specifications for ZVSP surveys in the Chukchi Sea in 2015

Source Type	No. Sources	Max. Total Chamber Size	Pressure	Source Depth	Zero-Peak Sound Pressure Level
Sleeve Array	(3) airguns (3) 150 in^3	450 in^3 7,374 cm^3	3,000 psi 207 bar	23 ft. (7.0 m)	241 dB rms re1µPa @1m
Sleeve Array	(2) airguns (2) 250 in^3	500 in^3 8,194 cm^3	3,000 psi 207 bar	23 ft. (7.0 m)	239 dB rms re1µPa @1m

dB re 1 µPa – decibels referenced 1 microPascal
dB – decibel

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* or *Polar Pioneer* with a crane, the sound source will be 50-200 ft. (15-61 m) from the wellhead depending on crane location, and reach a depth of approximately 10-23 ft. (3-7 m) below the water surface. The VSI along with its four receivers will be temporarily anchored in the wellbore at depth. The sound source will be pressured up to 3,000 pounds per square inch (psi) (207 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. The interval between anchor points for the VSI is usually 200-300 ft. (61-91 m). A normal ZVSP survey for each well 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

In anticipation of potential ice hazards that may be encountered, Shell will implement a Drilling Ice Management Plan (DIMP) to ensure real-time ice and weather forecasting that will identify conditions that could put operations at risk, allowing Shell to modify its activities accordingly. Shell's DIMP relies heavily on the observations and experience of its Ice Specialists and Ice Advisors, a group with experience in ice management and Arctic conditions whose sole duty is to provide critical information and provide advice to drilling unit supervisors and the drilling unit master about any and all ice-related threats. These observers and advisors will be stationed on the drilling units, the ice management vessels and the anchor handlers. The DIMP also contains ice threat classification levels depending on the time available to suspend drilling operations, secure the well and escape from advancing hazardous ice. Real-time ice and weather forecasting will be available to operations personnel for planning purposes and as a tool 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 Data Synthetic Aperture Radar - provides all-weather imagery of ice conditions with very high resolution;
- Moderate Resolution Imaging Spectroradiometer (MODIS) - a satellite providing lower resolution visual and near infrared imagery;
- Other publically available remote sensing satellite data such as Visible Infrared Imaging Radiometer Suite, Oceansat-2 Scatterometer, and Advanced Very High Resolution Radiometer;
- Aerial reconnaissance - Opportunistic photographic and observational feedback from rotary or fixed wing aircraft;
- Reports from Ice Specialists on the ice management vessel and anchor handler and from the Ice Observer on the drilling units;
- Incidental ice data provided by commercial ships transiting the area; and
- Information from the National Oceanic and Atmospheric Administration (NOAA) ice centers and the University of Colorado

Shell's ice management fleet will consist of four vessels: two ice management vessels and two anchor handler/icebreakers. Ice management that is necessary for safe operations during 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. Shell vessels will also communicate movements and activities through the 2015 North Slope Communications Centers (Com Center). Management of ice will occur during the drilling season predominated by open water, thus it will not contribute to ice hazards, such as ridging, override, or pileup in an offshore or nearshore environment.

The ice-management/anchor handling vessels will manage the ice by deflecting any ice floes that could affect the *Discoverer* or the *Polar Pioneer* when they are drilling or anchor mooring buoys even if the drilling units are not anchored at a drill site. When managing ice, the ice management vessels will generally operate upwind of the drilling units, since the wind and currents contribute to the direction of ice movement. Ice reconnaissance or ice scouting forays may occur out to 48.3 km (30 mi) from the drilling units and are conducted by the ice management vessels into ice that may move into the vicinity of exploration drilling activities. This will provide the vessel and shore-based ice advisors with the information required to decide whether or not active ice management is necessary. The actual distances from the drilling units and the patterns of ice management (distances between vessels, and width of the swath in which ice management occurs) will be determined by the ice floe speed, size, thickness, and character, and wind forecast.

Ice floe frequency and intensity is unpredictable and could range from no ice to ice densities that exceed ice-management capabilities, in which case drilling activities might be stopped and the drilling units disconnected from their moorings and moved off site. The *Discoverer* was disconnected from its moorings once during the 2012 season to avoid a potential encounter with multi-year ice flows of sufficient size to halt activities. Advance scouting of ice primarily north and east of the Burger A well by the ice management vessels did not detect ice of sufficient size or thickness to warrant disconnecting the *Discoverer* from its moorings during the remainder of the 2012 season. If ice is present, ice management activities may be necessary in early July, at discrete intervals at other times during the season, and towards the end of operations in late October. However, data regarding historic ice patterns in the area of activities indicate that it will not be required throughout the planned 2015 drilling season.

Figure 3 depicts the vessel tracts of the *Fennica* and *Tor Viking* in the Chukchi Sea from August 31-to September 13, 2012, during which active ice management occurred in relation to the location of Burger A. Combined, these vessel tracts show the patterns of ice management by vessels and the duration of time necessary for active ice management in 2012. In total, seven days of active ice management by vessels occurred in support of Shell’s exploration drilling program in the Chukchi Sea during the 2012 season.

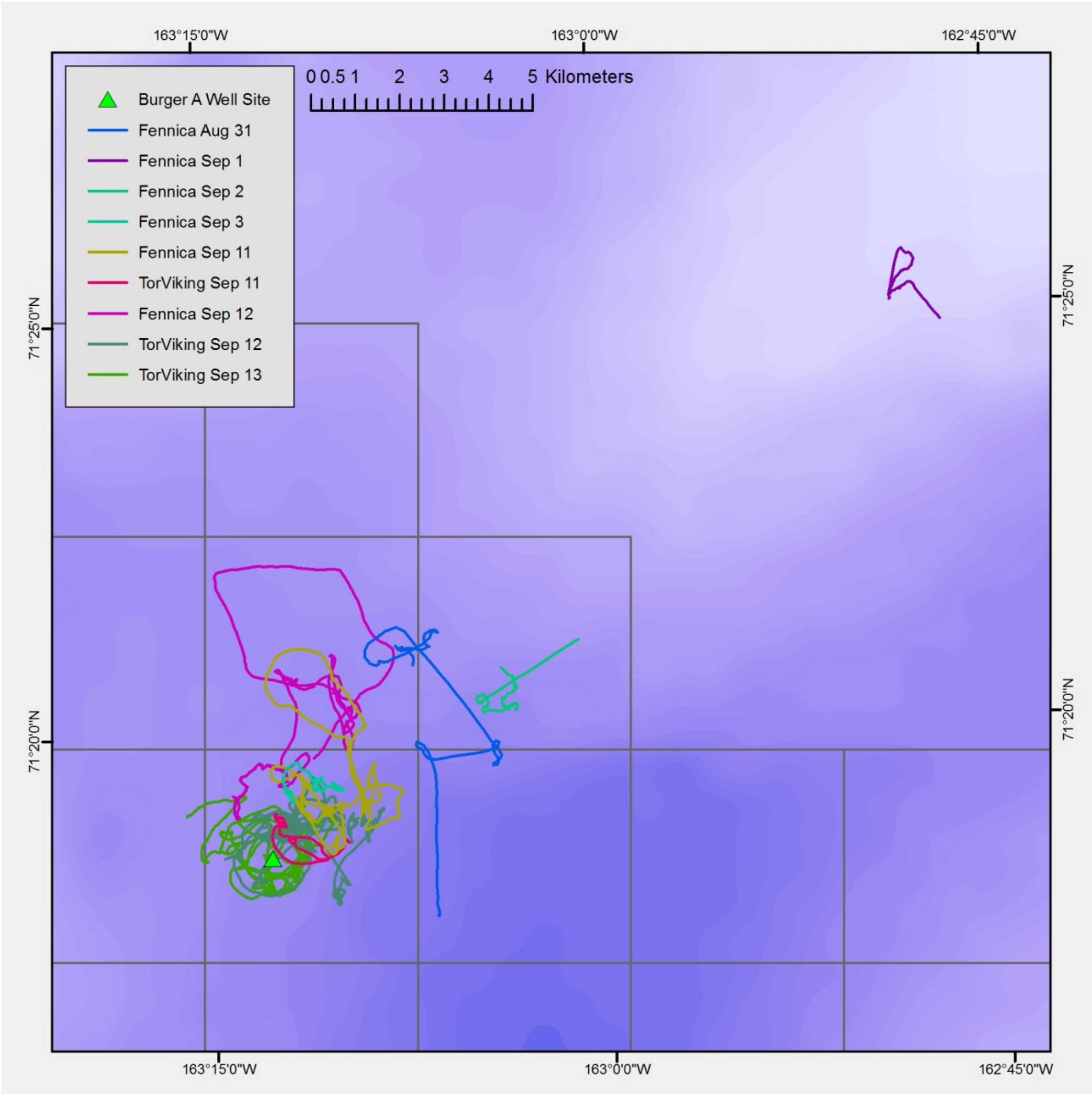

Figure 3. Ice Management Vessel Movements during 2012 in the Chukchi Sea

When ice is present at a drill site, ice disturbance will be limited to the minimum amount needed to allow drilling to continue. First-year ice will be the type most likely to be encountered. The ice-management vessel will be tasked with managing the ice so that it flows easily around the drilling units and their anchor moorings without building up in front of either. This type of ice is managed by the ice-management vessel continually moving back and forth across the drift line, directly up drift of the drilling units and making turns at both ends, or in circular patterns. During ice-management, the vessel's propeller is rotating at approximately 15 to 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, and thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice features that would be managed at a much slower speed than that used to manage first-year ice.

As detailed in Shell's DIMP, in 2012 Shell's ice management vessels conducted ice management to protect moorings for the *Discoverer* after the drilling unit was moved off of the Burger A well. This work consisted of re-directing flows as necessary to avoid potential impact with mooring buoys, without the necessity to break up multi-year ice flowbergs. Actual breaking of ice may need to occur in the event that ice conditions in the immediate vicinity of activities create a safety hazard for the drilling unit, or its moorings. In such a circumstance, operations personnel will follow the guidelines established in the DIMP 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. Despite Shell's experience in 2012, historical data relative to ice conditions in the Chukchi Sea in the vicinity of Shell's planned 2015 activities, establishes that there is a low probability for the type of hazardous ice conditions that might necessitate icebreaking (e.g., records of the National Naval Ice Center archives; Shell/SIWAC). The probability, however, could be greater at the beginning and/or the end of the drilling season (early July or late October). For the purposes of evaluating possible impacts of the planned activities, Shell has assumed icebreaking activities for a limited period of time, and estimated incidental exposures of marine mammals from such activities.

Mitigation Measures Required by PR1

The mitigation measures described below are required per the NMFS IHA stipulations, and will be implemented by Shell to reduce potential impacts to marine mammals from drilling activities.

All authorizations for shipboard surveys and drilling operations would include guidance for protected species identification, vessel strike avoidance and injured/dead protected species reporting. The lessee and/or operator must ensure that all vessels conducting exploration activities comply with the vessel strike avoidance measures specified below except under extraordinary circumstances when the safety of the vessel or crew are in doubt or the safety of life at sea is in question.

Vessel strike avoidance measures have been included in the proposed action, and include maintaining a vigilant watch for listed whales and pinnipeds and slowing down or stopping vessels to avoid striking protected species by observing the 5 kt (9.26 km/h) speed restriction when within 900ft of cetaceans or pinnipeds.

(a) All vessels shall reduce speed to a maximum of 5 knots when within 900 ft (300 yards /274 m) of whales. Those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group; For purposes of the MMPA authorization, a group is defined as a being three or more whales observed within a 500 meter area and displaying behaviors of directed or coordinated activity (e.g., group feeding);

(b) Avoid multiple changes in direction and speed when within 900 ft (300 yards /274 m) of whales;

(c) When weather conditions require, such as when visibility drops, support vessels must reduce speed and change direction, as necessary (and as operationally practicable), to avoid the likelihood of injury to whales;

(d) Aircraft shall not fly within 1,000 ft (305 m) of marine mammals or below 1,500 ft (457 m) altitude (except during takeoffs, landings, or in emergency situations) while over land or sea;

(e) Check the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the propellers are engaged;

(f) In the Chukchi Sea, vessels should remain as far offshore as weather and ice conditions allow and at least 5 mi (8 km) offshore during transit;

(g) Utilize two, NMFS-approved vessel-based Protected Species Observers (PSOs) (except during meal times and restroom breaks, when at least one PSO will be on watch) aboard the drilling units to visually watch for and monitor marine mammals near the drilling units or support vessel during active drilling or airgun operations (from nautical twilight-dawn to nautical twilight-dusk), before and during start-ups of airguns day or night, and for 30 minutes after the activities are ceased. At least one PSO will be aboard each support vessel to conduct watch. The vessels' crew shall also assist in detecting marine mammals, when practicable.

(h) PSOs shall have access to reticle binoculars (7x50 Fujinon), big-eye binoculars (25x150), and night vision devices. PSO shifts shall last no longer than 4 consecutive hours and shall not be on watch more than 12 hours in a 24-hour period. PSOs shall also make observations during daytime periods when active operations are not being conducted for comparison of animal abundance and behavior, when feasible;

(i) When a mammal sighting is made, the following information about the sighting will be recorded by the PSOs:

(i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from the PSO, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;

(ii) Time, location, speed, activity of the vessel, sea state, ice cover, visibility, and sun glare;

(iii) The positions of other vessel(s) in the vicinity of the PSO location; and

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

(j) PSO teams shall consist of Alaska Native observers and experienced field biologists to the extent practicable. An experienced field crew leader will supervise the PSO team onboard the survey vessel. New observers shall be paired with experienced observers to avoid situations where lack of experience impairs the quality of observations;

(k) PSOs will complete a two or three-day training session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2015 open-water season. The training session(s) will be conducted by qualified marine mammalogists with extensive crew-leader experience during previous vessel-based monitoring programs. A marine mammal observers' handbook, adapted for the specifics of the planned program, will be reviewed as part of the training;

(l) PSO training that is conducted prior to the start of the survey activities shall be conducted with both Alaska Native PSOs and biologist PSOs being trained at the same time in the same room. There shall not be separate training courses for the different PSOs; and

(m) PSOs shall be trained using visual aids (e.g., videos, photos), to help them identify the species that they are likely to encounter in the conditions under which the animals will likely be seen.

(n) Within safe limits, the PSOs should be stationed where they have the best possible viewing. Viewing may not always be best from the ship bridge, and in some cases may be best from higher positions with less visual obstructions (e.g., flying bridge);

(o) PSOs should be instructed to identify animals as unknown where appropriate rather than strive to identify a species if there is significant uncertainty;

(p) PSOs should maximize their time with eyes on the water. This may require new means of recording data (e.g., audio recorder) or the presence of a data recorder so that the observers can simply relay information to them; and

(q) PSOs should plot marine mammal sightings in near real-time for their vessel into a GIS software program and relay information regarding the animal(s)' position between platforms and vessels with emphasis placed on relaying sightings with the greatest potential to involve mitigation or reconsideration of the vessel's course.

ZVSP Mitigation and Monitoring Measures

(a) PSOs shall conduct monitoring while the airgun array is being deployed or recovered from the water;

(b) PSOs shall visually observe the entire extent of the exclusion zone (EZ) (which is the area defined by the 180 dB re 1 μPa [rms] isopleth for cetaceans and the 190 dB re 1 μPa [rms] isopleth for pinnipeds) using NMFS-qualified PSOs, for at least 30 minutes (min) prior to starting the airgun array (day or night). If the PSO finds a marine mammal within the EZ, Shell must delay the seismic survey until the marine mammal(s) has left the area. If the PSO sees a marine mammal that surfaces then dives below the surface, the PSO shall continue the watch. If the marine mammal has not been observed outside of the EZ at the conclusion of the initial 30 min period, the start of the survey shall, if necessary, be delayed such that it has been 15 min for species with shorter dive durations (small odontocetes and pinnipeds) or 30 min for species with longer dive durations (mysticetes and large odontocetes such as beluga whales) since the animal was observed in the

EZ. If the PSO sees no marine mammals during that time, they may assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 min period (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 μPa (rms), the Holder of this Authorization may start the second airgun without observing the entire EZ for 30 min prior, provided no marine mammals are known to be near the EZ;

(c) Establish and monitor a 180 dB re 1 μPa (rms) and a 190 dB re 1 μPa (rms) EZ for marine mammals before the airgun array is in operation. Before the field verification tests, described in condition 10(c)(i) below, the 180 dB radius is temporarily designated to be 1.38 km and the 190 dB radius is temporarily designated to be 255 m;

(d) Implement a "ramp-up" procedure when starting up at the beginning of seismic operations.

Ramp-up Procedures:

A ramp-up procedure gradually increases airgun volume at a specified rate to encourage any marine mammals to leave the area prior to experiencing harm. Shell will use the ramp-up procedure prior to commencing airgun operations after shutdowns. The ramp-up rate shall be less than a 6 dB increase in volume per five minute period. During the pre-ramp-up observation period, the entire EZ must be visible at all times. Ramp-up will not be initiated if a listed marine mammal is observed within the EZ. Should marine mammals enter the EZ during ramp-up, ramp-up operations will cease until the EZ is void of all listed marine mammals. At this time, ramp-up procedures will begin anew (i.e., the process will not resume at the level of acoustic output at which ramp-up was discontinued due to the presence of marine mammals). Pre-ramp-up observation periods are not necessary if a mitigation gun has been operating continuously during a daytime power-down or during a daytime shut-down lasting less than 10 minutes. Ramping up following a power-down that concluded between sunset and sunrise will only occur if the source vessels' mitigation gun has been operating continuously since initiation of the power-down, noting that the mitigation gun may not be operated for more than three hours at a time. Ramp-up procedures are not required if there has been an interruption of airgun operations for less than 10 minutes, and operations are returning to a state in which acoustic output is equal to or less than what was occurring prior to the <10-minute interruption of airgun acoustic output.

(e) Power-down or shutdown the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant EZ.

Power-Down Procedures:

A power-down means reducing the number of operating airguns to a single operating airgun, which reduces the EZ to degree spatial extent that the animal(s) is no longer in or about to enter. Following a power-down, if the marine mammal approaches the smaller designated EZ, the airguns must then be completely shutdown. Power-down procedures will begin immediately when any member of the vessel crew observes one or more listed marine mammals approaching the EZ, or upon orders by the PSO. If one or more threatened or endangered marine mammals are detected adjacent to, but outside of the EZ, and is determined by any PSO that the animal or animals are likely to enter the EZ, then power-down procedures will be implemented. Increase in acoustic output from airguns or airgun arrays will not occur until the EZ is void of listed marine mammals. The EZ will be considered void of listed marine mammals if:

- The animals that were observed within the EZ were all observed to have left; or
- No listed marine mammals have been seen within the EZ for:
  - 15 minutes, in the case of pinnipeds;
  - 30 minutes, in the case of cetaceans.

Note that if a power-down lasts for more than 10 minutes, ramp up procedures will be followed.

Shut-down Procedures:
A shutdown occurs when all airgun activity (including mitigation guns) ceases. Shut-down procedures will begin immediately upon observing one or more listed marine mammals within their respective EZ by any member of the vessel crew, or upon orders by any PSO. In addition, if one or more threatened or endangered cetaceans are detected adjacent to, but outside of, the 180 dB cetacean exclusion zone, or if one or more threatened or endangered pinnipeds are detected adjacent to, but outside of, the 190 dB pinniped exclusion zone, and it is determined by any PSO that the animal or animals are likely to enter the exclusion zone, then the PSO will issue the order to shut down seismic operations.

Following a shutdown, airgun activity will not resume until the EZ is void of listed marine mammals. The EZ will be considered void of listed marine mammals if:

- The animals that were observed within the EZ were all observed to have left the area and no other animals have entered the EZ since the shut down: or
- Listed marine mammals have not been seen within the EZ for:
  - 15 minutes, in the case of pinnipeds,
  - 30 minutes, in the case of cetaceans.

After a shutdown of seismic operations, ramp-up procedures will be followed. If there is a gap in airgun operations of more than 30 minutes between sunset and sunrise, seismic survey activities will be suspended until after sunrise and at such time that the entirety of the 160 dB disturbance zone is visible for at least 30 minutes prior to commencing ramp-up.

(f) ZVSP surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant EZs are visible and can be effectively monitored;

(i) If, for any reason, electrical power to the airgun array has been discontinued for a period of 10 minutes or more, ramp-up procedures shall be implemented. Only if the PSO watch has been suspended, a 30-minute clearance of the exclusion zone is required prior to commencing ramp-up. Discontinuation of airgun activity for less than 10 minutes does not require a ramp-up; and

(j) No initiation of airgun array operations is permitted from a shutdown position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant EZ cannot be effectively monitored by the PSO(s) on duty.

(k) When utilizing the mitigation airgun, use a reduced duty cycle.

Monitoring Measures:

(a) Vessel-based Monitoring: Shell shall designate trained PSOs aboard drilling units, ice management vessels, and anchor handlers. All support vessels will be staffed with at least one trained PSO. The PSOs are required to monitor for marine mammals in order to implement the mitigation measures described in conditions 7 and 8 above;

(b) Aerial Survey Monitoring: Shell must implement the aerial survey monitoring program detailed in its Marine Mammal Mitigation and Monitoring Plan (4MP); and

(c) Acoustic Monitoring:

(i) Field Source Verification: Shell is required to conduct sound source verification tests for the drilling units, support vessels, and the airgun array not measured in previous seasons. Sound source verification shall consist of distances where broadside and endfire directions at which broadband received levels reach 190, 180, 170, 160, and 120 dB re 1 μPa (rms) for all active acoustic sources that may be used during the activities. For the airgun array, the configurations shall include at least the full array and the operation of a single source that will be used during power downs.

(ii) Acoustic "Net" Array: Deploy acoustic recorders widely across the U.S. Chukchi Sea and on the prospect in order to gain information on the distribution of marine mammals in the region. This program must be implemented as detailed in the 4MP.

Reporting Requirements:

(a) Submit daily PSO logs to NMFS as reasonably practicable;

(b) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the exploration drilling program. This report must contain and summarize the following information:

(i) Summaries of monitoring effort (e.g., total hours, total distances, and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals);

(ii) Sound source verification and sound source characterization results for drilling units and vessels recorded in 2015;

(iii) Analyses of the effects of various factors influencing detectability of marine mammals (e.g., sea state, number of observers, and fog/glare);

(iv) Species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover;

(v) Sighting rates of marine mammals during periods with and without exploration drilling activities (and other variables that could affect detectability), such as:

(A) initial sighting distances versus drilling state;

(B) closest point of approach versus drilling state;

(C) observed behaviors and types of movements versus drilling state;

(D) numbers of sightings/individuals seen versus drilling state;

(E) distribution around the survey vessel versus drilling state; and

(F) estimates of take by harassment;

(vi) Reported results from all hypothesis tests should include estimates of the associated statistical power when practicable;

(vii) Estimate and report uncertainty in all take estimates. Uncertainty could be expressed by the presentation of confidence limits, a minimum-maximum, posterior probability distribution, etc.; the exact approach will be selected based on the sampling method and data available;

(viii) The report should clearly compare authorized takes to the level of actual estimated takes;

(ix) Sampling of the relative near-field around operations should be corrected for effort to provide the best possible estimates of marine mammals in EZs and exposure zones;
(x) If changes are made to the monitoring program after the independent monitoring plan peer review, those changes must be detailed in the report; and
(xi) Sightability curves and analysis overlaying visual and acoustic detections.

(c) The draft report will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final report prior to acceptance by NMFS. The draft report will be considered the final report for this activity under this Authorization if NMFS has not provided comments and recommendations within 90 days of receipt of the draft report.

(d) A draft comprehensive report describing the aerial, acoustic, and vessel-based monitoring programs will be prepared and submitted within 240 days after the date of this Authorization. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of all industry activities and their impacts on marine mammals in the Arctic Ocean during 2015.

(e) The draft comprehensive report will be subject to review and comment by NMFS, the Alaska Eskimo Whaling Commission, and the North Slope Borough Department of Wildlife Management. The draft comprehensive report will be accepted by NMFS as the final comprehensive report upon incorporation of comments and recommendations.

Level A harassment

(a) In the unanticipated event that the drilling program operation clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), Shell shall immediately cease operations and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, by phone or email and the Alaska Regional Stranding Coordinator. The report must include the following information:

(i) time, date, and location (latitude/longitude) of the incident;
(ii) the name and type of vessel involved;
(iii) the vessel’s speed during and leading up to the incident;
(iv) description of the incident;
(v) status of all sound source use in the 24 hours preceding the incident;
(vi) water depth;
(vii) environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
(viii) description of marine mammal observations in the 24 hours preceding the incident;
(ix) species identification or description of the animal(s) involved;
(x) the fate of the animal(s); and
(xi) photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with Shell to determine what is necessary to minimize the likelihood of further prohibited take and ensure compliance with the MMPA and ESA. Shell may not resume its activities until notified by NMFS via letter, email, or telephone.

(b) In the event that Shell discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), Shell will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, by phone or email and the NMFS Alaska Stranding Hotline and/or by email to the Alaska Regional Stranding Coordinator. The report must include the same information identified in Condition (a) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with Shell to determine whether modifications in the activities are appropriate.

(c) In the event that Shell discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Shell shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, by phone or email and the NMFS Alaska Stranding Hotline and/or by email to the Alaska Regional Stranding Coordinator, within 24 hours of the discovery. Shell shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

Oil Spill - In the unlikely event of an oil spill, Shell shall comply with NOAA's Marine Mammal Oil Spill Response Guidelines, to the extent practicable.

Mitigation Measures Required by BOEM

In consultation with NMFS on BOEM's Lease Sale 193, BOEM implemented the following mitigation measures regarding transit through designated North Pacific right whale critical habitat in the Bering Sea. This action falls under the programmatic scope of that biological opinion (NMFS 2015), and so this mitigation measure is considered part of this action.

The lessee and/or operator will avoid transits within designated North Pacific right whale critical habitat. If transit with North Pacific right whale critical habitat cannot be avoided, vessel operators are requested to exercise extreme caution and observe the of 10 kn (18.52 km/h) vessel speed restriction while within North Pacific right whale critical habitat. Lessee and/or operators transiting through North Pacific right whale critical habitat will have PSOs actively engaged in sighting marine mammals. PSOs would increase vigilance and allow for reasonable and practicable actions to avoid collisions with North Pacific right whales. Lessee and/or operators will maneuver vessels to keep 800 m away from any observed North Pacific right whales while within their designated critical habitat, avoid approaching whales head-on consistent with vessel safety. Vessels should take reasonable steps to alert other vessels in the vicinity of whale(s), and report of any dead or injured listed whales or pinnipeds.

2.1 Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). For this reason, the action area is typically larger than the project area and extends out to a point where no measurable effects from the proposed action occur.

The action area for this biological opinion includes: (1) the exploration drilling sites in the OCS of the Chukchi Sea; (2) the ensonified area plus a safety factor; (3) coastal communities that supply refueling and resupply; (4) State of Alaska waters between planning areas and the Alaska coastline; and (5) transit route from Dutch Harbor through the Bering Strait into the Chukchi Sea (Figure 4).

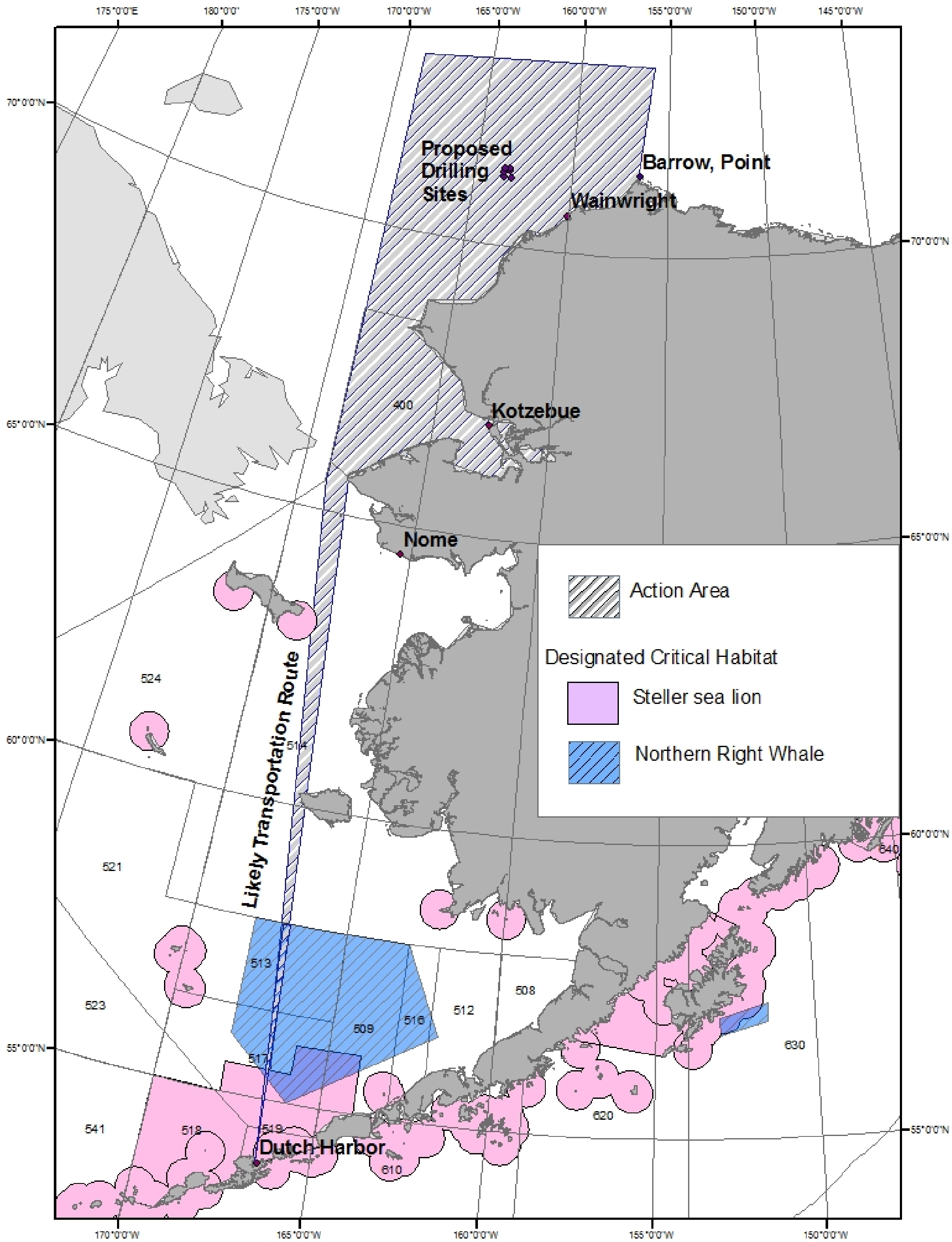

Figure 4. Action Area and its juxtaposition to Steller sea lion and Northern right whale critical habitat.

The Chukchi Sea

The Chukchi Sea is a marginal sea of the Arctic Ocean that is bounded on the west by the De Long Strait of Wrangel Island and in the east by Point Barrow, Alaska, beyond which lays the Beaufort Sea. The Bering Strait forms its southernmost limit and connects it to the Bering Sea and the Pacific Ocean. The Chukchi Sea is predominantly a shallow sea with a mean depth of 40 to 50 m (131 to 164 ft). Gentle mounds and shallow troughs characterize the seafloor morphology of the Chukchi Sea. The Chukchi Sea shelf is approximately 500 km (311 mi) wide and extends roughly 800 km (497 mi) northward from the Bering Strait to the continental shelf break. Beyond the shelf break, water depths increase quickly beyond 1,000 m (3,281 ft) (BOEMRE 2011a).

Exploration Drilling

All drill sites for this action are located at Shell's Burger Prospect as described in the Revised Chukchi Sea EP submitted to BOEM. Shell has identified a total of six Chukchi Sea lease blocks on the Burger Prospect. All six drill sites listed in Table 5 are located more than 64 mi (103 km) off the Chukchi Sea coast. During 2015, the *Discoverer* and *Polar Pioneer* will be used to conduct exploration drilling activities at up to four exploration drill sites. As with any Arctic exploration program, weather and ice conditions will dictate actual operations.

Activities associated with the Chukchi Sea exploration drilling program include operation of the *Discoverer*, *Polar Pioneer*, and associated support vessels. The drilling units 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. Potential Drilling sites are shown in Figure 5.

Table 5. Drill Site Locations and Water Depths

Drill Site	Approximate Distance from shore (statute miles)	Lease Block Number	Surface Location (NAD 83)		Water Depth
			Latitude (north)	Longitude (west)	Feet/Meters
Burger A[1]	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

[1] Burger A drill site where a partial well was begun in 2012

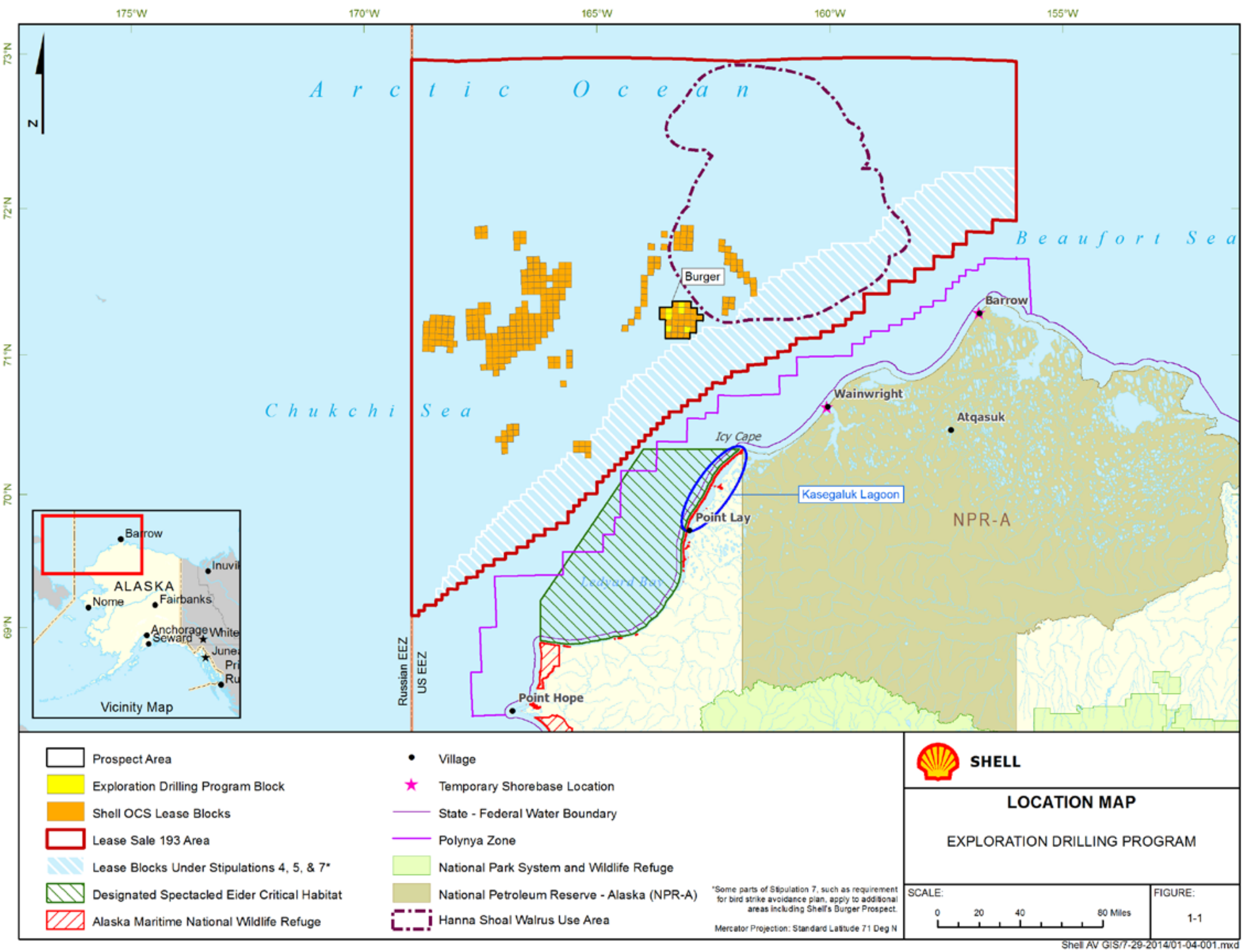

Figure 5. Drill Site Locations

Sound Propagation Conservative Measures

Shell included conservative measures in their estimations of ensonified areas for both continuous and pulsed sounds. For continuous sounds, a "safety factor" of 1.3 dB re 1µPa rms was added to the source level for each sound source prior to modeling activity scenarios to account for variability across the project area associated with received levels at different depths, geoacoustical properties, and sound-speed profiles. The addition of the 1.3 dB re 1 µPa rms safety factor to source levels resulted in an approximate 20 percent increase in the distance to the 120 dB re 1µPa rms threshold for each continuous source. For pulsed sounds, after all possible array configurations and operating depths were modeled to identify the arrangement with the greatest sound propagation characteristics; the resulting ≥160 dB re 1µPa rms radius was multiplied by 1.5 as a conservative measure prior to estimating exposed areas, which is discussed in greater detail below. The depictions of these areas are shown in Figure 14 through Figure 17.

Alaska State Waters

The action area includes State of Alaska waters between drilling locations and the Alaska coastline. Drilling will occur within the OCS of the Chukchi Sea. However, staging, crew change, and resupply activities may occur from Alaskan Arctic communities (e.g. Barrow, Nome, Kotzebue, and Wainwright). Approximately 40 Barrow to Burger Prospect round trip flights will occur each week to support the additional crew change necessities (Shell 2015). While the activities described as part of this proposed action may affect areas within state waters directly or indirectly, the drilling will not be conducted within state waters.

Transit Areas

Shell's exploration drilling activities will occur within the OCS of the Chukchi Sea and will use three offshore supply vessels (OSV) for resupply of the drilling units and support vessels. Drilling materials, food, fuel, and other supplies will be picked up in Dutch Harbor (with possible minor resupply coming out of Kotzebue) and transported to the drilling units and support vessels. Two tugs will tow the *Polar Pioneer* from Dutch Harbor to the Burger Prospect (Shell 2015). For these reasons, the oceanographic area extends along a navigational route from Dutch Harbor through the Bering Strait. We recognize that staging and resupply may also occur from Alaskan Arctic communities (e.g. Nome, Kotzebue, Wainwright, Barrow, Prudhoe Bay, and Deadhorse). These locations and their staging waters are already encompassed in the action area under state waters.

2.2 Introduction to the Biological Opinion

Section 7(a)(2) of the ESA requires federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts to the conservation value of the designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). As NMFS explained when it promulgated this definition, NMFS considers the likely impacts to a species' survival as well as likely impacts to its recovery. Further, it is possible that in certain, exceptional circumstances, injury to recovery alone may result in a jeopardy biological opinion (51 FR 19926, 19934; June 2, 1986).

This biological opinion does not rely on the regulatory definition of 'destruction or adverse modification' of critical habitat at 50 CFR 402.02, which the Ninth Circuit Court of Appeals held to be invalid in *Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service*, 378 F.3d 1059 (9th Cir. 2004) amended by 387 F.3d 968 (9th Cir. 2004). Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. [2]

Approach to the Assessment

We will use the following approach to determine whether the proposed action described in Section 1.3 is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify those aspects of proposed actions that are likely to have direct and indirect effects on the physical, chemical, and biotic environment of the project area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step represent the action area for the consultation.

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called “primary constituent elements” or PCEs in some designations) - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 2.2.

- Describe the environmental baseline for the proposed action. The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area*. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

- Analyze the effects of the proposed actions. Identify the listed species that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action’s effects and the populations or subpopulations those individuals represent. NMFS also evaluates the proposed action’s effects on critical habitat features. The effects of the action are described in Section 2.4 of this opinion with the exposure analysis described in Section 2.4.2 of this opinion.

- Once we identify which listed species are likely to be exposed to an action’s effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed species are likely to respond given their exposure (these represent our *response analyses*). Response analysis is considered in Section 2.4.3 of this opinion.

[2] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the “Destruction or Adverse Modification” Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

- Describe any cumulative effects. Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.

- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of survival of the species in the wild by reducing its numbers, reproduction, or distribution; (2) appreciably reduce the likelihood of recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (3) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2). The final steps of our analyses - establishing the risks those responses pose to listed resources - are different for listed species and designated critical habitat (these represent our *risk* analyses). Integration and synthesis with risk analyses occurs in Section 2.6 of this opinion.

- Reach conclusions regarding whether jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7. These conclusions flow from the logic and rationale presented in the Integration and Synthesis section 2.6.

- If NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative(s) (RPA) to the action in Section 2.8. The RPAs must not be likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify their designated critical habitat, and the RPAs must meet other regulatory requirements.

Risk Analyses

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those species have been listed, which can include subspecies and distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations is determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals' risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

When individual, listed plants or animals are expected to experience reductions in their current or expected future reproductive success or experience reductions in the rates at which they grow, mature, or become reproductively active, we would expect those reductions to also reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Stearns 1992). Reductions in one or more of these variables (or one of the variables we derive from them) is a necessary condition for reductions in a population's viability, which is itself a necessary condition for reductions in a species' viability. On the other hand, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (for example, see Anderson 2000, Mills and Beatty 1979, Stearns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

If, however, we conclude that listed plants or animals are likely to experience reductions in their current or expected future reproductive success, our assessment tries to determine if those reductions are likely to be sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this opinion) as our point of reference. Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the Status of the Species section of this opinion) as our point of reference. This approach allows us to assess how particular behavioral decisions are likely to influence individual reproductive success (Bejder et al. 2009). Individual-level effects can then be translated into changes in demographic parameters of populations, thus allowing for an assessment of the biological significance of particular human disturbances.

3.0 Rangewide Status of the Species and Critical Habitat

Nine species of marine mammals listed under the ESA under NMFS's jurisdiction may occur in the action area. The action area also includes designated critical habitat for the North Pacific right whale and the western Steller sea lion (**Table** 6).

Table 6. Listing status and critical habitat designation for marine mammal species considered in this opinion.

Species	Status	Listing	Critical Habitat
Balanea mysticetus (Bowhead Whale)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Balaneoptera physalus (Fin Whale)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Megaptera novaeangliae (Humpback Whale [2])	Endangered	NMFS 1970, 35 FR 18319	Not designated
Eubalaena japonica (North Pacific Right Whale)	Endangered	NMFS 2008, 73 FR 12024	NMFS 2008, 73 FR 19000
Eschrichtius robustus (Western DPS North Pacific Gray Whale)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Physeter macroephalus (Sperm Whale)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Phoca hispida hispida (Arctic Ringed Seal)	Threatened	NMFS 2012, 77 FR 76706	Proposed Designation
Erignathus barbatus nauticus (Beringia DPS Bearded Seal[1])	Threatened	NMFS 2012, 77 FR76740	Not proposed
Eumetopias jubatus (Western DPS Steller Sea Lion)	Endangered	NMFS 1997, 62 FR 24345	NMFS 1993, 58 FR 45269

[1] As noted above under section 1.1, the threatened status for Beringia DPS bearded seals was vacated by the US District Court for the District of Alaska, but that ruling is under appeal and in the interim our biological opinions continue to address effects to bearded seals so action agencies have the benefit of NMFS's analysis.

[2] NMFS recently conducted a global status review and proposed changing the status of humpback whales under the ESA such that the Central North Pacific stock would no longer be listed (80 FR 22304; April 21, 2015). Final action on that proposal is not expected until after this consultation and the 2015 drilling season are completed.

3.1 Species and Critical Habitat Not Considered Further in this Opinion

As described in the *Approach to the Assessment* section of this opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are likely to be adversely affected. The first criterion was *exposure* or some reasonable expectation of a co-occurrence between one or more potential stressors associated with Shell's activities and a listed species or designated critical habitat. The second criterion is the probability of a *response* given exposure. For endangered or threatened species, we consider the *susceptibility* of the species that may be exposed;

for example, species that are exposed to sound fields produced by active seismic activities, but are not likely to exhibit physical, physiological, or behavioral responses given that exposure (at the combination of sound pressure levels and distances associated with an exposure), are not likely to be adversely affected by the seismic activity. For designated critical habitat, we consider the *susceptibility* of the constituent elements or the physical, chemical, or biotic resources whose quantity, quality, or availability make the designated critical habitat valuable for an endangered or threatened species. If we conclude that the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to a stressor and a stressor is not likely to exclude listed individuals from designated critical habitat, we would conclude that the stressor may affect, but is not likely to adversely affect the designated critical habitat.

We applied these criteria to the species and critical habitats listed above and determined that the following species and designated critical habitats are not likely to be adversely affected by the proposed action: North Pacific right whales, Western DPS of gray whales, sperm whales, Western DPS of Steller sea lion or the designated critical habitats of these species. Our rationale follows.

Cetaceans

Vessels transiting to and from drilling locations in the Chukchi Sea will overlap with the ranges of North Pacific right whales, western gray whales, and sperm whales as well as the designated critical habitat of North Pacific right whales in the eastern Bering Sea. Shell anticipates using 27 vessels during this action (Table 1 and Table 2).

Based on the extremely small number of observations of North Pacific right, western gray, and sperm whales in the Bering Sea, the limited number of vessels being mobilized out of Dutch Harbor, the transitory nature of vessels heading to and from project sites, the lack of spatial overlap between North Pacific right, western gray, and sperm whales known distribution and the drilling areas in the Chukchi Sea (Figure 4), mitigation measures to avoid cetaceans while vessels are transiting, and the decades of vessels transiting in the Bering and Chukchi Seas without a known ship strike of these species, it is extremely unlikely that any of these cetaceans will be struck by vessels associated with Shell's proposed activities, and such effects are discountable. Any noise or visual disturbance from vessels transiting would be brief and the effects on these whales are expected to be small enough in scale to be immeasurable. The resulting effects on cetaceans would be insignificant and would not result in take. Therefore, we conclude that the proposed action is not likely to adversely affect these cetaceans and we do not consider them further in this opinion.

Critical habitat for the North Pacific right whale (NPRW) was designated in the eastern Bering Sea and in the Gulf of Alaska on April 8, 2008 (73 FR 19000). Only the critical habitat in the eastern Bering Sea overlaps with the proposed action (see Figure 7). The primary constituent elements deemed necessary for the conservation of North Pacific right whales include the presence of specific copepods (*Calanus marshallae, Neocalanus cristatus,* and *N. plumchris*), and euphausiids (*Thysanoessa Raschii*) that act as primary prey items for the species.

Vessels transiting to and from Dutch Harbor may enter the Bering Sea portion of North Pacific right whale critical habitat. However, vessel traffic alone is not anticipated to affect aggregations of copepods or euphausiids, and therefore will not affect the PCEs associated with NPRW whale critical habitat. In addition, the critical habitat in the Bering Sea would not be exposed to stressors associated with drilling operations since those activities are only authorized to occur within the Chukchi Sea and the activities will occur far enough away from the critical habitat area that received sound levels within the habitat will not exceed 120 dB re 1 μPa (rms). For these reasons, we do not expect critical habitat for the NPRW whale to be adversely affected by Shell's authorized activities; therefore, we do not consider North Pacific right whale critical habitat further in this opinion.

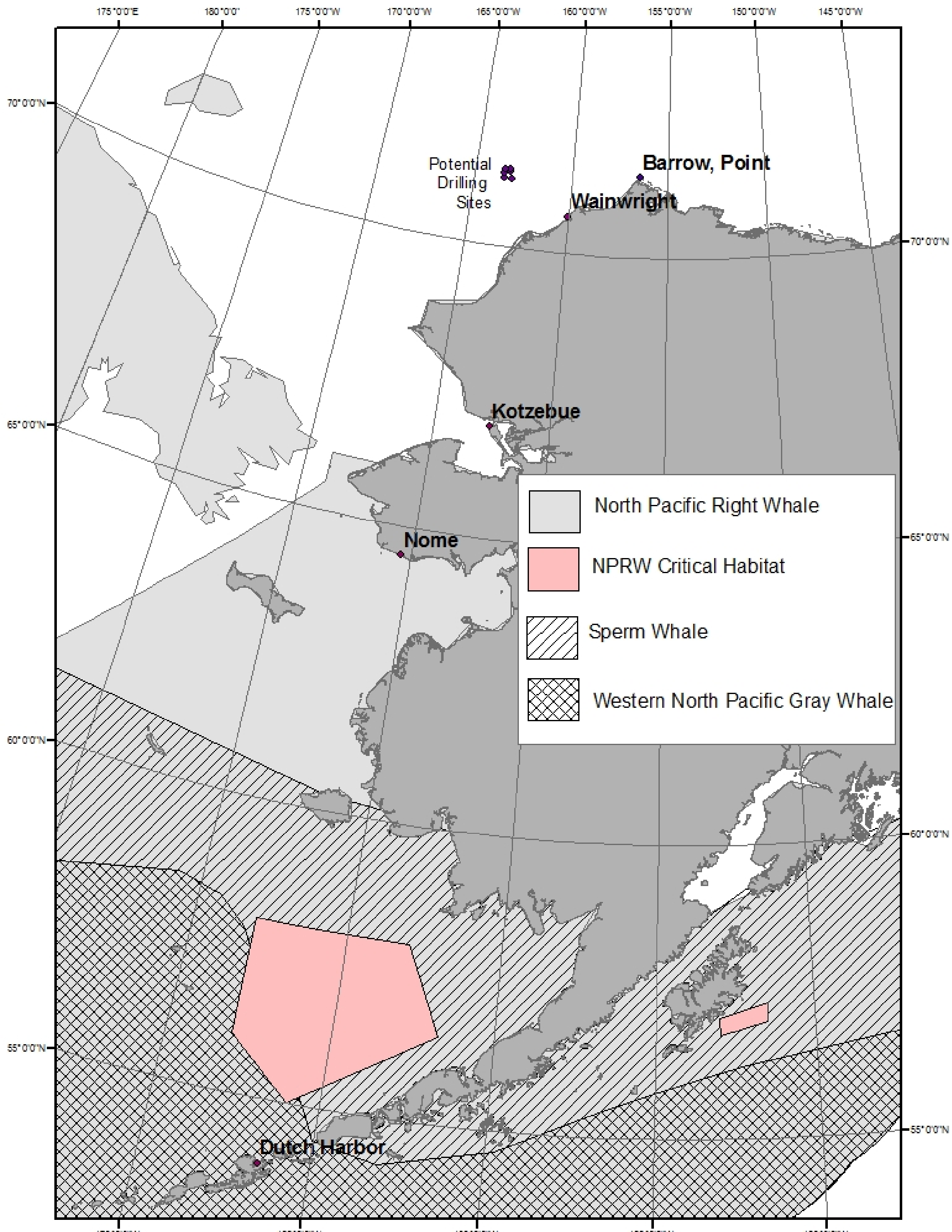

Figure 6. Approximate range of cetacean species and right whale critical habitat in the vicinity of the action area.

Pinnipeds

Vessels transiting to and from Dutch Harbor in association with Shell's drilling activities in the Chukchi Sea will be within the range of the western DPS of Steller sea lions, and overlap with their designated critical habitat (Figure 7). Dutch Harbor sits within the Bogoslof designated foraging area and is within the 20 nm aquatic zone associated with rookery and haulout locations (Figure 8). In addition, depending on the routes vessels take to transit through the Bering Strait, they may overlap with critical habitat designated on the Pribilof Islands, St. Matthew Island, or St. Lawrence Island.

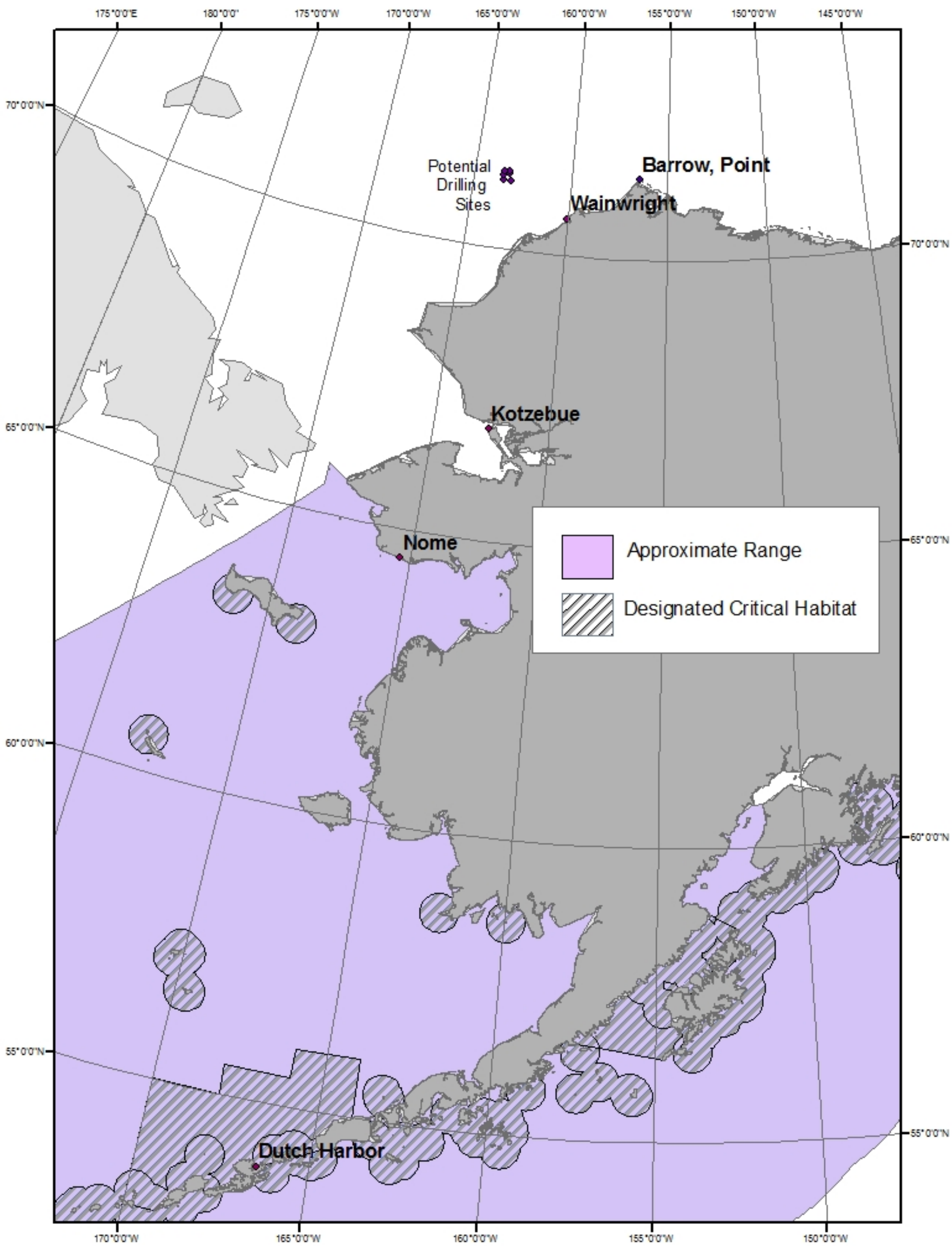

Figure 7. Approximate range of Steller sea lions in the vicinity of the action area.

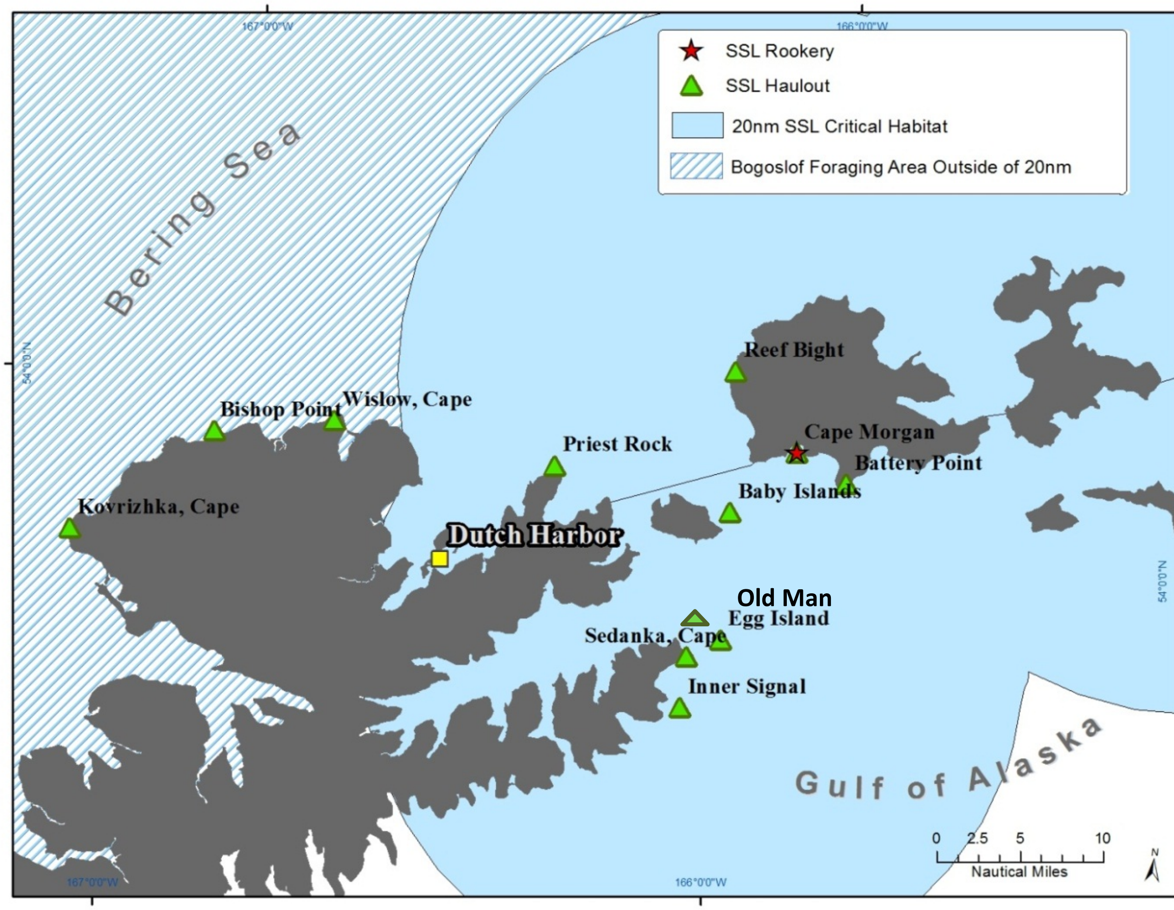

Figure 8. Haulout and rookery locations for the western DPS of Steller sea lion near Dutch Harbor.

Designated critical habitat for the western DPS of Steller sea lions includes terrestrial, air, and aquatic habitats that support reproduction, foraging, rest and refuge. These designations were based on the location of terrestrial rookery and haulout sites where breeding, pupping, refuge and resting occurs; aquatic areas surrounding rookeries and haulouts, the spatial extent of foraging trips, and availability of prey items, and rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas. Within the action area, vessels have the potential to transit through the 20nm aquatic zone around rookery and haulout zones, and the Bogoslof foraging area.

The 3-mile no transit zones are established and enforced around rookeries in the area for further protection, and NMFS' guidelines for approaching marine mammals discourage vessels approaching within 100 yards of haulout locations. The Bogoslof Foraging Area is the only foraging area designated as critical habitat which occurs within the action area. This site historically supported large aggregations of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for SSLs (Fiscus and Baines 1966, Kajimura and Loughlin 1988). While vessels transiting to and from the OCS drilling activities may enter Bogoslof Forgaging Area, noise associated with vessel operations is not anticipated to affect PCEs or impact foraging.

Despite all of the vessel traffic in and around rookery and haulout locations near Dutch Harbor, there have been no reported incidents of ship strike of Steller sea lions in Alaska. In addition, the Steller sea lion population in and around Dutch Harbor has been increasing at about 3% per year, indicating that vessel traffic has not prohibited population growth (Fritz 2012).

Vessels would have a short-term presence in the Bering Sea as they transit to drilling operations in the Chukchi Sea. NMFS is not able to quantify existing traffic conditions across the entire Bering Sea to provide context for the addition of approximately 27 Shell authorized vessels. However, Dutch Harbor (which is at the lower extent of the action area) is anticipated to have thousands of vessel transits per year, so the addition of 27 transitory authorized vessels in the area is anticipated to be incremental in comparison to the total number of vessels in the area. In addition, the absence of collisions involving any vessels and Steller sea lions in the Bering Sea despite decades of spatial and temporal overlap suggests that the probability of collision is very low.

Based on the small number of vessels associated with the proposed action in comparison to the thousands of vessels known to transit the Bering Sea, the continued growth of the population near Dutch Harbor despite heavy traffic, mitigation measures in place to avoid marine mammals and designated critical habitat, and the years of spatial and temporal overlap that have not resulted in a known collision, we conclude that some individuals may be exposed to vessel traffic and noise but the exposure would be brief and the resulting effects on Steller sea lions would be insignificant and not result in take. In addition, we do not anticipate any adverse effects to designated critical habitat or impacts to foraging; therefore, we do not consider Steller sea lions or their designated critical habitat further in this opinion.

3.2 Status of Listed Species

The remainder of this section consists of narratives for each of the endangered and threatened species that occur in the action area and that may be adversely affected by the proposed drilling operations. In each narrative, we present a summary of information on the population structure and distribution of each species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

After the *Status* subsection of each narrative, we present information on the feeding and prey selection, and diving and social behavior of the different species because those behaviors help determine how certain activities may impact each species, and help determine whether aerial and ship-board surveys are likely to detect each species. We also summarize information on the vocalization and hearing of the different species to inform our assessment of how the species are likely to respond to sounds produced from the proposed activities.

More detailed background information on the status of these species can be found in a number of published documents including a stock assessment report on Alaska marine mammals by Allen and Angliss (2014), and recovery plans for fin whales (NMFS 2010), and humpback whales (NMFS 1991). Cameron et al. (2010) and Kelly *et al.* (2010) provided status reviews of bearded and ringed seals. Richardson *et al.* (1995) and Tyack (2000, 2009) provided detailed analyses of the functional aspects of cetacean communication and their responses to active seismic. Finally, Croll *et al.* (1999), NRC (2000, 2003, 2005), and Richardson *et al.* (1995) provide information on the potential and probable effects of active seismic activities on the marine animals considered in this opinion.

Bowhead Whale

Population Structure

The International Whaling Commission (IWC) recognizes four stocks of bowhead whale for management purposes (Allen and Angliss 2014). Out of all of the stocks, the Western Arctic stock is the largest, and the only stock to inhabit U.S. waters(Allen and Angliss 2014). It is also the only bowhead stock within the action area.

Distribution

Bowhead whales have a circumpolar distribution in high latitudes in the Northern Hemisphere, and ranges from 54º to 85º N latitude. They live in pack ice for most of the year, typically wintering at the southern limit of the pack ice, or in polynyas (large, semi-stable open areas of water within the ice), and move north as the sea ice breaks up and recedes during the spring. In the North Pacific Ocean in the action area, bowhead whales are distributed in the seasonally ice-covered waters of the Arctic and near-Arctic, generally occurring north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984, Rugh, Demaster et al. 2003). They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year.

The majority of the western Arctic stock migrates annually from wintering areas (December to March) in the northern Bering Sea, through the Chukchi in spring (April through May), to the Beaufort Sea where they spend much of the summer (June through September) before returning again to the Bering Sea in fall (October through December) to overwinter (Allen and Angliss 2014) (see Figure 9). Fall migrating whales typically reach Cross Island in September and October, although some whales might arrive as early as late August. Some of the animals remain in the eastern Chukchi and western Beaufort seas during the summer (Ireland, Rodrigues et al. 2009, Clarke, Christman et al. 2011). Aerial surveys of offshore portions of the Chukchi Sea from 2008–2012 have shown a relatively consistent pattern of few bowhead whales being present in June–August, and then increasing numbers in September and October (Clarke, Ferguson et al. 2011, Clarke, Christman et al. 2012, Clarke, Stafford et al. 2013). However, satellite tracking of bowheads has also shown that some whales move to the Chukchi Sea prior to September (Quakenbush, Citta et al. 2010). Bowhead whale call count data recorded in the Chukchi Sea in 2012 showed the highest detection number during September and October. Similar to 2012 CSESP visual data, there were few call detections south of 71°N (Delarue, J. Vallarta et al. 2013), which supports satellite tagging data showing that most bowhead whales migrate north of 71°N during the fall (Quakenbush, Citta et al. 2010).

In the Chukchi Sea, bowheads are generally found in waters between 50 and 200 m deep (Clarke and Ferguson. 2010). During spring migration in the Chukchi Sea, bowhead whales typically follow polynyas in the sea ice along the coast of Alaska, generally in the zone between the shorefast ice and mobile pack ice (Allen and Angliss 2014). During the fall migration south into the Bering Sea, bowheads appear to select shallow-shelf waters in low to moderate sea ice conditions, and slope waters in heavy ice conditions (Moore 2000).

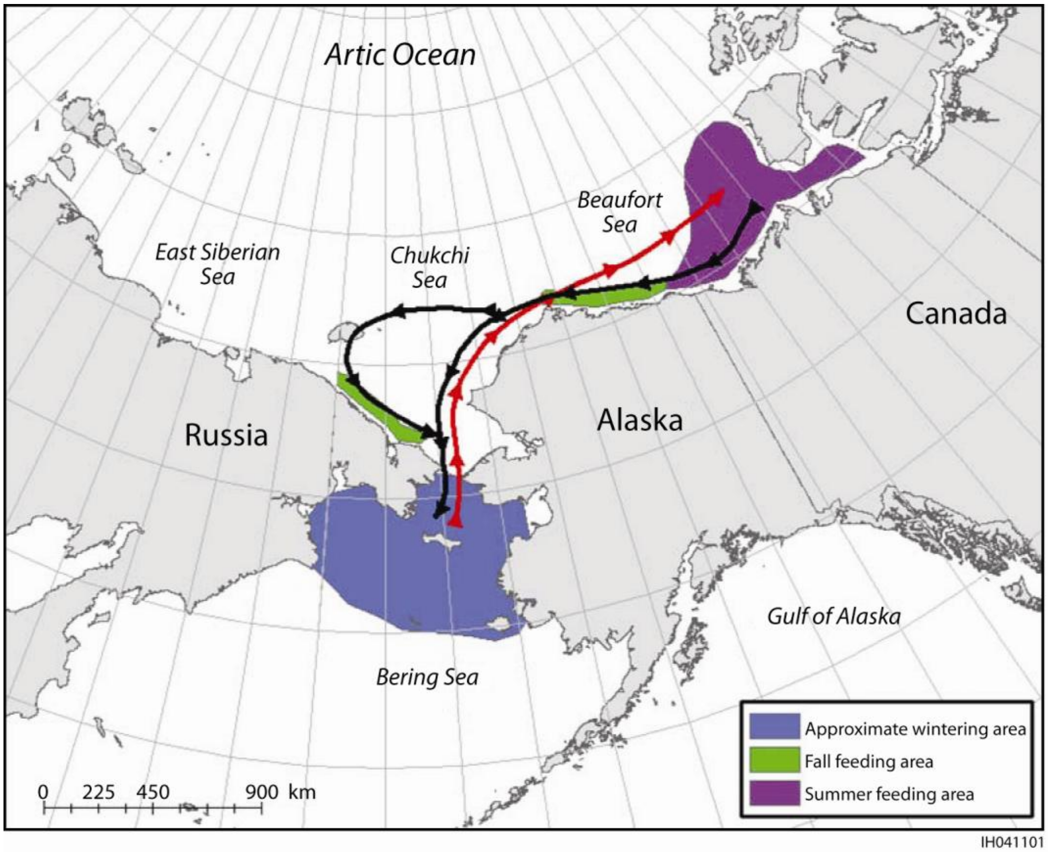

Figure 9. Generalized Migration Route, Feeding Areas, and Wintering Area for Western Arctic Bowhead Whale

Most spring-migrating bowhead whale would likely pass through the Chukchi Sea prior to open-water seismic or exploratory drilling activities. However, a few whales may remain in the Chukchi Sea during the summer and could encounter survey and drilling activities or transiting vessels. More encounters with bowhead whales are anticipated during the westward fall migration in late September through October (Shell 2014). Most bowhead 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, Citta et al. 2010)(see Figure 5). Prior to 2012, the majority of satellite-tagged whales crossed the Chukchi Sea quickly; however tagged whales in 2012 remained in the central Chukchi Sea concurrently with drilling operations before entering the Bering Sea in December, possibly due to opportunistic feeding (Quakenbush, Small et al. 2013).

In the North Atlantic Ocean, three additional populations are found in the Atlantic and Canadian Arctic in the Davis Strait and in Baffin Bay, Hudson Bay, and Foxe Basin, as well as Spitsbergen Island and the Barents Sea.

Threats to the Species

NATURAL THREATS. Little is known about the natural mortality of bowhead whales (Philo, Shotts et al. 1993). From 1964 through the early 1990s, at least 36 deaths were reported in Alaska, Norway, Yukon and Northwest Territories for which the cause could not be established (Philo, Shotts et al. 1993). Bowhead whales have no known predators except perhaps killer whales. The frequency of attacks by killer whales upon the Western Arctic stock of bowhead whales is assumed to be low (George, Philo et al. 1994). Of 195 whales examined from the Alaskan subsistence harvest (1976-92), only 8 had been wounded by killer whales. Also, hunters on St. Lawrence Island found two small bowhead whales (<9 m) dead as a result of killer whale attacks (George, Philo et al. 1994). Predation could increase if the refuge provided to bowhead whales by sea-ice cover diminishes as a result of climate change.

Predation by killer whales may be a greater source of mortality for the Eastern Canada-Western Greenland population. Inuit have observed killer whales killing bowhead whales and stranded bowhead whales have been reported with damage likely inflicted by killer whales (NWMB (Nunavut Wildlife Management Board) 2000). Most beached carcasses found in the eastern Canadian Arctic are of young bowhead whales, and they may be more vulnerable than adults to lethal attacks by killer whales (Finley 1990, Moshenko, Cosens et al. 2003). About a third of the bowhead whales observed in a study of living animals in Isabella Bay bore scars or wounds inflicted by killer whales (Finley 1990). A relatively small number of whales likely die as a result of entrapment in ice.

ANTHROPOGENIC THREATS. Historically, bowhead whales were severely depleted by commercial harvesting, which ultimately led to the listing of bowhead whales as an endangered species in 1970 (35 FR 8495). Bowhead whales have been targeted by subsistence whaling for at least 2,000 years (Stoker and Krupnik 1993). Subsistence harvest is regulated by quotas set by the International Whaling Commission (IWC) and allocated by the Alaska Eskimo Whaling Commission. Bowhead whales are harvested by Alaskan Natives in the Beaufort, Bering, and Chukchi Seas. Alaska Native subsistence hunters take approximately 0.1-0.5% of the population per annum, primarily from 11 Alaska communities (Philo, Shotts et al. 1993, Suydam, George et al. 2011).

Canadian and Russian Natives are also known to take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. Twelve whales were harvested by Russian subsistence hunters between 1999-2005 (Allen, Helker et al. 2014). No catches for Western Arctic bowheads were reported by either Canadian or Russian hunters for 2006-2007 or by Russia in 2009, but two bowheads were taken in Russia in 2008, and in 2010 (IWC 2012, Allen, Helker et al. 2014). The annual average subsistence take (by Natives of Alaska, Russia, and Canada) during the 5-year period from 2007 to 2011 was 39 bowhead whales(Allen, Helker et al. 2014).

Some additional mortality may be due to human-induced injuries including embedded shrapnel and harpoon heads from hunting attempts, rope and net entanglement in harpoon lines and crab-pot lines, and ship strikes (Philo, Shotts et al. 1993). Several cases of rope or net entanglement have been reported from whales taken in the subsistence hunt (Philo, Shotts et al. 1993). Further, preliminary counts of similar observations based on reexamination of bowhead harvest records indicate entanglements or scarring attributed to ropes may include over 20 cases (Allen and Angliss 2014). There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. However, some bowhead whales have historically had interactions with crab pot gear. There are several documented cases of bowheads having ropes or rope scars on them. Alaska Region stranding reports document three bowhead whale entanglements between 2001 and 2005. In 2003 a bowhead whale was found dead in Bristol Bay entangled in line around the peduncle and both flippers; the origin of the line is unknown. In 2004 a bowhead whale near Point Barrow was observed with fishing net and line around the head. A dead bowhead whale found floating in Kotzebue Sound in July 2010 was entangled in crab pot gear similar to that used in the Bering Sea crab fishery (Allen and Angliss 2014). During the 2011 spring aerial survey of bowhead near Point Barrow, one entangled bowhead was photographed (Mocklin, George et al. 2012). The minimum average annual entanglement rate in U.S. commercial fisheries for the five year period from 2007-2011 is 0.4; however, the overall rate is currently unknown (Allen and Angliss 2014).

Bowhead whales are among the slowest moving of whales, which may make them particularly susceptible to ship strikes although records of strikes on bowhead whales are rare (Laist, Knowlton et al. 2001). About 1% of the bowhead whales taken by Alaskan Inupiat bore scars from ship strikes (George, Philo et al. 1994). Until recently, few large ships have passed through most of the bowhead whale's range but this situation may be changing as northern sea routes become more navigable with the decline in sea ice. This increase in vessel presence could result in an increased number of vessel collisions with bowhead whales. Increasing oil and gas development in the Arctic has led to an increased risk of various forms of pollution in bowhead whale habitat, including oil spills and contaminants. Noise produced by the increased number of seismic surveys and increased vessel traffic resulting from shipping and offshore energy exploration is also a concern (Allen and Angliss 2014). Exposure to manmade noise and contaminants may have short- and long-term effects (Bratton, Spainhour et al. 1993, Richardson and Malme 1993, Richardson, Greene et al. 1995), which compromise health and reproductive performance.

Status

The bowhead whale was listed as endangered under the ESA in 1970 (35 FR 8495). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for bowhead whales. The IWC continued a prohibition on commercial whaling, and called for a ban on subsistence whaling in 1977. The U.S. requested a modification of the ban and the IWC responded with a limited quota. Currently, subsistence harvest is limited to nine Alaskan villages.

WESTERN ARCTIC. Woodby and Botkin (1993) summarized previous efforts to determine a minimum worldwide population estimate prior to commercial whaling of 50,000, with 10,400-23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling). Brandon and Wade (2006) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 (9,190-13,950; 5th and 9th percentiles, respectively) bowheads in 1848 at the start of commercial whaling (Allen and Angliss 2014).

From 1978-2011, the Western Arctic stock of bowhead whales has increased at a rate of 3.7% (95% Confidence Interval (CI) = 2.8-4.7%) during which time abundance tripled from approximately 5,000 to approximately 16,000 whales (Givens, Edmondson et al. 2013). Similarly, Schweder et al. (2010) estimated the yearly growth rate to be 3.2% between 1984 and 2003 using a sight-resight analysis of aerial photographs. The ice-based abundance estimate, based on surveys conducted in 2001, is 10,545 (Coefficient of Variation (CV) = 0.128) (updated from (George, Zeh et al. 2004) by (Zeh and Punt 2005)). Ten years later in 2011, the ice-based abundance estimate was 16,892 (95% CI 15,704-18,928) (Givens, Edmondson et al. 2013). See Table 7 for summary of population abundance estimates (Allen and Angliss 2014). Using the 2011 population estimate of 16,892 and its associated CV= 0.2442, the minimum population estimate for the Western Arctic stock of bowhead whales is 13,796 (Allen and Angliss 2014). The population may be approaching carrying capacity despite showing no sign of a slowing in the population growth rate (Brandon and Wade 2006).

Table 7. Summary of population abundance estimates for the Western Arctic stock of bowhead whales (Allen and Angliss 2014).

Year	Abundance Estimate (CV)	Year	Abundance Estimate (CV)
Historical estimate	10,400-23,000	1985	5,762 (0.253)
End of commercial whaling	1,000-3,000	1986	8,917 (0.215)
1978	4,765 (0.305)	1987	5,298 (0.327)
1980	3,885 (0.343)	1988	6,928 (0.120)
1981	4,467 (0.273)	1993	8,167 (0.017)
1982	7,395 (0.281)	2001	10,545 (0.128)
1983	6,573 (0.345)	2011	16,892 (0.244)

The current estimate for the rate of increase for this stock of bowhead whales is 3.2-3.4% (George, Zeh et al. 2004, Schweder, Sadykova et al. 2010). However, it is recommended that the cetacean maximum theoretical net productivity rate (R_{max}) of 4% be used for the Western Arctic stock of bowhead (Wade and Angliss 1997).[3]

The count of 121 calves during the 2001 census was the highest yet recorded and was likely caused by a combination of variable recruitment and the large population size (George, Zeh et al. 2004). The calf count provides corroborating evidence for a healthy and increasing population.

The potential biological removal (PBR) for this stock is 103 animals (10,314 x 0.02 x 0.5) (see (Allen and Angliss 2014)). However, the IWC bowhead whale quota takes precedence over the PBR estimate for the purpose of managing the Alaska Native subsistence harvest for this stock. For 2013-2018, the IWC established a block quota of 336 landed bowheads. Because some animals are struck and lost, a strike limit of 67 (plus up to 15 previously unused strikes) could be taken each year.

The Sea of Okhotsk stock, estimated at about 3,000-6,500 animals prior to commercial exploitation (Shelden and Rugh 1995), currently numbers about 150-200, although precise population estimates are not currently available. It is possible this population has mixed with the Bering Sea population, although the available evidence indicates the two populations are essentially separate (Moore and Reeves 1993).

NORTH ATLANTIC. The estimated abundance of the Spitsbergen stock was 24,000 prior to commercial exploitation, but currently numbers less than one hundred. The Baffin Bay-Davis Strait stock was estimated at about 11,750 prior to commercial exploitation (Woodby and Botkin 1993)

[3] The R_{max} value of 3.2-3.4% should not be used because the population is currently being harvested and because the population has recovered to population levels where the growth is expected to be significantly less than R_{max} Allen, B. M. and R. P. Angliss (2013). Alaska marine mammal stock assessments, 2012, U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-245: 282..

and the Hudson Bay-Foxe Basin stock at about 450. The current abundance of the Baffin Bay-Davis Straight is estimated at about 350 (Zeh, Clark et al. 1993), and recovery is described as "at best, exceedingly slow"(Davis and Koski 1980). No precise estimate exists for the Hudson Bay-Foxe Basin stock; however, Mitchell and Reeves (1981) place a conservative estimate at 100 or less. More recently, estimates of 256-284 whales have been presented for the number of whales within Foxe Basin (Cosens, Cleator et al. 2006). There has been no appreciable recovery of this population.

Reproduction and Growth

Important winter areas in the Bering Sea include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island. Bowheads congregate in these polynyas before migrating (Moore and Reeves 1993). Most mating occurs in late winter and spring in the Bering Sea, although some mating occurs as late as September and early October (Koski, Davis et al. 1993, Reese, Calvin et al. 2001). The conception date and length of gestation suggests that calving is likely to occur in mid-May to mid-June, when whales are between the Bering Strait and Point Barrow (BOEM 2011). The calving interval is about three to four years. Juvenile growth is relatively slow. Bowheads reach sexual maturity at about 15 years of age (12 to 14 m [39 to 46 ft] long) (Nerini, Braham et al. 1984). Growth for both sexes slows markedly at about 40 to 50 years of age (George, Bada et al. 1999).

Given the life history of bowhead whales and gestational constraints on minimum calving intervals (e.g., Reese et al. 2001), and assuming that adult survival rates based on aerial photo-ID data (Zeh et al. 2002; Schweder et al. 2010) and age-at-maturity have remained stable, the trend in abundance implies that the population has been experiencing relatively high annual calf and juvenile survival rates. This is consistent with documented observations of native whalers around St. Lawrence Island, who have reported not only catching more pregnant females but also seeing more young whales than during earlier decades (Noongwook et al. 2007). It is also interesting to note, with the caveat that sample size was small, that the pregnancy rate from the 2012 Alaskan harvest data indicate that 2013 calf production could be higher than average (George et al. 2004b; George et al. 2011; Suydam et al. 2013).

A change in either calf production or survival rates (or age-at-sexual maturation) of young whales in the future could be indicative of a population level response to anthropogenic stressors, or alternatively, a signal of the seemingly inevitable event that this population approaches the carrying capacity of its environment (Eberhardt 1977). Since the late 1970s and the initiation of surveys for abundance, however, the estimates of population size do not indicate that either anthropogenic (e.g., offshore oil and gas activities, subsistence whaling catch quotas, etc.) or natural factors (e.g., prey availability) have resulted in any negative influence on the BCB bowhead whale trend in abundance (LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc. et al. 2013).

Feeding and Prey Selection

Bowheads are filter feeders, filtering prey from the water through baleen (Lowry 1993). They feed throughout the water column, including bottom feeding as well as surface skim feeding (Würsig, Dorsey et al. 1989). Skim feeding can occur when animals are alone or may occur in coordinated echelons of over a dozen animals (Würsig, Dorsey et al. 1989). Bowhead whales typically spend a high proportion of time on or near the ocean floor. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush, Citta et al. 2010). Laidre *et al.* (2007) and others have identified krill concentrated near the sea bottom and bowhead whales have been observed with mud on heads and bodies and streaming from mouths (Mocklin 2009). Food items most commonly found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, and amphipods

(Lowry, Sheffield et al. 2004, Moore, George et al. 2010). Euphausiids and copepods are thought to be their primary prey. Lowry, Sheffield, and George (2004) documented that other crustaceans and fish also were eaten but were minor components in samples consisting mostly of copepods or euphausiids.

Concentrations of zooplankton appear necessary for bowhead whales and other baleen whales to feed efficiently to meet energy requirements (Kenney, Hyman et al. 1986, Lowry 1993). It is estimated that a 60 ton bowhead whale eats 1.5 t of krill each day. Estimated rate of consumption is 50,000 individual copepods, each weighing about 0.004 g, per minute of feeding time (BOEM 2011).

Western Arctic bowhead whales feed in the OCS of the Chukchi and Beaufort Seas and this use varies in degree among years, among individuals, and among areas. It is likely that bowheads continue to feed opportunistically where food is available as they move through or about the Alaskan Beaufort Sea, similar to what they are thought to do during the spring migration. Observations from the 1980s documented that some feeding occurs in the spring in the northeastern Chukchi Sea, but this feeding was not consistently seen (e.g., (Carroll, George et al. 1987, Ljungblad, Moore et al. 1987)). Stomach contents from bowheads harvested off St. Lawrence Island during May, and between St. Lawrence and Point Barrow during April into June also indicated it is likely that some whales feed during the spring migration (Hazard and Lowry. 1984, Carroll, George et al. 1987, Shelden and Rugh 1995). The stomach contents of one bowhead harvested in the northern Bering Sea indicated that the whale had fed entirely on benthic organisms, predominantly gammarid amphipods and cumaceans (not copepods, euphausiids, or other planktonic ogranisms) (Hazard and Lowry. 1984).

Carroll *et al.* (1987) reported that the region west of Point Barrow seems to be of particular importance for feeding, at least in some years, but whales may feed opportunistically at other locations in the lead system where oceanographic conditions produce locally abundant food. A bowhead whale feeding "hotspot" (Okkonen, Ashjian et al. 2011) commonly forms on the western Beaufort Sea shelf off Point Barrow in late summer and fall due to a combination of the physical and oceanographic features of Barrow Canyon, combined with favorable wind conditions (Ashjian, Braund et al. 2010, Moore, George et al. 2010, Okkonen, Ashjian et al. 2011).

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 may also occur in small numbers in the Bering and Chukchi seas during the summer (Rugh, DeMaster et al. 2003). Ireland et al. (2009) also reported bowhead sightings in 2006 and 2007 during summer aerial surveys in the Chukchi Sea.

Diving and Social Behavior

Bowhead diving behavior is situational (Stewart 2002). Calves dive for very short periods and their mothers tend to dive less frequently and for shorter durations. Feeding dives tend to last from 3 to 12 minutes and may extend to the relatively shallow bottom in the Beaufort Sea. "Sounding" dives average between 7 and 14 minutes.

The bowhead whale usually travels alone or in groups of three to four individuals. However, in one day on BWASP survey in 2009, researchers observed 297 individual bowheads aggregated near Barrow (Clarke, Christman et al. 2011). During this survey, a group of 180 bowhead whales were seen feeding and milling (Clarke, Christman et al. 2011).

Bowhead whale calls might help maintain social cohesion of groups (Wursig and Clark 1993). (Würsig, Dorsey et al. 1989) indicated that low-frequency tonal calls, believed to be long distance contact calls by a female and higher frequency calls by calf, have been recorded in an instance where the pair were separated and swimming toward each other.

Vocalizations and Hearing

Bowhead whales are among the more vocal of the baleen whales (Clark and Johnson 1984). They mainly communicate with low frequency sounds. Most underwater calls are at a fairly low frequency and easily audible to the human ear. Vocalization is made up of moans of varying pitch, intensity and duration, and occasionally higher-frequency screeches. Bowhead calls have been distinguished by Würsing and Clark (1993): pulsed tonal calls, pulsive calls, high frequency calls, low-frequency FM calls (upsweeps, inflected, downsweeps, and constant frequency calls). However, no direct link between specific bowhead activities and call types was found. Bowhead whales have been noted to produce a series of repeating units of sounds up to 5000 Hz that are classified as songs, produced primarily by males on the breeding grounds (Delarue 2011). It appears that bowhead whale singing behavior differs from that of other mysticetes in that multiple songs are sung each year (Johnson, Stafford et al. 2014). Also, bowhead whales may use low-frequency sounds to provide information about the ocean floor and locations of ice.

Bowhead whales have well-developed capabilities for navigation and survival in sea ice. Bowhead whales are thought to use the reverberations of their calls off the undersides of ice floes to help them orient and navigate (Ellison, Clark et al. 1987, George, Clark et al. 1989). This species is well adapted to ice-covered waters and can easily move through extensive areas of nearly solid sea ice cover (Citta, Quakenbush et al. 2012). Their skull morphology allows them to break through ice up to 18 cm thick to breathe in ice covered waters (George, Clark et al. 1989).

Bowhead whales are grouped among low frequency functional hearing baleen whales (Southall, Bowles et al. 2007). Inferring from their vocalizations, bowhead whales should be most sensitive to frequencies between 20 Hz-5 kHz, with maximum sensitivity between 100-500 Hz (Erbe 2002). Bowhead whale songs have a bandwidth of 20 to 5000 Hz with the dominant frequency at approximately 500 Hz and duration lasting from 1 minute to hours. Pulsive vocalizations range between 25 and 3500 Hz and last 0.3 to 7.2 seconds (Clark and Johnson 1984, Wursig and Clark 1993, Erbe 2002). While there is no direct data on hearing in low-frequency cetaceans, the functional hearing range is anticipated to be between 7 Hz to 30 kHz (Watkins 1986, Au, Pack et al. 2006, Southall, Bowles et al. 2007, Ciminello, R. Deavenport et al. 2012, NOAA 2013).

Bowhead whales in western Greenland waters produced songs of an average source level of 185 ±2 dB rms re 1 mPa @ 1 m centered at a frequency of 444 ±48 Hz (Roulin, Tervo et al. 2012). Given background noise, this allows bowheads whales an active space of 40-130 km (Roulin, Tervo et al. 2012).

Other Senses

Bowhead whales appear to have good lateral vision. Recognizing this, whalers approach bowheads from the front or from behind, rather than from the side (Rexford 1997, Noongwook, Huntington et al. 2007). In addition, whalers wear white parkas on the ice so that they are not visible to the whales when they surface (Rexford 1997).

Olfaction may also be important to bowhead whales. Recent research on the olfactory bulb and olfactory receptor genes suggest that bowheads not only have a sense of smell but one better developed than in humans (Thewissen, George et al. 2011). The authors suggest that bowheads may use their sense of smell to find dense aggregations of krill upon which to prey.

Fin Whale

Population Structure

Fin whales have two recognized subspecies: *B. p. physalus* occurs in the North Atlantic Ocean (Gambell 1985), while *B. p. quoyi* occurs in the Southern Ocean (Fischer 1829). Most experts consider the North Pacific fin whales a separate unnamed subspecies.

In the North Atlantic Ocean, the IWC recognizes seven management units or “stocks” of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea is believed to be genetically distinct from other fin whales populations (as used in this opinion, “populations” are isolated demographically, meaning, they are driven more by internal dynamics — birth and death processes — than by the geographic redistribution of individuals through immigration or emigration. Some usages of the term “stock” are synonymous with this definition of “population” while other usages of “stock” do not).

In U.S. Pacific waters, the IWC recognizes three “stocks”: (1) Alaska (Northeast Pacific), (2) California/Washington/Oregon, and (3) Hawaii (Allen and Angliss 2014). However, Mizroch *et al.* (2009) suggests that this structure should be reviewed and updated, if appropriate, to reflect current data which suggests there may be at least 6 populations of fin whales.

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrate that individual fin whales migrate between management units (Mitchell 1974, Rice 1974), which suggests that these management units are not geographically isolated populations.

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean (where they have only recently begun to appear). In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985). Approximate fin whale distribution in the action area in shown in Figure 10.

In the North Atlantic Ocean, fin whales occur in summer foraging areas from the coast of North America to the Arctic, around Greenland, Iceland, northern Norway, Jan Meyers, Spitzbergen, and the Barents Sea. In the western Atlantic, they winter from the edge of sea ice south to the Gulf of Mexico and the West Indies. In the eastern Atlantic, they winter from southern Norway, the Bay of Biscay, and Spain with some whales migrating into the Mediterranean Sea (Gambell 1985).

In the Southern Hemisphere, fin whales are distributed broadly south of 50° S in the summer and migrate into the Atlantic, Indian, and Pacific Oceans in the winter, along the coast of South America (as far north as Peru and Brazil), Africa, and the islands in Oceania north of Australia and New Zealand (Gambell 1985).

Mizroch et al. (2009) summarized information about the patterns of distribution and movements of fin whales in the North Pacific from whaling harvest records, scientific surveys, opportunistic sightings, acoustic data from offshore hydrophone arrays, and from recoveries of marked whales. Mizroch et al. (2009) notes that fin whales range from the Chukchi Sea south to 35° North on the Sanriku coast of Honshu., to the Subarctic boundary (ca. 42°) in the western and Central Pacific, and to 32° N off the coast of California. Berzin and Rovnin (1966) indicate historically "In the Chukchi Sea the finbacks periodically form aggregations in the region to the north of Cape Serdtse-Kamon' along the Chukotka coast."

Recent information on seasonal fin whale distribution has been gleaned from the reception of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore, Stafford et al. 1998, Watkins, Daher et al. 2000, Moore, Stafford et al. 2006, Stafford, Mellinger et al. 2007, Širović, Williams et al. 2013, Soule and Wilcock 2013). Moore et al. (1998, 2006) Watkins et al. (2000), and Stafford et al. (2007) both documented high levels of fin whale call rates along the U.S. Pacific coast beginning in August/September and lasting through February, suggesting that these may be important feeding areas during the winter. In addition, fin whale calls were detected in the northeastern Chukchi Sea using instruments moored there in July through October from 2007 through 2010 (Delarue et al. 2013). Call data collected from the Bering Sea suggests that several fin whale stocks may feed in the Bering Sea, but call data collected in the northeast Chukchi Sea suggests that only one of the putative Bering Sea stocks appears to migrate this far north to feed (Delarue, Martin et al. 2013).

Fin whales were seen regularly and sometimes caught by Soviet whalers in the Chukchi Sea until the 1940s (Allen and Angliss 2014). Fin whales are again being seen increasingly during sighting surveys in the Chukchi Sea in summer (Funk, Ireland et al. 2010, Aerts, McFarland et al. 2013, Clarke, Christman et al. 2013), and have been recorded each year from 2007-2010 in August and September on bottom-mounted hydrophones in the Chukchi (Delarue, Martin et al. 2013) suggesting they may be re-occupying habitat used prior to large-scale commercial whaling (Allen and Angliss 2014).

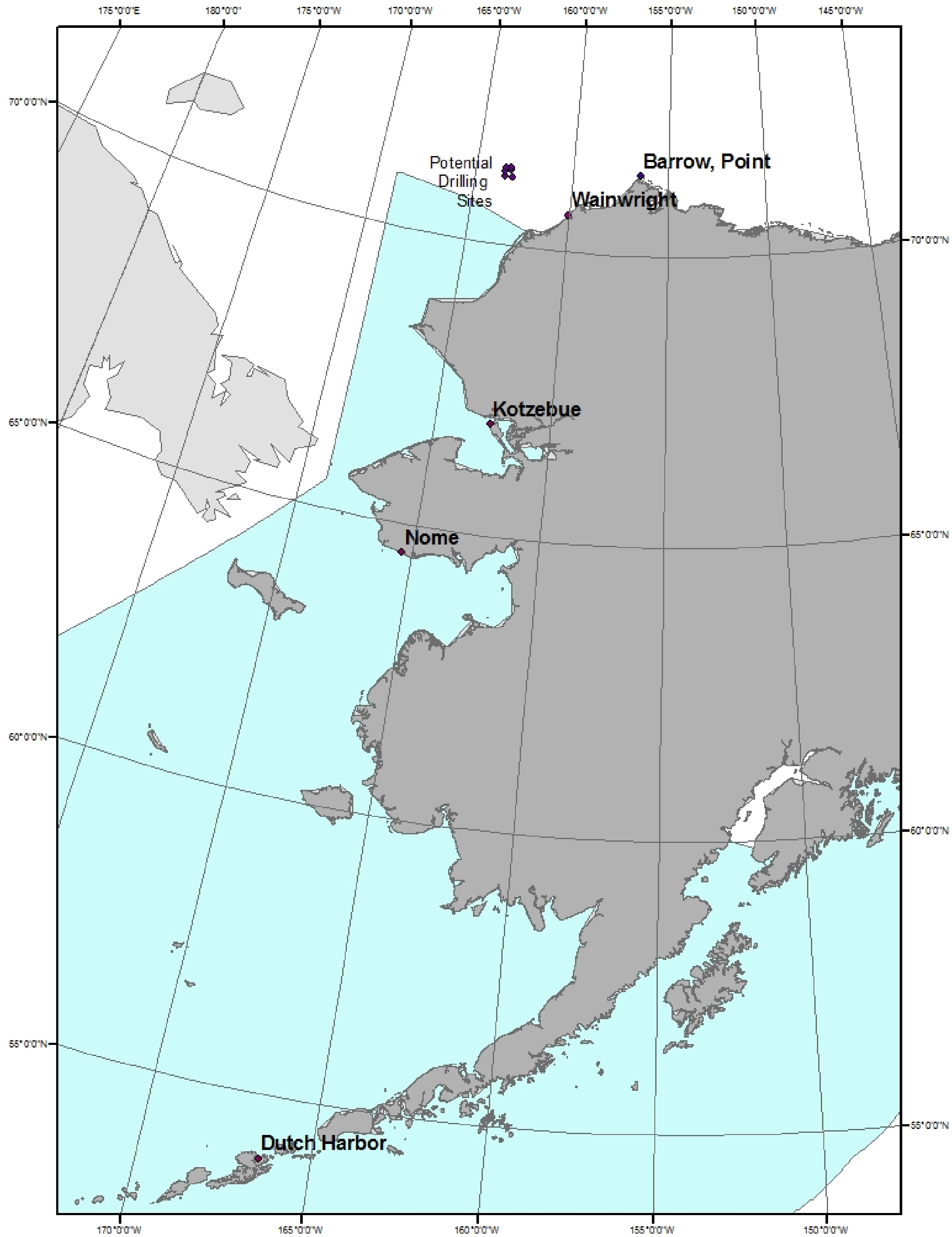

Figure 10. **Approximate distribution of fin whales in and near the action area, shown in light blue.**

Threats to the Species

NATURAL THREATS. Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range from 0.04 to 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992). Killer whale or shark attacks may injure or kill very young or sick whales (Perry, DeMaster et al. 1999).

ANTHROPOGENIC THREATS. Historically, whaling represented the greatest threat to every population of fin whales and was ultimately responsible for listing fin whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing fin, blue (*Balaenoptera musculus*), and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steampowered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. After blue whales were depleted in most areas, fin whales became the focus of whaling operations and more than 700,000 fin whales were landed in the Southern Hemisphere alone between 1904 and 1979 (IWC 1995).

As its legacy, whaling has reduced fin whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push fin whales closer to extinction. Otherwise, whaling currently does not threaten every fin whale population, although it may threaten specific populations. There is no authorized subsistence take of fin whales in the Northeast Pacific stock (Allen and Angliss 2014). In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit. The Japanese whalers plan to kill 50 fin whales per year starting in the 2007-2008 season and continuing for the next 12 years.

Fin whales are also hunted in subsistence fisheries off West Greenland. In 2004, 5 males and 6 females were killed and landed; 2 other fin whales were struck and lost in the same year. In 2003 2 males and 4 females were landed and 2 other fin whales were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery (2005); however, the IWC's Scientific Committee recommended limiting the number of fin whale killed in this fishery to 1 to 4 individuals until accurate population estimates are produced.

Despite anecdotal observations from fishermen which suggest that large whales swim through their nets rather than get caught in them, fin whales have been entangled by fishing gear off Newfoundland and Labrador in small numbers: a total of 14 fin whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Perkins and Beamish 1979, Lien 1994). Of these 14 fin whales, 7 are known to have died as a result of that capture, although most of the animals that died were less than 15 meters in length (Lien 1994). Between 1999 and 2005, there were 10 confirmed reports of fin whales being entangled in fishing gear along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole, Hartley et al. 2005, Nelson, Garron et al. 2007). Of these reports, Fin whales were injured in 1 of the entanglements and killed in 3 entanglements. Between 2009 and 2013, there was one observed incidental mortality of a fin whale in the ground tackle of a commercial mechanical jig fishing vessel in Alaska waters (Allen, Helker et al. 2014), resulting in a mean annual mortality rate of 0.2. These data suggest that, despite their size and strength, fin whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

Fin whales are also killed and injured in collisions with vessels more frequently than any other whale. Of 92 fin whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 31 (33%) showed evidence of collisions with ships (Laist, Knowlton et al. 2001). Between 1999 and 2005, there were 15 reports of fin whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole, Hartley et al. 2005, Nelson, Garron et al. 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 11 fin whales.

Jensen and Silber’s (2004) review of the NMFS’ ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26% of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawaii. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas, Calambokidis et al. 2008). From 1994-1998, two fin whales were presumed killed by ship strikes. More recently, in 2002, three fin whales were struck and killed by vessels in the eastern North Pacific (Jensen and Silber 2003).

Two fin whale deaths due to ship strikes (one in 2009 and one in 2010) in Alaska waters were reported to the NMFS Alaska Region stranding database between 2009 and 2013(Allen, Helker et al. 2014), resulting in a mean annual mortality rate of 0.4 fin whales due to ship strikes.

The total estimated annual rate of mortality and serious injury for the Northeast Pacific stock is 0.6 based on takes incidental to U.S. commercial fisheries (0.2) and ship strikes (0.4). Because the PBR is unknown, the level of annual U.S. commercial fishery-related mortality that can be considered insignificant and approaching zero mortality and serious injury rate is unknown (Allen and Angliss 2014).

Ship strikes were identified as a known or potential cause of death in 8 (20%) of 39 fin whales that stranded on the coast of Italy in the Mediterranean Sea between 1986 and 1997 (Laist, Knowlton et al. 2001). Throughout the Mediterranean Sea, 46 of the 287 fin whales that are recorded to have stranded between 1897 and 2001 were confirmed to have died from injuries sustained by ship strikes (Panigada, Pesante et al. 2006). Most of these fin whales (n = 43), were killed between 1972 and 2001 and the highest percentage (37 of 45 or ~82%) killed in the Ligurian Sea and adjacent waters, where the Pelagos Sanctuary for Marine Mammals was established. In addition to these ship strikes, there are numerous reports of fin whales being injured as result of ship strikes off the Atlantic coast of France and the United Kingdom (Jensen and Silber 2004).

Increased noise in the ocean stemming from shipping seems to alter the acoustic patterns of singing fin whales, possibly hampering reproductive parameters across wide regions (Castellote, Clark et al. 2012).

Status

Fin whales were listed as endangered in 1970 (35 FR 18319) and that listing was carried over after Congress enacted the ESA (39 FR 41367). In 1976, the IWC protected fin whales from commercial whaling (Allen 1980). Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2012). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for fin whales. A Final Recovery Plan for the Fin Whale (*Balaenoptera physalus*) was published on July 30, 2010 (NMFS 2010).

It is difficult to assess the current status of fin whales because (1) there is no general agreement on the size of the fin whale population prior to whaling and (2) estimates of the current size of the different fin whale populations vary widely. Prior to exploitation by commercial whalers, fin whales are thought to have numbered greater than 464,000 worldwide, and are now thought to number approximately 119,000 worldwide (Braham 1991).

Ohsumi and Wada (1974) estimated that the North Pacific fin whale population ranged from 42,000-45,000 before whaling began. Of this, the "American population" (i.e., the component centered in waters east of 180º W longitude), was estimated to be 25,000-27,000. Based on visual surveys, Moore *et al.* (2002) estimated 3,368 (CV=0.29) and 683 (CV=0.32) fin whales in the central eastern Bering Sea and southeastern Bering Sea, respectively, during summer surveys in 1999 and 2000. However, these estimates are considered provisional because they were never corrected for animals missed on the track line or that may have been submerged when the ship passed. Dedicated line transect cruises were conducted in coastal waters of western Alaska and the eastern and central Aleutian Islands in July-August 2001-2003 (Zerbini, Kennedy et al. 2009). Fin whale sightings (n = 276) were observed from east of Kodiak Island to Samalga Pass, with high aggregations recorded near the Semidi Islands. Zerbini et al. (2006) estimated that 1,652 (95% CI: 1,142-2,389) whales occurred in the area. An annual increase of 4.8% (95% CI: 4.1-5.4%) was estimated for the period of 1987-2003 (Allen, Helker et al. 2014).

The best estimate of the fin whale population west of the Kenai Peninsula is 1,368, the greater minimum estimates from the 2008 and 2010 surveys (Friday, Zerbini et al. 2013). This is a minimum estimate for the entire stock because it was estimated from surveys which covered only a small portion of the range of this stock.

The minimum estimate for the California/Oregon/Washington stock, as defined in the U.S. Pacific Marine Mammal Stock Assessments: 2008, is about 2,316 (Carretta, Forney et al. 2009). An increasing trend between1979/80 and 1993 was suggested by the available survey data, but it was not statistically significant (Barlow, Forney et al. 1997).

Similarly, estimates of the current size of the different fin whale populations and estimates of their global abundance also vary widely. The final recovery plan for fin whales accepts a minimum population estimate of 2,269 fin whales for the Western North Atlantic stock (NMFS 2010). However, based on data produced by surveys conducted between 1978-1982 and other data gathered between 1966 and 1989, Hain *et al.* (1992) estimated that the population of fin whales in the western North Atlantic Ocean (specifically, between Cape Hatteras, North Carolina, and Nova Scotia) numbered about 1,500 whales in the winter and 5,000 whales in the spring and summer. Because authors do not always reconcile "new" estimates with earlier estimates, it is not clear whether the current "best" estimate represents a refinement of the estimate that was based on older data or whether the fin whale population in the North Atlantic has declined by about 50% since the early 1980s.

The East Greenland-Iceland fin whale population was estimated at 10,000 animals (95 % confidence interval = 7,600- 14,200), based on surveys conducted in 1987 and 1989 (Buckland, Cattanach et al. 1992). The number of eastern Atlantic fin whales, which includes the British Isles-Spain-Portugal population, has been estimated at 17,000 animals (95% confidence interval = 10,400 -28,900; (Buckland, Cattanach et al. 1992)). These estimates are both more than 15 years old and the data available do not allow us to determine if they remain valid.

Forcada *et al.* (1996) estimated the fin whale population in the western Mediterranean numbered 3,583 individuals (standard error = 967; 95% confidence interval = 2,130-6,027). This is similar to a more recent estimate published by Notarbartolo-di-Sciara *et al.* (2003). Within the Ligurian Sea, which includes the Pelagos Sanctuary for Marine Mammals and the Gulf of Lions, the fin whale population was estimated to number 901 (standard error = 196.1) whales (Forcada, Disciara et al. 1995).

Regardless of which of these estimates, if any, have the closest correspondence to the actual size and trend of the fin whale population, all of these estimates suggest that the global population of fin whales consists of tens of thousands of individuals and that the North Pacific population consists of at least 5,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Nevertheless, based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

Feeding and Prey Selection

In the North Pacific overall, fin whales prefer euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristatus*), followed by schooling fish such as herring, walleye Pollock (*Theragra chalcogramma*), and capelin (Nemoto 1970, Kawamura 1982).

Fin whales killed off central California in the early twentieth century were described as having either "plankton" (assumed to have been mainly or entirely euphausiids) or "sardines" (assumed to have been anchovies, *Engraulis mordax*) in their stomachs (Clapham, Leatherwood et al. 1997). A larger sample of fin whales taken off California in the 1950s and 1960s were feeding mainly on krill, mostly *Euphausia pacifica*, with only about 10% of the individuals having anchovies in their stomachs (Rice 1963). Fin whales in the Gulf of California prey mainly on zooplankton such as *Nyctiphanes simplex* (Tershy 1992).

Feeding may occur in waters as shallow as 10 m when prey are at the surface, but most foraging is observed in high-productivity, upwelling, or thermal front marine waters (Gaskin 1972, Sergeant 1977, Nature Conservancy Council 1979 as cited in ONR 2001, Panigada, Zanardelli et al. 2008).

Diving and Social Behavior

The percentage of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives with each of these dive lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985, Stone, Katona et al. 1992, Lafortuna, Jahoda et al. 2003). Other authors have reported that the fin whale's most common dives last between 2 and 6 minutes, with 2 to 8 blows between dives (Watkins 1981, Hain, Ratnaswamy et al. 1992). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll, Acevedo-Gutierrez et al. 2001). However, Lafortuna *et al.* (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known (Panigada, Zanardelli et al. 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75 percent of sightings during the Cetacean and Turtle Assessment Program (Hain, Ratnaswamy et al. 1992). Barlow (2003) reported mean group sizes of 1.1–4.0 during surveys off California, Oregon, and Washington.

There is considerable variation in grouping frequency by region. In general, fin whales, like all baleen whales, are not very socially organized, and most fin whales are observed as singles. Fin whales are also sometimes seen in social groups that can number 2 to 7 individuals. However, up to 50, and occasionally as many as 300, can travel together on migrations (NMFS 2010).

In waters off the Atlantic Coast of the U.S. individual fin whales or pairs represented about 75% of the fin whales observed during the Cetacean and Turtle Assessment Program (Hain, Ratnaswamy et al. 1992). Individual whales or groups of less than five individuals represented about 90% of the observations (out of 2,065 observations of fin whales, the mean group size was 2.9, the modal value was 1, and the range was 1 – 65 individuals; (Hain, Ratnaswamy et al. 1992)). Fin whales in the Alaska Chukchi Sea have only been observed as individuals or in small groups.

Vocalizations and Hearing

The sounds fin whales produce underwater are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981, Watkins, Tyack et al. 1987, Edds 1988, Thompson, Findley et al. 1992). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels for fin whales are 140-200 dB re 1 µPa m (Patterson and Hamilton 1964, Watkins, Tyack et al. 1987, Thompson, Findley et al. 1992, McDonald, Hildebrand et al. 1995, Clark and Gagnon 2004). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald, Hildebrand et al. 1995), Clark personal communication, McDonald personal communication). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins, Tyack et al. 1987), while the individual counter calling data of McDonald *et al.* (1995) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson, Findley et al. 1992).

As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses (which include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by (Thompson, Findley et al. 1992) for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Payne and Webb 1971, Edds-Walton 1997). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

While there is no direct data on hearing in low-frequency cetaceans, the functional hearing range is anticipated to be between 7 Hz to 30 kHz (Watkins 1986, Au, Pack et al. 2006, Southall, Bowles et al. 2007, Ciminello, R. Deavenport et al. 2012, NOAA 2013).

Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Humpback Whale

Population Structure

Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they feed. During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different reproductive areas will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form “open” populations; that is, populations that are connected through the movement of individual animals.

NMFS recently completed a global status review of the species and proposed changing the status of many DPSs under the ESA (80 FR 22304; April 21, 2015).

NORTH PACIFIC OCEAN. NMFS’ Stock Assessment Reports recognize three stocks or populations of humpback whales in the North Pacific Ocean, based on genetic and photo-identification studies: (1) the California/Oregon/Washington and Mexico stock, (2) the Central North Pacific stock, and (3) the Western North Pacific stock (Baker, Palumbi et al. 1990, Calambokidis, Steiger et al. 1997, Perry, DeMaster et al. 1999). Individuals from the Western Pacific stock and the Central North Pacific stock could occur in the Bering Sea with access to the Chukchi and Beaufort Seas.

These stocks are based on where these humpback whales winter: California-Oregon-Washington-Mexico stock winters along coasts of Central America and Mexico, and migrate to the coast of California to southern British Columbia in the summer/fall, whereas the central North Pacific stock winters in the waters around Hawai'i, and migrates primarily to northern British Columbia/Southeast

Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands. The western North Pacific stock winters off of Asia and migrates primarily to Russia and the Bering Sea/Aleutian Islands. However, Calambokidis *et al.* (1997) identified humpback whales from Southeast Alaska (central North Pacific), the California-Oregon-Washington (eastern North Pacific), and Ogasawara Islands (Japan, Western Pacific) groups in the Hawai'ian Islands during the winter; humpback whales from the Kodiak Island, Southeast Alaska, and British Columbia groups in the Ogasawara Islands; and whales from the British Columbia, Southeast Alaska, Prince William Sound, and Shumagin-Aleutian Islands groups in Mexico- indicating that while wintering grounds appear to be separate, there may be considerable overlap in summer feeding grounds.

Herman (1979), however, presented extensive evidence and various lines of reasoning to conclude that the humpback whales associated with the main Hawai'ian Islands immigrated to those waters only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai'i and those that winter off Mexico (with further mixing on feeding areas in Alaska) and suggested that the humpback whales that winter in Hawai'i may have emigrated from wintering areas in Mexico. Based on these patterns of movement, we conclude that the various stocks of humpback whales are not true populations or, at least, they represent populations that experience substantial levels of immigration and emigration.

Between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (also known as the SPLASH project) (Calambokidis, Falcone et al. 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches. SPLASH results suggest that the current view of population structure is incomplete. The overall pattern of movements is complex but indicates a high degree of population structure (Allen and Angliss 2014). In the future, there may be a restructuring of populations in the North Pacific based on summer feeding areas, similar to the structure of the Atlantic populations.

Distribution

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern Oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they reproduce and give birth to calves) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In their summer foraging areas and winter calving areas, humpback whales tend to occupy shallower, coastal waters; during their seasonal migrations; however, humpback whales disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait ((Nemoto 1957, Johnson and Wolman 1984) as cited in (Allen and Angliss 2013)). Humpback whales have also been observed during the summer in the Chukchi and Beaufort Seas(Allen and Angliss 2014). Approximate distribution of humpback whales in the action area is shown in Figure 11.

In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen, Green et al. 2009). Additionally, Ireland *et al.* (2008) reported three humpback sightings in 2007 and one in 2008 during surveys of the eastern Chukchi Sea.

Hartin et al.(2013) reported four humpback whales during vessel-based surveys in the Chukchi Sea in 2007, two in 2008, and one in 2010. Five humpback sightings (11 individuals) occurred during the Chukchi Sea Environmental Studies Program (CSESP) vessel-based surveys in 2009 and 2010 (Aerts, Kirk et al. 2012), and a single humpback was observed several kilometers west of Barrow during the 2012 CSESP vessel-based survey (Aerts, Hetrick et al. 2013).

The Aerial Surveys of Arctic Marine Mammals (ASAMM) reported four humpback whale sightings near the coast between Icy Cape and Pt. Barrow in July and August of 2012, as well as 24 individual humpback whales on 11 September south and east of Pt. Hope (Clarke, Christman et al. 2013). Prior to 2012 only a single humpback had been sighted during the COMIDA (Clarke, Ferguson et al. 2011).

Humpback whales have been seen and heard with some regularity in recent years (2009-2012) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Hashagen, Green et al. 2009, Clarke, Ferguson et al. 2011, Crance, Berchok et al. 2011). Additional sightings of four humpback whales occurred in 2009 south of Point Hope, while transiting to Nome (Brueggeman 2010). The approximate distribution of humpback whales in Alaskan waters is provided in Figure 11 below.

Figure 11. Approximate range of humpback whales in and near the action area.

Threats to the Species

NATURAL THREATS. There is limited information on natural phenomena that kill or injure humpback whales. Humpback whales are killed by orcas (Whitehead and Glass 1985, Dolphin 1987, Florezgonzalez, Capella et al. 1994, Naessig and Lanyon 2004), and are probably killed by false killer whales and sharks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Seven female and seven male humpback whales stranded on the beaches of Cape Cod and had died from toxin produced by dinoflagellates between November 1987 and January 1988, we also know that adult and juvenile humpback whales can be killed by naturally-produced biotoxins (Geraci 1990). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992).

Entrapments in ice have been documented in the spring ice pack in Newfoundland (Merdsoy, Lien et al. 1979), and up to 25 entrapped in the same event (Lien and Stenson 1986), and some mortalities have been reported. No humpback ice entrapments have been reported in the Chukchi Sea.

Other natural sources of mortality, however, remain largely unknown. Similarly, we do not know whether and to what degree natural mortality limits or restricts patterns of growth or variability in humpback whale populations.

ANTHROPOGENIC THREATS. Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of humpback whales and was ultimately responsible for listing humpback whales as an endangered species. From 1900 to 1965, nearly 30,000 whales were taken in modern whaling operations of the Pacific Ocean. Prior to that, an unknown number of humpback whales were taken (Perry, DeMaster et al. 1999). In 1965, the International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean. As its legacy, whaling has reduced humpback whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push these whales closer to extinction.

Subsistence hunters in Alaska have reported one subsistence take of a humpback whale in South Norton Sound in 2006. There have not been any additional reported takes of humpback whales from this stock by subsistence hunters in Alaska or Russia (Allen and Angliss 2014).

Humpback whales are also killed or injured during interactions with commercial fishing gear, although the evidence available suggests that these interactions on humpback whale populations may not have significant, adverse consequence for humpback whale populations. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada: a total of 595 humpback whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Perkins and Beamish 1979, Lien 1994). Of these whales, 94 are known to have died as a result of that capture, although, like fin whales, most of the animals that died were smaller: less than 12 meters in length (Lien 1994). From 1979-2008, 1,209 whales were recorded entangled, 80% of which were humpback whales (Benjamins, Ledwell et al. 2012). Along the Pacific coast of Canada, 40 humpback whales have been reported as entangled since 1980, four of which are known to have died (Ford, Rambeau et al. 2009, COSEWIC 2011).

Brownell et al. (2000) compiled records of bycatch in Japanese and Korean commercial fisheries between 1993 and 2000. During the period 1995-99, there were six humpback whales indicated as “bycatch”. In addition, two strandings were reported during this period. Furthermore, analysis of four samples from meat found in markets indicated that humpback whales are being sold. At this time, it is not known whether any or all strandings were caused by incidental interactions with commercial fisheries; similarly, it is not known whether the humpback whales identified in market samples were killed as a result of incidental interactions with commercial fisheries. It is also not known which fishery may be responsible for the bycatch. Regardless, these data indicate a minimum mortality level of 1.1/year (using bycatch data only) to 2.4/year (using bycatch, stranding, and market data) in the waters of Japan and Korea. Because many mortalities pass unreported, the actual rate in these areas is likely much higher. An analysis of entanglement rates from photographs collected for SPLASH found a minimum entanglement rate of 31% for humpback whales from the Asia breeding grounds (Cascadia Research 2003).

A photography study of humpback whales in southeastern Alaska in 2003 and 2004 found at least 53% of individuals showed some kind of scarring from fishing gear entanglement (Neilson, Gabriele et al. 2005). From 2007-2011, 2 humpback whales of the Central North Pacific population were found entangled in fishing gear in Alaska, and one was injured in Hawaii shallow set longline fishery, resulting in an estimated annual human-caused mortality and serious injury rate of 2.15 (Allen and Angliss 2014). Between 2007 and 2011, there was one mortality of a Western North Pacific humpback whale in the Bering Sea/Aleutian Islands pollock trawl fishery, and one mortality in the Bering Sea/Aleutian Islands flatfish trawl (Allen and Angliss 2014). Average minimum annual mortality from observed fisheries was 0.40 humpbacks from this stock (Allen and Angliss 2014).

In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill, Demaster et al. 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. Also in 1996, a vessel from Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crab pot floats from the whale; the gear was traced to a recreational fisherman in southeast Alaska.

Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 101 reports of humpback whales being entangled in fishing gear between 2006 and 2010(Henry, Cole et al. 2012). Of these, 20 resulted in serious injury, and 9 resulted in mortalities of humpbacks

These data suggest that, despite their size and strength, humpback whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

The number of humpback whales killed by ship strikes is exceeded only by fin whales (Jensen and Silber 2004). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow, Forney et al. 1997). There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales (Neilson, Gabriele et al. 2012). The majority of strikes were reported in southeastern Alaska, where the number of humpback whale collisions increased 5.8% annually from 1978 to 2011 (Neilson, Gabriele et al. 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010). However, no vessel collisions or prop strikes involving humpback whales have been documented in the Chukchi Sea (BOEM 2011).

Vessel collisions with humpback whales remains a significant management concern, given the increasing abundance of humpback whales foraging in Alaska, as well as the growing presence of marine traffic in Alaska's coastal waters. Based on these factors, injury and mortality of humpback whales as a result of vessel strike may likely continue into the future (NMFS 2006).

Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole, Hartley et al. 2005, Nelson, Garron et al. 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 7 humpback whales.

In addition to ship strikes in North America and Hawai'i, there are several reports of humpback whales being injured as result of ship strikes off the Antarctic Peninsula, in the Caribbean Sea, the Mediterranean Sea, off Australia, Bay of Bengal (Indian Ocean), Brazil, New Zealand, Peru, South Africa (NMFS 2010).

Status

Humpback whales were listed as endangered in 1970 (35 FR 18319) and that listing was carried over after Congress enacted the ESA (39 FR 41367). Humpback whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for humpback whales. A final recovery plan for the humpback whale was completed in November of 1991 (NMFS 1991). NMFS recently conducted a global status review and proposed changing the status of humpback whales under the ESA such that the Central North Pacific stock would no longer be listed (80 FR 22304; April 21, 2015). Final action on that proposal is not expected until after this project occurs.

It is difficult to assess the current status of humpback whales for the same reasons that it is difficult to assess the status of fin whales: (1) there is no general agreement on the size of the humpback whale population prior to whaling and (2) estimates of the current size of the different humpback whale populations vary widely and produce estimates that are not always comparable to one another, although robust estimates of humpback whale populations in the western North Atlantic have been published.

Winn and Reichley (1985) argued that the global population of humpback whales consisted of at least 150,000 whales in the early 1900s, with the largest population historically occurring in the Southern Ocean. Based on analyses of mutation rates and estimates of genetic diversity, Palumbi and Roman (2006) concluded that there may have been as many as 240,000 (95% confidence interval = 156,000 – 401,000) humpback whales in the North Atlantic before whaling began. In the western North Atlantic between Davis Strait, Iceland and the West Indies, Mitchell and Reeves (1983) estimated there were at least 4,685 humpback whales in 1865 based on available whaling records (although the authors note that this does not represent a "pre-exploitation estimate" because whalers from Greenland, the Gulf of St. Lawrence, New England, and the Caribbean Sea had been hunting humpback whales before 1865).

NORTH PACIFIC OCEAN. Estimates of the number of humpback whales occurring in the different populations that inhabit the Northern Pacific have risen over time. In the 1980s, estimates ranged from 1,407 to 2,100 (Baker 1985, Darling and Morowitz 1986, Baker and Herman 1987), while recent estimates place the population size at about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis, Steiger et al. 1997, Cerchio 1998, Mobley, Grotefendt et al. 1999).

Based on data collected between 1980 and 1983, Baker and Herman (1987) used a capture-recapture methodology to produce a population estimate of 1,407 whales (95% confidence interval = 1,113 - 1,701). More recently, (Calambokidis, Steiger et al. 1997) relied on resightings estimated from photographic records of individuals to produce an estimate of 6,010 humpback whales occurred in the North Pacific Ocean. Because the estimates produced by the different methodologies are not directly comparable, it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,000 individuals results from a real increase in the size of the humpback whale population, sampling bias in one or both studies, or assumptions in the methods used to produce estimates from the individuals that were sampled. Since the last of these estimates was published almost 20 years ago, we do not know if the estimates represent current population sizes.

Between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis, Falcone et al. 2008). The SPLASH effort identified a total of 7,971 unique individuals from photographs taken during close approaches. Of this total, 4,516 individuals were identified at wintering regions in at least one of the three seasons in which the study surveyed wintering area and 4,328 individuals were identified at least once at feeding areas in one of the two years in which the study surveyed feeding areas. Based on the results of that effort, Calambokidis *et al.* (2008) estimated that the current population of humpback whales in the North Pacific Ocean consisted of about 18,300 whales, not counting calves.

Individuals from the Western Pacific stock and the Central North Pacific stock could occur in the Bering Sea with access to the Chukchi and Beaufort Seas.

Central North Pacific (CNP) Stock-
Initial mark-recapture estimates have been calculated from the SPLASH data with point estimates of abundance for the Central North Pacific stock of humpback whales which winter in Hawaii ranging from 7,469 to 10,103 (Allen and Angliss 2014). The SPLASH abundance estimates ranged from 2,889 to 13,594 combined for the Aleutian Islands and Bering Sea for the Central North Pacific stock in their summer feeding areas (Allen and Angliss 2014).

Although there is no estimate of the maximum net productivity rate (R_{max}) for the Central North Pacific stock, the R_{max} for this stock is assumed to be at least 7% (Allen and Angliss 2014). Using the smallest SPLASH study abundance estimate for 2004-2005 for Hawaii of 7,469 with an assumed CV of 0.300 and its associated N_{min} of 5,833, potential biological removal (PBR) was calculated to be 61.2 animals (5,833 x 0.035 x 0.3) (Allen and Angliss 2014).[4]

Western North Pacific (WNP) Stock-
Point estimates of abundance for the Western North Pacific stock which winters in Asia (combined across three areas) for 2004 to 2006 were relatively consistent across models, ranging from 938 to 1,107 (Allen and Angliss 2014). On the summer feeding grounds WNP estimates of abundance, ranged from 6,000 to 14,000 for the Bering Sea and Aleutian Islands (Allen and Angliss 2014).

[4] This is considered the PBR for the entire CNP stock Allen, B. M. and R. P. Angliss (2014). Alaska marine mammal stock assessments, 2013, U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-277..

Similar to the Centeral North Pacific stock, there is no estimate of the maximum net productivity rate[5] (R_{max}) for the Western North Pacific stock. However, the R_{max} for this stock is assumed to be at least 7% (Allen and Angliss 2014). Using the smallest SPLASH abundance estimate calculated for 2004-2006 of 938 animals with an assumed CV of 0.300 for the entire Western North Pacific stock of humpback whale, Allen and Angliss (2014) calculated the PBR to be 2.6 animals (732 x 0.035 x 0.1). Alternatively, using the number of unique individuals seen during the SPLASH study results in a PBR of 2.0 (566 x 0.035 x 0.1).

NORTH ATLANTIC OCEAN. Stevick *et al.* (2003) estimated the size of the North Atlantic humpback whale population between 1979 and 1993 by applying statistical analyses that are commonly used in capture-recapture studies to individual humpback whales that were identified based on natural markings. Between 1979 and 1993, they estimated that the North Atlantic populations (what they call the "West Indies breeding population") consisted of between 5,930 and 12,580 individual whales. The best estimate they produced (11,570; 95% confidence interval = 10,290 -13,390) was based on samples from 1992 and 1993. If we assume that this population has grown according to the instantaneous rate of increase Stevick *et al.* (2003) estimated for this population (r = 0.0311), this would lead us to estimate that this population might consist of about 18,400 individual whales in 2007-2008.

Regardless of which of these estimates, if any, most closely correspond to the actual size and trend of the humpback whale population, all of these estimates suggest that the global population of humpback whales consists of tens of thousands of individuals, that the North Atlantic population consists of at least 2,000 individuals and the North Pacific population consists of about 18,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, humpback whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that humpback whales will have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) rather than endogenous threats caused by the small size of their population.

Reproduction and Growth

Humpbacks give birth and presumably mate on low-latitude wintering grounds in January to March in the Northern Hemisphere. Females attain sexual maturity at 5 years in some populations and exhibit a mean calving interval of approximately two years (Clapham 1992, Barlow and Clapham 1997). Gestation is about 12 months, and calves probably are weaned by the end of their first year (Perry, DeMaster et al. 1999).

Although long-term relationships do not appear to exist between males and females, mature females do pair with other females; those individuals with the longest standing relationships also have the highest reproductive output, possibly as a result of improved feeding cooperation (Ramp, Hagen et al. 2010).

[5] Maximum net productivity rate refers to the highest theoretical or estimated net productivity rate of a stock at a small population size. Net productivity rate refers to the annual per capita rate of increase in a stock due to reproduction less losses due to natural mortality (Garner et al, 1999).

Feeding and Prey Selection

Humpback whales tend to feed on summer grounds and not on winter grounds. However, some opportunistic winter feeding has been observed at low-latitudes (Perry, DeMaster et al. 1999). Humpback whales engulf large volumes of water and then filter small crustaceans and fish through their fringed baleen plates.

Humpback whales are relatively generalized in their feeding compared to some other baleen whales. In the Northern Hemisphere, known prey includes: euphausiids (krill); copepods; juvenile salmonids, Oncorhynchus spp.; Arctic cod, Boreogadus saida; walleye pollock, Theragra chalcogramma; pollock, Pollachius virens; pteropods; and cephalopods (Johnson and Wolman 1984, Perry, DeMaster et al. 1999). Foraging is confined primarily to higher latitudes (Stimpert, Wiley et al. 2007), such as the action area.

Diving and Social Behavior

In Hawai'ian waters, humpback whales remain almost exclusively within the 1800 m isobath and usually within waters depths less than 182 meters. Maximum diving depths are approximately 170 m (558 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton, Stone et al. 1997). They may remain submerged for up to 21 min (Dolphin 1987). Dives on feeding grounds ranged from 2.1-5.1 min in the north Atlantic (Goodyear unpublished manuscript). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales, with the deepest dives to 148m (Dolphin 1987), while whales observed feeding on Stellwagon Bank in the North Atlantic dove <40m (Hain et al. 1992). Because most humpback prey is likely found above 300 m depths most humpback dives are probably relatively shallow. Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

In a review of the social behavior of humpback whales, Clapham (1996) reported that they form small, unstable social groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long-periods of times. There is good evidence of some territoriality on feeding (Clapham 1994, Clapham 1996), and calving areas (Tyack 1981). In calving areas, males sing long complex songs directed towards females, other males or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Inter-male competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds which may be as high as 2.4:1.

Average group size near Kodiak Island is 2-4 individuals, although larger groups are seen near Shuyak and Sitkalidak islands and groups of 20 or more have been documented (Wynne, Foy et al. 2005). Humpback whales observed in the Alaska Chukchi Sea have been single animals and one cow calf pair was observed in the U.S. Beaufort Sea (Hashagen, Green et al. 2009).

Vocalization and Hearing

While there is no direct data on hearing in low-frequency cetaceans, the functional hearing range is anticipated to be between 7 Hz to 30 kHz (Watkins 1986, Au, Pack et al. 2006, Southall, Bowles et al. 2007, Ciminello, R. Deavenport et al. 2012, NOAA 2013). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Humpback whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 20-5000 Hz range and intensities as high as 181 dB (Payne 1970, Winn, Perkins et al. 1970, Thompson, Cummings et al. 1986). Source levels average 155 dB and range from 144 to 174 dB (Thompson, Winn et al. 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Tyack 1981, Silber 1986).

Social sounds in breeding areas associated with aggressive behavior in male humpback whales are very different than songs and extend from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Tyack and Whitehead 1983, Silber 1986). These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead 1983).

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson, Cummings et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent, Nilson et al. 1985, Sharpe and Dill 1997).

In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20 Hz–5 kHz with estimated source levels from 144– 174 dB; these are mostly sung by males on the breeding grounds (Winn, Perkins et al. 1970, Richardson, Greene et al. 1995, Au, Popper et al. 2000, Frazer and Mercado 2000, Au, Pack et al. 2006);
2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson, Greene et al. 1995); and
3. Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels in excess of 175 dB re 1 Pa at 1m (Thompson, Cummings et al. 1986, Richardson, Greene et al. 1995).

Arctic Ringed Seal

Population Structure

A single Alaskan stock of ringed seal is currently recognized in U.S. waters. This stock is part of the Artic ringed seal subspecies.

Distribution

Arctic ringed seals have a circumpolar distribution. They occur in all seas of the Arctic Ocean, and range seasonally into adjacent seas including the Bering Sea. In the Chukchi and Beaufort Seas, where they are year-round residents, they are the most widespread seal species.

Arctic ringed seals have an affinity for ice-covered waters and are able to occupy areas of even continuous ice cover by abrading breathing holes in that ice (Hall 1865, Bailey and Hendee 1926, McLaren 1958). Throughout most of their range, Arctic ringed seals do not come ashore and use sea ice as a substrate for resting, pupping, and molting (Kelly, Burns et al. 1988, Kelly, Bengtson et al. 2010). Outside the breeding and molting seasons, they are distributed in waters of nearly any depth; their distribution is strongly correlated with seasonally and permanently ice-covered waters and food availability (e.g. (Simpkins, Hiruki-Raring et al. 2003, Freitas, Kovacs et al. 2008).

The seasonality of ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation. Three ecological seasons have been described as important to ringed seals: the "open-water" or "foraging" period when ringed seals forage most intensively, the subnivean period in early winter through spring when seals rest primarily in subnivean lairs (snow caves) on the ice, and the basking period between lair abandonment and ice break-up (Born, Teilmann et al. 2004, Kelly, Badajos et al. 2010).

Overall, the record from satellite tracking indicates that during the foraging period, ringed seals breeding in shorefast ice either forage within 100 km of their shorefast breeding habitat or they make extensive movements of hundreds or thousands of kilometers to forage in highly productive areas and along the pack ice edge (Freitas, Kovacs et al. 2008, Kelly, Bengtson et al. 2010). Movements during the foraging period by ringed seals that breed in the pack ice are unknown. During the winter subnivean period, ringed seals excavate lairs in the snow above breathing holes where the snow depth is sufficient. These lairs are occupied for resting, pupping, and nursing young in annual shorefast and pack ice. Movements during the subnivean period are typically limited, especially when ice cover is extensive. During the (late) spring basking period, ringed seals haul out on the surface of the ice for their annual molt.

Because Arctic ringed seals are most readily observed during the spring basking period, aerial surveys to assess abundance are conducted during this period. Frost *et al.* (2004) reported that water depth, location relative to the fast ice edge, and ice deformation showed substantial and consistent effects on ringed seal densities during May and June in their central Beaufort Sea study area—densities were highest in relatively flat ice and near the fast ice edge, as well as at depths between 5 and 35 m. Bengtson *et al.* (2005) found that in their eastern Chukchi Sea study area during May and June, ringed seals were four to ten times more abundant in nearshore fast and pack ice than in offshore pack ice, and that ringed seal preference for nearshore or offshore habitat was independent of water depth. They observed higher densities of ringed seals in the southern region of the study area south of Kivalina and near Kotzebue Sound.

Threats to the Species

Threats to Arctic ringed seals are described in detail in the species' Status Review (Kelly, Bengtson et al. 2010) and the proposed listing rule (75 FR 77476), and are briefly summarized below. Details about individual threats in the action area will also be discussed in the *Environmental Baseline* section.

Predation. Polar bears are the main predator of ringed seals, but other predators include Arctic and red foxes, walruses, wolves, wolverines, killer whales, and ravens (Burns and Eley 1976, Heptner, Chapskii et al. 1976, Fay, Sease et al. 1990, Derocher, Lunn et al. 2004, Melnikov and Zagrebin 2005). The threat currently posed to ringed seals by predation is moderate, but predation risk is expected to increase as snow and sea ice conditions change with a warming climate (75 FR 77476).

Parasites and Diseases. Ringed seals have co-evolved with numerous parasites and diseases, and these relationships are presumed to be stable. Since July 2011, more than 60 dead and 75 diseased seals, mostly ringed seals, have been reported in Alaska. The underlying cause of the disease remains unknown, and is under investigation. Kelly *et al.* (2010) noted that abiotic and biotic changes to ringed seal habitat could lead to exposure to new pathogens or new levels of virulence, but the potential threats to ringed seals were considered low.

Climate Change: Loss of Sea Ice and Snow Cover. Diminishing sea ice and snow cover were identified as the greatest challenges to the persistence of Arctic ringed seals. Within this century, snow cover is projected to be inadequate for the formation and occupation of birth lairs over a substantial portion of the subspecies' range. Without the protection of the lairs, ringed seals–especially newborn–are vulnerable to freezing and predation (75 FR 77476). Additionally, high fidelity to birthing sites exhibited by ringed seals makes them more susceptible to localized degradation of snow cover (Kelly, Bengtson et al. 2010).

Climate Change: Ocean Acidification. Although no scientific studies have directly addressed the impacts of ocean acidification on ringed seals, the effects would likely be through their ability to find food. The decreased availability or loss of prey species from the ecosystem may have a cascading effect on ringed seals (Kelly, Bengtson et al. 2010).

Harvest. Ringed seals were harvested commercially in large numbers during the 20th century, which led to the depletion of their stocks in many parts of their range. Arctic ringed seals have been hunted by humans for millennia and remain a fundamental subsistence resource for many northern coastal communities today. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. Currently there is no comprehensive effort to quantify harvest levels of seals in Alaska. As of August 2000 the subsistence harvest database indicated that the statewide annual ringed seal subsistence harvest is 9,567 (Allen and Angliss 2014). Data on community subsistence harvests are no longer routinely being collected and no new annual harvest estimates exist. Kelly *et al.* (2010) concluded that although subsistence harvest of Arctic ringed seals is currently substantial in some parts of their range, harvest levels appear to be sustainable.

Commercial Fisheries Interactions. Commercial fisheries may impact ringed seals through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations. Based on data from 2007 and 2011, there have been an average of 3.52 (CV=0.06) mortalities of ringed seals incidental to commercial fishing operations per year (Allen and Angliss 2014).

For indirect interactions, Kelly *et al.* (2010) noted that commercial fisheries target a number of known ringed seal prey species such as walleye pollock (*Theragra chalcogramma*), Pacific cod, herring (*Clupea* sp.), and capelin. These fisheries may affect ringed seals indirectly through reductions in prey biomass and through other fishing mediated changes in ringed seal prey species. The extent that reduced numbers in individual fish stocks affect the viability of Arctic ringed seals is unknown. However, Arctic ringed seals were not believed to be significantly competing with or affected by commercial fisheries in the waters of Alaska (Frost 1985, Kelly, Burns et al. 1988).

Shipping. Current shipping activities in the Arctic pose varying levels of threats to Arctic ringed seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with ringed seal habitats. These factors are inherently difficult to know or predict, making threat assessment highly uncertain. Most ships in the Arctic avoid areas of ice. This necessarily mitigates many of the risks of shipping to ringed seals. Icebreakers pose special risks to ringed seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (*e.g.,* tankers and bulk carriers) through ice-covered areas.

Contamination. Contaminants research on Arctic ringed seals has been conducted in most parts of the subspecies' range. Pollutants such as organochlorine (OC) compounds and heavy metals have been found in Arctic ringed seals. The variety, sources, and transport mechanisms of the contaminants vary across the ringed seal's range, but these compounds appear to be ubiquitous in the Arctic marine food chain. Statistical analysis of OCs in marine mammals has shown that for most OCs, the European Arctic is more contaminated than the Canadian and U.S. Arctic. Tynan and DeMaster (1997) noted that climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic, highlighting the importance of continued monitoring of contaminant levels.

Oil and gas activities have the potential to impact ringed seals primarily through noise, physical disturbance, and pollution, particularly in the event of a large oil spill. Within the range of the Arctic ringed seal, offshore oil and gas exploration and production activities are currently underway in the United States, Canada, Greenland, Norway, and Russia. In the United States, oil and gas activities have been conducted off the coast of Alaska since the 1970s, with most of the activity occurring in the Beaufort Sea. Although five exploratory wells have been drilled in the past, no oil fields have been developed or brought into production in the Chukchi Sea to date.

Research. Mortalities may occur occasionally incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. However, to date no mortalities have resulted from research to ringed seals, and only one mortality of a bearded seal has occurred between 2007-2011 (Allen and Angliss 2014).

The large range and population size of the Arctic DPS, however, make it less vulnerable to other perturbations, such as hunting, fisheries interactions, and research takes. Therefore, ESA Section 4(d) protective regulations and Section 9 prohibitions were deemed unnecessary for the conservation of the species (http://www.nmfs.noaa.gov/pr/pdfs/species/ringedseal_frn_filed.pdf).

Status

NMFS listed the Arctic ringed seals as threatened under the ESA on December 28, 2012 (77 FR 76706). NMFS proposed designation of critical habitat for the Arctic ringed seal on December 9, 2014 (79 FR 73010). NMFS proposed to designate critical habitat for the Arctic subspecies (*Phoca hispida hispida*) of ringed seal on December 9, 2014 (79 FR 73010), based on the location of three features essential to the conservation of the species: sea ice habitat suitable for the formation and maintenance of subnivean birth lairs; sea ice habitat suitable as a platform for basking and molting; and primary prey resources to support Arctic ringed seals. The proposed area encompasses the outer boundary of the EEZ in the Chukchi, Beaufort, and Bering Seas, with a southern boundary of Bristol Bay in years with extensive ice coverage. Proposed ringed seal critical habitat is not included in this consultation because the designation is not expected to be finalized in 2015.

There are no specific estimates of population size available for the Arctic subspecies of the ringed seal, but most experts would postulate that the population numbers in the millions. Based on the available abundance estimates for study areas within the Chukchi-Beaufort Sea region and extrapolations for pack ice areas without survey data, Kelly *et al.* (2010) indicated that a reasonable estimate for the Chukchi and Beaufort Seas is one million seals, and for the Alaskan portions of these seas is at least 300,000 seals.

Bengtson *et al.* (2005) estimated the abundance of ringed seals from spring aerial surveys conducted along the eastern Chukchi coast from Shishmaref to Barrow at 252,500 seals in 1999 and 208,900 in 2000 (corrected for seals not hauled out). However, the estimates from 1999 and 2000 in the Chukchi Sea only covered a portion of this stock's range, and were conducted over a decade ago(Allen and Angliss 2014). Frost *et al.* (2004) conducted spring aerial surveys along the Beaufort Sea coast from Oliktok Point to Kaktovik in 1996–1999. They reported density estimates for these surveys (0.98/km^2), but did not derive abundance estimates. During April-May in 2012 and 2013, U.S. and Russian researchers conducted comprehensive and synoptic aerial abundance and distribution surveys of ice-associated seals in the Bering and Okhotsk Seas (Moreland et al. 2013). Preliminary analysis of the U.S. surveys, which included only a small subset of the 2012 data, produced an estimate of about 170,000 ringed seals in the U.S. Exclusive Economic Zone (EEZ) of the Bering Sea in late April (Conn, Ver Hoef et al. 2014).

Current and precise data on trends in abundance for the Alaska stock of ringed seals are considered unavailable. PBR for this stock is also unknown at this time (Allen and Angliss 2014).

Feeding and Prey Selection

Many studies of the diet of Arctic ringed seal have been conducted and although there is considerable variation in the diet regionally, several patterns emerge. Most ringed seal prey is small, and preferred prey tends to be schooling species that form dense aggregations. Ringed seals rarely prey upon more than 10-15 prey species in any one area, and not more than 2-4 of those species are considered important prey. Fishes are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by availability of various types of prey during particular seasons as well as preference, which in part is guided by energy content of various available prey (Reeves 1998, Wathne, Haug et al. 2000). Invertebrate prey seem to become more important in the diet of Arctic ringed seals in the open water season and often dominate the diet of young animals (e.g., (Lowry, Frost et al. 1980, Holst, Stirling et al. 2001).

Despite regional and seasonal variations in the diet of Arctic ringed seals, fishes of the cod family tend to dominate the diet from late autumn through early spring in many areas (Kovacs 2007). Arctic cod (*Boreogadus saida*) is often reported to be the most important prey species for ringed seals, especially during the ice-covered periods of the year (Lowry, Frost et al. 1980, Smith 1987, Holst, Stirling et al. 2001, Labansen, Lydersen et al. 2007). Quakenbush *et al.* (2011) reported evidence that in general, the diet of Alaska ringed seals sampled consisted of cod, amphipods, and shrimp. They found that fish were consumed more frequently in the 2000s than during the 1960s and 1970s, and identified the five dominant species or taxa of fishes in the diet during the 2000s as: Arctic cod, saffron cod, sculpin, rainbow smelt, and walleye pollock. Invertebrate prey were predominantly mysids, amphipods, and shrimp, with shrimp being the most dominant.

Diving, Hauling out, and Social Behavior

Behavior of ringed seals is poorly understood because both males and females spend much of their time in lairs built in pressure ridges or under snowdrifts for protection from predators and severe weather (ADFG 1994). Figure 5 summarizes the approximate annual timing of reproduction and molting for Arctic ringed seals.

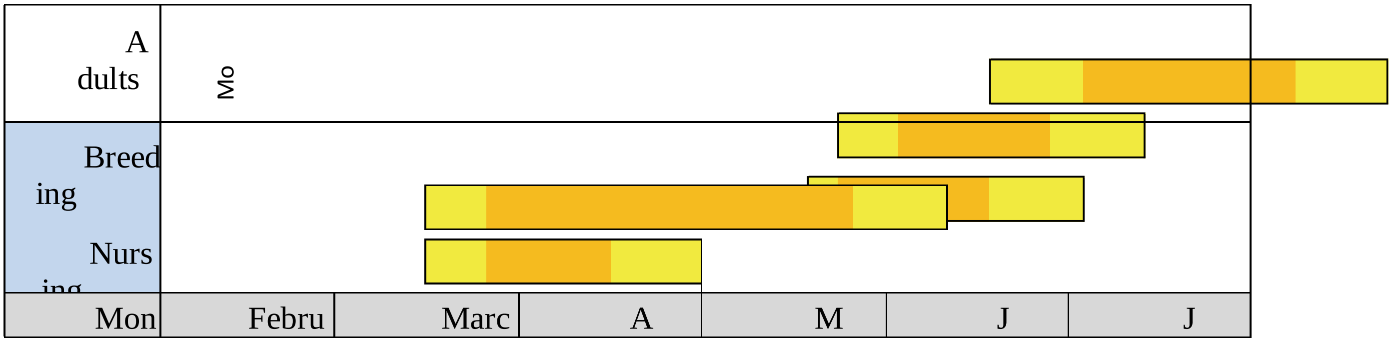

Figure 12. **Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicated the "peak" timing of each event (source: (Kelly, Bengtson et al. 2010).**

Arctic ringed seals use sea ice as a platform for resting throughout the year, and they make and maintain breathing holes in the ice from freeze-up until breakup (Frost, Lowry et al. 2002). They normally give birth in late winter-early spring in subnivean lairs constructed in the snow on the sea ice above breathing holes, and mating takes place typically in May shortly after parturition. In the spring, as day length and temperature increase, ringed seals haul out in large numbers on the surface of the ice near breathing holes or lairs. This behavior is associated with the annual May-July molt.

Ringed seal pups spend about 50% of their time in the water during the nursing period, diving for up to 12 minutes and as deep as 89 m (Lydersen and Hammill 1993). The pups' large proportion of time spent in the water, early development of diving skills, use of multiple breathing holes and nursing/resting lairs, and prolonged lanugo stage were interpreted as adaptive responses to strong predation pressure, mainly by polar bears (*Ursus maritimus*) and Arctic foxes (*Alopex lagopus*) (Smith and Lydersen 1991, Lydersen and Hammill 1993).

Tagging studies revealed that Arctic ringed seals are capable of diving for at least 39 minutes (Teilmann, Born et al. 1999) and to depths of over 500 m (Born, Teilmann et al. 2004); however, most dives reportedly lasted less than 10 minutes and dive depths were highly variable and were often limited by the relative shallowness of the areas in which the studies took place (Lydersen 1991, Kelly and Wartzok 1996, Teilmann, Born et al. 1999, Gjertz, Kovacs et al. 2000). Based on three-dimensional tracking, Simpkins *et al.* (2001) categorized ringed seal dives as either travel, exploratory, or foraging/social dives. Ringed seals tend to come out of the water during the daytime and dive at night during the spring to early summer breeding and molting periods, while the inverse tended to be true during the late summer, fall, and winter (Kelly and Quakenbush 1990, Lydersen 1991, Teilmann, Born et al. 1999, Carlens, Lydersen et al. 2006, Kelly, Bengtson et al. 2010). Captive diving experiments conducted by Elsner et al. (1989) indicated that ringed seals primarily use vision to locate breathing holes from under the ice, followed by their auditory and vibrissal senses for short-range pilotage.

Vocalizations and Hearing

Ringed seals vocalize underwater in association with territorial and mating behaviors. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz and make calls between 90 Hz and 16 kHz (Richardson, Greene et al. 1995). A more recent review suggests that the function hearing range phocids should be considered to be 75 Hz to 100 kHz (Hemila, Nummela et al. 2006, Kastelein, Wensveen et al. 2009, NOAA 2013). The airgun sound sources being proposed for this project are anticipated to be between below 1 kHz, and should be well within the auditory bandwidth for the Arctic ringed seal.

Most phocid seals spend greater than 80% of their time submerged in the water (Gordon, Gillespie et al. 2003). Phocids have good low-frequency hearing; thus, it is expected that they will be more susceptible to masking of biologically significant signals by low frequency sounds, such as those from seismic surveys (Gordon, Gillespie et al. 2003). Masking of biologically important sounds by anthropogenic noise could be considered a temporary loss of hearing acuity. Brief, small-scale masking episodes might have few long-term consequences for individual ringed seals. The consequences might be more serious in areas where many surveys are occurring simultaneously (Kelly, Bengtson et al. 2010). There is no specific evidence that exposure to pulses of airgun sound can cause permanent threshold shifts to the hearing of any marine mammal, even with large arrays of airguns. Nevertheless, direct impacts causing injury from seismic surveys may occur if animals entered the zone immediately surrounding the sound source (Kelly, Bengtson et al. 2010).

In addition, noise exposure may affect the vestibular and neurosensory systems. Unlike cetaceans, pinnipeds have a well-developed more conventional vestibular apparatus that likely provides multiple sensory cues similar to those of most land mammals. Marine mammals may be subject to noise-induced effects on vestibular function as has been shown in land mammals and humans (Southall, Bowles et al. 2007). Noise-induced effects on vestibular function may be even more pronounced than in land mammals considering a single vibrissa on a ringed seal contains ten times the number of nerve fibers typically found in one vibrissa of a land mammal (Hyvärinen 1989). However, more data are needed to more fully assess potential impacts of underwater sound exposure on non-auditory systems in pinnipeds.

Elsner *et al.* (1989) indicated that ringed seals primarily use vision to locate breathing holes from under the ice, followed by their auditory and vibrissal senses for short-range pilotage. Hyvärinen (1989) suggested that ringed seals in Lake Saimaa may use a simple form of echolocation along with a highly developed vibrissal sense for orientation and feeding in dark, murky waters. The vibrissae likely are important in detecting prey by sensing their turbulent wakes as demonstrated experimentally for harbor seals (Dehnhardt, Mauck et al. 1998). Sound waves could be received by way of the blood sinuses and by tissue conduction through the vibrissae (Riedman 1990).

Beringia DPS of Bearded Seals

Population Structure

There are two recognized subspecies of the bearded seal: *E. b. barbatus*, often described as inhabiting the Atlantic sector (Laptev, Kara, and Barents seas, North Atlantic Ocean, and Hudson Bay; (Rice 1998)); and *E. b. nauticus*, which inhabits the Pacific sector (remaining portions of the Arctic Ocean and the Bering and Okhotsk seas; (Ognev 1935, Scheffer 1958, Manning 1974, Heptner, Chapskii et al. 1976). Geographic boundaries for the divisions between the two subspecies are subject to the caveat that distinct boundaries do not appear to exist (Cameron, Bengtson et al. 2010). Two distinct population segments were identified for the *E. b. nauticus* subspecies–the Okhotsk DPS in the Sea of Okhotsk, and the Beringia DPS, encompassing the remainder of the range of this subspecies. Only the Beringia DPS of bearded seals is found in U.S. waters (and the action area), and these are of a single recognized Alaska stock.

Distribution

Bearded seals are a boreoarctic species with a circumpolar distribution (Fedoseev 1965, Johnson, Fiscus et al. 1966, Burns 1967, Burns and Frost 1979, Frost, Lowry et al. 1979, Burns 1981, Smith 1981, Kelly, Burns et al. 1988). Their normal range extends from the Arctic Ocean (85°N) south to Sakhalin Island (45°N) in the Pacific, and south to Hudson Bay (55°N) in the Atlantic (Allen 1880, Ognev 1935, King 1983). The range of the Beringia DPS of the bearded seal is defined as extending from an east-west Eurasian dividing line at Novosibirskiye in the East Siberian Sea, south into the Bering Sea (Kamchatka Peninsula and 157°E division between the Beringia and Okhotsk DPSs), and to a north American dividing line (between the Beringia DPS of the E. b. nauticus subspecies and the E. B. barbatus subspecies) at 122°W (midpoint between the Beaufort Sea and Pelly Bay).

Bearded seals are closely associated with sea ice – particularly during the critical life history periods related to reproduction and molting – and can be found in a broad range of ice types. They generally prefer ice habitat that is in constant motion and produces natural openings and areas of open water such as leads, fractures, and polynyas for breathing, hauling out on the ice, and access to water for foraging (Heptner, Chapskii et al. 1976, Fedoseev 1984, Nelson, Burns et al. 1984). The bearded seal's effective range is generally restricted to areas where seasonal sea ice occurs over relatively shallow waters. Cameron *et al.* (2010) defined the core distribution of bearded seals as those areas over waters less than 500 m deep.

The region that includes the Bering and Chukchi seas is the largest area of continuous habitat for bearded seals (Burns 1981, Nelson, Burns et al. 1984). The Bering-Chukchi Platform is a shallow intercontinental shelf that encompasses half of the Bering Sea, spans the Bering Strait, and covers nearly all of the Chukchi Sea. Bearded seals can reach the bottom everywhere along the shallow shelf and so it provides them favorable foraging habitat (Burns 1967). The Bering and Chukchi seas are generally covered by sea ice in late winter and spring and are then mostly ice free in late summer and fall, a process that helps to drive a seasonal pattern in the movements and distribution of bearded seals in this area (Burns 1967, Burns 1981, Nelson, Burns et al. 1984). During winter, most bearded seals in Alaskan waters are found in the Bering Sea, while smaller numbers of year-round residents remain in the Beaufort and Chukchi Seas, mostly around lead systems and polynyas. From mid-April to June, as the ice recedes, many bearded seals that overwinter in the Bering Sea migrate northward through the Bering Strait into the Chukchi and Beaufort Seas, where they spend the summer and early fall at the southern edge of the Chukchi and Beaufort Sea pack ice at the wide, fragmented margins of multiyear ice. A small number of bearded seals, mostly juveniles, remain near the coasts of the Bering and Chukchi seas for the summer and early fall instead of moving with the ice edge. These seals are found in bays, brackish water estuaries, river mouths, and have been observed up some rivers (Burns 1967, Heptner, Chapskii et al. 1976, Burns 1981).

Threats to the Species

Threats to the Beringia DPS of bearded seal are described in detail in the species' Status Review (Cameron, Bengtson et al. 2010) and the proposed listing rule (75 FR 77496), and are briefly summarized below. Details about individual threats in the action area will also be discussed in the *Environmental Baseline* section.

<u>Predation.</u> Polar bears are the primary predator of bearded seals. Other predators include brown bears, killer whales, sharks, and walruses (seemingly infrequent). Predation under the future scenario of reduced sea ice is difficult to assess; polar bear predation may decrease, but predation by killer whales, sharks, and walrus may increase (Cameron, Bengtson et al. 2010).

Parasites and Diseases. A variety of diseases and parasites have been documented to occur in bearded seals. The seals have likely coevolved with many of these and the observed prevalence is typical and similar to other species of seals. However, since July 2011, over 100 sick or dead seals have been reported in Alaska. The cause of the Arctic seal disease remains unknown, and is under investigation. Cameron *et al.* (2010) noted that abiotic and biotic changes to bearded seal habitat could lead to exposure to new pathogens or new levels of virulence, but the potential threats to ringed seals were considered low.

Climate Change: Sea Ice Loss. For at least some part of the year, bearded seals rely on the presence of sea ice over the productive and shallow waters of the continental shelves where they have access to food–primarily benthic and epibenthic organisms–and a platform for hauling out of the water. With loss of sea ice, the spring and summer ice edge may retreat to deep waters of the Arctic Ocean basin, which could separate sea ice suitable for pup maturation and molting from benthic feeding areas.

Climate Change: Ocean Acidification. The process of ocean acidification has long been recognized, but the ecological implications of such chemical changes have only recently begun to be appreciated. The waters of the Arctic and adjacent seas are among the most vulnerable to ocean acidification. The most likely impact of ocean acidification on bearded seals will be through the loss of benthic calcifiers and lower trophic levels on which the species' prey depends. Cascading effects are likely both in the marine and freshwater environments. Our limited understanding of planktonic and benthic calcifiers in the Arctic (*e.g.*, even their baseline geographical distributions) means that future changes are difficult to detect and evaluate. However, due to the bearded seals' apparent dietary flexibility, these threats are of less concern than the direct effects of potential sea ice degradation.

Ocean acidification may also impact bearded seals by affecting the propagation of sound in the marine environment. Researchers have suggested that effects of ocean acidification will cause low-frequency sounds to propagate more than 1.5x as far (Hester, Peltzer et al. 2008, Brewer and Hester 2009), which, while potentially extending the range bearded seals can communicate under quiet conditions, will increase the potential for masking when man-made noise is present.

Harvest. Bearded seals were among those species hunted by early Arctic inhabitants (Krupnik 1984), and today they remain a central nutritional and cultural resource for many northern communities (Hart and Amos 2004, ACIA 2005, Hovelsrud, McKenna et al. 2008). The solitary nature of bearded seals has made them less suitable for commercial exploitation than many other seal species. Still, within the Beringia DPS they may have been depleted by commercial harvests in the Bering Sea during the mid-20th century.

Alaska Native hunters mostly take bearded seals of the Beringia DPS during their northward migration in the late spring and early summer, using small boats in open leads among ice floes close to shore (Kelly, Burns et al. 1988). Allen and Angliss (2014) reported that based on subsistence harvest data maintained by ADFG primarily for the years 1990 to 1998, the mean estimated annual harvest level in Alaska averaged 6,788 bearded seals as of August 2000. Data on community subsistence harvests are no longer being collected and no new annual harvest estimates exist (Allen and Angliss 2014). Cameron *et al.* (2010) noted that ice cover in hunting locations can dramatically affect the availability of bearded seals and the success of hunters in retrieving seals that have been shot, which can range from 50-75% success in the ice (Burns and Frost 1979, Reeves, Stewart et al. 1992) to as low as 30% in open water (Burns 1967, Smith and Taylor 1977, Riewe and Amsden

1979, Davis and Koski 1980). Using the mean annual harvest reported from 1990-1998, assuming 25 to 50% of seals struck are lost, they estimated the total annual hunt by Alaska Natives would range from 8,485 to 10,182 bearded seals.

Assuming contemporary harvest levels in eastern Siberia are similar to Alaska, as was the pattern in the 1970s and 1980s, and a comparable struck-loss rate of 25-50%, the total annual take from the entire Bering and Chukchi Seas would range from 16,970 to 20,364 bearded seals (Cameron, Bengtson et al. 2010). In the western Canadian Beaufort Sea, bearded seal hunting has historically been secondary to ringed seal harvest, and its importance has declined further in recent times (Cleator 1996). Cameron *et al.* (2010) concluded that although the current subsistence harvest is substantial in some areas, there is little or no evidence that subsistence harvests have or are likely to pose serious risks to the Beringia DPS (Cameron, Bengtson et al. 2010).

Commercial Fisheries Interactions. Commercial fisheries may impact bearded seals through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations. Estimates of bearded seal bycatch could only be found for commercial fisheries that operate in Alaska waters. Between 2007 and 2011, there were incidental serious injuries and mortalities of bearded seals in the Bering Sea/Aleutian Islands Pollock trawl and the Bering Sea/Aleutian Islands flatfish trawl. The estimated minimum mortality rate incidental to commercial fisheries is 1.8 (CV= 0.05) bearded seals per year, based exclusively on observer data (Allen and Angliss 2014). For indirect impacts, Cameron *et al.* (2010) noted that commercial fisheries target a number of known bearded seal prey species, such as walleye pollock (*Theragra chalcogramma*) and cod. Bottom trawl fisheries also have the potential to indirectly affect bearded seals through destruction or modification of benthic prey and/or their habitat.

Shipping. Current shipping activities in the Arctic pose varying levels of threats to bearded seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with bearded seal habitats. These factors are inherently difficult to know or predict, making threat assessment highly uncertain. Most ships in the Arctic avoid areas of ice. This necessarily mitigates many of the risks of shipping to bearded seals. Icebreakers pose special risks to bearded seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (*e.g.*, tankers and bulk carriers) through ice-covered areas.

Research. Mortalities may occasionally occur incidental to marine mammal research activities authorized under the MMPA permits issued to a variety of government, academic, and other research organizations. Between 2007-2011, there was one mortality resulting from research on the Alaska stock of bearded seals, which results in an average of 0.2 mortalities per year from this stock (Tammy Adams, Permits, Conservation, and Education Division, Office of Protected Resources, pers comm. as cited in (Allen and Angliss 2014).

Contamination. Research on contaminants and bearded seals is limited compared to the extensive information available for ringed seals. Pollutants such as OC compounds and heavy metals have been found in most bearded seal populations. The variety, sources, and transport mechanisms of the contaminants vary across the bearded seal's range, but these compounds appear to be ubiquitous in the Arctic marine food chain. Statistical analysis of OCs in marine mammals has shown that, for most OCs, the European Arctic is more contaminated than the Canadian and U.S. Arctic. Tynan and DeMaster (1997) noted climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic, highlighting the importance of continued monitoring of bearded seal contaminant levels.

Oil and Gas. Within the range of the Beringia DPS, offshore oil and gas exploration and production activities are underway in the United States, Canada, and Russia. Oil and gas exploration, development, and production activities include: seismic surveys; exploratory, delineation, and production drilling operations; construction of artificial islands, causeways, ice roads, shore-based facilities, and pipelines; and vessel and aircraft operations. These activities have the potential to impact bearded seals, primarily through noise, physical disturbance, and pollution, particularly in the event of a large oil spill.

In the United States, oil and gas activities have been conducted off the coast of Arctic Alaska since the 1970s, with most of the activity occurring in the Beaufort Sea. Although five exploratory wells have been drilled in the past, no oil fields have been developed or brought into production in the Chukchi Sea to date.

Status

NMFS listed the Beringia DPS of bearded seals as threatened under the ESA on December 28, 2012 (77 FR 76740). On July 25, 2014, the U.S. District Court for the District of Alaska issued a decision vacating this listing (Alaska Oil and Gas Association v. Pritzker, Case No. 4:13-cv-00018-RPB). NMFS is appealing that decision, and we include the species in this opinion so that NMFS PR1 will have the benefit of NMFS AKR's analysis of the consequences of the proposed action on this DPS, even though the listing of the species is not in effect.

The precise number for the present population of the Beringia DPS is highly uncertain. Ver Hoef et al. (2014) calculated an abundance of 61,800 (95% CI 34,900-171,600) bearded seals in a core area (297,880 km^2) of the central and eastern Bering Sea using survey data collected from helicopters operating off of an ice breaker in 2007. In spring of 2012 and 2013, NOAA researchers, in collaboration with Russian colleagues, conducted aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland, Cameron et al. 2013). The data from these image-based surveys are still being analyzed, but Conn et al. (2014), using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of approximately 299,174 (95% CI 245,476 - 360,544) bearded seals in those waters. These data do not include bearded seals in the Chukchi and Beaufort Seas, and so may have provided an estimate of the abundance of this DPS that is biased low. The differences in abundance estimates from 2007 (Ver Hoef, Cameron et al. 2014) and 2012 (Conn, Ver Hoef et al. 2014) are likely attributable to differences in area sampled and refinement of abundance estimates over time.

At present, precise data on the minimum population estimate, trends in population abundance or the maximum net productivity rate of the Alaska stock of bearded seals are unavailable (Allen and Angliss 2014). Because a precise estimate of minimum abundance is currently not available, the PBR for this stock is unknown (Allen and Angliss 2014).

Feeding and Prey Selection

Bearded seals feed primarily on a variety of invertebrates (crabs, shrimp, clams, worms, and snails) and some fishes found on or near the sea bottom (Burns 1981, Kelly, Burns et al. 1988, Reeves, Stewart et al. 1992, Hjelset, Andersen et al. 1999, Cameron, Bengtson et al. 2010). They primarily feed on or near the bottom, diving to depths of less than 100 m (though dives of adults have been recorded up to 300 m and young-of-the-year have been recorded diving down to almost 500 m; (Gjertz, Kovacs* et al. 2000). Unlike walrus that root in the soft sediment for benthic organisms, bearded seals are believed to scan the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall, Amin et al. 2006, Marshall, Kovacs et al. 2008). They are also able to switch their diet to include schooling pelagic fishes when advantageous. Satellite tagging indicates that adults, subadults, and to some extent pups, show some level of fidelity to feeding areas, often remaining in the same general area for weeks or months at a time (Cameron 2005, Cameron and Boveng 2009). Diets may vary with age, location, season, and possible changes in prey availability (Kelly, Burns et al. 1988).

Quakenbush *et al.* (2011) reported that fish consumption appeared to increase between the 1970s and 2000s for Alaska bearded seals sampled in the Bering and Chukchi Seas, although the difference was not statistically significant. Bearded seals also commonly consumed invertebrates, which were found in 95% of the stomachs sampled. In the 2000s, sculpin, cod, and flatfish were the dominant fish taxa consumed (Quakenbush, Citta et al. 2011). The majority of invertebrate prey items identified in the 2000s were mysids, isopods, amphipods, and decapods. Decapods were the most dominant class of invertebrates, and were strongly correlated with the occurrence of shrimp and somewhat correlated with the occurrence of crab. Mollusks were also common prey, occurring in more than half of the stomachs examined throughout the years of the study.

Diving, Hauling out, and Social Behavior

The diving behavior of adult bearded seals is closely related to their benthic foraging habits and in the few studies conducted so far, dive depths have largely reflected local bathymetry (Gjertz, Kovacs* et al. 2000, Krafft, Lydersen et al. 2000). Studies using depth recording devices have until recently focused on lactating mothers and their pups. These studies showed that mothers in the Svalbard Archipelago make relatively shallow dives, generally <100 m in depth, and for short periods, generally less than 10 min in duration. Nursing mothers dived deeper on average than their pups, but by 6 weeks of age most pups had exceeded the maximum dive depth of lactating females (448-480 m versus 168-472 m) (Gjertz, Kovacs* et al. 2000). Adult females spent most of their dive time (47-92%) performing U-shaped dives, believed to represent bottom feeding (Krafft, Lydersen et al. 2000); U-shaped dives are also common in nursing pups (Lydersen, Hammill et al. 1994).

There are only a few quantitative studies concerning the activity patterns of bearded seals. Based on limited observations in the southern Kara Sea and Sea of Okhotsk it has been suggested that from late May to July bearded seals haul out more frequently on ice in the afternoon and early evening (Heptner, Chapskii et al. 1976). From July to April, three males (2 subadults and 1 young adult) tagged as part of a study in the Bering and Chukchi Seas rarely hauled out at all, even when occupying ice covered areas. This is similar to both male and female young-of-year bearded seals instrumented in Kotzebue Sound, Alaska (Frost, Whiting et al. 2008); suggesting that, at least in the Bering and Chukchi Seas, bearded seals may not require the presence sea ice for a significant part of the year. The timing of haulout was different between the age classes in these two studies however, with more of the younger animals hauling out in the late evening (Frost, Whiting et al. 2008) while adults favored afternoon.[6]

Other studies using data recorders and telemetry on lactating females and their dependent pups showed that, unlike other large phocid seals, they are highly aquatic during a nursing period of about three weeks (Lydersen and Kovacs 1999). At Svalbard Archipelago, nursing mothers spent more than 90% of their time in the water, split equally between near-surface activity and diving/foraging

[6] M. Cameron, Unpubl. data, National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, as cited in Cameron, M. F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring and J. M. Wilder (2010). Status review of the bearded seal (*Erignathus barbatus)*. NOAA Technical Memorandum NMFS-AFSC-211. Seattle, WA, U.S. Department of Commerce: 246..

(Holsvik 1998, Krafft, Lydersen et al. 2000), while dependent pups spent about 50% of their time in the water, split between the surface (30%) and diving (20%) (Lydersen, Hammill et al. 1994, Lydersen, Kovacs et al. 1996, Watanabe, Lydersen et al. 2009). In addition to acquiring resources for lactation, time spent in the water may function to minimize exposure to surface predators (Lydersen and Kovacs 1999, Krafft, Lydersen et al. 2000). Mothers traveled an average 48 km per day and alternated time in the water with one to four short bouts on the ice to nurse their pups usually between 0900 h and 2100 h (Krafft, Lydersen et al. 2000). This diurnal pattern also coincides with the timing of underwater mating calls by breeding males (Cleator, Stirling et al. 1989, Van Parijs, Kovacs et al. 2001). In the spring, adult males are suspected to spend a majority of their time in the water vocalizing and defending territories, though a few observations suggest they are not entirely aquatic and may haul out near females with or without pups (Krylov, Fedoseev et al. 1964, Burns 1967, Fedoseev 1971, Finley and Renaud 1980).

The social dynamics of mating in bearded seals are not well known because detailed observations of social interactions are rare, especially underwater where copulations are believed to occur. Theories regarding their mating system have centered around serial monogamy and promiscuity, and more specifically on the nature of competition among breeding males to attract and gain access to females (Stirling, Calvert et al. 1983, Budelsky 1992, Stirling and Thomas 2003). Whichever mating system is favored, sexual selection driven by female choice is predicted to have strongly influenced the evolution of male displays, and possibly size dimorphism, and caused the distinct geographical vocal repertoires recorded from male bearded seals in the Arctic (Stirling, Calvert et al. 1983, Atkinson 1997, Risch, Clark et al. 2007). Bearded seals are solitary throughout most of the year except for the breeding season.

Vocalizations and Hearing

Pinnipeds have a well-developed more conventional vestibular apparatus that likely provides multiple sensory cues similar to those of most land mammals (Southall, Bowles et al. 2007). Bearded seals are believed to scan the surface of the seafloor with their highly sensitive whiskers, burrowing only in pursuit of prey (Marshall, Amin et al. 2006). It is possible that marine mammals may be subject to noise-induced effects on vestibular function as has been shown in land mammals and humans (Southall, Bowles et al. 2007). Responses to underwater sound exposures in human divers and other immersed land mammals suggest that vestibular effects are produced from intense underwater sound at some lower frequencies (Steevens, Sylvester et al. 1997).

The facial whisker pads of bearded seals have 1,300 nerve endings associated with each whisker, making them among the most sensitive in the animal kingdom (Marshall, Amin et al. 2006), as reported in (Burns 2009). Schusterman (1981) speculated sightless seals use sound localization and other non-visual, perhaps tactile, cues to locate food.

Most phocid seals spend greater than 80% of their time submerged in the water (Gordon, Gillespie et al. 2003); consequently, they will be exposed to sounds from seismic surveys that occur in their vicinity. Phocids have good low-frequency hearing; thus, it is expected that they will be more susceptible to masking of biologically significant signals by low frequency sounds, such as those from seismic surveys (Gordon, Gillespie et al. 2003).

Bearded seals vocalize underwater in association with territorial and mating behaviors. The predominant calls produced by males during breeding, termed trills, are described as frequency-modulated vocalizations. Trills show marked individual and geographical variation, are uniquely identifiable over long periods, can propagate up to 30 km, are up to 60 s in duration, and are usually associated with stereotyped dive displays (Cleator, Stirling et al. 1989, Van Parijs, Kovacs et al. 2001, Van Parijs 2003, Van Parijs, Lydersen et al. 2003, Van Parijs, Lydersen et al. 2004, Van Parijs and Clark 2006).

Underwater audiograms for ice seals suggest that they have very little hearing sensitivity below 1 kHz; but hear underwater sounds at frequencies up to 60 kHz; and make calls between 90 Hz and 16 kHz (Richardson, Greene et al. 1995). A more recent review suggests that the function hearing range phocids should be considered to be 75 Hz to 100 kHz (Hemila, Nummela et al. 2006, Kastelein, Wensveen et al. 2009, NOAA 2013).

4.0 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

A number of human activities have contributed to the current status of populations of large whales and seals in the action area. Some of those activities, most notably commercial whaling, occurred extensively in the past, and no longer appear to affect these whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect populations of endangered whales and threatened ice seals.

Stressors for Species in the Action Area

The following discussion summarizes the principal stressors that affect these endangered and threatened species.

Targeted Hunts

Whaling in the Alaskan Arctic and sub-arctic has taken place for at least 2,000 years. Stoker and Krupnik (1993) documented prehistoric hunts of bowhead whales by indigenous peoples of the arctic and subarctic regions. Alaska Natives continue this tradition of subsistence whaling as they conduct yearly hunts for bowhead whales. In addition to subsistence hunting, commercial whaling occurred during the late 19th and early 20th centuries.

Historical Commercial Harvest

Bowhead Whale
Pelagic commercial whaling for the Western Arctic stock of bowheads was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort Seas (Bockstoce, Botkin et al. 2005). Woodby and Botkin (1993) estimated that the historic abundance of bowhead whales in this population was between 10,400 and 23,000 whales before commercial whaling began in 1848. Within the first two decades (1850-1870), over 60% of the estimated pre-whaling abundance was harvested, although effort remained high into the 20th century (Braham 1984). It is estimated that the pelagic whaling industry harvested 18,684 whales from this stock (Woodby and Botkin 1993). During 1848-1919, shore-based whaling operations (including landings as well as struck and lost estimates from U. S., Canada, and Russia) took an additional 1,527 animals (Woodby and Botkin 1993). An unknown percentage of the animals taken by the shore-based operations were harvested for subsistence and not commercial purposes. Estimates of mortality likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost animals. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution.

Fin Whale
Between 1911 and 1985, 49,936 fin whales were reported killed throughout the North Pacific (Mizroch, Rice et al. 2009), although newly revealed information about illegal Soviet catches indicates that the Soviets over-reported catches of about 1,200 fin whales, presumably to hide catches of other protected species (Doroshenko 2000).

Humpback Whale

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century (Rice 1978). A total of 3,277 reported catches occurred in Asia between 1910 and 1964, with 817 catches from Ogasawara between 1924 and 1944 (Nishiwaki 1966, Rice 1978). After World War II, substantial catches occurred in Asia near Okinawa (including 970 between 1958 and 1961), as well as around the main islands of Japan and the Ogaswara Islands. On the feeding grounds, substantial catches occurred around the Commander Islands and western Aleutian Islands, as well as in the Gulf of Anadyr (Springer, Vliet et al. 2006).

Humpback whales in the North Pacific were theoretically fully protected in 1965, but illegal catches by the USSR continued until 1972 (Ivashchenko, Clapham et al. 2007). From 1961 to 1971, over 6,793 humpback whales were killed illegally by the USSR. Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); however, additional illegal catches were made across the North Pacific, from the Kuril Islands to the Queen Charlotte Islands, and other takes in earlier years may have gone unrecorded.

Ringed and Bearded Seals

While substantial commercial harvest of both ringed and bearded seals in the late 19th and 20th Centuries led to local depletions, commercial harvesting of ice seals has been prohibited in U.S. waters since 1972 by the MMPA. Since that time, the only harvest of ringed and bearded seals allowed in U.S. waters is for subsistence for Alaska Native communities.

Subsistence Harvest

Bowhead Whale

Alaska Natives have been taking bowhead whales for subsistence purposes for at least 2,000 years (Marquette and Bockstoce. 1980, Stoker and Krupnik 1993). Subsistence takes have been regulated by a quota system under the authority of the IWC since 1977. This harvest represents the largest known human-related cause of mortality in the Western Arctic stock. Alaska Native subsistence hunters take approximately 0.1-0.5% of the population per annum, primarily from eleven Alaska communities (Philo, Shotts et al. 1993). Under this quota, the number of kills has ranged between 14 and 72 per year, the number depending in part on changes in management strategy and in part on higher abundance estimates in recent years (Stoker and Krupnik 1993). Suydam and George (2011) summarized Alaskan subsistence harvests of bowheads from 1974 to 2011 reporting a total of 1,149 whales landed by hunters from 12 villages with Barrow landing the most whales (n = 590) while Shaktoolik landed only one. Alaska Natives landed 37 bowheads in 2004 (Suydam, George et al. 2005, Suydam, George et al. 2006), 55 in 2005 (Suydam, George et al. 2006), 31 in 2006 (Suydam, George et al. 2007), 41 in 2007 (Suydam, George et al. 2008), and 38 in 2008 (Suydam, George et al. 2009), 31 in 2009 (Suydam, George et al. 2010), 45 in 2010 (Suydam, George et al. 2011), and 38 in 2011 (Suydam, George et al. 2012). The number of whales landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions. The efficiency of the hunt (the percent of whales struck that are retrieved) has increased since the implementation of the bowhead quota in 1978. In 1978 the efficiency was about 50%, the mean for 2000-2009 was 77% (SD=7%), and in 2010 it was 63% (Suydam, George et al. 2011), and in 2011 it was 76% (Suydam, George et al. 2012).

For 2013-2018, the IWC established a block quota of 306 landed bowheads. Because some animals are struck and lost, a strike limit of 67 plus up to 15 previously unused strikes could be taken each year (Allen and Angliss 2014). This quota includes an allowance of 5 animals to be taken by Chukotka Natives in Russia.

Ringed Seal

Ringed seals are an important species for Alaska Native subsistence hunters. The estimated annual subsistence harvest in Alaska dropped from 7,000 - 15,000 in the period from 1962 to 1972 to an estimated 2,000 - 3,000 in 1979 (Frost 1985). Based on data from two villages on St. Lawrence Island, the annual take in Alaska during the mid-1980s likely exceeded 3,000 seals (Kelly, Burns et al. 1988).

The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. As of August 2000; the subsistence harvest database indicated that the estimated number of ringed seals harvested for subsistence use per year was 9,567. Data on community subsistence harvests are no longer being collected and no new annual harvest estimates exist (Allen and Angliss 2014). Kelly *et al.* (2010) concluded that although subsistence harvest of Arctic ringed seals is currently substantial in some parts of their range, harvest levels appear to be sustainable.

Bearded Seal

Bearded seals are an important species for Alaska subsistence hunters, with estimated annual harvests of 1,784 (SD = 941) from 1966 to 1977 (Burns 1981). Between August 1985 and June 1986, 791 bearded seals were harvested in five villages in the Bering Strait region based on reports from the Alaska Eskimo Walrus Commission (Kelly, Burns et al. 1988). Five Alaska Native communities in the Northwest Arctic region of Alaska voluntarily reported a total of 258 bearded seals were harvested during 2012 (Ice Seal Committee 2013).

Information on subsistence harvest of bearded seals was compiled for 129 villages from reports from the Division of Subsistence (Coffing, Scott et al. 1998, Georgette, Coffing et al. 1998, Wolfe and Hutchinson-Scarbrough 1999) and a report from the Eskimo Walrus Commission (Sherrod 1982). Data were lacking for 22 villages; their harvests were estimated using the annual per capita rates of subsistence harvest from a nearby village. Harvest levels were estimated from data gathered in the 1980s for 16 villages; otherwise, data gathered from 1990 to 1998 were used. As of August 2000 the subsistence harvest database indicated that the estimated number of bearded seals harvested for subsistence use per year is 6,788 (Allen and Angliss 2014).

Cameron *et al.* (2010) noted that ice cover in hunting locations can dramatically affect the availability of bearded seals and the success of hunters in retrieving seals that have been shot, which can range from 50-75% success in the ice (Burns and Frost 1979, Reeves, Stewart et al. 1992), to as low as 30% in open water (Burns 1967, Smith and Taylor 1977, Riewe and Amsden 1979, Davis and Koski 1980). Using the mean annual harvest reported from 1990-1998, assuming 25 to 50% of seals struck are lost, they estimated the total annual hunt by Alaska Natives would range from 8,485 to 10,182 bearded seals (Cameron, Bengtson et al. 2010).

At this time, there are no efforts to quantify the current level of harvest of bearded seals by all Alaska communities (Allen and Angliss 2014).

Acoustic Noise

Ambient Noise. Generally, a signal would be detectable only if it is stronger than the ambient noise at similar frequencies. The lower the intensity of ambient noise, the farther signals would travel. There are many sources of ambient noise in the ocean, including wind, waves, ice, rain, and hail; sounds produced by living organisms; noise from volcanic and tectonic activity; and thermal noise that results from molecular agitation (which is important at frequencies greater than 30 kHz). We discuss two general categories of ambient noise: (1) variability in environmental conditions (i.e. sea ice, temperature, wind, etc.); and (2) the presence of marine life.

Environmental Conditions. The presence of ice can contribute substantially to ambient sound levels and affects sound propagation. While sea ice can produce substantial amounts of ambient sounds, it also can also function to dampen ambient sound. As ice forms, especially in very shallow water, the sound propagation properties of the underlying water are affected in a way that can reduce the transmission efficiency of low frequency sound (Blackwell and Greene 2001). Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. The spectrum of cracking ice sounds typically displays a broad range from 100 Hz to 1 kHz, and the spectrum level has been observed to vary as much as 15 dB within 24 hours due to the diurnal change of air temperature (BOEM 2011). Urick (1984) discussed variability of ambient noise in water including under Arctic ice; he states that "…the ambient background depends upon the nature of ice, whether continuous, broken, moving or shore-fast, the temperature of air, and the speed of the wind." Data are limited, but in at least one instance it has been shown that ice-deformation sounds produced frequencies of 4-200 Hz (Greene 1981). As icebergs melt, they produce additional background sound as the icebergs tumble and collide.

During the open-water season in the Arctic, wind and waves are important sources of ambient sound with levels tending to increase with increased wind and sea state, all other factors being equal (Greene and Moore 1995). Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The frequency spectrum and level of ambient noise can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas. The marginal ice zone, the area near the edge of large sheets of ice, usually is characterized by quite high levels of ambient sound compared to other areas, in large part due to the impact of waves against the ices edge and the breaking up and rafting of ice floes (Milne and Ganton 1964).

Year-round recordings of background ambient sound levels collected through the CSESP from 2006 to 2013 confirm that the background ambient levels are well below the levels that might affect the acoustic effects zones modeled in this analysis. The CSESP data showed seasonal variation in ambient sound levels, but minimal spatial variability across the Lease Sale 193 area. Additionally, long-term data from one recorder that was in the center of the Chukchi Sea revealed little inter-annual variation (mean broadband level: 99.7 dB re 1µPa; standard deviation: 1 dB). This supports the conclusion from the multi-station analysis that there is a significant difference between seasonal ambient levels (median broadband levels: 104.6 dB re 1 µPa and 94.5 dB re 1µPa for summer and winter, respectively)(Austin, O'Neill et al. 2015).

Presence of Marine Life. At least seasonally, marine mammals can contribute to the background sounds in the acoustic environment of the Beaufort Sea. Frequencies and levels are highly dependent on seasons. For example, source levels of bearded seal songs have been estimated to be up to 178 dB re 1 µPa at 1 m (Ray, Watkins et al. 1969, Stirling 1983, Richardson, Greene et al. 1995, Thomson and Richardson 1995). Ringed seal calls have a source level of 95-130 dB re 1 µPa at 1 m, with the dominant frequency under 5 kHz (Stirling 1973, Cummings, Holliday et al. 1986, Thomson and Richardson 1995). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with estimated source levels ranging from 128-189 dB re 1 µPa at 1 m in frequency ranges from 20-3,500 Hz. Thomson and Richardson (1995) summarized that most bowhead whale calls are "tonal frequency-modulated" sounds at 50-400 Hz. There are many other species of marine mammals in the arctic marine environment whose vocalizations contribute to ambient sound.

Anthropogenic Noise. Levels of anthropogenic (human-caused) sound can vary dramatically depending on the season, type of activity, and local conditions. These noise sources include transportation, dredging, and construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson, Greene et al. 1995).

Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994, Richardson, Greene et al. 1995, NRC 1996, NRC 2000, NRC 2003, Jasny, Reynolds et al. 2005, NRC 2005). As discussed in the preceding section, much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003).

Sounds from Vessels. Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the oceans (NRC 2003, Simmonds and Hutchinson 1996).

The types of vessels in the Beaufort Sea typically include barges, skiffs with outboard motors, icebreakers, tourism and scientific research vessels, and vessels associated with oil and gas exploration, development, and production. In the Beaufort and Chukchi seas, vessel traffic and associated noise presently is limited primarily to late spring, summer, and early autumn.

Shipping sounds are often at source levels of 150-190 dB re 1 µPa at 1m (BOEM 2011). Shipping traffic is mostly at frequencies from 20-300 Hz (Greene and Moore 1995). Sound produced by smaller boats typically is at a higher frequency, around 300 Hz (Greene and Moore 1995). In shallow water, vessels more than 10 km (6.2 mi) away from a receiver generally contribute only to background-sound levels (Greene and Moore 1995). Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce louder, but also more variable, sounds than those associated with other vessels of similar power and size (Greene and Moore 1995). The greatest sound generated during ice-breaking operations is produced by cavitations of the propeller as opposed to the engines or the ice on the hull; extremely variable increases in broad-band (10 Hz-3 kHz) noise levels of 5-10 dB are caused by propeller cavitation (Greene and Moore 1995, Austin, O'Neill et al. 2015). Broadband source levels for icebreaking operations are anticipated to be ~198 dB re 1 µPa at 1m (Austin, O'Neill et al. 2015). Icebreaking activities are anticipated to be the loudest noise sources associated with the proposed action and noise may reach the 120 dB re 1 µPa rms isopleth at 45 km (Austin, O'Neill et al. 2015).

Sound from Oil and Gas Activities. Anthropogenic noise levels in the Beaufort Sea are higher than the Chukchi Sea due to the oil and gas developments of the nearshore and onshore regions of the North Slope, particularly in the vicinity of Prudhoe Bay. Sound from oil and gas exploration and development activities include seismic surveys, drilling, and production activities.

The oil and gas industry in Alaska conducts marine (open-water) surveys in the summer and fall, and in-ice seismic surveys in the fall and winter to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or subsea terrain. The OCS leaseholders also conduct low-energy, high-resolution geophysical surveys to evaluate geohazards, biological communities, and archaeological resources on their leases.

Two-dimensional (2D) seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea since the late 1960s and early 1970s, resulting in extensive coverage over the area. Seismic surveys vary, but a typical 2D/three-dimensional (3D) seismic survey with multiple guns would emit sound at frequencies at about 10 Hz-3 kHz (Austin, O'Neill et al. 2015). Seismic airgun sound waves are directed towards the ocean bottom, but can propagate horizontally for several kilometers (Greene and Richardson 1988, Greene and Moore 1995). Analysis of sound associated with seismic operations in the Beaufort Sea and central Arctic Ocean during ice-free conditions also documented propagation distances up to 1300 km (Richardson 1998, Richardson 1999, Thode, Kim et al. 2010). Because the Chukchi Sea continental shelf has a highly uniform depth of 30-50m, it strongly supports sound propagation in the 50-500 Hz frequency band (Funk, Hannay et al. 2008). This is of particular interest because most of the industrial sounds from large vessels, seismic sources, and drilling are in this band and this likely overlaps with the greatest hearing sensitivity of listed cetacean species under consideration in this opinion.

NMFS issued an IHA to Conoco Phillips Alaska to take 8 species of marine mammals by Level B behavioral harassment incidental to conducting geophysical surveys in the Chukchi on May 23, 2008 (73 FR 30064). From 2008-2010, NMFS issued Shell three IHAs to take a small number of marine mammals incidental to marine seismic, shallow hazard, and sites clearance survey activities in the Chukchi and Beaufort Seas (73 FR 66106, 74 FR 55368, and 75 FR 27708). In 2010 and 2011, NMFS issued Statoil two IHAs to take small numbers of marine mammals by harassment incidental to marine seismic and shallow hazard surveys in the Chukchi Sea (75 FR 32379, 76 FR 30110). In 2012, NMFS issued an IHA to Shell and ION Geophysical to take small numbers of marine mammals by harassment incidental to conducting an exploratory drilling program in the Chukchi Sea (77 FR 27322), and in-ice 2D seismic surveys in the Beaufort and Chukchi Seas (77 FR 65060; October 24, 2012) respectively.

Under the Arctic Regional Biological Opinion (ARBO) (NMFS 2013), annual takes by harassment associated with marine seismic and geohazard surveys in the Chukchi Sea is anticipated to be (124) bowhead whales, (64) fin whales, (64) humpback whales, (2,152) ringed seals, and (4,320) bearded seals.
Recently, in 2013, NMFS issued an IHA to Shell and TGS to take small numbers of marine mammals by harassment incidental to site clearance and shallow hazard surveys and equipment recovery and maintenance activities in the Chukchi Sea (78 FR 47495), and marine seismic surveys in the Chukchi (78 FR 51147) respectively. The site specific consultations that were done for these IHAs fall under the umbrella of the take issued by ARBO.

Available information does not indicate that marine and seismic surveys for oil and gas exploration activities have had detectable long-term adverse population-level effects on the overall health, current status, or recovery of marine mammals in the Arctic region. For example, data indicate that the bowhead whale population has continued to increase over the timeframe that oil and gas activities have occurred. There is no evidence of long-term displacement from habitat (although studies have not specifically focused on addressing this issue). Past behavioral (primarily avoidance) effects on bowhead whales from oil and gas activity have been documented in many studies. Inupiat whalers have stated that noise from seismic surveys and some other activities at least temporarily displaces whales farther offshore, especially if the operations are conducted in the main migration corridor. Monitoring studies indicate that most fall migrating whales avoid an area with a radius about 20 - 30 km around a seismic vessel operating in nearshore waters (Miller, Moulton et al. 2005). NMFS is not aware of data that indicate that such avoidance is long-lasting after cessation of the activity (NMFS 2013).

During the 2012 exploration drilling activities, measurements of sounds produced by the drillship *Discoverer* were made on the Burger prospect in the Chukchi Sea. Broadband source levels of the *Discoverer* ranged from 177 to 185 dB re 1 μPa rms (Austin M. and Warner 2010). Most of the acoustic energy was contained in the 100-1000 Hertz (Hz) and 1-10 kHz frequency bands, both of which typically were at levels just below 120 dB re 1 μPa rms. When no other vessels were present near the *Discoverer* and drilling was occurring, broadband sound levels fell below 120 dB re 1 μPa rms at 1.5 km (Austin, A. McCrodan et al. 2013).

The modeled sound-level radii from the *Northern Explorer II*, indicate that the sound would not exceed the 180 dB. The ≥160-dB radius for the drillship was modeled to be 172 ft (52.5 m); the ≥120-dB radius was modeled to be 4.6 mi (7.4 km). Data from the floating platform *Kulluk* in Camden Bay, indicated broadband source levels (20-10,000 Hz) during drilling were estimated to be 191 and 179 dB re μPa at 1 m, respectively, based on measurements at a water depth of 20 m in water about 30 m deep (Greene and Moore 1995). Measured sound levels for the semisubmersible *Polar Pioneer* while drilling were not available, however, JASCO estimated the ≥ 120 dB re 1 μPa sound footprint with a Marine Operations Noise Model. An average source level for the *Polar Pioneer* was derived from a number of acoustic measurements of comparable semi-submersible drill units. The model yielded a propagation rage of 350 m for rms sound pressure level of 120 dB re 1 μPa for the *Polar Pioneer* while drilling on the Burger prospect (Shell 2014).

Measured distance to the 120 dB re 1 μPa threshold of the *Nordica* in dynamic positioning at the Burger prospect when in broadside to the line of recorders was 4.5 km (JASCO Applied Sciences 2013). The noise from mudline cellar construction from the *Discoverer* in the Chukchi Sea in 2012 was calculated to diminish below the 120 dB re 1 μPa rms threshold at 8.2 km from the drill site (JASCO Applied Sciences 2013). Distance to the 120 dB re 1 μPa rms during anchor handling by the *Tor Viking* was estimated to be 14 km during Shell's exploration drilling program at Burger (JASCO Applied Sciences 2013). Sounds produced by vessels managing the ice were recorded and the distance to the 120 dB re 1 μPa rms isopleth was calculated to occur at 9.6 km (JASCO Applied Sciences 2013).

The level and duration of sound received underwater from aircraft depends on altitude and water depth. Received sound level decreases with increasing altitude. For a helicopter operating at an altitude of 1,000 ft (305 m), there were no measured sound levels at a water depth of 121 ft (37 m) (Greene 1985).

Miscellaneous Sound Sources. Other acoustic systems that may be used in the Arctic by researchers, military personnel, or commercial vessel operators include high-resolution geophysical equipment, acoustic Doppler current profilers, mid-frequency sonar systems, and navigational acoustic pingers (LGL 2005, 2006). These active sonar systems emit transient sounds that vary widely in intensity and frequency (BOEM 2011).

Vessel Interactions

The general Arctic maritime season lasts only from June through October, and unaided navigation occurs within a more limited time frame. However, this pattern appears to be rapidly changing, as ice-diminished conditions become more extensive during the summer months. Between 2008 and 2012, vessel activity in the U.S. Arctic went from 120 vessels to 250, an increase of 108 percent (ICCT 2015). This includes only the northern Bering Sea, the Bering Strait, Chukchi Sea and Beaufort Sea to the Canadian border. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the near-shore Prudhoe Bay from oil and gas exploration activity is particularly pronounced (ICCT 2015).

Most vessel traffic associated with anthropogenic activities in the Arctic Ocean occurs in the summer months. On September 16, 2012, Arctic sea ice reached its lowest coverage extent ever recorded (Biello 2012), paving the way for the longest Arctic navigation season on record. On February 25, 2015 Arctic sea ice reached its maximum extent for the year, which was the lowest maximum ice extent in the satellite record starting in 1979 (National Snow and Ice Data Center (NSIDC)http://nsidc.org/arcticseaicenews/2015/03/2015-maximum-lowest-on-record). However, there is little relation between the winter maximum and summer minimum (http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4281). The weather conditions in the Arctic during the summer melt season are the most crucial factor in determining whether a record low is possible in any given year.

To better understand vessel distribution and density as activity increases, satellite automatic identification system (AIS) data were analyzed for the U.S Arctic above the Aleutian Islands. Vessel projects for the Arctic assume: 1) there will not be a U.S. Arctic deep-water port available in the next decade; 2) no increase in military presence or Coast Guard assets to the region, and 3) number of research vessels, cruise ships and adventure tourism will remain consistent with 2013 levels.

A direct comparison was made of July through November vessel locations for 2011 and 2012. The most apparent pattern between years is the shift from coastal traffic to more offshore traffic. During this time, Shell was involved in offshore drilling, and much of this shift could be attributable to offshore supply and support for oil and gas exploration and drilling on the outer continental shelf of the Chukchi Sea (ICCT 2015). For years when offshore drilling activities are assumed, 2012 serves as an appropriate reference to highlight areas of relative increased activity (ICCT 2015).

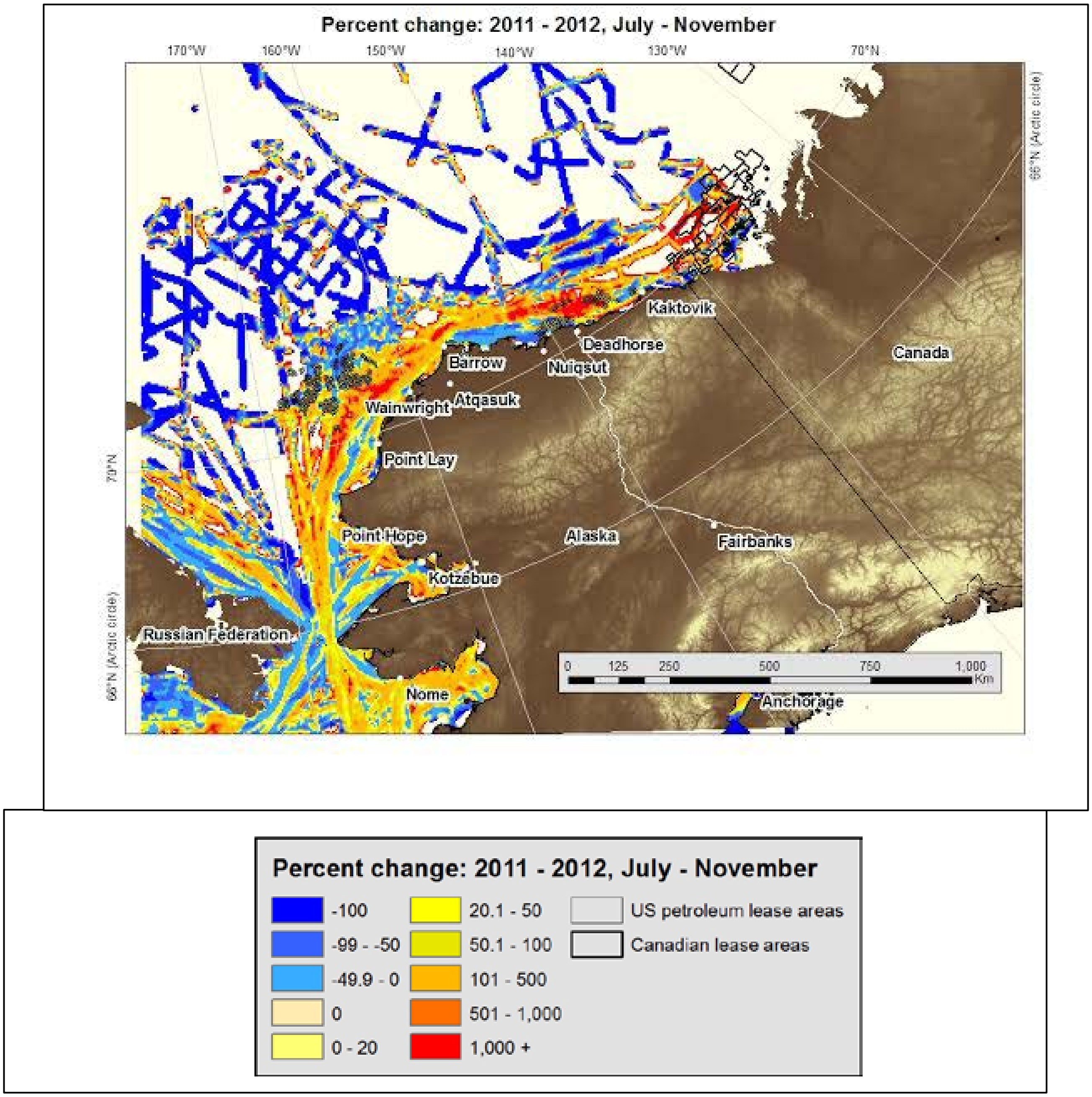

Figure 13. **Percent difference in vessel activity from 2011 to 2012 using 5 km grid cells (ICCT 2015).**

Vessel traffic can pose a threat to marine mammals because of the risk of ship strikes and the disturbance associated with noise from the vessel. Although there is no official reporting system for ship strikes, numerous incidents of vessel collisions with marine mammals have been documented in Alaska (NMFS 2010). Records of vessel collisions with large whales in Alaska indicate that strikes have involved cruise ships, recreational cruisers, whale watching catamarans, fishing vessels, and skiffs. Vessel strikes have not been recorded in the action area.

The frequency of observations of vessel-inflicted injuries suggests that the incidence of ship collisions with bowhead whales is very low. Between 1976 and 1992, only two ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George, Philo et al. 1994). The low number of observations of ship-strike injuries (along with the very long lifespan of these animals) suggests that bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

Two ship strike mortalities of fin whales occurred in Alaska waters between 2007-2011, and have been reported in the Alaska Region stranding database (Allen, Helker et al. 2014), resulting in a mean annual mortality rate of 0.4 fin whales.

In addition, the mean annual mortality rate for humpback whales in Alaska waters between 2007-2011 reported to the Alaska Region stranding database was 1.16 (Allen, Helker et al. 2014).

Current shipping activities in the Arctic pose varying levels of threats to ice seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with ice seal habitats. The presence and movements of ships in the vicinity of some seals can affect their normal behavior (Jansen, Boveng et al. 2010) and may cause ringed seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne 1979, Mansfield 1983). To date, no bearded or ringed seal carcasses have been found with propeller marks. However, Sternfield (2004) documented a singled spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike. Icebreakers pose special risks to ice seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (*e.g.*, tankers and bulk carriers) through ice-covered areas. Reeves (1998) noted that some ringed seals have been killed by ice-breakers moving through fast-ice breeding areas.

Commercial Fishing Interactions

While currently no commercial fishing is authorized in the Chukchi Sea OCS, the species present in the action area may be impacted by commercial fishing interactions as they migrate through the Bering Sea to the Chukchi Sea.

Bowhead Whale

Several cases of rope or net entanglement have been reported from bowhead whales taken in the subsistence hunt (Philo, Shotts et al. 1993). Further, preliminary counts of similar observations based on reexamination of bowhead harvest records indicate entanglements or scarring attributed to ropes may include over 20 cases (Craig George, Department of Wildlife Management, North Slope Borough, pers. comm., as cited in Allen and Angliss 2014).

There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. However, some bowhead whales have historically had interactions with crab pot gear. There are several documented cases of bowheads having ropes or rope scars on them. In 2003 a bowhead whale was found dead in Bristol Bay entangled in line around the peduncle and both flippers; the origin of the line is unknown. In 2004 a bowhead whale near Point Barrow was observed with fishing net and line around the head. One dead whale was found floating in Kotzebue Sound in early July 2010 entangled in crab pot gear similar to that used by commercial crabbers in the Bering Sea (Suydam, George et al. 2011). During the 2011 spring aerial photographic survey of bowhead whales near Point Barrow, one entangled bowhead was photographed (Mocklin, George et al. 2012). The minimum average annual entanglement rate in U.S. commercial fisheries for the 5-year period from 2007-2011 is 0.4 (Allen and Angliss 2014). However, the overall rate is currently unknown.

Fin Whale

Between 2007 and 2011, there were no observed incidental mortalities of fin whales in any Alaska commercial fisheries (Breiwick 2013).

Humpback whale

Until 2004, there were six different federally-regulated commercial fisheries in Alaska that occurred within the range of the Western North Pacific (WNP) humpback whale stock that were monitored for incidental mortality by fishery observers (Allen and Angliss 2014). As of 2004, changes in fishery definitions in the List of Fisheries have resulted in separating these 6 fisheries into 22 fisheries (69 FR 70094, December 2, 2004). This change does not represent a change in fishing effort, but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska. Between 2007 and 2011, there were two incidental mortalities of humpbacks due to fisheries in Alaska. Since all events occurred within the area of known overlap with WNP and CNP whale stocks, the stock identification is unknown. One mortality occurred in the Bering Sea/Aleutian Islands (BSAI) pollock trawl fishery, and one mortality in the BSAI flatfish(Allen and Angliss 2014). Average minimum annual mortality from observed fisheries was 0.40 humpbacks from both stocks (Allen and Angliss 2014).

Ringed Seal

Until 2004, there were three different federally-regulated commercial fisheries in Alaska that could have interacted with ringed seals and were monitored for incidental mortality by fishery observers. As of 2004, changes in fishery definitions in the List of Fisheries have resulted in separating these three fisheries into 12 fisheries (69 FR 70094, December 2, 2004). This change does not represent a change in fishing effort, but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska.

Between 2007 and 2011, there were incidental serious injuries and mortalities of ringed seals in the Bering Sea/Aleutian Islands flatfish trawl fishery, the BSAI pollock trawl, BSAI cod trawl, and BSAI cod longline. Based on data from 2007 to 2011, there have been an average of 3.52 (CV = 0.06) mortalities of ringed seals incidental to commercial fishing operations (Allen and Angliss 2014).

Bearded Seal

Similar to ringed seals, the monitoring of incidental serious injury or mortality of bearded seals changed as of 2003, and provided managers a better insight into how each fishery in Alaska was potentially impacting the species (Allen and Angliss 2014).

Between 2007 and 2011, there were incidental serious injuries and mortalities of bearded seals in the BSAI pollock trawl and the BSAI flatfish trawl fisheries (Allen and Angliss 2014). The estimated minimum mortality rate incidental to commercial fisheries is 1.8 (CV = 0.05) bearded seals per year, based exclusively on observer data (Allen and Angliss 2014).

Pollutants and Contaminants

Anthropogenic pollution in the Chukchi Sea has primarily originated outside of the region, and transported by water, sea ice, air or biota (BOEM 2015). Aspects of water quality we are primarily concerned with include trace metal and hydrocarbon concentrations.

Regional industrial activities that influence water quality include the Red Dog port and mine that have been operating since 1989, five offshore exploration wells that were drilled in the Chukchi Sea between 1989 and 1991, and the "top hole" exploratory well drilled in 2012 (BOEM 2015).

Trace Metals

Previous drilling operations in the lease sale area may cause elevated trace metals in the sediment. As an example, barium concentrations at 15 sample stations in the northeastern Chukchi Sea were up to 10,000 µg/g within 200m of the 1989 drill hole, whereas natural background levels of barium were around 700 µg/g (Trefry, Trocine et al. 2014). These results indicate that barium from drilling muds settled at drilling sites and at least a portion of the barium did not disperse despite drilling having occurred over 25 years ago (BOEM 2015).

Anomalies were also detected for copper, mercury, lead, and zinc at 4 stations within 200 m (656 ft) of 1989 drilling sites. The mercury, they concluded, was part of the cuttings brought up during drilling from the geologic formation and residual mercury that occurred in drilling muds. At present, sediments in the northeastern Chukchi Sea are pristine with respect to trace metals of anthropogenic origin, excluding the area immediately around drilling sites (Trefry, Trocine et al. 2014). Given that seafloor sediments repeatedly re-suspend, metal concentrations in the seafloor sediments introduce and elevate total-metal concentrations into the bottom water (BOEM 2015).

Hydrocarbons

Neff et al. (2010) examined the chemical characterization of seafloor sediments in 2008 in the northeastern Chukchi Sea in the region of the Burger and Klondike oil and gas prospects. Their results showed that the concentration and distribution of hydrocarbons varied in surface sediments throughout the Burger and Klondike prospects, with higher concentrations in some surface and subsurface sediment samples at exploration 1989 sites drilled in in these prospects. With the exception of hydrocarbon concentrations in sediments at these two historic drill sites, hydrocarbon concentrations at the other sites sampled within the prospects were within the range of background concentrations reported by other studies in Alaskan coastal and shelf sediments (Neff 2010).

Authorized Discharges

Bioavailability is the extent to which a chemical can be absorbed (bioaccumulated) by a living organism by active (biological) or passive (physical or chemical) processes. Bioavailability of metals and hydrocarbons can be divided into two components: environmental accessibility and environmental bioavailability (Neff 2010).

Environmental accessibility is a measure of the fraction of the total chemical that is in a form or location in the environment that is accessible for bioaccumulation by organisms. Metals of all forms buried in deep layers of sediment or cuttings have a low accessibility to marine organisms.

Environmental bioavailability depends on the interactions of a marine organism with its environment. Exposure occurs at the interface between environmental media (i.e., water, sediment, and food) and permeable biological membranes of the marine organism in contact with the different media (Neff 2010).

Existing development in the action area provides multiple sources of contaminants that may be bioavailable (NMFS 2013). Although drilling fluids and cuttings can be disposed of through onsite injection into a permitted disposal well, or transported offsite to a permitted disposal location, some drilling fluids are discharged at the sea floor before well casings are in place. Drill cuttings and fluids contain relatively high concentrations of contaminants that have high potential for bioaccumulation, such as dibenzofuran and Polycyclic Aromatic Hydrocarbons (PAHs). Historically, drill cuttings and fluids have been discharged from oil and gas developments in the project area, and residues from historical discharges may be present in the affected environment (Brown, Boehm et al. 2010). BOEM estimated that drill cuttings and exploration fluids from one exploration well would be 5,800 bbl and 3,200 bbl respectively. The proposed action assumes that the synthetic drilling mud would be reconditioned and reused with an efficiency of 80%. All of the rock cuttings would be discharged at the exploration site (BOEM 2015). PAHs are also emitted to the atmosphere by flaring water gases at production platforms or gas treatment facilities. Approximately 162,000 million standard cubic feet of waste gas was flared at Northstar in 2004 (Neff 2010).

The aqueous solubility of a contaminant is an important parameter for determining its behavior in the environment, and the potential pathways through which organisms could be exposed to the contaminant. Many of the organic contaminants associated with past development in the project area (*e.g.*, PAH) have low solubility in water due to their nonpolar molecular structures. As a result of low aqueous solubility, these compounds tend to associate with organic material or solid-phase particles (such as sediments) in the environment. Similarly, the elemental forms of some potentially toxic metals, such as lead and mercury, have low aqueous solubility. However, these metals may react with other naturally occurring chemical species to form soluble compounds (BOEM 2015).

Regulations for Discharge

The principal regulatory method for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic Region OCS is the Clean Water Act (CWA) of 1972. Section 402 establishes the National Pollution Discharge Elimination System (NPDES). The Environmental Protection Agency (EPA) issues general permits for a term of five years.

The EPA Arctic general permit restricts the seasons of operation, discharge depths, and areas of operation, and has monitoring requirements and other conditions. The EPA regulations at 40 CFR 125.122 require a determination that the permitted discharge will not cause unreasonable degradation to the marine environment.

The current NPDES general permit for exploration discharges in the Chukchi Sea is the 2012–2017 NPDES general permit for Oil and Gas Exploration Facilities on the Outer Continental Shelf in the Chukchi Sea (AK 28-8100) (EPA 2012). The terms of this permit are indicative of the expected terms of future General Permits (BOEM 2014).NMFS consulted on the issuance of the NPDES permits on April 11, 2012. NMFS concurred with the EPA’s determination that the planned actions, “may affect, but are not likely to adversely affect” bowhead, fin, and humpback whales, bearded seals and ringed seals in the Beaufort Sea or Chukchi Sea area of coverage (NMFS 2012, NMFS 2012). Discharges from regulated activities must meet the permit requirements, including any maximum concentration limits.

In addition, EPA issued a Vessel General Permit for Discharges Incidental to the Normal Operations of Vessels (VGP) authorized to discharge under NPDES permit (EPA 2013). The final VGP applies to owners and operators of non-recreational vessels that are 24 m (79 ft) and greater in length, as well as to owners and operators of commercial vessels of less than 79 ft which discharge ballast water. Pollutant constituents in the VGPs may include nutrients, pathogens, oil and grease, metals, biochemical oxygen demand, pH, total suspended solids, aquatic nuisance species, and other toxic and non-conventional pollutants with toxic effects (BOEM 2014). In addition to complying with NPDES requirements, vessels discharging in the contiguous zone and ocean (seaward of the outer limit of the territorial seas) are subject to the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), implemented by the U.S. Coast Guard pursuant to 33 CFR Part 151).

The water quality of the Chukchi Sea meets the qualitative criteria for protection of marine life described in Section 403 of the Clean Water Act. As of the most recent listing by the State of Alaska Department of Environmental Quality (ADEC 2014), no water bodies are identified as impaired, as defined by the Section 303d of the CWA, within the Arctic region (BOEM 2015).

Accidental Discharges - Oil Spills and Gas Releases

BOEM and BSEE define small oil spills as <1,000 barrels (bbl). Large oil spills are defined as 1,000-150,000 bbl, and very large oil spills (VLOS) are defined as ≥ 150,000 bbl (BOEM 2015).

Small Oil Spills

Offshore petroleum exploration activities have been conducted in State of Alaska waters and the OCS of the Chukchi Sea Planning Area since the late 1960s. Small oil spills have occurred with routine frequency. Small spills during exploration activities are expected to consist of refined oils because crude and condensate oil would not be produced during exploration (BOEM 2015).

Based on a review of potential discharges and on the historical oil spill occurrence data for the Alaska OCS and adjacent State of Alaska waters, several spills from refueling operations (primarily at West Dock) have been reported to the National Response Center in the Beaufort and Chukchi Seas and all the spills were small (BOEM 2014).

From 1971-2010 industry drilled 84 exploration wells in the entire Alaska OCS (BOEM 2011). Within the Beaufort and Chukchi OCS, the oil industry drilled 35 exploratory wells. During the time of this drilling, industry has had 35 small spills totaling 26.7 bbl or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up (BOEM 2011).

Large Oil Spills and Very Large Oil Spills

BOEM and BSEE analyzed historical data on oil spills over the entire U.S. OCS from 1971-2010, and determined that no crude oil spills ≥1,000 bbl have occurred during exploration, other than the Deepwater Horizon (DWH) incident (BOEM 2015). No large or very large oil spills have occurred historically in the action area.

The potential effects of unauthorized oil spill associated with this action and other actions that fall under BOEM's Chukichi Lease Sale 193 were analyzed as part of NMFS's programmatic biological opinion with BOEM/BSEE on lease sale 193 (NMFS 2015). That analysis indicates that while the consequences of a large or very large spill would be severe, the probability of such an event occurring and exposing listed species is extremely low. In addition, on May 11, 2015 BOEM granted conditional approval to Shell's Exploration Plan as part of their authorization of Shell's 2015 drilling program in the Chukchi Sea and ensured that their authorization was consistent with the oil spill risk analysis conducted for the lease sale. BOEM's conditional approval requires the issuance of permits from other federal agencies (including the IHA permit which this analysis is supporting) and is documented online at http://www.boem.gov/uploadedFiles/BOEM/About_BOEM/BOEM_Regions/Alaska_Region/Leasing_and_Plans/Plans/2015-05-11-Shell-EP-Conditional-Approval.pdf

Contaminants in Bowhead Whales, Ringed Seals, and Bearded Seals

Metals and hydrocarbons introduced into the marine environment from offshore exploratory drilling activities are not likely to enter the Chukchi Sea food webs in ecologically significant amounts. As an example, none of the metals and hydrocarbons measured in tissues of Beaufort Sea invertebrates and fish during the MMS ANIMIDA/cAMIMIDA Monitoring Program bioaccumulated to higher than background concentrations (Neff 2010).

However, there is a growing body of scientific literature on concentrations of metals and organochlorine chemicals (e.g., pesticides and polychlorinated biphenyls (PCBs)) in tissues of higher trophic level marine animals such as marine mammals, from cold-water environments. In most cases, these animals were not collected in the immediate vicinity of active drilling operations, so it is not possible to identify sources of contaminants in their tissues (Neff 2010). The organochlorines are not anticipated to occur from drilling operation; in most cases, they enter the Arctic environment in long-range transport in the atmosphere (MacDonald et al. 2005).

There is particular concern about mercury in Arctic marine mammal food webs (Macdonald 2005). Mercury concentrations in marine waters in much of the Arctic are higher than concentrations in temperate and tropical waters due in large part to deposition of metallic and inorganic mercury from long-range transport and deposition from the atmosphere (Outridge, Macdonald et al. 2008). However, there is no evidence that significant amounts of mercury are coming from oil operations around Prudhoe Bay (Snyder-Conn, Garbarino et al. 1997) or from offshore drilling operations (Neff 2010).

Bowhead Whale

Some environmental contaminants, such as chlorinated pesticides, are lipophilic and can be found in the blubber of marine mammals (Becker, Mackey et al. 1995). Tissues collected from whales landed at Barrow in 1992 (Becker, Mackey et al. 1995) indicate that bowhead whales have very low levels of mercury, PCB's, and chlorinated hydrocarbons, but they have elevated concentrations of cadmium in their liver and kidneys. Bratton *et al.* (1993) measured organic arsenic in the liver tissue of one bowhead whale and found that about 98% of the total arsenic was arsenobetaine. Arsenobetaine is a common substance in marine biological systems and is relatively non-toxic.

Bratton *et al.* (1993) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowhead whales harvested from 1983-1990. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time between 1983 and 1990. The metal levels observed in all tissues of the bowhead are similar to levels reported in the literature in other baleen whales. The bowhead whale has little metal contamination as compared to other arctic marine mammals, except for cadmium.

Mössner and Ballschmiter (1997) reported that total levels of polychlorinated biphenyls and chlorinated pesticides in bowhead blubber from the North Pacific/Arctic Ocean were many times lower than that in beluga whales or northern fur seals. However, while total levels were low, the combined level of three isomers of the hexachlorocyclohexanes chlorinated pesticides was higher in the bowhead blubber tested than in the North Atlantic's pilot whale, the common dolphin, and the harbor seal. These results were believed to be due to the lower trophic level of the bowhead relative to the other marine mammals tested.

Fin Whale

Based on studies of contaminants in baleen whales, including fin whales, and other marine mammals, habitat pollutants do not appear to be a major threat to fin whales in most areas where fin whales are found (NMFS 2010). O'Shea and Brownell (1994) state that concentrations of OCs and metal contaminants in tissues of baleen whales are low, and lower than other marine mammal species. They further state that there is no firm evidence that levels of OCs, organotins, or heavy metals in baleen whales generally are high enough to cause toxic or other damaging effects. Among baleen whales, Aguilar (1983)observed that mean levels of dichloro-diphenyltrichloroethane (DDT) and PCB in a study of North Atlantic fin whales were significantly lower (0.74 and 12.65 respectively) than in a study of North Atlantic sperm whales (4.68 and 26.88 respectively).

Humpback Whale

Concentrations of OC pesticides, heavy metals, and PCB's have been reported in humpback whale tissues from Canadian, United States, and Caribbean waters (Taruski, Olney et al. 1975). Biopsy blubber samples from male individuals (n=67) were collected through SPLASH, a multi-national research project, in eight North Pacific feeding grounds. Persistent organic pollutants were measured in the samples and used to assess contaminant distribution throughout the feeding areas, as well as to investigate the potential for health impacts on the study populations.

Concentrations of PCBs, DDTs, and polybrominated diphenyl ethers were more prevalent along the U.S. West Coast, with highest concentrations detected in southern California and Washington whales. A different pattern was observed for chlordanes and hexachlorocyclohexanes, with highest concentrations detected in the western Gulf of Alaska whales and those from other high latitude regions, including southeast Alaska and eastern Aleutian Islands. In general, contaminant levels in humpback whales were comparable to other mysticetes, and lower than those found in odontocete cetaceans and pinnipeds. Concentration levels likely do not represent a significant conservation threat (Elfes, VanBlaricom et al. 2010).

Ringed Seal

Contaminants research on ringed seals is extensive throughout the Arctic environment where ringed seals are an important part of the diet for coastal human communities. Pollutants such as OC compounds and heavy metals have been found in all of the subspecies of ringed seal (with the exception of the Okhotsk ringed seal). The variety, sources, and transport mechanisms of contaminants vary across ringed seal ecosystems (Kelly, Bengtson et al. 2010).

Heavy metals such as mercury, cadmium, lead, selenium, arsenic, and nick accumulate in ringed seal vital organs, including liver and kidneys, as well as in the central nervous system (Kelly, Bengtson et al. 2010). Gaden et al. (2009) suggested that during ice-free periods the seals eat more Arctic cod (and mercury). They also found that mercury levels increased with age for both sexes. Dehn et al.'s (2005) finding near Barrow also supports this. Becker *et al.* (1995) reported ringed seals had higher levels of arsenic in Norton Sound than ringed seals taken by residents of Point Hope, Point Lay, and Barrow. Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals, which might reflect localized natural arsenic sources.

Bearded Seal

Research on contaminants and bearded seals is limited compared to the information for ringed seals. However, pollutants such as OC compounds and heavy metals have been found in most bearded seal populations. Similar to ringed seals, climate change has the potential to increase the transport of pollutant from lower latitudes to the Arctic (Tynan and Demaster 1997).

Research

NMFS PR1 has issued scientific research permits, which are likely to adversely affect ringed and bearded seals in the action area. Permit No. 15142 authorizes the capture of four bearded seals (Beringia DPS); up to two of the captured seals would be placed into permanent captivity for non-invasive sensory research (Permit No. 14535). Permit No. 18537 authorizes the incidental disturbance (i.e., harassment during aerial surveys) of ringed (N = 200) and bearded seals (N = 200), during scientific research targeting the Steller sea lion (Western DPS). Permit No. 14610 authorizes the incidental disturbance (i.e., harassment during vessel surveys) of ringed (N = 10) and bearded seals (N = 10), during scientific research targeting beluga and bowhead whales. Permit No. 15324 authorizes the incidental disturbance (i.e., harassment during aerial and vessel surveys, and incidental to capture) of ringed (N = 300,050) and bearded seals (N = 150,050), the capture, drug, and tagging of ringed (N=200), and bearded seals (N= 200), and the unintentional mortality of ringed (N=5) and bearded seals (N=5).While these authorized numbers of directed takes may seem high, the actual number of take that results from these permits is often low. As an example, between 2003-2007, there was one mortality resulting from research of the Alaska stock of bearded seals, which results in an average of 0.2 mortalities per year from this stock.

Climate Change

"The Arctic marine environment has shown changes over the past several decades, and these changes are part of a broader global warming that exceeds the range of natural variability over the past 1000 years" (Walsh 2008). The changes have been sufficiently large in some areas of the Arctic (e.g., the Bering Sea and Chukchi Sea) that consequences for marine ecosystems appear to be underway (Walsh 2008). The proximate effects of climate change in the Arctic are being expressed as increased average winter and spring temperatures and changes in precipitation amount, timing, and type (Serreze, Walsh et al. 2000). Increases of approximately 75 days or more days in the number of days with open water occur north of the Bering Strait in the Beaufort, Chukchi, and East Siberian Seas; and increases by 0-50 days elsewhere in the Arctic Ocean have been seen (Walsh 2008).

A general summary of the changes attributed to the current trends of arctic warming indicate sea ice in the Arctic is undergoing rapid changes with little slowing down forecasted for the future (Budikova 2009). There are reported changes in sea-ice extent, thickness, distribution, age, and melt duration. In general, the sea-ice extent is becoming much less in the arctic summer and slightly less in winter. The thickness of arctic ice is decreasing. The distribution of ice is changing, and its age is decreasing. The melt duration is increasing. These factors lead to a decreasing perennial arctic ice pack. It is generally thought that the Arctic will become ice free in summer, but at this time there is considerable uncertainty about when that will happen.

Predictions of future sea-ice extent, using several climate models and taking the mean of all the models, estimate that the Arctic will be ice free during summer in the latter part of the 21st century (Parry 2007). There is considerable uncertainty in the estimates of summer sea ice in these climate models, with some predicting 40-60% summer ice loss by the middle of the 21st century (Holland, Bitz et al. 2006). Using a suite of models, a 40% loss is estimated for the Beaufort and Chukchi seas (Overland and Wang 2007). Some investigators, citing the current rate of decline of the summer sea-ice extent, believe it may be sooner than predicted by the models (Stroeve, Holland et al. 2007). Other investigators suggest that variability at the local and regional level is very important for making estimates of future changes. While the annual minimum of sea ice extent is often taken as an index of the state of Arctic sea ice, the recent reductions of the area of multi- year sea ice and the reduction of sea ice thickness is of greater physical importance. It would take many years to restore the ice thickness through annual growth, and the loss of multi-year sea ice makes it unlikely that the Arctic will return to previous climatological conditions in the foreseeable future. Continued loss of sea ice will be a major driver of changes across the Arctic over the next decades, especially in late summer and autumn.

Increasing ocean acidification predicted to cause changes in the ecosystem processes and present additional stressors to organisms in the Arctic (BOEM 2014). Ocean acidification occurs as carbon dioxide (CO_2) increases in the atmosphere and is absorbed into ocean waters. The increase in CO_2 lowers pH over time and reduces the concentration of calcium carbonate in the sea (BOEM 2014). Mathis and Questel (2013) studied the carbonate chemistry in the leased area in the northeast Chukchi Sea during August, September, and October 2010 and found low saturation rates of calcite and aragonite (two forms of calcium carbonate) as summer progressed.

These changes are resulting, or are expected to result, in changes to the biological environment, causing shifts, expansion, or retraction of home range, changes in behavior, and changes in population parameters of plant and animal species. Much research in recent years has focused on the effects of naturally-occurring or human-induced global climate regime shifts and the potential for these shifts to cause changes in habitat structure over large areas. Although many of the forces driving global climate regime shifts may originate outside the Arctic, the impacts of global climate change are exacerbated in the Arctic (ACIA 2005). Temperatures in the Arctic have risen faster than in other areas of the world as evidenced by glacial retreat and melting of sea ice. Threats posed by the direct and indirect effects of global climatic change are or will be common to Northern species. These threats will be most pronounced for ice-obligate species such as the polar bear, walrus, and ice seals.

The main concern about the conservation status of ice seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projects accelerated warming in the foreseeable future. A second concern, related by the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem (75 FR 77502). According to climate model projections, snow cover is forecasted to be inadequate for the formation and occupation of birth lairs for ringed seals within this century over the Alaska stock's entire range (Kelly, Bengtson et al. 2010). Bearded seals, on the other hand, are restricted to areas where seasonal sea ice occurs over relatively shallow waters where they may forage on the bottom (Fedoseev 2000), and although bearded seals usually associate with sea ice, young seals may be found in ice-free areas such as bays and estuaries.

However, not all arctic species are likely to be adversely influenced by global climate change. Conceptual models by Moore and Laidre (2006) suggested that, overall reductions in sea ice cover should increase the Western Arctic stock of bowhead whale prey availability.

This theory may be substantiated by the steady increase in the Western Arctic bowhead population during the nearly 20 years of sea ice reductions (Walsh 2008). Moore and Huntington (2008) anticipate that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change. Shelden *et al.* (2003) notes that there is a high probability that bowhead abundance will increase under a warming global climate.

The recent observations of humpback and fin whales in the eastern Chukchi Sea may be due to reoccupation of previous habitats following the population's recovery from whaling; however, given the virtual absence of these species in the region in historical data, it is also possible that these sightings reflect a northward range expansion related to the effects of climate change. The feeding range of fin whales is larger than that of other species and consequently, it is likely that the fin whale may be more resilient to climate change, should it affect prey, than a species with a narrower range. Range expansions in response to habitat change are not uncommon among cetaceans. Since humpback and fin whales are not ice-obligate or ice-associated species, it is unknown how long this habitat will remain viable for the species. However, it is logical to assume these whales will continue to utilize these waters as long as the availability of prey remains.

Summary of Stressors Affecting Listed Species in the Action Area

Several of the activities described in the *Environmental Baseline* have adversely affected listed marine mammals that occur in the action area:

- Commercial whaling reduced large whale populations in the North Pacific down to a fraction of historic population sizes. However, the Western Arctic bowhead stock of the bowhead whale is showing marked recovery with numbers approaching the low end of the historic population estimates.

- Subsistence whaling for bowhead by Alaska Natives represents the largest known human-related cause of mortality for the Western Arctic stock (0.1-0.5% of the stock per year). However, the long-term growth of this stock indicates that the level of subsistence take has been sustainable. Subsistence harvest of Arctic ringed seals and bearded seals is currently substantial in some regions but is not considered a threat at the population or species level.

- Levels of anthropogenic noise can vary dramatically depending on the season, type of activity, and local conditions. These noise levels may be within the harassment and injury thresholds for marine mammals.

- Numerous incidents of vessel collisions with large whales have been documented in Alaska. Strikes have involved cruise ships, recreational cruisers, whale watching catamarans, fishing vessels, and skiffs. Shipping and vessel traffic is expected to increase in the Arctic Region OCS if warming trends continue.

- Shipping activities in the U.S. Arctic pose varying levels of threats to ice seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with ice seal habitats. The presence and movements of ships in the vicinity of some ringed and bearded seals may cause some seals to abandon their preferred breeding habitats in areas with high traffic, and ice-breaker activities have been known to kill ringed seals when ice breaking occurs in breeding areas.

- Concentrations of organochlorine and metal contaminants in tissues of baleen whales are low, and are not thought to be high enough to cause toxic or other damaging effects. The relative impact to the recovery of baleen whales due to contaminants and pollution is thought to be low. Pollutants such as OC compounds and heavy metals have been found in both bearded and ringed seals in the Arctic.

- Mortalities incidental to marine mammal research activities authorized under MMPA permits appears to be low. There was only one documented mortality resulting from research on the Alaska stock of bearded seals, which results in an average of 0.2 mortalities per year from this stock.

- Currently, there are insufficient data to make reliable predictions of the effects of Arctic climate change on baleen whales. A study reported in George *et al.* (2006) showed that landed bowheads had better body condition during years of light ice cover. This, together with high calf production in recent years, suggests that the stock is tolerating the recent ice-retreat at least at present (Allen and Angliss 2014). The feeding range of fin whales is larger than that of other species and consequently, as feeding generalists, it is likely that the fin whale may be more resilient to climate change, should it affect prey, than feeding specialists. Recent observations of fin and humpback whales in the Chukchi Sea may be indicative of seasonal habitat expansion in response to receding sea ice or increases in prey availability which these whales now exploit.

- The ringed seal's broad distribution, ability to undertake long movements, diverse diet, and association with widely varying ice conditions suggest resilience in the face of environmental variability. However, ringed seal's long generation time and ability to produce only a single pup each year may limit its ability to respond to environmental challenges such as the diminishing ice and snow cover, particularly the forecast reduced depth of snow on ice for forming birth lairs.

- Bearded seals are restricted to areas where seasonal sea ice occurs over relatively shallow waters where they may forage on the bottom. The retreat of the spring and summer ice edge in the Arctic may separate suitable sea ice for pup maturation and molting from benthic feeding areas.

Bowhead, fin, and humpback whales in the Action Area appear to be increasing in population size – or, at least, their population sizes do not appear to be declining – despite their continued exposure to the direct and indirect effects of the activities discussed in the *Environmental Baseline*. We do not have current abundance estimates for ringed and bearded seals, so we do not know whether they are presently declining or holding constant.

Although we do not have information on other measures of the demographic status of these species (for example, age structure, gender ratios, or the distribution of reproductive success) that would facilitate a more robust assessment of the probable impact of the *Environmental Baseline*,[7] we infer from their increasing abundance that the *Environmental Baseline* is not currently preventing their population size from increasing.

[7] Increase in a population's abundance is only one piece of evidence that a population is improving in status; however, because populations can increase while experiencing low juvenile survival (e.g., if low juvenile survival is coupled with reduced adult mortality) or when those individuals that are most sensitive to a stress regime die, leaving the most resistant individuals, increases in abundance are not necessarily indicative of the long-term viability of a species.

5.0 Effects of the Action on Listed Species

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

Effects of the action that reduce the ability of a listed species to meet its biological requirements or that reduce the conservation value of designated critical habitat increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of designated critical habitat.

The direct, indirect, and cumulative effects of historical exploration and leasing operations on listed species are described in the preceding section under environmental baseline conditions. Some of those activities and their effects will continue into the future as part of the proposed action.

This biological opinion relies on the best scientific and commercial information available. We try to note of areas of uncertainty, or situations where data is not available. In analyzing the effects of the action, NMFS gives the benefit of the doubt to the listed species by minimizing the likelihood of false negative conclusions (concluding that adverse effects are not likely when such effects are, in fact, likely to occur). The action agency must carry its burden to demonstrate that the action will not violate section 7(a)(2) of the ESA.

We organize our effects analyses using a stressor identification – exposure – response – risk assessment framework for the proposed exploration activities. Then we provide a description of the potential effects that could arise from Shell's proposed activity.

We conclude this analysis with an *Integration and Synthesis of Effects* that integrates information presented in the *Status of the Species* and *Environmental Baseline* sections of this opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

As noted in Section 2.0, NMFS uses generic sound levels to determine "take" by harassment. Sources of sound are described below.

5.1 Continuous Sound Sources

The continuous sound sources used for sound propagation modeling included:

1) *drilling unit and drilling sounds,*
2) *supply & support vessels using dynamic positioning (DP) when tending to a drilling unit,*
3) *MLC construction,*
4) *anchor handling in support of mooring a drilling unit,* and
5) *ice management activities*.

The information used to generate sound level characteristics for each continuous sound source is summarized below to provide background on the model inputs.

A “safety factor” of 1.3 dB re 1µPa rms was added to the source level for each sound source prior to modeling activity scenarios to account for variability across the project area associated with received levels at different depths, geoacoustical properties, and sound-speed profiles. The addition of the 1.3 dB re 1 µPa rms safety factor to source levels resulted in an approximate 20 percent increase in the distance to the 120 dB re 1µPa rms threshold for each continuous source.
Table 8 summarizes the 120 dB re 1 µPa rms radii for individual sound sources, both the “original” radii as measured in the field, and the “adjusted” values that were calculated by adding the “safety factor” of 1.3 dB re 1 µPa rms to each source. The adjusted source levels were then used in sound propagation modeling of activity scenarios to estimate ensonified areas and associated marine mammal exposure estimates. Additional details for each of the continuous sound sources presented in Table 8 are discussed below.

Other small sources of continuous sound include noise from vessel transit and from helicopters. NMFS does not expect these sources to rise to the level of take, but the sound sources are discussed below.

Table 8. Measured and Adjusted 120 dB re 1 µPa rms Radii for Individual, Continuous Sound Sources (Adjusted Radii Were Used for Sound Propagation Modeling of Activity Scenarios)

	Radii of 120 dB re 1 µPa (rms) Isopleth (meters)	
Activity / Continuous Sound Source	Original Measurement	With 1.3 dB re 1 µPa Added to Source Level
Drilling at 1 Site	1,500	1,800
Vessel in DP	4,500	5,500
Mudline Cellar Construction at 1 Site	8,200	9,300
Anchor Handling at 1 Site (Assumed to be 2 Vessels)**	19,000	22,000
Single Vessel Ice Management	9,600	11,000

**The measurement of anchor handling in 2012 involved a single vessel. Anchor handling in 2015 is likely to involve two concurrently-operating vessels at a single site. To account for this, the 2012 anchor handling measurement was treated as two separate but concurrently-operating sound sources and modeled for subsequent application in activity scenarios involving anchor handling.

Drilling Units and Drilling Sounds

Prior to 2012, sounds from the *Discoverer* had not 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 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 1.31 km to the point at which drilling sounds would likely fall below 120 dB re 1µPa rms. In the 2012 IHA application, the modeled 1.31 km distance was multiplied by 1.5 as a precautionary measure (equaling 1.97 km) before calculating the total area that may be ensonified with continuous sounds ≥120 dB re 1 µPa rms by the *Discoverer* at each drill site on the Burger Prospect.

During 2012 exploration drilling activities, measurements of sounds produced by the *Discoverer* were made on the Burger prospect. The recorded data show a number of tonal components likely produced by vibrations from rotating machinery. Most of the acoustic energy was contained in the 100-1000 Hertz (Hz) and 1-10 kHz frequency bands, both of which typically were at levels just below 120 dB re 1 µPa rms. When no other vessels were present near the *Discoverer* and drilling was occurring, broadband sound levels fell below 120 dB re 1 µPa rms at 1.5 km (Austin et al. 2013). This measurement of the *Discoverer* in 2012, plus addition of the 1.3 dB re 1 µPa rms safety factor, was used for sound propagation modeling of all 2015 activity scenarios involving the *Discoverer*.

Measured sound levels for the *Polar Pioneer* while drilling were not available, therefore the ≥ 120 dB re 1 µPa sound footprint was estimated using JASCO Applied Science's Marine Operations Noise Model (MONM). An average source level for the *Polar Pioneer* was derived from a number of acoustic measurements of comparable semi-submersible drill units. Taken into account were reported sound levels from the drilling units *Ocean Bounty* (Gales 1982), SEDCO 708 (Greene 1986), and *Ocean General* (McCauley 1998). One-third-octave band received sound levels were extracted from these reports and were back-propagated to a range of 1 m. The resulting 1/3-octave source levels were averaged to provide a distribution that was input to MONM as a surrogate for the *Polar Pioneer*. The model yielded a propagation range of 350 m for rms sound pressure levels of 120 dB re 1 µPa rms for the *Polar Pioneer* while drilling at the Burger Prospect. This estimate of the *Polar Pioneer*, plus the safety factor, was used for sound propagation modeling of 2015 activity scenarios involving the *Polar Pioneer*.

Supply and Drilling Support Vessels using Dynamic Positioning

When support vessels arrive to transfer materials to or from drilling units, or to conduct other drilling support activities, dynamic positioning (DP) thrusters are commonly used to keep the vessel stationary next to the drilling unit or on location.

Acoustic measurements of the *Nordica* in DP mode while supporting Shell's 2012 drilling operation in the Chukchi Sea were made from multiple recorders deployed to monitor sounds from the overall drilling operation. Distances to these recorders ranged from 1.3 km to 7.9 km and maximum sound pressure levels ranged from 112.7 dB re 1 µPa rms to 129.9 dB re 1 µPa rms. Analysis of the data indicates the maximum 120 dB re 1 µPa rms distance was approximately 4 km from the vessel. In 2011, Statoil conducted geotechnical coring operations in the Chukchi Sea using the vessel *Fugro Synergy*. Measurements were taken using bottom founded recorders at 50 m, 100 m, and 1 km away from the borehole while the vessel was in DP mode (Warner and McCrodan 2011). Sound levels measured at the recorder 1 km away ranged from 119 dB re 1 µPa rms to 129 dB re 1 µPa rms. A propagation curve fit equation applied to the data and encompassing 90 percent of all measured values during the period of strongest sound emissions provides an estimate that sound levels would drop below 120 dB re 1 µPa rms at 2.3 km.

More recently, the *Nordica* was operated by Shell in 2013 at the Burger Prospect to conduct well site maintenance activities. The vessel operated in DP much of the time and was measured during these periods by a line of hydrophones moored to the seafloor at distances of 0.5, 1, 2, 4, and 8 km from the well (JASCO and Greeneridge 2014). Results indicated a strong relationship between sound levels received at the hydrophones and the orientation of the vessel relative to the linear array of recorders. Measured distances to the 120 dB re 1 µPa rms threshold were nearly three times greater when the vessel was perpendicular to the line of acoustic recorders compared to when it was oriented nearly parallel along the same line as the recorders. The 90th percentile distance to the 120 dB re 1 µPa rms threshold for periods when the Nordica was broadside to the line of recorders was 4.5 km (JASCO and Greeneridge 2014). This measurement of the *Nordica*, plus the 1.3 dB re 1 µPa rms safety factor, was used for sound propagation modeling of 2015 activity scenarios involving supply and drilling support vessels in DP.

Mudline Cellar Construction

A MLC is a relatively large-diameter hole constructed so that equipment at the top of the well can be installed below the level of the seabed, hence below the greatest depth of a potential ice keel gouge. The construction of this hole during Shell's 2012 exploration drilling program in the Chukchi Sea generated broadband sounds that were recorded by hydrophones moored to the seafloor at distances of 1, 2, 4, and 8 km. JASCO (2014) calculated that these sounds diminished below the 120 dB re 1 µPa rms threshold at 8.2 km from the drill site. This 2012 *Discoverer* MLC measurement (JASCO and Greeneridge 2014), plus the safety factor, was used for sound propagation modeling of all activity scenarios involving construction of MLCs.

Anchor Handling

The *Discoverer* drillship was held in place at the Chukchi Sea well site in 2012 by connecting to eight large anchors that were placed and set into the seabed prior to the arrival of the *Discoverer*. The setting of these anchors, as well as the process of connecting the *Discoverer* to the anchors, generated sound levels above those of drilling alone.

JASCO (2014) measured sound levels produced by the *Tor Viking* during activities associated with anchor handling in the Chukchi Sea during Shell's 2012 exploration drilling program at Burger. Distance to the 120 dB re 1 µPa rms distance during these activities was estimated to be 14 km (JASCO and Greeneridge 2014). This measurement, however, involved only a single vessel, whereas anchor handling in 2015 may involve two vessels working in tandem. To account for this, the 2012 anchor handling measurement (JASCO and Greeneridge 2014) was scaled upward using the safety factor and treated as two separate but concurrently-operating sound sources for sound propagation modeling of 2015 activity scenarios involving anchor handling. In 2015, anchor handling activities are expected to occur whenever a drilling unit moves on to or off a drill site. Activity scenarios 5, 6, and 7 each include anchor handling events. These scenarios have been assigned 3, 8, and 6 activity days, per season, respectively.

Ice Management 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 five 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 this equation, the estimated distance to the 120 dB re 1 µPa rms threshold level for continuous sounds from icebreaking was 7.63 km. These measurements of the Robert Lemeur were taken in the Beaufort Sea under presumably similar conditions as would be encountered in the Chukchi Sea in 2015.

During exploration drilling operations on the Burger Prospect in 2012, encroachment of sea ice required the *Discoverer* to temporarily depart the drill site. While it was standing by to the south, ice management vessels remained at the drill site to protect buoys that were attached to the anchors. Sounds produced by vessels managing the ice were recorded and the distance to the 120 dB re 1 µPa rms isopleth was calculated to occur at 9.6 km (JASCO and Greeneridge 2014).

Measurements of ice management sounds near Burger in 2012 involved only a single vessel, the *Tor Viking II* (JASCO and Greeneridge 2014). Operations in 2015 could involve up to four ice management vessels operating at one time, split between two drill sites. To account for this difference, the 2012 measurement of ice management was scaled upward using the 1.3 dB re 1 µPa rms safety factor and treated as four separate but concurrently-operating sound sources for sound propagation modeling. A second ice management activity scenario was modeled to estimate areas exposed to ≥120 dB re 1 µPa rms when only two vessels were managing ice at a given time.

Ice management could occur at any time in the vicinity of the Burger Prospect during Shell's planned 2015 exploration drilling program. The need to manage ice, however, is expected to be greater in summer compared to fall when the Burger Prospect becomes sea-ice free as in most years.

Aircraft Noise

Helicopters may be used for personnel and equipment transport to and from the drilling units and support vessels. 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 drilling units will generally maintain straight-line routes at altitudes of 1,500 ft. (457 m) above sea level, thereby limiting the received levels at and below the surface.

Vessel Noise

In addition to the drilling units, various types of vessels will be used in support of the operations including ice management vessels, anchor handlers, OSVs, and OSR 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 rms 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 rms at ~13 mi (~21 km) from the source, with a sound level of 150 dB re 1 µPa rms at 85 ft. (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies. During 2012, underwater sound from ten (10) vessels in transit, and in two instances towing or providing a tow-assist, were recorded by JASCO in the Chukchi Sea as a function of the Sound Source Characterization (SSC) study required in the Shell 2012 Chukchi Sea drilling IHA. SSC transit and tow results from 2012 include ice management vessels, an anchor handler, OSR vessels, the OST, support tugs, and OSVs. The recorded sound pressure levels to 120 dB re 1 µPa rms for vessels in transit primarily range from ~ 0.8 mi – 4.3 mi (1.3 - 6.9 km), whereas the measured 120 dB re 1 µPa rms for the drilling unit *Kulluk* under tow by the *Aiviq* in the Chukchi

Sea was ~ 11.8 mi (19 km) (O'Neill and McCrodan 2012a,b). Measurements of vessel sounds from Shell's 2012 exploration drilling program in the Chukchi Sea are presented in detail in the 2012 Comprehensive Monitoring Report (LGL et al. 2014).

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.

5.2 Pulsed Sound Sources

The pulsed sound sources used for sound propagation modeling of activity scenarios consisted of two small airgun arrays proposed for ZVSP activities. All possible array configurations and operating depths were modeled to identify the arrangement with the greatest sound propagation characteristics. The resulting ≥160 dB re 1µPa rms radius was multiplied by 1.5 as a conservative measure prior to estimating exposed areas, which is discussed in greater detail below.

ZVSP Activities

Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in^3 (2,458 cm^3) airguns for a total volume of 450 in^3 (7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4,097 cu cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3). Sound footprints for each of the two proposed ZVSP airgun array configurations were estimated using JASCO Applied Sciences' MONM. The model results were maximized over all water depths from 9.8 to 23 ft. (3 to 7 m) to yield precautionary sound level isopleths as a function of range and direction from the source. The 450 in^3 airgun array at a source depth of 7 m yielded the maximum ranges to the ≥190, ≥180, and ≥160 dB re 1 µPa rms isopleths.

There are two reasons that the radii for the 450 in^3 airgun array are larger than those for the 500 in^3 array. First, the sound energy does not scale linearly with the airgun volume, rather it is proportional to the cube root of the volume. Thus, the total sound energy from three airguns is larger than the total energy from two airguns, even though the total volume is smaller. Second, larger volume airguns emit more low-frequency sound energy than smaller volume airguns, and low-frequency airgun sound energy is strongly attenuated by interaction with the surface reflection. Thus, the sound energy for the larger-volume array experiences more reduction and results in shorter sound threshold radii.

The estimated 95th percentile distances to the following thresholds for the 450 in^3 airgun array were: ≥190 dB re 1 µPa rms = 170 m, ≥180 dB re 1 µPa rms = 920 m, and ≥160 dB re 1 µPa rms = 7,970 m. The ≥160 dB re 1 µPa rms distance was multiplied by 1.5 for a distance of 11,960 m. This radius was used for estimating areas ensonified by pulsed sounds to ≥160 dB re 1 µPa rms during a single ZVSP survey. ZVSP surveys may occur at up to two different drill sites during Shell's planned 2015 exploration drilling program in the Chukchi Sea.

5.3 Vessel Strike

As discussed in the *Environmental Baseline,* collision with vessels remains a source of anthropogenic mortality for whales, and to a lesser degree, pinnipeds. The proposed action will lead to increased ship traffic during drilling activities and ZVSP that would not exist but for the proposed action. NMFS cannot determine a precise percentage increase in vessel traffic, but the list of vessel associated with this action is provided in Table 1. This increase in vessel traffic will result in some increased risk of vessel strike of listed species. However, due to the limited information available regarding the incidence of ship strike and the factors contributing to ship strike events, it is difficult to determine how a particular number of vessel transits or a percentage increase in vessel traffic will translate into a number of likely ship strike events or percentage increase in collision risk.

Vessel operations are anticipated to occur on or in the vicinity of the Burger prospect. These vessels would be operating during open-water season of July through October 2015. Vessels and their operations produce effects through a visual presence; traffic frequency and speed; and operating noise of on-board equipment, engines, and in the dynamic positioning, thruster noise. Stressors associated with presence and noise are discussed separately. This section focuses on the potential for strike associated with vessels. Listed species may be exposed to vessels when seasonal distribution and habitat selection overlaps in time and space with proposed vessel activities.

Vessel Type and Collision Risk

The frequency and severity of ship strikes is thought to be influenced by vessel speed. Laist *et al.* (2001) noted 89% of all collision accounts pertained to whales that were killed or severely injured from vessels moving at 14 knots or faster. None of those collisions occurred at speeds of less than 10 knots. For the activities considered in this proposed action, maxiumum vessel speeds could go up to 16 knots (Table 1).

Shell is anticipating using 2 drilling rigs, 16 support vessels and 9 oil spill response vessels to carry out drilling operations in the summer and fall of 2015. It is anticipated that some of these will be large vessels, up to 400 ft (Table 1). These large vessels cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammals when traveling (BOEM 2011a). Large vessels may operate at high transit speeds and operate in periods of darkness and poor visibility, increasing the collision risk with marine mammals.

5.4 Oil and Gas Spills

Because of the 2010 Deepwater Horizon explosion, the federal government, along with industry, adopted new rules and safety measures related to oil-spill prevention, containment, and response. BOEM and BSEE instituted regulatory reforms in response to many of the recommendations expressed in the various reports prepared following the Deepwater Horizon event, including both prescriptive and performance-based regulation and guidance, as well as OCS safety and environmental protection requirements. The reforms strengthen the requirements for all aspects of OCS operations. Ongoing reform and research endeavors of BSEE to improve workplace safety and to strengthen oil-spill prevention, planning, containment, and response are described in the 2012-2017 Programmatic EIS (BOEM 2012).

BSEE published its Final Drilling Safety Rule in August 2012 (77 FR 50856). The Final Rule:

- Establishes new casing installation requirements
- Establishes new cementing requirements
- Requires independent third party verification of blind-shear ram capability
- Requires independent third party verification of subsea BOP stack compatibility
- Requires new casing and cementing integrity tests
- Establishes new requirements for subsea secondary BOP intervention
- Requires function testing for subsea secondary BOP intervention
- Requires documentation for BOP inspections and maintenance
- Requires a Registered Professional Engineer to certify casing and cementing requirements; and
- Establishes new requirements for specific well control training to include deepwater operations

In the first few days following a spill, evaporation is the most significant weathering process affecting the volume and chemical composition of oil (Geraci and St. Aubin 1990). The lighter, more volatile hydrocarbons evaporate most quickly, increasing the density and viscosity, and decreasing the toxicity and vapors of the oil (Mackay 1985). About 30-40% of spilled crude consists of volatile hydrocarbons that evaporate, with approximately 25% of the evaporation occurring in the first 24 hours (Fingas, Duval et al. 1979, NRC (National Research Council) 1985). Initial evaporation rate increases with increased wind speed, temperature, and sea state. Approximately 2-5% of spilled crude oil is dissolved into the water column (Payne, McNabb et al. 1987). Dispersion is the most significant weathering process in the breakdown of an oil slick already reduced by evaporation (Geraci and St. Aubin 1990), and results in the transport of small oil particles into the water column (NRC (National Research Council) 1985). Increased wave action and water turbulence are directly associated with an increased rate of dispersion (Mackay 1985).

Small Oil Spills

Small oil spills have occurred with routine frequencyin drilling operations, are considered likely, and would consist of refined oils because crude and condensate oil would not be produced during exploration (BOEM 2015).

Based on a review of potential discharges and on the historical oil spill occurrence data for the Alaska OCS and adjacent State of Alaska waters, several spills from refueling operations (primarily at West Dock) have been reported to the National Response Center in the Beaufort and Chukchi Seas and all the spills were small (BOEM 2014).

From 1971-2010 industry drilled 84 exploration wells in the entire Alaska OCS (BOEM 2011). Within the Beaufort and Chukchi OCS, the oil industry drilled 35 exploratory wells. During the time of this drilling, industry has had 35 small spills totaling 26.7 bbl or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up (BOEM 2011).

Refined oil is used in exploratory drilling activity for equipment and refueling. BOEM estimated 0–2 small refined fuel spills may occur annually during all exploration and delineation drilling activities (including Shell’s planned activities) on the OCS (BOEM 2015).

Large Oil Spills

BOEM and BSEE analyzed historical data on oil spills over the U.S. OCS from 1971-2010, and determined that no crude oil spills ≥1,000 bbl have occurred during exploration, other than the Deepwater Horizon (DWH) incident (BOEM 2015). No large or very large oil spills have occurred historically in the action area.

BOEM and BSEE estimated the predicted rate of large oil spills occurring as 0.074 spill per 1,000 years (BOEM 2015). Since Shell's proposed drilling operation is only during the open-water season of one year, NMFS does not anticipate any large spills (>1,000–150,000 bbl) would occur during the proposed action.

Very Large Oil Spills

It is highly unlikely, but cannot be entirely discounted, that a VLOS could occur from a well control incident followed by a long duration flow during exploratory drilling. A VLOS is extremely unlikely to occur because the frequency of occurrence of such a spill from a loss of well control incident is extremely low, and the number of wells anticipated to be drilled during proposed action is low. BOEM anticipates that the VLOS chance of occurrence during the first nine years of exploration activities on lease sale 193 would be between 10^{-4} and 10^{-5} per well (BOEM 2015). The chance of occurrence of a VLOS occurring during a single open water season when Shell's proposed action will occur, is far lower. NMFS does not anticipate any VLOS would occur during the proposed action.

5.5 Exposure Analysis

As discussed in the *Approach to the Assessment* section of this opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with the effects of the action in space and time and the nature of that co-occurrence. In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

The narratives that follow present the approach NMFS used to estimate the number of marine mammals that might be exposed to exploratory drilling activities PR1 proposes to permit in the Chukchi Sea (which are described in the *Proposed Action* section of this opinion).

Activity Scenarios

PR1 has issued incidental harassment authorizations to the oil and gas industry for the non-lethal taking of small numbers of marine mammals related to exploration drilling at least since the early 1990s. The exploration drilling planned for the 2015 season is a continuation of the Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Exploration Drilling Program) that began in 2012, and resulted in the completion of a partial well at the location known as Burger A. By extension, the individual stressors associated with the activities PR1 may authorize are stressors that have occurred previously in the Chukchi Sea action area.

Previous IHA applications for offshore Arctic exploration programs estimated areas potentially ensonified to ≥120 or ≥160 dB re 1µPa rms *independently* for each continuous or pulsed sound source, respectively (e.g., drilling, ZVSP, etc.). However, many of the continuous sound sources described above will operate concurrently at one or more nearby locations in 2015 during Shell's planned exploration drilling program in the Chukchi Sea. It is therefore appropriate to consider the concurrent operation of numerous sound sources and the additive acoustic effects from combined sound fields when estimating areas potentially exposed to levels ≥120 dB re 1 µPa rms.

A wide range of potential activity scenarios was derived from a realistic operational timeline by considering the various combinations of different continuous sound sources that may operate at the same time at one or more locations. The total number of possible activity combinations from all sources at up to four different drill sites would not be practical to assess or present in a meaningful way because of the very large number of possible combinations, some of which would not inform the analysis. For example, concurrent drilling and anchor handling as one activity scenario is not substantially different from anchor handling alone because of the negligible contribution of drilling sounds to the total area ensonified by both activities. Table 9 shows that the area ensonified to the 120 dB threshold level for one drilling site is 0.6% of the ensonified area associated with anchor handling at one site. For these reasons, various combinations of similar activities were grouped into representative activity scenarios shown in

Table 9. Ensonified areas for these representative activity scenarios were estimated through sound propagation modeling. Activity scenarios were modeled spatially for different drill site combinations and, as a conservative measure, the drill site locations resulting in the largest ensonified area were chosen for each activity scenario. In other words, by binning all potential scenarios into the most conservative representative scenario, the largest possible ensonified area for each combination of activities was identified for analysis. A total of nine representative activity scenarios were modeled to estimate areas exposed to continuous sounds ≥120 dB re 1 µPa rms for Shell’s planned 2015 exploration drilling program in the Chukchi Sea (

Table 9). A tenth scenario was modelled to estimate areas explosed to pulsed sounds ≥160 dB re 1 µPa rms for the ZVSP activities.

Table 9. Sound Propagation Modeling Results of Representative Drilling Related Activity Scenarios and Estimates of the Total Area Potentially Ensonified above Threshold Levels at the Burger Prospect in the Chukchi Sea, Alaska 2015.

Scenario Number & Description	Threshold Level	Area Potentially Ensonified (km^2) Summer	Area Potentially Ensonified (km^2) Fall
1 Drilling at 1 site	120 dB	10.2	10.2
2 Drilling and DP Vessel at 1 site	120 dB	111.8	111.8
3 Drilling and DP Vessel (1 site) + Drilling and DP Vessel (2nd site)	120 dB	295.5	295.5
4 Mudline Cellar Construction at 2 different sites	120 dB	575.5	575.5
5 Anchor Handling at 1 site	120 dB	1,534.9	1,534.9
6 Drilling and DP Vessel at 1 site + Anchor Handling at 2nd site	120 dB	1,759.2	1,759.2
7 Mudline Cellar Construction at 2 different sites + Anchor Handling at 3rd site	120 dB	2,046.3	2,046.3
8 Two-vessel Ice Management	120 dB	937.4	937.4
9 Four-vessel Ice Management	120 dB	1,926.0	1,926.0
10 ZVSP at 2 different sites	160 dB	0.0	898.0

As noted above, sound propagation modelling of ensonified areas involved multiple sources that would be operating at the same time. Such concurrent operations result in additive acoustic effects in areas where there is overlap in the sound fields produced by the equipment in use. Therefore, the ensonified areas associated with each of these scenarios represents the additive acoustic effects from concurrently- operating, continuous sound sources at different locations, and they result in irregular or non-circular ensonified areas when activities are occurring at different locations (activity scenarios 3-4 and 6-9;
Table **9**). Unlike a circular acoustic footprint from a single continuous sound source or sources at a single location, these irregular areas do not have defined radii.

Figure 14 through Figure 17 depict estimated areas ensonified by continuous sound levels ≥120 dB re 1 µPa rms for a representative sample of activity scenarios (1, 3, 7, and 8 from
Table **9)**. Sound propagation modeling of each activity scenario was performed by incorporating each of the respective individual, continuous sound sources using measured source levels, and then again after adding a 1.3 dB re 1 µPa rms "safety factor" to each source level. The resulting ensonified areas from each method are shown for activity scenarios 1, 3, 7, and 8 in Figure 14 through Figure 17. However, only the larger areas resulting from the application of the "safety factor" were used to estimate marine mammal exposures.

The areas potentially ensonified by each activity scenario assume all sound sources identified for that scenario would be operating concurrently. Generally each scenario consists of one to three sources; scenarios 3 and 9 are the exceptions, each of which includes four sources (
Table **9**). This approach was an attempt to move away from assessing ensonified areas stemming from different sources in isolation, or independently one-by-one, and instead begin assessing the acoustic environment more realistically as an aggregate of multiple sound sources operating concurrently. This approach to sound propagation modeling allows for the consideration of additive acoustic effects from overlapping sound fields produced by numerous, continuous sound sources (Figure 15 through Figure 16). Ultimately, this method attempts to more accurately simulate the underwater acoustic environment resulting from an exploratory drilling program such as that proposed by Shell in 2015.

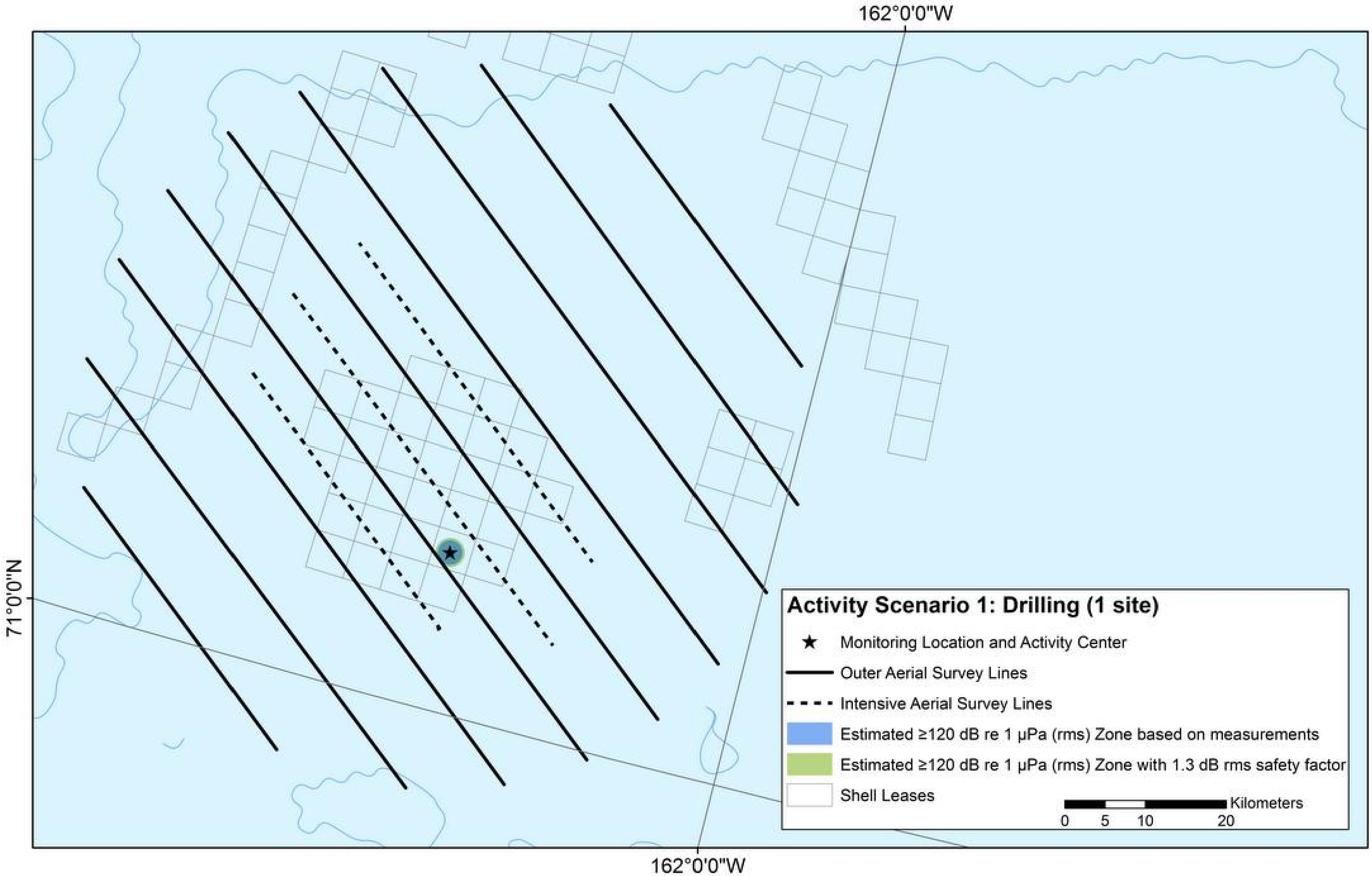

Figure 14. **Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 1, Drilling at a Single Site. Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to each Source**

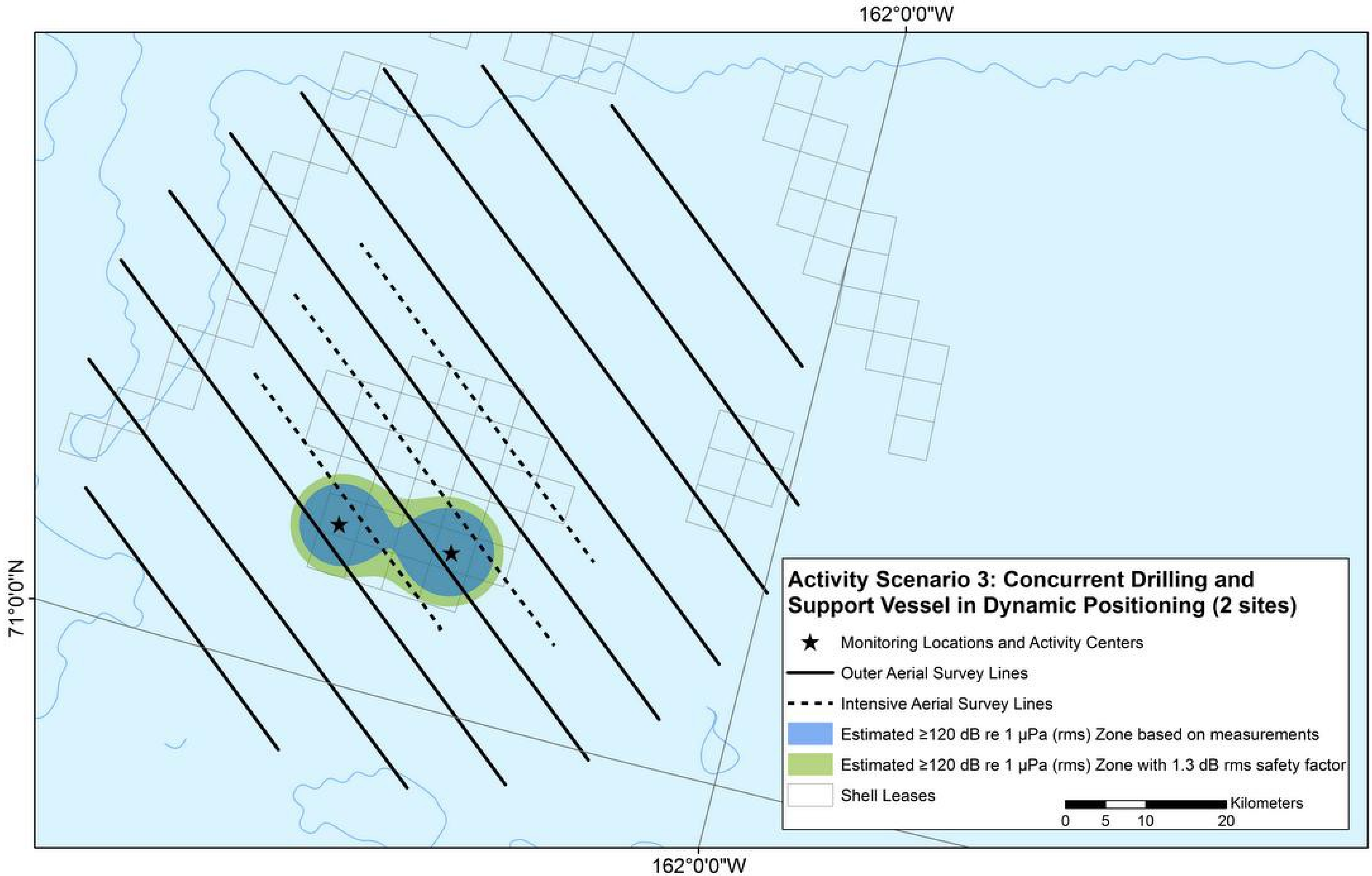

Figure 15. **Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 3, Concurrent Drilling with an Adjacent Support Vessel in DP at Two Sites. Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to each Source**

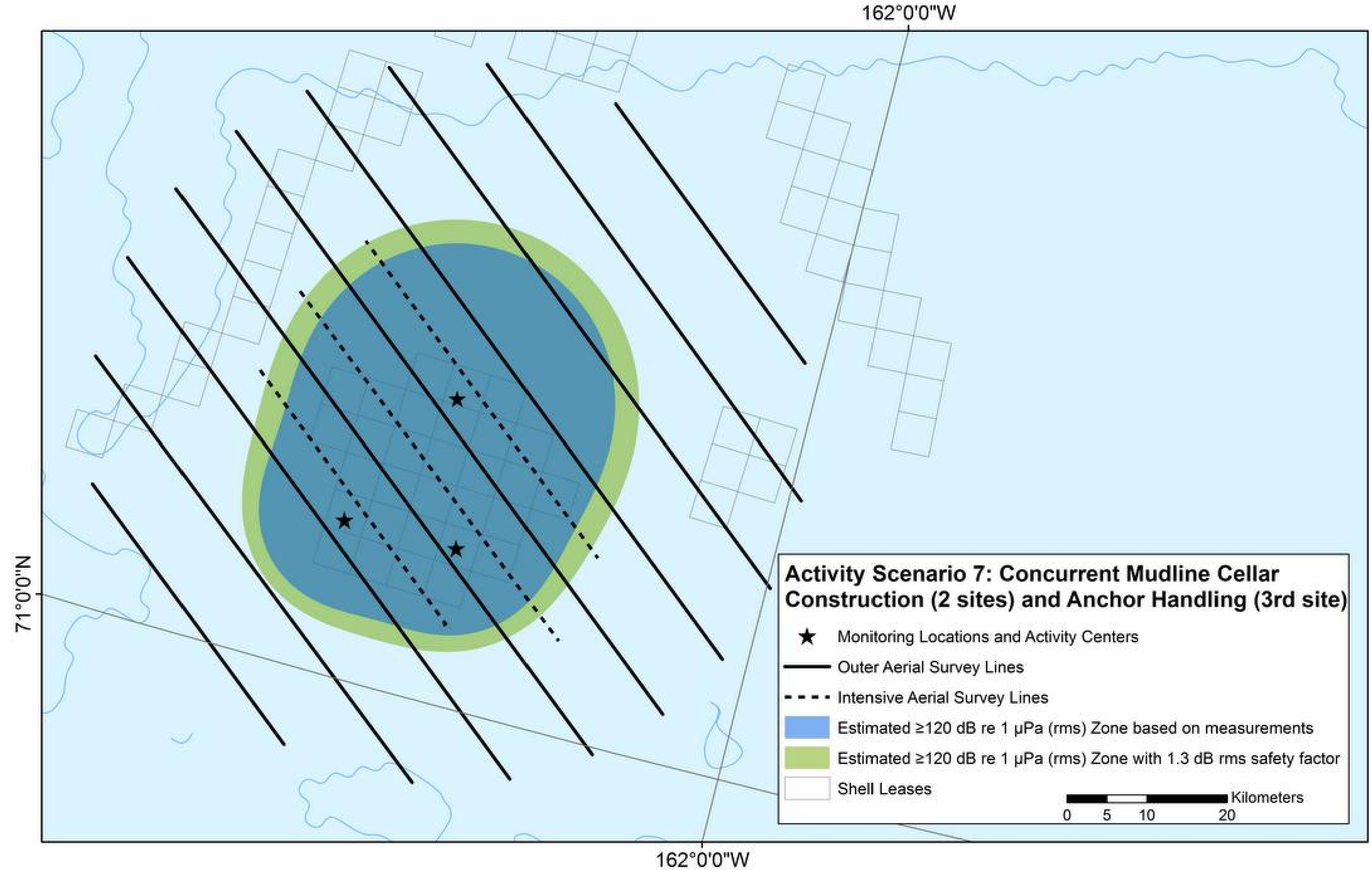

Figure 16. Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 7, Concurrent Mudline Cellar Construction at Two Sites and Anchor Handling at a Third Site. Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to each Source

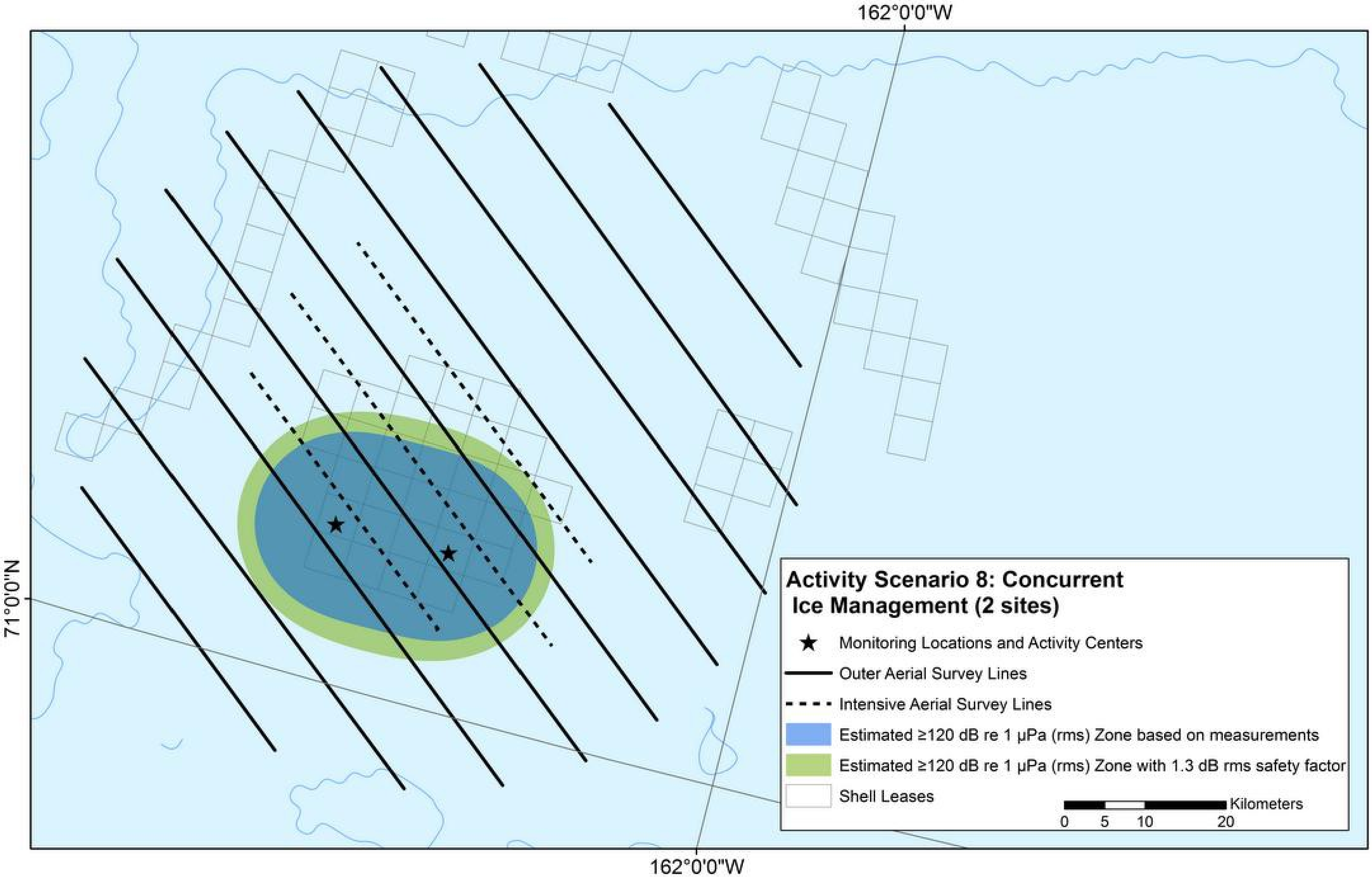

Figure 17. **Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 8, Concurrent Ice Management at Two Sites (Offset 500 Meters to the NE of Each Well). Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to each Source**

The largest area estimated to be ensonified by continuous sounds of ≥120 dB re 1 µPa rms from a single activity scenario was 2,046.3 km^2 and resulted from concurrent MLC construction at two different sites and anchor handling at a third site (activity scenario 7;

Table 9; Figure 16). The smallest area estimated to be ensonified by continuous sound levels ≥ 120 dB re 1 µPa rms was 10.3 km^2, which represented drilling alone at a single site by the *Discoverer* (activity scenario 1;

Table 9; Figure 14). The *Discoverer* was used as the sound source for the single site drilling-only scenario as a conservative measure because it is expected to be the louder of the two drilling units. The specific estimated sound source levels for the *Discoverer* and the *Polar Pioneer* were used for the modeling of activity scenarios that involved concurrent drilling at two different drill sites. In general, scenarios that involved anchor handling and/or MLC construction resulted in the largest estimated areas that would be ensonified to levels ≥120 dB re 1 µPa rms (activity scenarios 4-7;

Table 9; Figure 16 and Figure 17). Activity scenarios that involved drilling and/or DP vessel operations produced the smallest acoustic footprints (activity scenarios 1-3;

Table 9; Figure 14 and Figure 15).

It is possible that ice management and drilling activities could have overlapping acoustic footprints; however, it is difficult to meaningfully quantify the countless ways in which this could occur due to the temporal and spatial variability of ice conditions. It is also likely that ice management will occur at distances from the drill sites that would result in independent, non-overlapping acoustic footprints with respect to continuous sound sources operating at or near exploration drill sites. For these reasons, concurrent ice management activity scenarios were modeled separately from non-ice management scenarios, and results from each were summed together below to conservatively estimate the maximum total area ensonified to continuous sound levels ≥120 dB re 1 µPa rms.

The two scenarios that were modeled to estimate areas ensonified by continuous sounds ≥120 dB re 1 µPa rms from ice management involved either two or four vessels engaged in concurrent operations. The two-vessel scenario assumed a single ice management vessel positioned 500 m to the northeast of two different drill sites. The four-vessel scenario assumed ice management associated with two different drill sites with one vessel located 500 m to the northeast of each site and a second vessel positioned 2 km to the northeast of each site. The estimated areas ensonified by continuous sounds ≥ 120 dB re 1 µPa rms from two- and four-vessel ice management activities were 937.4 and 2,046.3 km^2, respectively (activity scenarios 8 and 9;
Table **9**).

No ZVSP surveys are expected to occur in the summer. Following the completion of drilling at each of the first two exploration wells in fall of 2015, a ZVSP survey will be conducted at each site. This would result in exposure of twice the area from a single ZVSP survey to pulsed sound levels ≥160 dB re 1 µPa rms, or 898 km^2 (activity scenario 10;
Table **9**).

Estimated Marine Mammal Density in the Action Area

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 activities are occurring: open water or ice margin. In the IHA application, Shell made several numerical assumptions to calculate marine mammal densities. After a review of the best available information on bowhead whale density and in consultation with NMFS, Shell also revised the bowhead whale density estimates used in calculating exposure to

match those provided by NMFS's National Marine Mammal Lab for similar analyses. Assumptions that apply to all species are described below, and those related to individual species are described in their respective sections.

Assumptions about seasonality of ice coverage

More ice is likely to be present in the area of activities during the July–August period and less ice is likely to present in the action area in September-October. Ice extent in the action area changes from year to year as well as season to season. Shell estimated percentages of ice-margin cover in the action area for two seasons during the action based on prior observation and experience in the action area. Summer ice-margin densities have been applied to 50 percent of the area that may be ensonified from drilling 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 ensonified from drilling and ZVSP activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since ice management activities would only occur within ice-margin habitat, the entire area potentially ensonified by ice management activities has been multiplied by the ice-margin densities in both seasons.

Accounting for uncertainty in density estimates

There is some uncertainty about density estimates of marine mammals in the action area. To provide some allowance for these 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. 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).

Bowhead Whales

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 10,686 km of on-transect effort in the Chukchi Sea by Moore et al. (2000). Bowhead whales were also rarely sighted in July-August of 2006-2010 during aerial surveys of the Chukchi Sea coast (Thomas and Koski 2013). This is consistent with movements of tagged whales (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.

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 those bowheads will be encountered in the Chukchi Sea at this time of year. Moore et al. (2000) reported 34 bowhead sightings during 44,354 km of on-transect survey effort in the Chukchi Sea during September-October. Thomas and Koski (2013) also reported increased sightings on coastal surveys of the Chukchi Sea during October and November of 2006-2010. GPS tagging of bowheads appear to show that migration routes through the 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 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).

To estimate bowhead whale densities in summer (July-August) and fall (September-October), NMFS used data from the 2008 through 2014 ASAMM aerial surveys flown in the Chukchi Sea (Ferguson 2015); www.afsc.noaa.gov/nmml). Only "on-transect" sighting and effort data were used. The analysis was further restricted to sightings made by primary observers, and did not include repeat sightings or sightings of dead animals.

The temporal variability in animal density was incorporated by computing separate density estimates for each month (July-October) using the 35-50m depth contour, which includes the anticipated depth for Shell's drilling activities.

Density was computed using a standard line-transect equation[8]:

$$D_{m,z,y} = \frac{n_{m,z,y} s_{m,z,y} f(0)}{2L_{m,z,y} g(0)}$$

Values for *f(0)* were taken from Ferguson and Clarke (2013). Because there currently are no estimates of trackline detection probability for the ASAMM sighting data, values for *g(0)* were taken from Thomas et al. (2002). Resulting density estimates are shown in **Error! Reference source not found.**.

There is insufficient information to determine quantitatively how bowhead whale densities north of 72°N compare to those within the ASAMM study areas. However, Quakenbush et al. (2010, 2013) shows tracks of multiple bowhead whales that transited across the northern portion of the Chukchi Sea. Bowhead densities are anticipated to be similar north and south of 72°N (Ferguson 2015).

Assumption about bowhead whale ice margin fall density

Shell used a fall ice-margin density that was twice the open-water density. Moore et al. (2000) found that bowheads were strongly associated with heavy ice cover (71-100%) in the northern Chukchi Sea in September and October and were observed less than expected in 0-10% ice cover. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in September-November of 2006-2010 (Hartin et al. 2013) ranged from 0.0003 to 0.0052/km2 with a maximum 95 percent CI of 0.051/km2. This suggests the fall densities used in the calculations and shown in Table 11 are somewhat higher than are likely to be present in the area of the planned

[8] *m* = month, *z* = depth stratum, *y*= year, *n* = number of sightings, *s* = average group size, *f(0)*= sighting probability density at zero perpendicular distance, or equivalently, 1/effective strip width, *g(0)*= probability of sighting an object located directly on the trackline.

exploration drilling activities. NMFS anticipates that bowheads will be more commonly associated with heavy ice cover in the fall season based on available research, and so concurs with this conservative density inflation for ice margin fall habitat. The same adjustment was also used in NMFS's biological opinion on the effects of Shell's seismic surveys in 2013 (NMFS 2013).

Humpback and Fin Whales

Although there is evidence of the occasional occurrence of humpback and fin whales in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned exploration drilling program and therefore minimum densities have been assigned to these species (Table 10 and

Table 11). Clarke et al. (2011, 2013) and Hartin et al. (2013) reported humpback whale and fin whale sightings. Allen and Angliss (2014) recently concluded these whales occur in very low numbers in the project area, but may occur regularly. In the absence of more definitive data regarding humpback and fin whale desities in the Chukchi Sea, we use minimum densities for these species (avg 0.0001 and max 0.0004) across seasons. See Table 10.

Ringed and Bearded Seals

Ringed and bearded seals are 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.

Ringed seal and bearded seals "average" and "maximum" summer ice-margin densities (Table 10) 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 because the seals would be spending more time on their preferred pack ice habitat, if it isstill present in the Chukchi Sea.

Assumptions about ice seal density due to ice-edge habitat preference

Shell estimated average and maximum open-water densities for ice seals as 3/4 of the ice margin densities during both seasons for both species. They also estimated the fall density of ringed seals in the offshore Chukchi Sea as 2/3 the summer densities (

Table 11). Both of these adjustments were also calculated in NMFS's biological opinion on the effects of Shell's seismic surveys in 2013 (NMFS 2013). NMFS concurs with these adjustments because of ice seals' habitat preferences as discussed in Section 2.23 and particularly the habit of ringed seals 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 not differentiated from summer densities for this species.

For comparison, the ringed seal density estimates calculated from data collected during summer 2006-2010 industry operations ranged from 0.0138/km^2 to 0.0464/km^2 with a maximum 95 percent CI of 0.1581/km^2 (Hartin et al. 2013). These estimates are lower than those made by Bengtson et al.

(2005), which is not surprising given the different survey methods and timing.

Table 10. Expected Densities of Cetaceans and Seals in Areas of the Chukchi Sea, Alaska for the Summer (July–August) Period.

Species	Open Water		Ice Margin	
	Average Density (#/km^2)	Maximum Density (#/km^2)	Average Density (#/km^2)	Maximum Density (#/km^2)
Mysticetes				
Bowhead whale	0.0010	0.0050	0.0010	0.0050
Fin whale	0.0001	0.0004	0.0001	0.0004
Humpback whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ringed seal	0.3668	0.6075	0.4891	0.8100

Table 11. Expected Densities of Cetaceans and Seals in Areas of the Chukchi Sea, Alaska for the Fall (September–October) Period.

Species	Open Water		Ice Margin	
	Average Density (#/km^2)	Maximum Density (#/km^2)	Average Density (#/km^2)	Maximum Density (#/km^2)
Mysticetes				
Bowhead whale	0.0230	0.0780	0.0460	0.1560
Fin whale	0.0001	0.0004	0.0001	0.0004
Humpback whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ringed seal	0.2458	0.4070	0.3277	0.5427

Approach to Estimating Exposure

Each of the continuous noise, pulsed sounds, and vessel strike stressors was discussed previously. In this section we will discuss how NMFS estimated marine mammal exposure to drilling unit and drilling sounds, supply and drilling support vessels using dynamic positioning (DP) when tending to a drilling unit, MLC construction, anchor handling in support of morring a drilling unit, ice management activities, ZVSP, and vessel strike. Because of the "activity scenario" method that Shell used in its IHA application, NMFS presents the analysis below as a way to combine effects from stressors to marine mammals in a more realistic approach than simply examining the effects of each single stressor individually. The activity scenarios incorporate all stressors except for vessel strike and oil spills, so those stressors are described separately from the activitiy scenarios later in this section.

These exposure estimates indicate the number of instances in which whales and pinnipeds might be exposed to energy accumulations equivalent to a particular exposure level (which we call the estimated instances of exposure). To accumulate energy, we had to assume that a single animal was exposed multiple times as it moved through sound fields generated by a survey and that the time interval between subsequent exposures was small enough for animals not to recover from earlier exposures. However, as we previously indicated, it would be unrealistic to assume that each exposure event would involve a different animal; some animals might be exposed once during a seismic or drilling operation while other animals may be exposed more than once. The data we would need to estimate the number of times individual whales are likely to be exposed are unavailable. By focusing on "instances of exposure" rather than "number of individuals exposed," we do not need to make any assumptions about the number of times an individual whale might be exposed.

Conservative Assumptions used in the Exposure Analysis

Shell used several models to estimate exposure to marine mammals from noise associated with drilling operations. Like all models, these approaches are sensitive to the use of assumptions when complete information is not available. In reviewing Shell's exposure models, NMFS concludes that they are conservative in that they tend to over-estimate the number of marine mammals that may be exposed to noise from drilling activities because of the following assumptions and model components.

- Application of a 1.3 dB re 1 μPa rms safety factor to the source level of each continuous sound source prior to sound propagation modeling of areas exposed to Level B thresholds resulted in an approximate 20 percent increase in the distance to the dB re 1 μPa rms threshold;
- The radius estimating ZVSP sound received at ≥160 dB re 1μPa rms was multiplied by 1.5 prior to estimating exposed areas.
- Binning of similar activity scenarios into a representative scenario, each of which reflected the largest exposed area for a related group of activities;
- Modeling numerous iterations of each activity scenario at different drill site locations to identify the spatial arrangement with the largest exposed area for each;
- Multiple activity scenarios may occur on the same day, so scenarios that are likely to produce louder sounds and ensonified larger areas to sounds above Level B thresholds have been used on those days;

- Ice management and drilling activities could have overlapping acoustic footprints; however, independent, non-overlapping acoustic footprints are also possible. Concurrent ice management activity scenarios were modeled separately from non-ice management scenarios in the estimates below, and results from each were summed together below to estimate the maximum total area ensonified to continuous sound levels ≥120 dB re 1 μPa rms;
- Despite the likelihood of the entire area ensonified by pulsed sound levels ≥160 dB re 1 μPa rms from ZVSP surveys to be within areas ensonified by continuous sound levels ≥120 dB re 1μPa rms, the estimated areas ensonified by the two different sound types, and associated number of activity days, were treated independently (Table 12);
- The activities in scenario 7 and 9 (used for analysis below) generate louder continuous sounds than drilling; however, they will occur for only brief periods relative to the entire exploration drilling period. Regardless of the short duration of these louder sounds compared to the overall drilling period, the area from those scenarios was used to estimate potential exposures of marine mammals above Level B threshold levels on a *seasonal* basis;
- Assuming 100 percent daily turnover[9] of individuals likely overestimates the number of different individuals that would be exposed, especially during non-migratory periods; and
- Calculated densities assume no avoidance by marine mammals of areas exposed to Level B thresholds in the first two calculation methods. (Shell modelled both zero and 50% avoidance in the IHA application.)

Modelling Ensonified Area

As discussed in the Activity Scenarios section, Shell used activity scenarios which are various combinations of similar activities derived from a realistic operational timeline, to more closely approximate combined exposure from several sound sources occurring simultaneously. Total ensonified areas from these activity scenarios are presented in
Table **9**.

To estimate the maximum total area that might be ensonified by continuous sounds ≥120 dB re 1 μPa rms in either summer or fall during Shell's 2015 exploration drilling program in the Chukchi Sea, the largest ensonified area estimated for the non-ice management scenarios (two MLC constructions and anchor handling, scenario 7) was added to the ensonified area estimated for the four-vessel ice management scenario (scenario 9). The sum of areas ensonified to ≥120 dB re 1 μPa rms from these two scenarios results in a total area of 3,972.3 km^2 (activity scenarios 7 and 9;
Table **9**). These activities generate louder continuous sounds than drilling; however, they will occur for only brief periods relative to the entire exploration drilling period. Regardless of the short duration of these louder sounds compared to the overall drilling period, this area has been used to estimate potential exposures of marine mammals above Level B thresholds for both the summer

[9] One hundred percent daily turnover assumes a constant density of animals in the action area. For example, if an animal leaves the area, another one immediately replaces it. NMFS considers this a conservative assumption for bowhead whales and ringed seals because of the data available for these species which documents their migration through this area. The whales and seals may be in the area for a length of time and then absent from the area for a length of time.

and winter seasons using seasonal densities (both ≥120 dB re 1 µPa rms for continuous sounds and ≥160 dB re 1 µPa rms for pulsed sounds).

Methods for Calculating Exposure

The instances of exposure for each species were estimated by multiplying:

- the anticipated area to be ensonified to the specified levels in each season (summer and fall) and habitat zone (open water and ice margin) to which a density applies, by
- the expected species density. Expected density estimates of marine mammals in the action area by season and by habitat are shown in Table 10 and Table 11.

NMFS considered exposure estimates of marine mammals to sound from drilling activities in the action area using several methods of calculation.

1. Exposure estimates without turnover of individuals, which assumes that there is no movement of animals into and out of ensonified areas(*Exposure without turnover*)
2. Exposure estimates including 24-hour turnover of individuals, no avoidance of sound stressors, and changing daily activity scenarios (*Exposure with 24-hour turnover and no avoidance*)
3. Exposure estimates including 48-hour turnover of bowhead whales and ringed seals and 24-hour turnover of humpback whales, fin whales, and bearded seals, avoidance with (and without) an energetic cost for bowhead whales and ringed seals, and changing daily activity scenarios (*Exposure with turnover and avoidance*)

A description of these methods follows. NMFS considered each approach and presents rationale for each method used.

1. Exposure without turnover

The number of individuals of each species potentially exposed to received levels of continuous drilling related sounds ≥120 dB re 1 µPa rms or to pulsed airguns sounds ≥160 dB re 1 µPa rms within each season (summer and fall) and habitat zone (% ice cover) was estimated by multiplying the anticipated area ensonified to the threshold level(s) 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. This method did not account for movement of individuals into and out of ensonified areas (i.e., turnover) or avoidance (by marine mammals) of sound generated by drilling activities. It also did not account for varying drilling activities on any given day.

Although this analysis method has been used in previous IHA applications for exploration drilling in Alaska, NMFS determined that the other methods are more appropriate for estimating exposure since they encompass animal movement in and out of the action area, consider marine mammals' avoidance of stressors, and allow for a variety of activity scenarios to occur on a daily basis. NMFS expects that these more descriptive methods more closely represent actual effects from stressors on marine mammals, although numerous assumptions and the lack of complete information cause bias in those methods as well.

2. Exposure with turnover and no avoidance

The second method used an identical calculation (i.e., ensonified area X animal density); however, it incorporated two very important additional considerations: accounting for animal movements and avoidance and variation in the size of ensonified areas for each day across the operation.

1. This method assumed the entire population of all species of marine mammals within the area ensonified to sounds above the Level B thresholds for continuous and pulsed sounds would be different every day during drilling and related support activities (i.e. complete turnover in a 24-hour period).

2. T his method also allowed for the different ensonified areas corresponding to the activity scenarios in

3. Table 9 to be changed on a daily basis to reflect the anticipated operational timeline.

In order to do number 2 above, the numbers of days within each season were split between the various activity scenarios and summed within the two seasons (Table 12). When multiple activity scenarios occured on the same day, a day was added to the "Activity Days per Season" count of the largest ensonified area (Table 12), inorder to provide a conservative estimate.

Activity days for ice management and ZVSP were assigned in addition to the number of days allocated to the other activity scenarios within each season. Ice management could occur at distances far enough from the drill sites to produce independent, non-overlapping acoustic footprints with respect to the other continuous sound sources operating at or near exploration drill sites. Despite the likelihood of the entire area ensonified by pulsed sound levels ≥160 dB re 1 µPa rms from ZVSP surveys to be within areas ensonified by continuous sound levels ≥120 dB re 1µPa rms, the estimated areas ensonified by the two different sound types, and associated number of activity days, were treated independently as an additional conservative measure (Table 12). After days were assigned to louder activity scenarios (e.g., MLC construction and anchor handling), the remaining days within each season were assigned to quieter, drilling-related scenarios.

Table 12. Sound Propagation Modeling Results of Drilling Related Representative Activity Scenarios and Estimates of the Total Area Potentially Ensonified above Threshold Levels Summed on a Daily Basis at the Burger Prospect in the Chukchi Sea, Alaska.

Activity Scenario Number	Activity Scenario Description	Threshold Level (dB re 1 µPa)	Single Day Area Potentially Ensonified (km²)		Acti per
			Summer	Fall	Summ
1	Drilling at 1 site	120 dB	10.2	10.2	4
2	Drilling and DP Vessel at 1 site	120 dB	111.8	111.8	2
3	Drilling and DP Vessel (1 site) + Drilling and DP Vessel (2nd site)	120 dB	295.5	295.5	21
4	Mudline Cellar Construction at 2 different sites	120 dB	575.5	575.5	14
5	Anchor Handling at 1 site	120 dB	1,534.9	1,534.9	3
6	Drilling and DP Vessel at 1 site + Anchor Handling at 2nd site	120 dB	1,759.2	1,759.2	8
7	Mudline Cellar Construction at 2 different sites + Anchor Handling at 3rd site	120 dB	2,046.3	2,046.3	6
8	Two-vessel Ice Management	120 dB	937.4	937.4	20
9	Four-vessel Ice Management	120 dB	1,926.0	1,926.0	4
10	ZVSP at 2 different sites	160 dB	0.0	898.0	0

The number of individuals that may occur at some point in time within the area ensonified to sounds above Level B thresholds during each season is likely to vary greatly by species, oceanographic conditions, and other factors. Individual marine mammals may move into or out of exposed areas and new individuals may move through subsequently (i.e., turnover). It is possible that this turnover of marine mammals within the ensonified area would be greater during the fall season than the summer season since many of the species present in the fall are migrating through the Chukchi Sea. However, wide ranging foraging patterns of some species may result in a similar amount of turnover within the ensonified area during the summer period as during migratory movements in the fall period. In either case, it is likely an overestimate of the number of individuals exposed to the sound sources to assume that the entire group of marine mammals within the ensonified area around each drill site or ice management location would turnover every day (i.e. a completely new set of individual marine mammals is present on a daily basis). Regardless, that is the assumption that has been made in the second method for calculating exposure, which results from multiplying the 'Total Area Potentially Ensonified' for each activity scenario shown in Table 12 by the density estimates for each season. These estimates of individual marine mammals potentially exposed to sounds above Level B thresholds are thus a very high and unlikely estimate, particularly for bowhead whales and ringed seals since data is available that suggests that they may remain in the area for more than 24 hours, and so a longer turnover is more appropriate for these species. Information about the exact length of time that animals may be staying in a particular area before moving to a new location is not available. However, the third method, described below, incorporates the research that is available to inform this assumption.

NMFS concurs with Shell's view that the estimates of the numbers of marine mammals potentially exposed to continuous sounds ≥120 dB re 1 μPa rms or pulsed sounds ≥160 dB e 1 μPa rms in the second method are overly conservative. Assumptions included upward scaling of source levels for all sound sources, assuming no avoidance of activities/sounds by individual marine mammals, and assuming 100% turnover of individuals in ensonified areas every 24 hours. The resulting exposure estimates are highly sensitive to any variation in these assumptions. Furthermore, many studies suggest that these assumptions are overly conservative, especially for non-migratory species/periods and for cetaceans in particular, which are known to avoid anthropogenic activities and associated sounds at varying distances depending on the context in which activities and sounds are encountered (Koski and Miller 2009; Moore 2000; Moore et al. 2000; Treacy et al. 2006). Although NMFS and Shell recognize these assumptions may be overly conservative, it is difficult to scale variables in a more precise fashion until new research can be incorporated into updated analysis techniques.

3. Exposure with turnover and avoidance

The third method calculated a range of exposure estimates for bowhead whales and ringed seals. Estimates were generated based on an evaluation of the best available science which suggests different assumptions surrounding avoidance behavior and the frequency of turnover are appropriate for these two species. In addition to demonstrating the sensitivity of exposure estimates to variable assumptions, the wide range of estimates is more informative for assessing impacts than a single estimated value that would carry a high degree of uncertainty.

Bowhead Whales

In its IHA application, Shell calculated multiple scenarios of bowhead whale exposure estimates based on varying assumptions surrounding bowhead whale avoidance and the frequency of turnover. Shell also calculated the corresponding percentage of the projected 2015 bowhead whale population of 19,534. This value is based on the Givens et al. 2013 bowhead whale abundance estimate of 16,892 individuals in 2011 with an annual growth rate of 3.7%.

NMFS's approach to considering avoidance and turnover in estimating bowhead whale density is discussed below. NMFS selected a turnover rate of 48 hours to estimate exposure (to account for intermittent periods of migrating and feeding individuals) and 50% avoidance that may result in take due to energetic cost. These choices and assumptions are discussed below.

Avoidance

If bowhead whales avoid drilling and related support activities at distances of approximately 20 km in 2015, as was noted consistently by Davis (1987) and Schick and Urban (2000), this would preclude exposure of the vast majority of individuals to continuous sounds ≥120 dB re 1 µPa rms or pulsed sounds ≥160 dB e 1 µPa rms. The largest ensonified areas during Shell's 2012 exploration drilling program were produced by mudline cellar construction, ice management, and anchor handling (Shell 2015). Only anchor handling is expected to result in the lateral propagation of continuous sound levels ≥120 dB re 1 µPa rms to distances of 20 km or greater from the source, as is evident in the depiction of activity scenario 7 in Figure 16 (Shell 2015) and Table 8.

Since most of the sound sources in this action would dissipate below threshold levels at or before the 20 km avoidance distance discussed above, bowhead whales are likely to avoid most of the noise associated with this action. By conservatively assuming up to half of the 1,083 exposed bowhead whales (instead of assuming all of the bowhead whales) could choose to avoid the area with sound levels above harassment thresholds, and assuming this avoidance may come at an energetic cost that could rise to the level of take, the take estimates effectively remain the same (i.e. take is occurring either due to exposure to noise or due to the animal having to move around the noise at an energetic cost).

Turnover

It is difficult to determine an appropriate average turnover time for a group of animals in a particular area of the Chukchi Sea. Reasons for this include differences in residency time for migratory and non-migratory species, changes in distribution of food and other factors such as behavior that influence animal movement, variation among individuals of the same species, etc. Complete turnover of individual bowhead whales in the project area each 24-hour period may occur during fall migration when bowheads are traveling through the area. Even during this fall period, bowheads often move in pulses with one to several days between major pulses of whales (Miller et al. 2002). Gaps between groups of whales can probably be accounted for partially by bowhead whales stopping to feed opportunistically when food is encountered. The extent of feeding by bowhead whales during fall migration across the Beaufort and Chukchi Seas varies greatly from year to year based on the location and abundance of prey (Shelden and Mocklin

2013). For example, if a turnover rate of 48 hours to account for intermittent periods of migrating and feeding individuals is assumed, then the bowhead whale exposure estimate would be reduced accordingly by 50% compared to a 24-hour turnover.

During the summer, relatively few bowhead whales are present in the Chukchi Sea and in most cases, given that the operations area is not known to be a critical feeding area (Citta et al. 2014; Allen and Angliss 2014), whales would likely avoid the area of operations (Schick and Urban 2000; Richardson et al. 1995a). Similarly, during migration many whales would likely travel around the area (i.e., avoid it) as it is not known to be important habitat for bowheads during any portion of the year (Citta et al. 2014; Allen and Angliss 2014). There is a large body of evidence indicating that bowhead whales avoid anthropogenic activities and associated underwater sounds depending on the context in which these activities are encountered (LGL et al. 2014; Koski and Miller 2009; Moore 2000; Moore et al. 2000; Treacy et al. 2006). Increasing evidence suggests that proximity to an activity or sound source, coupled with an individual's behavioral state (e.g., feeding vs traveling) among other contextual variables, as opposed to received sound level alone, strongly influences the degree to which an individual whale demonstrates aversion or other behaviors (reviewed in Richardson et al. 1995b; Gordon et al. 2004; Koski and Miller 2009; Ljungblad et al. 1988; Miller et al. 2005; Moore 2000; Moore et al. 2000; Treacy et al. 2006).

For these reasons, NMFS anticipates that a 24-hour turnover period for modeling the exposure of bowhead whales to continuous sound source levels greater than 120 dB is unrealistic. NMFS therefore selected a turnover rate of 48 hours to estimate exposures as a more reasonable approximation of reality and to account for intermittent periods of migrating and feeding individuals. NMFS assumes that take is occurring either due to exposure to noise, or due to the animals moving around the noise at an energetic cost.

Fin and Humpback Whales

The small numbers of fin and humpback whales that may occur in the Chukchi Sea are unlikely to be present around the planned exploration drilling activities but chance encounters may occur. The few individuals that could be exposed to noise associated with drilling activities represent only a very small proportion of their respective populations (

Table 13). NMFS did not apply modelling with a 48-hour turnover rate and assumprions regarding avoidance for fin and humpback whales because of the rarity of these species in the action area and the paucity of information on their movements in the action area. Instead, NMFS used a 24-hour turnover rate for both humpback and fin whales, as used above in the second method. Although this assumption may be overly conservative (i.e., it assumes more whales may occur in the vicinity of the planned drilling activities), it is difficult to further refine our estimates without additional data.

Ringed and Bearded Seals

In its IHA application, Shell calculated multiple scenarios of ringed seal exposure estimates based on varying assumptions surrounding ringed seal avoidance and the frequency of turnover. Shell also calculated the corresponding percentage of the population. At the time of listing under the ESA, NMFS (2012b) concluded ringed seals in the Arctic likely number in the millions. NMFS used 300,000 as a more localized estimate (Kelly et al 2010) in this analysis. Kelly et al. (2010) stated that this number is likely an underestimate for the Chukchi-Beaufort Seas population because surveys in the Beaufort Sea were limited to areas within 40 km of the shore. However, NMFS used this number as the best available information for the action area.

NMFS's approach to considering avoidance and turnover in estimating ringed and bearded seal density is discussed below. NMFS selected a turnover rate of 48 hours to estimate exposure, and did not further reduce the estimated exposure amount due to avoidance. These choices and assumptions are discussed below.

Avoidance

Data for some seal species suggest they may not avoid offshore exploration activities and associated sounds to the degree demonstrated by many cetaceans. Recent evidence suggests little change in the distribution of seals around offshore drilling operations. Moulton et al. (2005) reported that ringed seal densities in spring did not appear to be affected by proximity to construction, drilling, and oil production activities at a man-made island in the Beaufort Sea. There was no apparent difference in the detection distances and distributions of seals around Shell's two drilling units in 2012 when comparing periods of active drilling to non-drilling periods (LGL and JASCO 2014). PSOs working on Shell's 2012 exploration drilling program conducted detailed visual monitoring of seals in the Beaufort Sea from the *Kulluk* while it was drilling a pilot hole and excavating a mudline cellar in 2012. PSOs were able to identify individual ringed and bearded seals through unique markings on their pelage that were then documented and catalogued using high definition photographs. In total, 15 distinct, individual seals were identified; 12 ringed and 3 bearded (Patterson et al. 2014). Observations of these seals indicated numerous individuals were spending extended periods in the vicinity of the drilling unit. The time periods from when each of these seals was first identified as a unique individual to the last sighting of each respective individual ranged from 6 to 24 days (Patterson et al. 2014).

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). Some evidence, however, suggests that avoidance of active airguns by phocid seals in the Arctic may occur at slightly greater distances. Reiser et al. (2009b) reported a tendency for localized avoidance of areas immediately around the seismic source vessel along with coincident increased sighting rates at support vessels operating 1–2 km away.

NMFS does not anticipate any quantifiable ringed seal avoidance of the stressors associated with Shell's drilling activities in 2015, and therefore did not calculate avoidance in the exposure estimates for ringed seals.

Turnover

The State of Alaska Department of Fish and Game's Marine Mammals Program works with the Ice Seal Committee and interested seal hunters from villages along the west and north coasts of Alaska to capture and deploy satellite transmitters on ice seals to document their movements and habitat use. Data from these tagged animals provide some insight as to the movements of a few individuals. In addition to a long distance seasonal migration, there are many instances from July through September when individual ringed seals stayed in a relatively small area (compared to their migration route) up to multiple weeks, including on and around the OCS leased blocks. One example is included below as Figure 18. This figure and seal locations during other time periods, as well as an animated progression of tagged animals in 2014 are available on the ADF&G website at http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.icesealmovements

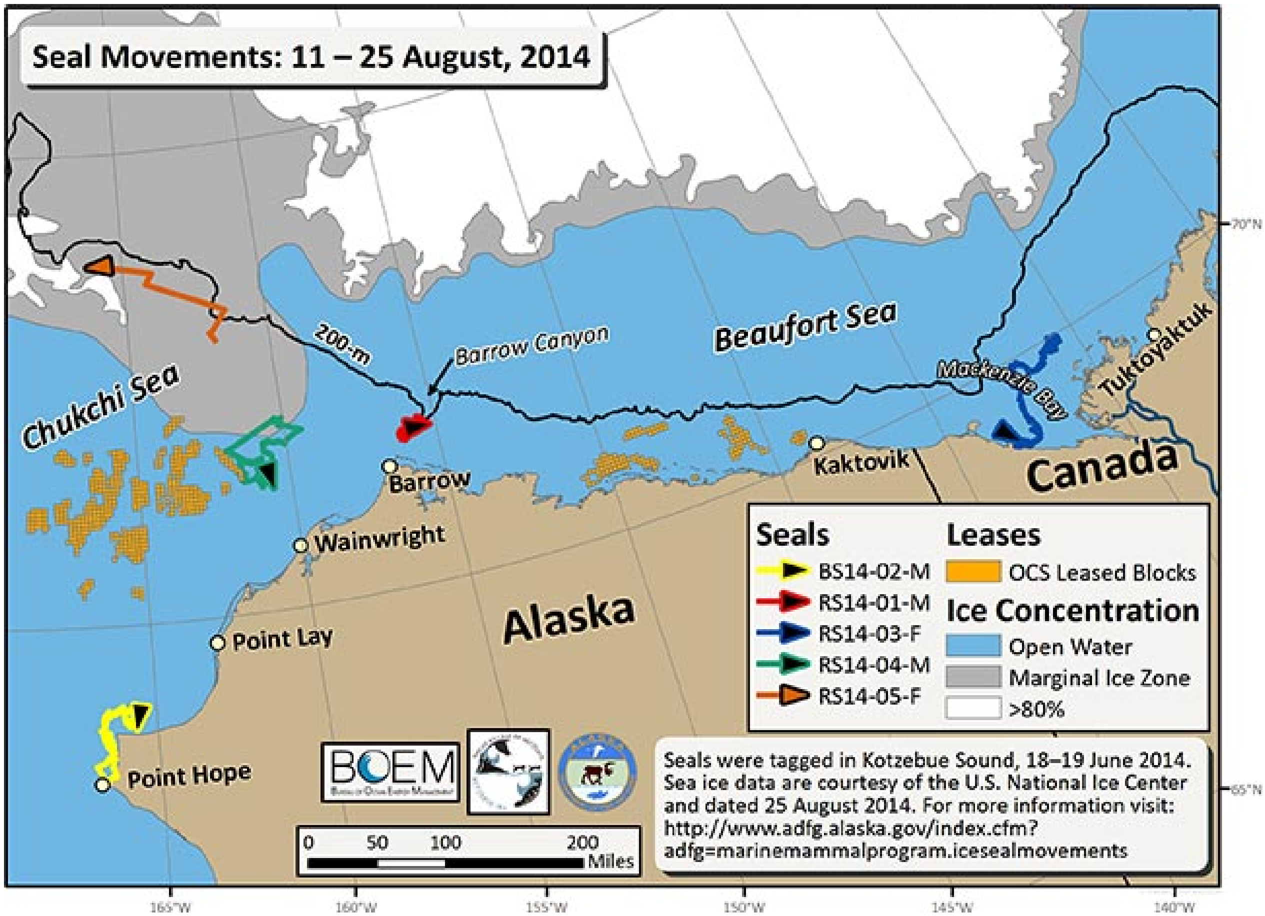

Figure 18. **Movements of 5 ice seals in August 2014, from ADF&G Marine Mammals Program. Ringed seal tracklines are shown in red, blue, green, and orange.**

In addition, Patterson et al. 2014 indicate a turnover period of a week or more for individual seals near a drilling operation in the Alaskan Arctic may be more appropriate, based on the 6-24 day area occupancy described above. These results suggest that assuming 100% turnover of all individual seals around an offshore drilling operation on a daily basis is unreasonable, and a period closer to a week may be more appropriate and yet still conservative for other individuals that remained in the area for longer periods.

Thus, NMFS considers the conservative exposure estimate associated with 24-hour turnover and zero avoidance to be an overestimate of individual exposures of ringed seals. While more data and analysis are necessary to determine a precise turnover rate for seal populations in the activity area, NMFS selected a turnover rate of 48 hours in this analysis as a conservative approach to quantifying ringed seal exposure to stressors from Shell's drilling activities.

Small numbers of bearded seals are expected to be exposed to sounds at the specified levels, representing a small proportion of the population (

Table 13). NMFS did not apply a 48-hour turnover rate for bearded seals because sufficient information on their movements, time spent foraging at one location, and satellite tagging information on bearded seals in the lease area were not available. Instead, NMFS used the 24-hour turnover rate for bearded seals. Although this assumption may be overly conservative (i.e., it assumes a high turnover rate in the vicinity of the planned drilling and seismic activities), it is difficult to scale variables more precisely without additional data.

Exposure Calculations using Exposure with turnover and avoidance method

Table 13 presents exposure estimates for the proposed 2015 exploration drilling program in the Chukchi Sea using the third method for bowhead whales and ringed seals, *Exposure with turnover and avoidance*, and the second method for the other species, *Exposure with turnover and zero avoidance*, all based on average marine mammal density from Table 10 and 11. The table also summarizes abundance estimates for each species and the corresponding percent of each population that may be exposed to continuous sounds ≥120 dB re 1 µPa rms or pulsed sounds ≥160 dB e 1 µPa rms. Although considerable evidence suggests these assumptions will result in an overestimation of exposures, the best available information does not include refined methods that accurately capture turnover rates and avoidance correction factors for each species.

It is important to note that very few precise population estimates exist for Arctic marine mammal species. In most cases, the best available abundance estimate for a population incorporates only a portion of the known range and distribution for the species. As a result, many of the existing population estimates are likely biased low (e.g., Kelly et al. 2010; Allen and Angliss 2014). Additionally, there are multiple, wide-ranging abundance estimates available for several species, but many are outdated or associated with low degrees of confidence (e.g., DeMaster 1998; Allen and Angliss 2014), which further adds to the difficulty of selecting a truly representative population estimate for a given species. All of these factors should be kept in mind when interpreting the final exposure estimates and corresponding percentages of populations presented in **Error! Reference source not found.**Table 13 – the actual percentages of the populations that are exposed are likely lower than the figures here because the abundance estimates (the denominator for the fraction) are likely low.

Table 13. The Total Number of Potential Instances of Exposure of Marine Mammals to Sound Levels ≥120 dB re 1 µPa rms or ≥160 dB re 1 µPa rms During the Planned Drilling Activities in the Chukchi Sea, Alaska, 2015. Estimates are also shown as a Percentage of Each Population

Species	Abundance Estimate*	Exposures**	% of Population
Mysticetes			
Bowhead whale	19,534[5]	1,083	5.5
Fin whale	1,652[6]	14	0.8
Humpback whale	20,800[8]	14	0.1
Pinnipeds			
Bearded seal	155,000[10]	1,722	1.1
Ringed seal	300,000[12]	25,217	8.4

*With the exception of bowhead and gray whale, precise population estimates do not exist and these percentages should be interpreted with care. Additionally, the best available abundance estimates often include only a portion of the known distribution and range for a given population, which tends to overestimate the percent of individuals exposed within those populations.

** Instances of exposure to Continuous Sounds ≥120 dB re 1 µPa (rms) or Pulsed Sounds ≥160 dB e 1 µPa (rms) Assumptions for each species included 100% daily turnover and no avoidance of ensonified areas except that a 48 hour turnover rate was applied to bowhead whales and ringed seals

[5] Givens et al. 2013, projected 2015 population using 2011 census of Bering-Chukchi-Beaufort Stock of 16,892 with annual growth rate of 3.7%

[6] Allen and Angliss 2014, estimate of Northeast Pacific Stock from Zerbini et al. 2006 surveys of Western Alaska conducted during 2001-2003

[8] Allen and Angliss 2014, estimate for entire North Pacific population

[10] Allen and Angliss 2014, estimate from Cameron et al. 2010 sum of bearded seals in Bering and Chukchi Seas

[12] Allen and Angliss 2014, estimate from Kelly et al. 2010 for Chukchi and Beaufort Seas

As discussed in the

Approach to Estimating Exposure section, NMFS considers these exposure estimates to be conservative. Additionally, post-season estimates of the number of marine mammals exposed to Level B thresholds per Shell 90-Day Reports consistently confirm that they are conservatively large. Most recently, exposure estimates reported by Reider et al. (2013) from Shell's 2013 exploration activities in the Chukchi Sea were considerably lower than those estimated in the modeling. The following summary of the numbers of cetaceans and pinnipeds that may be exposed to sounds above Level B thresholds is best interpreted as conservatively high. New methods are currently being developed that may producemore realistic methods for estimating marine mammal exposures, but they are not yet available.

No Level A takes are expected to result from this action, and none are authorized.

Results of Cetaceans Exposure Analysis for Drilling Activities

NMFS estimates 1,083 bowhead whales may be exposed to sounds at or above the Level B thresholds during the proposed 2015 exploration drilling program in the Chukchi Sea (Table 13). This estimate is approximately 5.5 percent of the expected 2015 BCB population of ~19,534 (Givens et al. 2013; Table 13**Error! Reference source not found.**). The small numbers of fin and humpback whales that may occur in the Chukchi Sea are unlikely to be present around the planned exploration drilling activities, but chance encounters may occur. The few individuals would represent only a very small proportion of their respective populations (Table 13).

Results of Pinnipeds Exposure Analysis for Drilling Activities

Ringed seal is by far the most abundant species expected to be encountered during the planned exploration drilling activities. The estimated number of individual ringed seals potentially exposed to sounds above threshold levels during the proposed exploration drilling program is 25,217, which represents approximately 8.4 percent of the estimated Chukchi-Beaufort Seas population (**Error! Reference source not found.**Table 13). As discussed earlier, NMFS (2012b) suspects there may be millions of ringed seals in the Arctic; however, the Kelly et al. (2010) population estimate of 300,000 ringed seals was used in this calculation due to its localized nature with respect to proposed operations. Fewer individual bearded seals are estimated to be exposed to sounds at the specified received levels, also representing small proportions of their populations (Table 13).

Approach to Estimating Exposures to Vessel Strike

As discussed in the *Proposed Action* section of this opinion, the activities PR1 proposes to authorize for Shell's 2015 drilling activities in the Chukchi Sea would increase the number of vessels transiting the area. Additional vessel traffic could increase the risk of collision between vessels and marine mammals. Anticipating increased vessel traffic related to drilling activities in the Chukchi Sea is based on the following assumptions:

- This action inclices 2 drilling rigs, 16 various support vessels, and 9 oil spill response vessels, none of which would be in the action area but for Shell's proposed project. Tables 1 and 2 list the numbers and types of vessels involved in this action.
- Shell plans to conduct crew changes and resupply at coastal port(s) during the season.
- Timing of operations would commence on or after approximately July 1 and end by October 30, 2015. At the start of the project, vessels are likely to transit from Dutch Harbor through

the Bering Strait into the Chukchi Sea, possibly resupplying in Kotzebue. At the end of the project, vessels are likely to exit the Chukchi Sea through the Bering Strait and transit back to Dutch Harbor.

Evidence suggests that a greater rate of mortality and serious injury to marine mammals correlates with greater vessel speed at the time of a ship strike (Laist *et al.* 2001, Vanderlaan and Taggert 2007, as cited in Aerts and Richardson 2008). Vessels transiting at speeds >10 knots present the greatest potential hazard of collisions (Jenson and Silber 2003; Silber *et al.* 2009). Most lethal and severe injuries resulting from ship strikes have occurred from vessels travelling at 14 knots or greater (Laist *et al.* 2001).

While most seismic survey and drilling operations occur at relatively low speeds (4-6 knots), large vessels are capable of transiting up to 20 knots and operate in periods of darkness and poor visibility (BOEM 2011a). In addition, large vessels when traveling cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammals (BOEM 2011a). All of these factors increase the risk of collisions with marine mammals (BOEM 2011a).

This action includes mitigation measures to help minimize the likelihood of vessel strike. These mitigation measures figure strongly into NMFS's conclusions about vessel strike as a potential stressor associated with this project, and are described in detail in Section 1.3.4.

Baleen Whale Exposure (bowhead, fin, humpback, and right whales)

Available information indicates that the rate of vessel strikes of whales in the region is low and there is no indication that strikes will become a major source of injury or mortality in the action area (BOEM 2011a).

Vessels will primarily transit during open-water periods (typically July through November), and bowhead, fin, and humpback whales are known to migrate and feed in the Chukchi Sea during open-water periods. North Pacific right whales are anticipated to be in the Bering Sea section of the action area during the open water season, potentially overlapping with vessels as they transit to the Chukchi Sea.

Vessels transiting to the Chukchi Sea from Dutch Harbor at the start of the open water season, returning at the end of the season, transiting between sites, or stopping in coastal communities along the Chukchi Sea have the highest chance of encountering migrating bowheads or aggregations feeding in more coastal regions of the northeast Chukchi (Clarke *et al*. 2011a,b, c).

Several behavioral factors of bowhead whales help determine whether transiting vessels may be able to detect the species or whether bowhead would be at depths to avoid potential collision. Bowhead whales typically spend a high proportion of time on or near the ocean floor when feeding. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush *et al.* 2010). Bowhead foraging dives are twice as long as most fin and humpback whales, and even at equivalent depths, their dives are followed by shorter recovery times at the surface (Kruzikowsky and Mate 2000). This behavior may make bowhead whales less likely to encounter a vessel transiting in the action area, and lowers the likelihood of vessels colliding with whales. However, calves have shorter dive duration, surface duration, and blow intervals than their mothers (BOEM 2011a), which puts them at a higher risk of ship strike. Bowhead whale neonates have been reported in the Arctic as early as March and as late as early August (BOEM 2011a). Most bowhead whales show strong avoidance reactions to approaching ships which may help them avoid collisions with vessels (NMFS 2013b). However, Alaska Native hunters report that bowheads are less sensitive to approaching boats when they are feeding (George *et al.* 1994), leaving them more vulnerable to vessel collisions. In addition, bowhead whales are also among the slowest moving whales, which may make them particularly susceptible to ship strikes if they happen to be on the surface when a vessel is transiting. The low number of observation of ship-strike injuries suggests that bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

NMFS is aware of no records of bowhead whales killed by ship strike in the Arctic. However, George *et al.* (1994) reported propeller scars on 2 of the 236 (0.8%) bowhead whales landed by Alaska Native whalers between 1976 and 1992. Even if vessel-related deaths were several times greater than observed levels of propeller scars, it would still be a small fraction of the total bowhead population (Laist *et al*. 2001). Bowhead whales are long lived and scars could have been from decades prior to the whale being harvested.

Around the world, fin whales are killed and injured in collisions with vessels more frequently than any other whale (Douglas *et al.* 2008; Jensen and Siber 2004; Laist *et al.* 2001). Differences in frequency of injury types among species may be related to morphology. The long, sleek, fin whale tends to be caught on the bows of ships and carried into port where they are likely found and recorded in stranding databases (Laist *et al.* 2001). There have been 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 3 involved fin whale (Neilson *et al.* 2012). None of the reported fin whale ship strikes occurred in Arctic waters. Even if vessel-related deaths of fin whales in the waters south of the action area where strike of fin whales has been known to occur were several times greater than observed levels, it would still be a small fraction of the total fin whale population (Laist *et al.* 2001).

Some of the unique feeding habits of fin whales may also put them at a higher risk of collision with vessels than other baleen whales. Fin whales lunge feed instead of skim feeding (BOEM 2011a). These lunges are quick movements which may put them in the path of an oncoming vessel, and give the captain of a vessel little time to react. In addition, despite their large body size, fin whales appear to be limited to short dive durations (Goldbogen 2007) which may make them more susceptible to ship strikes when they are near the surface. Based on ship-strike records, immature fin whales appear to be particularly susceptible to strike (Douglas *et al.* 2008).

The number of humpback whales killed worldwide by ship strikes is exceeded only by fin whales (Jensen and Silber 2004). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow *et al.* 1997). There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales (Neilson *et al.* 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010c). However, even if vessel-related deaths of humpback whales in the waters south of the action area where strike of humpback whales has been known to occur were several times greater than observed levels, it would still be a small fraction of the total humpback whale population (Laist *et al.* 2001). No vessel collisions or prop strikes involving humpback whales have been documented in the Chukchi Sea or Bering Sea (BOEM 2011a).

Ship strikes may affect the continued existence of North Pacific right whales. Little is known of the nature or extent of this problem in the North Pacific (Allen and Angliss 2011). However, their slow swim speed and skim feeding behavior (Allen and Angliss 2011) may put right whales at a high risk of collision if they were to overlap in time and space with a vessel.

Other populations of right whales are highly vulnerable to ship collisions, and North Pacific right whales cross a major Trans-Pacific shipping lane when traveling to and from the Bering Sea (e.g. Unimak Pass); their probability of ship-strike mortalities may increase with the likely future opening of an ice-free Northwest Passage (Wade *et al.* 2011). While no vessel collisions or prop strikes involving North Pacific right whales have been documented in the Bering Sea, because of the rarity of right whales the impact to the species from even low levels of interaction could be significant (NMFS 2006b).

Vessels associated with the proposed project would have a transitory and short-term presence in any specific location, except for the vicinity of the proposed drill sites. However, the rarity of collisions involving vessels and listed marine mammals in the Arctic despite decades of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated with the proposed action, the limited number of sightings of fin, humpback, and North Pacific right whales in the action area, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike in the Chukchi or Bering Seas, we conclude that the probability of a Shell vessel striking an endangered bowhead whale, fin, humpback, or north Pacific right whale in the Bering or Chukchi Seas is extremely unlikely to occur. Any such take is not authorized here.

Pinniped Exposure (ringed and bearded seals)

This section will focus on the potential exposure of listed pinnipeds to vessel traffic. Ringed seals and bearded seals have been the most commonly encountered species of any marine mammals in past exploration activities and their reactions have been recorded by PSOs on board source vessels and monitoring vessels. These data indicate that seals tend to avoid on-coming vessels and active seismic arrays (NMFS 2013b). Available information indicates that vessel strikes of seals in the region are low and there is no indication that strikes will become an important source of injury or mortality (BOEM 2011a).

During the open water foraging period for ringed seals there is a possibility that vessels could strike seals (BOEM 2011a). Seals that closely approach larger vessels also have some potential to be drawn into bow-thrusters or ducted propellers (BOEM 2011a). In recent years gray and harbor seal carcasses have been found on beaches in eastern North America and Europe with injuries indicating the seals may have been drawn through ducted propellers (BOEM 2011a). To date, no similar incidents have been documented in Alaska (BOEM 2011a). However, Sternfield (2004) documented a single spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike. There have been no incidents of ship strike with bearded seals documented in Alaska (BOEM 2011a) despite the fact that PSOs routinely sight bearded seals during oil and gas activities.

Ringed seals are often reported to be widely distributed in low densities (averaging 1-2 seal/km^2 in "good" habitats (Kovacs 2007)). The dispersed distribution may help mitigate the risks of localized shipping disturbance since the impacts from such events would be less likely to affect a large number of seals (Kelly *et al.* 2010b). However, pinnipeds may be at the greatest risk from shipping threats in areas of the Arctic where geographic constriction concentrates seals and vessel activity into confined areas, such as the Bering Strait (Arctic Council 2009). The Bering Strait area is used by bearded seals in the early spring for whelping, nursing, and mating (from April to May) and in the late spring for molting and migrating (from May to June).

Vessels associated with the proposed project would have a transitory and short-term presence in any specific location, except for the vicinity of the proposed drill sites. However, the absence of collisions involving vessels and ice seals in the Arctic and seals and sea lions in the subarctic despite decades of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated with the proposed activities in the Chukchi, the small number of vessels used for the proposed action, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike in the Chukchi Sea or Bering Sea for ice seals or Steller sea lions, and the mitigation measures in place to minimize exposure of pinnipeds to vessel activities, we conclude that the probability of a Shell vessel striking an endangered Steller sea lion or threatened ringed or bearded seal is extremely unlikely to occur. Any such take is not authorized here.

Approach to Estimating Exposures to Oil and Gas Spills

Baleen Whale Exposure (bowhead, fin, humpback, and right whales)

Some small spills could be in or close to areas used by bowhead, humpback, and fin whales. However, small refined oil spills rapidly dissipate volatile toxic compounds within hours to a few days through evaporation, and residual components rapidly disperse in open waters. If individual bowhead, humpback, or fin whales were exposed to small spills, the spills would have minimal effects on their health due to small spill sizes, weathering, and rapid spill dispersal. Humpback and fin whales occur in very low densities in the Chukchi Sea during the proposed action. Their low numbers further reduce the potential for exposure to oil spills (BOEM 2015).

A small fuel spill would be localized and would not permanently affect whale prey populations (e.g., forage fish and zooplankton). The amount of zooplankton and other prey lost in such a spill likely would be undetectable compared to what is available on the whales' summer feeding grounds. NMFS does not expect small spills of refined fuels at the rates predicted by BOEM will expose whales or their prey to a measureable level.

Based on the localized nature of small oil spills, the relatively rapid weathering expected for <1,000 bbl of refined oil, the small number of refueling activities in the proposed action, and the safeguards in place to avoid and minimize oil spills, the likelihood of a small spill affecting bowhead, fin, or humpback whales during the proposed action in the Chukchi Sea is low.

Large or very large spills are not reasonably foreseeable during the proposed action. If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate that whales would be exposed to large or very large oil spills during the proposed action.

Pinniped Exposure (ringed and bearded seals)

Ringed and bearded seals are commonly observed in the Chukchi Sea year-round. It is possible that some small spills may occur in, or close to areas used by ringed and bearded seals in the Chukchi Sea. Based on the localized nature of small spills and the relatively rapid attenuation and dispersion of < 1,000 bbl of refined oil, the small number of predicted spills, the safeguards in place to avoid and minimize oil spills, and the small number of past Arctic spills, the likelihood of a small spill affecting ringed and bearded seals during the proposed action in the Chukchi Sea is low. A small oil spill would be localized and would not permanently affect fish and invertebrate populations that are ringed and bearded seal prey. The amount of fish and other prey lost in such a spill likely would be undetectable compared to what is available throughout the range of the two seal species.

Large or very large spills are not reasonably foreseeable during the proposed action. If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate that seals would be exposed to large or very large oil spills during the proposed action.

5.6 Response Analysis

As discussed in the *Approach to the Assessment* section of this opinion, response analyses determine how listed species are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. Our assessments try to detect the probability of lethal responses, physical damage, physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

In addition, for critical habitat, we try to determine whether and how the quantity, quality, or availability of one or more of the physical or biological features that led us to conclude that the area was essential for the conservation of a listed species are likely to change in response to the exposure.

Instances of marine mammal exposure to noise from drilling activities are presented in Table 13 and discussed previously in Section 2.5.3.3. Marine mammals may respond differently to exposure to each of the stressors included in the activity scenarios, so cetacean and pinniped responses are presented below, grouped by similar responses to similar types of stressors. Because we found the probability of vessel strike of all species in this analysis to be extremely unlikely, responses to vessel strike are not analyzed here. They also are not authorized.

Responses to Noise from Drilling and MLC construction

As described in the *Exposure Analysis*, bowhead, humpback, and fin whales and ringed and bearded seals are all anticipated to occur in the action area and are anticipated to overlap with noise associated with drilling operations.

Baleen Whales (bowhead, fin, and humpback)

The majority of the information provided below focuses on bowhead whales as they are the most commonly occurring listed baleen whale in the action area, and a large amount of research has been done on this species. We anticipate responses from fin and humpback whales to be similar to the bowhead whale.

Bowhead reaction to drillship-operation noise is variable. Richardson and Malme (1993) point out that the data, although limited, suggest that stationary industrial activities producing continuous noise, such as stationary drillships, result in less dramatic reactions by whales than do moving sources, particularly ships. It also appears that bowhead avoidance is less around an unattended structure than one attended by support vessels. However, most observations of bowhead whales tolerating noise from stationary operations are based on opportunistic sightings of whales near ongoing oil-industry operations, and it is not known whether more whales would have been present in the absence of those operations. Other cetaceans seem to habituate somewhat to continuous or repeated noise exposure when the noise is not associated with a harmful event, and this may suggest that bowhead whales will habituate to certain noises that they learn are nonthreatening. Additionally, it is not known what components of the population were observed around the drillship (e.g., adult or juvenile males, adult females, etc.)(BOEM 2015).

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approach a source (LGL and Greenridge 1987, Richardson, Greene et al. 1995). McDonald et al. (2006) reported subtle offshore displacement of the southern edge of the bowhead whale migratory corridor offshore from the drilling on Northstar island.

Some bowheads likely avoid closely approaching drilling operations by changing their migration speed and direction, making distances at which reactions to drillships occur difficult to determine. Both LGL and Greenridge (1987) and Schick and Urban (2000) indicate that few whales approached within ~18 km of an offshore drilling operation in the Beaufort Sea. Results in Schick and Urban (2000) indicated that whales within hearing range of the drillship (<50 km [<31.1 mi]) were distributed farther from the rig than they would be under a random scenario. They concluded that spatial distribution was strongly influenced by the presence of the drillship but lacked data to assess noise levels. Other factors that could influence distribution relative to the drillship were support vessels and icebreakers operating in the vicinity, as well as ice thickness (Schick and Urban 2000). In a study by Koski and Johnson (1987), one whale appeared to alter course to stay 23 to 27 km (14.3 to 16.8 mi) from the center of the drilling operation. The study detected no bowhead whales within 9.5 km of the drillship, and few within 15 km. They concluded that westward migrating bowheads appeared to avoid the offshore drilling operation during the fall of 1986, and some may have avoided noise from drillships at 20 km (12.4 mi) or more.

During the 2012 drilling season, bowhead whales lingered within the Chukchi Sea lease sale area, co-occurring with drilling operations by Shell at the Burger Prospect (Quakenbush, Small et al. 2013). During fall migration, 97.6% of tagged bowhead whales entered the lease area 193

(Quakenbush, Small et al. 2013). There were a total of 107 cetaceans observed by PSOs aboard vessels in the Chukchi Sea during the 2012 while the *Discoverer* was conducting drilling operations. However, all but two of these individuals were recorded from distant support vessels in areas where received levels from drilling activities was <120 dB (rms) (Bisson, H.J. Reider et al. 2013). The remaining two unidentified mysticetes were anticipated to have been exposed to sounds between 130-140 dB from MLC construction operations at approximately 1.6-2 km from the vessel (Bisson, H.J. Reider et al. 2013).

Although bowheads have been observed well within the ensonified zones around active drill ships, playbacks of drillship noise to a small number of bowheads demonstrated some avoidance. Playbacks of *Explorer II* drillship noise (excluding components below 50 Hz) showed that some bowheads reacted to broadband received levels near 94-118 dB re 1 µPa – no higher than the levels tolerated by bowheads seen a few kilometers from drillships (Richardson, Fraker et al. 1985, Richardson, Greene et al. 1985, Richardson, Wursig et al. 1990). The playback results of Wartzok et al. (1989) seem consistent: the one observed case of strong avoidance of *Kulluk* drilling noise was at a broadband received level ≥ 120 dB.

Two explanations may account for the seemingly different reactions of summering bowhead to playbacks versus actual drilling: habituation and variable sensitivity. Bowheads may react to the onset of industrial noise (over several minutes) during a brief playback, but habituate when that sound level continues for a long period near a drillship. However, playback also showed that responsiveness varies among individuals and days. Thus, whales near actual drillships may have been some of the less responsive individuals- those remaining after the more responsive animals had moved out of the area. Both habituation and variable sensitivity may have been involved (Richardson, Greene et al. 1995).

Results of drilling noise playbacks indicated that a typical summering bowhead does not react overtly unless broadband received sound levels are ~115 dB re 1 µPa, or ~20 dB above the ambient level (Richardson, Greene et al. 1995). Based on noise within the dominant 1/3 octave band, the reaction criteria are ~110 dB re 1 µPa or ~30 dB above ambient in that band (Richardson, Wursig et al. 1990). Received industrial noise levels diminish to 20-30 dB above ambient noise level (radius of responsiveness) well before they diminish to the ambient level (radius of presumed audibility). Hence, the radius of responsiveness around a drillsite is apparently much smaller than the radius of audibility (Richardson, Greene et al. 1995).

If bowhead whales, fin whales, and humpback whales avoid drilling and related support activities at distances of approximately 20 km (consistent with avoidance distances presented in LGL and Greenridge 1987, Koski and Johnson 1987, Schick and Urban 2000), this would preclude exposure of the vast majority of individuals to continuous sounds ≥120 dB re 1 µPa rms from drilling activities (when compared to distances estimated in Table 8).

NMFS anticipates that many whales will avoid areas within 9.5-20 km of noise associated with drilling activities and should be outside the 120 dB isopleth. While PSOs are expected to monitor listed species cited during drilling operations, there are no power- or shut-down mechanisms in place if marine mammals enter the area ensonified to 120dB. Since drilling will be a continuous noise source, NMFS does not anticipate that marine mammals would enter into an area where they would suffer from acoustic harassment. However, less responsive individuals may be exposed within the 120 dB isopleth. These exposures may result in tolerance, slight avoidance, to displacement around dynamic positioning operations.

Sound energy generated from drilling operations is not anticipated to negatively impact the diversity or abundance of zooplankton or fish, and therefore is not likely to affect whales' prey resources.

Pinnipeds (ringed and bearded seals)

The effects of offshore drilling on ice seals in the Beaufort Sea have been investigated in the past (Frost, Lowry et al. 1988, Moulton, Richardson et al. 2003). Frost and Lowry (Frost, Lowry et al. 1988) concluded that local seal populations were less dense within a 2 nmi buffer of man-made islands and offshore wells that were being constructed in 1985-1987, and acoustic exposure was at least a contributing factor in that reduced density. Moulton et al. (Moulton, Richardson et al. 2003) found seal densities on the same locations to be higher in years 2000 and 2001 after a habituation period.

Richardson et al. (1990, 1991), reported that ringed and bearded seals appeared to tolerate playbacks of underwater drilling sounds and dove within 50 m of these projected broadcasts. At that distance, the received sound level at depths greater than a few meters was ~130 dB re 1 μPa.

Moulton et al. (Moulton, Richardson et al. 2003) reported no indication that drilling activities at BP's Northstar oil development affected ringed seal numbers and distribution although drilling and production sounds from Northstar could have been audible to ringed seals, out to about 1.5 km in water and 5 km in air (Blackwell, Greene et al. 2004). Richardson and Williams (Richardson and Williams 2004) found underwater noise from drilling reached background values at 2-4 km and underwater sound from vessels were sometimes detectable out to 30 km offshore. They concluded that the low-frequency industrial sounds emanating from the Northstar facility during the open-water season resulted in brief, minor localized effects on ringed seals with no consequences to ice seal populations. Adult ringed seals seem to habituate to long-term effects of drilling activities. Brewer et al. (Brewer, Gallagher et al. 1993) noted ringed seals were the most common marine mammal sighted and did not seem to be disturbed by drilling operations at the Kuvlum #1 project in the Beaufort Sea.

Harwood et al. (Harwood, Smith et al. 2007) evaluated the potential impacts of offshore exploratory drilling on ringed seals in the near shore Canadian Beaufort Sea, during February to June 2003-2006. The first 3 years of the study (2003-2005) were conducted prior to industry activity in the area, while a fourth year of study (2006) was conducted during the latter part of a single exploratory drilling season. Seal presence was not significantly different in distance from industrial activities during the non-industry (2003 and 2004) and industry (2006) years. Further, the movements, behavior, and home range size of 10 seals tagged in 2006 also did not vary statistically between the 19 days when industry was active (20 March to 8 April) and the following 19 days after industry operations had been completed. The density of basking seals was not significantly different among the different study years and was comparable to densities found in this same area during surveys conducted in 1974-1979, and no detectable effect on ringed seals was observed during the single season of drilling in the study area (Harwood, Smith et al. 2007).

Southall et al. (Southall, Bowles et al. 2007) reviewed literature describing responses of pinnipeds to continuous 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 nonpulsed sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies of pinnipeds responding to continuous noise 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.

During Shell's 2012 drilling operations in the Chukchi Sea, a total of 396 seals were observed by PSOs. It was impossible to determine precisely how many seals represented sightings of new individuals or if they were re-sightings of seals that already had been observed and recorded in the area. The vast majority (93%) of the seal sightings were recorded when the pilot hole was being drilled. The remaining 26 seals were observed during MLC construction. The estimated radius to received levels ≥120 dB (rms) during MLC excavation was 8.1 km compared to the 1.5 km during the pilot hole drilling (Bisson, H.J. Reider et al. 2013). They estimated that 97% of the observed pinnipeds were exposed to received levels ≤120 dB (rms). No seals were observed at distances where received levels were estimated to be ≥160 dB (rms) (Bisson, H.J. Reider et al. 2013).

While PSOs are expected to monitor the presence of marine mammals near drilling and MLC operations, there are no power- or shut-down mechanisms in place if marine mammals enter the area ensonified to 120dB. However, since both drilling and MLC construction will be a continuous noise source, based on the information presented above, NMFS does not anticipate that marine mammals would enter into an area where they would suffer from acoustic harassment.

While the potential instances of exposure derived from ringed and bearded seal density multiplied by the ensonified area of each source associated with drilling operations estimate a high number of exposures, the majority of these are anticipated to occur at received levels ≤ 120 dB. Even if exposure occurred at higher received levels, the tendency of pinnipeds such as ringed and bearded seals to raise their heads above water, or haul out (during the in-ice period) to avoid exposure to sound fields, reduce the potential for harassment of these species. Ringed and bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns.

Based on this information, we would not expect ringed and bearded seals that are more than 9.3 kilometers (including the 1.3 safety factor) from drilling operations to devote attention to that stimulus, even though received levels might be as high as 120 dB. If ringed and bearded seals respond in a similar manner to drilling and MLC construction as they have with previous drilling activities and playback simulations, we would anticipate slight behavioral changes from ringed and bearded seals at received levels between 120 and 140 dB. These exposures may result in tolerance, slight avoidance, masking, and/or temporary displacement around dynamic positioning operations.

Responses to Vessel Noise from Transit, Anchor Handling, Dynamic Positioning, and Ice Management

As described in the *Exposure Analysis* section, bowhead, humpback, and fin whales and ringed and bearded seals are all anticipated to overlap with noise associated with vessel transit, anchor handling, dynamic positioning, and ice management activities. Some individuals are likely to be exposed and respond to these noise sources.

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans *et al.* 1992, 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Speed, course changes for surveys, and sounds associated with engines and displacement of water along the bowline are potential stressors associated with the vessels involved in drilling and ZVSP activities (Table 1). Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (*see* Blumstein 2003 and Nonacs and Dill 1990): ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist; alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately; change their behavior proportional to increases in their perceived risk of predation which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity, or take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

The latter two options are energetically costly and reduce benefits associated with the animal‘s current behavioral state. As a result, animals that detect a predator or predatory stimulus at a greater distance are more likely to flee at a greater distance (see Lord *et al.* 2001). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts such as causing marine mammals to avoid an area (Salden 1988, Lusseau 2005) or alter a population’s behavioral budget (Lusseau 2004) which could have biologically significant consequences on the energetic budget and reproductive output of individuals and their populations.

In summary, NMFS expects that marine mammal responses to noise from vessels could vary, including any of the four reactions described above.

Baleen Whales (bowhead, fin, and humpback whales)

While cetaceans are a diverse group with varied life histories and migratory patterns (see Section 2.3), they share many important traits and exhibit similar physiological and behavioral responses. The majority of the information provided below focuses on bowhead whales as they are the most commonly occurring listed baleen whale in the action area, and a large amount of research has been done on this species. We anticipate responses from fin and humpback whales to be similar to the bowhead whale.

Transiting Vessels

Based on the suite of studies of cetacean behavior to vessel approaches (Au and Green 1990, Au and Perryman 1982, Bain *et al.* 2006, Bauer 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, David 2002, Erbé 2002b, Félix 2001, Magalhães *et al.* 2002, Goodwin and Cotton 2004, Hewitt 1985, Lusseau 2003, 2006; Lusseau and Bejder 2007, Ng and Leung 2003, Nowacek *et* *al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *et al.* 1998), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include: number of vessels, the distance between vessel and marine mammals, the vessel's speed and vector, the predictability of the vessel's path, noise associated with the vessel, the type of vessel, and the behavioral state of the marine mammals.

Most of those investigations cited above reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lusseau 2003; Lusseau 2004, 2005a; Nowacek *et al.* 2001; Williams *et al.* 2002). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Edds and Macfarlane 1987; Baker and Herman 1987; Kruse 1991; Evans *et al.* 1992). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991).

Richardson *et al.* (1985) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engaged in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distances of about 1 km (Edds and Macfarlane 1987). Baker *et al.* (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km.

Bowhead whales react to approaching vessels at greater distances than they react to most other activities. Vessel-disturbance experiments in the Canadian Beaufort Sea by Richardson and Malme (1993) showed that most bowheads begin to swim rapidly away when fast moving vessels approach directly. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.62 to 2.5 mi) away. Whales move away more quickly when approached closer than 2 km (1.2 mi) (Richardson and Malme 1993). A few whales reacted at distances of 5 to 7 km (3.1 to 4.3 mi), while others did not react until the vessel was <1 km (<0.62 mi) away. Received noise levels as low as 84 dB re 1 μPa, or 6 dB above ambient, elicited strong avoidance reactions from bowhead from an approaching vessel 4 km (2.5 mi) away. During the experiments, vessel disturbance temporarily disrupted activities, and socializing whales moved apart from one another. Fleeing from a vessel usually stopped soon after the vessel passed, but scattering lasted for a longer time period. Some bowheads returned to their original locations after the vessel disturbance (Richardson and Malme 1993). However, it is not known whether they would return after repeated disturbance (Richardson, Greene et al. 1995). Boat disturbance also tended to cause unusually brief surfacing with few respirations per surfacing (Richardson, Fraker et al. 1985). Bowheads showed clear reactions to approaching vessels as much as 4 km away, based on measurements of whale headings, speeds, surface times, and number of respirations per surfacing (Richardson and Malme 1993). Bowheads react less dramatically to and appear more tolerant of slow-moving vessels, especially if they do not approach directly.

Confirming assertions made by native bowhead hunters, low levels of underwater noise can elicit flight reactions in bowhead whales (Richardson and Malme 1993). In one test, received noise levels from an approaching fishing boat were only ~6-13 dB above the background noise and caused flight reactions in bowhead (Miles, Malme et al. 1987, Richardson and Malme 1993). Mothers traveling with calves can be particularly sensitive to vessel traffic, and showed strong evasive behaviors when vessels were over 15 km away (Richardson and Malme 1993). In contrast, animals that are actively feeding may be less responsive to boats (Wartzok, Watkins et al. 1989).

Humpback whale reactions to approaching boats are variable, ranging from approach to avoidance (Payne 1978, Salden 1993). On rare occasions humpbacks "charge" towards a boat and "scream" underwater, apparently as a threat (Payne 1978). Baker *et al.* (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km. Bauer and Herman (1986) concluded that reactions to vessels are probably stressful to humpbacks, but that the biological significance of that stress is unknown. Similar to bowhead whales, humpbacks seem less likely to react to vessels when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984). Mothers with newborn calves seem most sensitive to vessel disturbance (Clapham and Mattila 1993). Marine mammals that have been disturbed by anthropogenic noise and vessel approaches are commonly reported to shift from resting behavioral states to active behavioral states, which would imply that the incur an energy cost. Morete *et al.* (2007) reported that undisturbed humpback whale cows that were accompanied by their calves were frequently observed resting while their calves circled them (milling) and rolling interspersed with dives. When vessels approached, the amount of time cows and calves spent resting and milling, respectively declined significantly. Considering that one cow calf pair was observed in the Beaufort Sea (Hashagen, Green et al. 2009), there is the potential for interactions between vessels and cow calf pairs in the Arctic.

Fin whales responded to vessels at distances of about 1 km (Edds and Macfarlane 1987). Watkins (1981) found that fin and humpback whales appeared startled and increased their swimming speed to avoid approaching vessels. Jahoda *et al.* (2003) studied responses of fin whales in feeding areas when they were closely approached by inflatable vessels. The study concluded that close vessel approaches caused the fin whales to swim away from the approaching vessel and to stop feeding. These animals also had increases in blow rates and spent less time at the surface (Jahoda, Lafortuna et al. 2003). These responses can cause physiological changes, interrupt essential behavioral and physiological events, and/or alter time budget (an organisms' normal allocation of time spent foraging, resting, and performing other biologically necessary tasks for survival) (Sapolsky 2000, Frid and Dill 2002).

In general, baleen whales react strongly and rather consistently to approaching vessels of a wide variety of types and sizes. Whales are anticipated to interrupt their normal behavior and swim rapidly away if approached by a vessel. Surfacing, respiration, and diving cycles can be affected. The flight response often subsides by the time the vessel has moved a few kilometers away. After single disturbance incidents, at least some whales are expected to return to their original locations. Vessels moving slowly and in directions not toward the whales usually do not elicit such strong reactions (Richardson and Malme 1993).

Table 1 reports vessel speeds for vessels used in this action, with maximum vessel speeds of 16 knots. Mitigation measures specify procedures for changing vessel speed and/or direction to avoid groups of whales, avoid potential for collision, and PSOs are on board to spot nearby whales. NMFS anticipates that noise associated with transiting vessels could be above 120 dB at the source vessel, but would decline in proportion to distance away from the source and eventually drop to 120 dB within 7 km (or less) of most vessels associated with oil and gas activities, and within 19 km of vessels towing drilling units (O'Neill and McCrodan 2012, O'Neill and McCrodan 2012). At these distances, a whale that perceived the vessel noise is likely to ignore such a signal and devote its attentional resources to stimuli in its local environment. If animals do respond, they may exhibit slight deflection from the noise source, engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior, but these behaviors are not likely to result in adverse consequences for the animals. NMFS anticipates these impacts to be minor and insignificant.

Anchor Handling, Dynamic Positioning, and Ice Management
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.

Of the whales that might be exposed to received levels ≥120 dB during the proposed action, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming direction to avoid vessel operations, change their respiration rates, increase dive times, reduce feeding behavior, or alter vocalizations and social interactions (Richardson, Wursig et al. 1986, Ljungblad, Wursig et al. 1988, Richardson and Malme 1993, Greene, Altman et al. 1999, Frid and Dill. 2002, Christie, Lyons et al. 2009, Koski, Funk et al. 2009, Blackwell, Kim et al. 2010, Funk, Rodrigues et al. 2010, Melcon, Cummins et al. 2012). We assume that these responses are more likely to occur when whales are aware of multiple vessels in their surrounding area.

Some whales may be less likely to respond because they are feeding. Some whales might experience physiological stress (but not distress) responses if they attempt to avoid one vessel and encounter another vessel while they are engaged in avoidance behavior.

Sound energy generated from vessel operations is not anticipated to negatively impact the diversity or abundance of zooplankton or fish, and therefore is not likely to affect whales' prey resources.

Ringed and Bearded Seals

Vessel Transit

Few authors have specifically described the responses of pinnipeds to boats, and most of the available information on reactions to boats concerns pinnipeds hauled out on land or ice. However, the mere presence and movements of ships in the vicinity of seals can cause disturbance to their normal behaviors (Henry and Hammill 2001, Ferland and Decker 2005, Shaughnessy, Nicholls et al. 2008, Jansen, Boveng et al. 2010), and could potentially cause ringed seals and bearded seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne 1979, Mansfield 1983, Reeves 1998). Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals to leave haulout locations and enter the water (Richardson, Greene et al. 1995). Due to the relationship between ice seals and sea ice, the reactions of seals to vessel activity is likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during the open water conditions (BOEM 2015).

Ringed seals hauled out on ice pans often showed short-term escape reactions when a ship came within 250-500m (Brueggeman, Green et al. 1992). Jansen *et al.* (2006) reported that harbor seals approached by vessels to 100m (0.06 mi) were 25 times more likely to enter the water than were seals approached at 500m (0.3 mi). However, in places where boat traffic is heavy, there have been cases where seals have habituated to vessel disturbance (e.g. (Bonner 1982, Jansen, Bengtson et al. 2006). Such variations in seal responses may be explained as the result of the assessment of immediate risk, and conclusions made by individual seals on a case by case basis (BOEM 2015).

During the open water season in the Chukchi Sea, bearded and ringed seals are commonly observed close to vessels where received sound levels were low (e.g., (Harris, Miller et al. 2001, Moulton and Lawson 2002, Blees, Hartin et al. 2010, Funk, Rodrigues et al. 2010)). Funk et al. (2010) noted among vessels operating in the Chukchi Sea where received sound levels were <120 dB, 40% of observed seals showed no response to a vessel's presence, slightly more than 40% swam away from the vessel, 5% swam towards the vessel, and the movements of 13% of the seals were unidentifiable. More recently, Bisson et al. (2013) reported a total of 938 seals observed during vessel-based monitoring of exploratory drilling activities by Shell in the Chukchi Sea during the 2012 open-water season. This total includes animals sighted outside of the Leased Area during transits to and from the drill site. The majority of seals (42%) responded to moving vessels by looking at the vessel, while a sizeable portion showed no observable reaction (38%). The majority of seals (58%) showed no reaction to stationary vessels, while looking at the vessel was the second most common behavioral response (38%). Other reactions to both moving and stationary vessels included splashing and changing direction.

Adult ringed and bearded seals are agile and easily avoid vessels in open water conditions. Pups have a greater potential for heat loss than adults and so would be more prone to incur energetic costs of increased time in the water if vessel disturbance became a more frequent event (Cameron, Bengtson et al. 2010). If a vessel disturbs young ice seals, some might become energetically and behaviorally stressed, leading to lower overall fitness of those individuals. The potential for ship traffic to cause a mother to abandon her pup may be lower in bearded seals than in ringed seals (Smiley and Milne 1979), as bearded seal mothers appear to exhibit a high degree of tolerance when approached by small boats.

NMFS anticipates that noise associated with transiting vessels could be above 120 dB at the source vessel, but would decline in proportion to distance away from the source and eventually drop to 120 dB within 7 km (or less) of most vessels associated with oil and gas activities, and within 19 km of vessels towing drilling units (O'Neill and McCrodan 2012, O'Neill and McCrodan 2012). At these distances we would not anticipate that ice seals would devote attention to these stressors. If animals do respond, they may exhibit slight deflection from the noise source, engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior, but these behaviors are not likely to result in adverse consequences for the animals. Overall, vessel noise does not seem to strongly affect pinnipeds that are in the water (Richardson, Greene et al. 1995), which is anticipated for the open-water season.

In addition, with mitigation measures in place restricting vessel speed and approach, and PSOs on board to spot nearby seals, the impact of vessel transit on ringed and bearded seals is anticipated to be minor and insignificant.

Anchor Handling, Dynamic Positioning, and Ice Management

All vessels produce sounds during operation, which when propagated at certain frequencies and intensities can alter the normal behavior of marine mammals, mask their underwater communications and other uses of sound, and cause them to avoid noisy areas (Arctic Council 2009, Götz and Janik 2011). All ice-breeding pinniped species are known to produce underwater vocalizations (Richardson, Greene et al. 1995). Male bearded seals rely on underwater vocalizations to find mates. As background noise increases, underwater sounds are increasingly masked and uni-directional, deteriorate faster, and are detectable only at shorter ranges. Effects of vessel noise on bearded seal vocalizations have not been studied, though the frequency range of the predominant "trill" and "moan" calls (130-10590 Hz and 130-1280 Hz, respectively) that are broadcast during the mating season partially overlaps the range (20-300 Hz) over which ship noise dominates ambient noise in the oceans (Urick 1983, Cleator, Stirling et al. 1989, Ross 1993, Risch, Clark et al. 2007, Tyack 2008). Vocalizations of the sympatric harp seal were shown to be completely masked by stationary ship noise at a distance of 2 km (Terhune, Stewart et al. 1979), a finding supported by communication-range models for this species which predicted call masking and a significant loss of communication distances in noisy environments (Rossong and Terhune. 2009).

Studies show that animals adapt acoustic signals to compensate for environmental modifications to sound (Wilczynski and Ryan 1999). Indeed, background noise has been suggested to account for geographical differences in the range and quality of bearded seal calls (Rogers 2003, Risch, Clark et al. 2007). However, compensating for sound degradation – such as by delaying calling, shifting frequencies, moving to a quieter area, or calling louder, longer, and more frequently – incurs a cost (Tyack 2008). The cost of these adaptations, or that of missing signals, is inherently difficult to study in free-ranging seals and to date has not been measured in any phocid seal. Because bearded seals broadcast over distances of at least 30-45 km (Cleator, Stirling et al.

1989), and possibly over 100s of kilometers (Stirling 1983, Rossong and Terhune. 2009), their calls are increasingly susceptible to background interference. Though in some areas male bearded seals may "practice" calling throughout the year, the period of peak vocalization is during the breeding season (April to mid-June). This action will not start until July, minimizing any potential overlap with the bearded seal breeding season. Considering that vessels largely avoid areas of pack ice, where communication and mating occurs, or transit these areas outside the breeding season, effects are not expected to be as significant.

Of the seals that might be exposed to received levels ≥120 dB during the proposed action, some seals may change their behavior, alter their vocalizations, mask received noises, increase vigilance, and avoid noisy areas (Richardson and Malme 1993, Richardson, Greene et al. 1995, Rogers 2003, Blackwell, Lawson et al. 2004, Rossong and Terhune. 2009). We assume that these responses are more likely to occur when seals are aware of multiple vessels in their surrounding area.

Since anchor handling, dynamic positioning, and ice management will be continuous noise sources, it is not anticipated that marine mammals would enter into an area where they would be exposed to sound sources above damaging levels. In addition, with mitigation measures in place restricting vessel speed and approach, and PSOs on board to spot nearby seals, the impact of anchor handling, dynamic positioning, and ice management on ringed and bearded seals is anticipated to be minor.

Responses to Seismic Noise from ZVSP

Of all of the stressors we consider in this opinion, the potential responses of marine mammals exposed to low-frequency seismic noise from airgun pulses have received the greatest amount of attention and study from researchers and industry. Nevertheless, despite decades of study, empirical evidence on the responses of free-ranging marine animals to seismic noise is still very limited.

Baleen Whales (bowhead, fin, and humpback)

While cetaceans are a diverse group with varied life histories and migratory patterns (see Section 2.2.3), they share many important traits and exhibit similar physiological and behavioral responses. The majority of the information provided below focuses on bowhead whales as they are the most commonly occurring listed baleen whale in the action area, and a large amount of research has been done on this species. We anticipate responses from fin and humpback whales to be similar to the bowhead whale.

Given the large size of baleen whales, and their pronounced vertical blow, it is likely that PSOs would be able to detect bowhead, fin, and humpback whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of seismic sound, and the short duration and intermittent exposure to seismic airgun pulses, reduces the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions (reproduction or survival), or result in temporary threshold shift (TTS) or permanent threshold shift (PTS). However, despite observer effort to mitigate exposure to sounds ≥180 dB re 1 μPa rms, some whales may enter within the exclusion radii. In the Chukchi Sea in 2006 and 2008, 13 cetaceans were sighted within the ≥180 dB re 1 μPa rms radius and exposed to noise levels above that range before appropriate mitigation measures could be implemented (Haley, Beland et al.

2010).[10] The majority of cetaceans exhibited no reaction to vessels regardless of received sound levels (~96% of sightings). An increase in speed and splash were the next commonly observed reactions (Haley, Beland et al. 2010).

While there is no direct data describing hearing in low-frequency cetaceans, the functional hearing range is anticipated to be between 7 Hz to 30 kHz (Watkins 1986, Au, Pack et al. 2006, Southall, Bowles et al. 2007, Ciminello, R. Deavenport et al. 2012, NOAA 2013). This information leads NMFS to conclude that bowhead, fin, and humpback whales exposed to sounds produced by seismic airguns are likely to respond if they are exposed to low-frequency (7 Hz – 30 kHz) sounds. However, because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that received levels of up to 189 dB are not likely to damage the tissues of bowhead, fin, or humpback whales (Thompson, Cummings et al. 1986, Cummings and Holliday 1987, Clark and Gagnon 2004).

ZVSP will only take place during the fall season, after drilling is complete, when bowheads are migrating (starting as early as end of August) back through the Chukchi Sea (Allen and Angliss 2014). While fall densities in the Chukchi Sea are anticipated to be higher than summer densities, some bowhead whales may be present in the action area during the summer (Ireland, Rodrigues et al. 2009, Clarke, Christman et al. 2011). Humpback and fin whales are anticipated to occur in the action area in the summer to early fall (July-Oct), but in low densities (Aerts, Kirk et al. 2012, Clarke, Christman et al. 2013, Delarue, Martin et al. 2013).

ZVSP activity would likely impact bowhead, fin, and humpback whales, although the level of disturbance depends on whether the whales are feeding or migrating, as well as other factors such as the age of the animal and whether it is habituated to the sound. In addition to targeted studies in marine mammals indicating that frequency (beyond just differing sensitivities at different frequencies) can affect the likelihood of auditory impairment incurred, there is increasing evidence that contextual factors other than received sound level, including activity states of exposed animals, the nature and newness of the sound, and the relative spatial positions of sound and receiver, can strongly affect the probability of behavioral response (Ellison, Southall et al. 2012).

Tolerance

Numerous studies have shown that underwater sounds from industry activities are often readily detectable by marine mammals in the water at distances of many kilometers. Despite industry activities occurring at distances of only a few kilometers away, often times marine mammals show no apparent response to industry activities of various types (Miller, Moulton et al. 2005, Bain and Williams 2006). 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. Weir (2008) observed marine mammal responses to seismic pulses from a 24 airgun array firing a total volume of either 5,085 in^3 or 3,147 in^3 in Angolan waters between August 2004 and May 2005. Weir recorded a total of 207 sightings of humpback whales (n = 66), sperm whales (n = 124), and Atlantic spotted dolphins (n = 17) and reported that there were

[10] These are considered minimum estimates since they are based on direct observation.

no significant differences in encounter rates (sightings/hr) for humpback and sperm whales according to the airgun array's operational status (i.e., active versus silent). The airgun arrays used in the Weir (Weir 2008) study were larger than the array proposed for use during this seismic survey (total discharge volumes of 40 to 4500 in^3). Based on this information regarding marine mammal tolerance of underwater sounds, we anticipate that some baleen whales exposed to low frequency underwater sounds from exploration activities will show no response, in other words, show tolerance of the sound. Other likely responses and their consequences are discussed below.

Masking

Masking occurs when anthropogenic sounds and marine mammal signals overlap at both spectral and temporal scales. For the airgun sound generated from the proposed ZVSP, sound will consist of low frequency pulses with extremely short durations (less than one second). Lower frequency human-made sounds are more likely to affect detection of communication calls and other potentially important natural sounds such as surf and prey noise. There is little concern regarding masking near the sound source due to the brief duration of these pulses and relatively longer silence between airgun shots (approximately 5-6 seconds). However, at long distances (over tens of kilometers away), due to multipath propagation and reverberation, the durations of airgun pulses can be "stretched" to seconds with long decays (Madsen, Johnson et al. 2006), although the intensity of the sound is greatly reduced. This could affect communication signals used by low frequency mysticetes when they occur near the noise band and thus reduce the communication space of animals (e.g., (Clark, Ellison et al. 2009) and cause increased stress levels (e.g., (Foote, Osborne et al. 2004, Holt, Noren et al. 2009). However, marine mammals are thought to be able to compensate for masking by adjusting their acoustic behavior by shifting call frequencies, and/or increasing call volume and vocalization rates. For example, blue whales are found to increase call rates when exposed to seismic survey noise in the St. Lawrence Estuary (Di Lorio and Clark. 2010). In addition, the sound localization abilities of marine mammals suggest that, if signal and noise come from different directions, masking would not be as severe as the usual types of masking studies might suggest (Richardson, Greene et al. 1995).

Responses While Feeding

Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2015). Bowhead whales feeding in the Canadian Beaufort Sea in the 1980s showed no obvious behavioral changes in response to airgun pulses from seismic vessels 6 to 99 km (3.7 to 61.5 mi) away, with received sound levels of 107 to 158 dB rms (Richardson, Wursig et al. 1986). They did, however, exhibit subtle changes in surfacing–respiration–dive cycles. Seismic vessels approaching within approximately 3 to 7 km (2 to 4 mi), with received levels of airgun sounds of 152 to 178 dB, elicited avoidance (Richardson, Wursig et al. 1986, Ljungblad, Wursig et al. 1988, Richardson, Greene et al. 1995, Miller, Moulton et al. 2005). Richardson *et al.* (Richardson, Wursig et al. 1986) observed feeding bowheads start to turn away from a 30-airgun array with a source level of 248 dB re 1 μPa at a distance of 7.5 km (4.7 mi) and swim away when the vessel was within about 2 km (1.2 mi); other whales in the area continued feeding until the seismic vessel was within 3 km (1.9 mi).

While the ranges at which bowhead whales respond to approaching seismic vessels varied, the responses that have been reported point to a general pattern. First, the responses of bowhead whales appear to be influenced by their pre-existing behavior: bowhead whales are more tolerant of higher sound levels when they are feeding than during migration (Miller, Moulton et al. 2005, Harris, Elliott et al. 2007). Data from an aerial monitoring program in the Alaskan Beaufort Sea during 2006 to 2008 also indicate that bowheads feeding during late summer and autumn did not exhibit large-scale distribution changes in relation to seismic operations (Funk, Ireland et al. 2011). Feeding bowheads may be so highly motivated to stay in a productive feeding area that they remain in an area with noise levels that could, with long term exposure, cause adverse effects (NMFS 2010).

The absence of changes in the behavior of foraging bowhead whales should not be interpreted to mean that the whales were not affected by the noise. Animals that are faced with human disturbance must evaluate the costs and benefits of relocating to alternative locations; those decisions would be influenced by the availability of alternative locations, the distance to the alternative locations, the quality of the resources at the alternative locations, the conditions of the animals faced with the decision, and their ability to cope with or “escape” the disturbance (Lima and Dill 1990, Gill and Sutherland 2001, Frid and Dill. 2002, Beale and Monaghan 2004, Beale and Monaghan 2004, Bejder, Samuels et al. 2006, Bejder, Samuels et al. 2009). Specifically, animals delay their decision to flee from predatory stimuli they detect until they decide that the benefits of abandoning a location are greater than the costs of remaining at the location or, conversely, until the costs of remaining at a location are greater than the benefits of fleeing (Ydenberg and Dills 1986). Ydenberg and Dill (1986) and Blumstein (2003) presented an economic model that recognized that animals will almost always choose to flee a site over some short distance to a predator; at a greater distance, animals will make an economic decision that weighs the costs and benefits of fleeing or remaining; and at an even greater distance, animals will almost always choose not to flee. For example, in a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, had most of their energy at frequencies below or above the hearing capacities of these species, or were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale’s range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds.

As a result of using this kind of economic model to consider whales’ behavioral decisions, we would expect whales to continue foraging in the face of moderate levels of disturbance. For example, bowhead, fin, and humpback whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, are more likely to continue foraging in the face of disturbance. Similarly, a bowhead cow accompanied by her calf is less likely to flee or abandon an area at the cost of her calf’s survival. By extension, we assume that animals that choose to continue their pre-disturbance behavior would have to cope with the costs of doing so, which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill 2002, MMS 2008).

Responses While Migrating
As we discussed previously, migrating bowhead whales respond more strongly to seismic noise pulses than do feeding whales. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn showed avoidance out to 20 to 30 km (12.4 to 18.6 mi) from a medium-sized airgun source at received sound levels of around 120 to 130 dB re 1 μPa rms (Miller, Elliot et al. 1999, Richardson 1999). Avoidance of the area did not last more than 12 to 24 hours after seismic shooting stopped. Deflection might start as far as 35 km (21.7 mi) away and may persist 25 to 40 km (15.6 to 24.9 mi) to as much as 40 to 50 km (24.9 to 31.1 mi) after passing seismic-survey operations (Miller, Elliot et al. 1999). Preliminary analyses of recent data on traveling bowheads in the Alaskan Beaufort Sea also showed a stronger tendency to avoid operating airguns than was evident for feeding bowheads (Christie, Lyons et al. 2009, Koski, Funk et al. 2009). Most bowheads would be expected to avoid an active source vessel at received levels of as low as 116 to 135 dB re 1 μPa rms when migrating (MMS 2008). Richardson *et al.* (1999) suggests that migrating bowheads start to show significant behavioral disturbance from multiple pulses at received levels around 120 dB re 1 μPa.

Avoidance responses of migrating humpback whales to airgun noise appear consistent with bowhead and gray whale avoidance at received levels between 150-180 dB(Richardson, Greene et al. 1995). Migrating humpbacks showed localized avoidance of operating airguns in the range of received levels 157-164 dB. In addition, humpback whales seemed more sensitive to seismic airgun noise while exhibiting resting behavior (McCauley, Fewtrell et al. 2000). For resting humpback pods that contained cow-calf pairs, the mean airgun noise level for avoidance was 140 dB re 1 μPa rms, and a startle response was observed at 112 dB re 1μ Pa rms (McCauley, Fewtrell et al. 2000). When calves are small, comparatively weak and possibly vulnerable to predation and exhaustion, the potential continual dislocation of these animals in a confined area would interrupt this resting and feeding stage, with potentially more serious consequences than any localized avoidance response to an operating seismic vessel as seen during their migratory swimming behavior (McCauley, Fewtrell et al. 2000).

In 9 of the 16 trials (McCauley, Fewtrell et al. 2000), mostly single, large mature humpbacks approached the operating airgun within 100-400m to investigate before swimming off. These whales would have received maximum air gun signals at 100m of 179 dB re 1 μPa rms (or 195 dB re 1 μPa peak–peak). This level is equivalent to the high peak to peak 192 dB re 1μPa humpback whale sounds recorded in Alaska (Thompson, Cummings et al. 1986). The underwater signals produced by humpback whale breaching were audibly similar to air gun signals. McCauley *et al.* (2000) speculate that given the similarities between airgun and breaching signals, male humpback whales may identify airgun signals as a “competitor.” Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150dB re 1μ Pa/Hz at 350Hz (Lien, Todd et al. 1993, Todd, Stevick et al. 1996). However, at least two individuals were probably killed by the high-intensity, impulse blasts and had extensive mechanical injuries in their ears (Ketten, Lien et al. 1993, Todd, Stevick et al. 1996). Frankel and Clark (1998) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60 - 90 Hz sounds with a received level of up to 190 dB. Although these studies demonstrated that humpback whales may exhibit short-term behavioral reactions to playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

Studies of bowhead, gray, and humpback whales indicate 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. Fin whales are anticipated to respond in a similar manner.

Avoidance is one of many behavioral responses whales may exhibit when exposed to seismic noise. Other behavioral responses include evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology; increased vigilance of an acoustic stimulus, which would alter their time budget (that is, during the time they are vigilant, they are not engaged in other behavior); and continued pre-disturbance behavior with the physiological consequences of continued exposure.

In addition to these behavioral responses, whales alter their vocal communications when exposed to anthropogenic sounds. Communication is an important component of the daily activity of animals and ultimately contributes to their survival and reproductive success. Animals communicate to find food (Marler, Dufty et al. 1986, Elowson, Tannenbaum et al. 1991), acquire mates (Ryan 1985), assess other members of their species (Parker 1974, Owings, Rowe et al. 2002), evade predators (Greig-smith 1980), and defend resources (Zuberbuhler, Noe et al. 1997). Human activities that impair an animal's ability to communicate effectively might have significant effects on the survival and reproductive performance of animals experiencing the impairment.

At the same time, most animals that vocalize have evolved with an ability to make adjustments to their vocalizations to increase the signal-to-noise ratio, active space, and recognizability of their vocalizations in the face of temporary changes in background noise (Cody and Brown 1969, Brumm 2004, Patricelli and Blickley 2006). A few studies have demonstrated that marine mammals make the same kind of vocal adjustments in the face of high levels of background noise. For example, two studies reported that some mysticete whales stopped vocalizing – that is, adjust the temporal delivery of their vocalizations – when exposed to active sonar (Miller, Biassoni et al. 2000, Melcon, Cummins et al. 2012). Melcón *et al*. (2012) reported that during 110 of the 395 d-calls (associated with foraging behavior) they recorded during mid-frequency active sonar transmissions, blue whales stopped vocalizing at received levels ranging from 85 to 145 dB, presumably in response to the sonar transmissions. These d-calls are believed to attract other individuals to feeding grounds or maintain cohesion within foraging groups (Oleson, Wiggins et al. 2007). It should also be noted that mid-frequency sonar is not in the frequency range of most baleen whale calls, and a response by blue whales to mid-frequency sonar suggests that they have the ability to perceive and respond to these sounds (Erbe 2002, Southall, Bowles et al. 2007, Melcon, Cummins et al. 2012).

Another study by Pirotta et al. (2014) showed that the probability of recording a harbor porpoise "buzz" (inter-click interval associated with attempted prey captures or social communication) declined by 15% in the ensonified area of a 2D seismic operation. The probability of occurrence of buzzes increased significantly with distance from the seismic source. This suggests that the likelihood of buzzing was dependent upon received noise intensity. Observed changes in buzzing occurrence could reflect disruption of either foraging or social activities. These effects may result from prey reactions to noise, leading to reduced porpoise foraging rates. Alternatively, foraging effort may change if porpoises adjust time budgets or diving behavior to avoid noise (Pirotta, Brookes et al. 2014).

The effect of seismic airgun pulses on bowhead whale calling behavior has been extensively studied in the Beaufort Sea and is similar to the patterns reports in other whales. During the autumn season in 2007 and 2008, calling rates decreased significantly in the presence (<30 km [<18.6 mi]) of airgun pulses (Blackwell, Kim et al. 2010). There was no observed effect when seismic operations were distant (>100 km [>62 mi]). Call detection rates dropped rapidly when cumulative sound exposure levels (CSELs) were greater than 125 dB re 1 μPa2·s over 15 minutes. The decrease was likely caused by a combination of less calling by individual whales and by avoidance of the area by some whales in response to the seismic activity. Calls resumed near the seismic operations area shortly after operations ended. Aerial surveys showed high sighting rates of feeding, rather than migrating, whales near seismic operations (Miller, Moulton et al. 2005, Blackwell, Kim et al. 2010). In contrast, reduced calling rates during a similar study in 1996 to 1998 were largely attributed to avoidance of the area by whales that were predominantly migrating, not feeding (Miller, Elliot et al. 1999, Richardson 1999). Greene et al. (1999) concluded that the patterns seen were consistent with the hypothesis that exposure of bowhead whales to airgun sound resulted in diversion away from airguns, a reduction in calling rate, or a combination of both. Funk et al. (2010) findings are generally consistent with Greene et al. (1999), i.e., seismic surveys lead to a significant decrease in the call detection rates of bowhead whales. Blackwell *et al.* (2013) found a statistically significant drop in bowhead call localization rates with the onset of airgun operations nearby. This effect was evident for whales that were "near" the seismic operation (median distance 41-45 km) and exposed to median received levels (SPL) of at least 116 dB re 1 μPa. In these whales, call localization rates dropped from an average of 10.2 calls/h before the onset of seismic operations to 1.5 call/h during and after airgun use (Blackwell, Nations et al. 2013).

Distance to the 160 dB isopleth from ZVSP was calculated in Shell's IHA application as 7,970 m. That distance was multiplied by 1.5 in the analysis for a distance of 11,960 m. This 11,960 m radius was used for estimating areas ensonified by pulsed sounds to ≥160 dB re 1 μPa rms during a single ZVSP survey. ZVSP surveys may occur at up to two different drill sites during Shell's planned 2015 exploration drilling program in the Chukchi Sea.

Based on the biological information presented above, we would not anticipate migrating bowhead to devote attention to a seismic stimulus beyond the 120 dB isopleth, which may be more than 75 kilometers from the source. At these distances, a whale that perceived a signal is likely to ignore such a signal and devote its attention to stimuli in its local environment. Because of their distance from the seismic source, we would also not anticipate bowhead whales would change their behavior or experience physiological stress responses at received levels ≤ 120 dB; these animals may exhibit slight deflection from the noise source, but this behavior is not likely to result in adverse consequences for the animals exhibiting that behavior. Feeding bowhead, however, may cease calling or alter vocalization at significantly lower received levels. While calling rates may change for feeding bowhead in response to seismic noise at low received levels (85 dB-145 dB), we do not anticipate that low-level avoidance or short-term vigilance would occur until noise levels are >150 dB. Again, these behaviors are not likely to result in adverse consequences for the animals exhibiting the behavior.

Similarly, we would not anticipate that fin or humpback whales would devote attentional resources to a seismic stimulus beyond the 140 dB isopleth. We would not anticipate startle responses with ramp-up procedures in place. Females and females with calves may avoid sound sources ≥ 140 dB. However, we would not anticipate the majority of individuals to show low-level avoidance until noise levels are ≥ 150 dB.

Of the bowhead, fin, and humpback whales that may be exposed to received levels ≥160 dB during the proposed action, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming direction to avoid seismic operations, change their respiration rates, increase dive times, reduce feeding behavior, or alter vocalizations and social interactions (Richardson, Wursig et al. 1986, Ljungblad, Wursig et al. 1988, Richardson and Malme 1993, Greene, Altman et al. 1999, Frid and Dill. 2002, Christie, Lyons et al. 2009, Koski, Funk et al. 2009, Blackwell, Kim et al. 2010, Funk, Rodrigues et al. 2010, Melcon, Cummins et al. 2012). We assume that these responses are more likely to occur when whales are aware of multiple vessels in their surrounding area.

Some whales may be less likely to respond because they are feeding. The whales that are exposed to these sounds probably would have prior experience with similar seismic stressors resulting from their exposure during previous years; that experience will make some whales more likely to avoid the seismic activities while other whales would be less likely to avoid those activities. Some whales might experience physiological stress (but not distress) responses if they attempt to avoid one seismic vessel and encounter another seismic vessel while they are engaged in avoidance behavior.

Prey Resources

Sound energy generated from seismic operations is not anticipated to negatively impact the diversity and abundance of zooplankton, and will therefore have no direct effect on whales. Sound energy generated by the airgun arrays for the exploration activities will have no more than negligible effects on zooplankton. Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Chukchi Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Chu, Sze et al. 1996) respectively, and therefore have some sensitivity to sound; however any effects of airguns on zooplankton would be expected to be restricted to the area within a few feet or meters of the airgun array and would likely be sub-lethal.

The types of noises produced by ZVSP in the proposed action could cause hearing impairment and physical, physiological, and behavioral effects on fish and fish prey. Typical behavioral responses of fish to introduced sound, such as sound from seismic surveys, include: balance disturbance (i.e., staying in normal orientation); disoriented swimming behavior; increased swimming speed; disruption or tightening of schools; disruption of hearing; interruption of important biological behaviors (e.g., feeding, reproduction); shifts in the vertical distribution (either up or down); and occurrence of alarm and startle behaviors (BOEM 2015a).

Fish sensitivity to impulse sound such as that generated by seismic operations 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). Arctic cod in particular is a hearing specialist and is known to be acoustically sensitive (Normandeau Associates Inc. 2012).

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 and Hoss 1981). A recent study of feeding herring schools off of Northern Norway demonstrated no observed reaction in swimming speed, swimming direction, or school size that could be attributed to an approach by an active seismic vessel shooting a 3D seismic survey (Pena, Handegard et al. 2013). They attributed the unanticipated lack of response to the strong motivation for feeding combined with the slow approach of a distant seismic stimulus (Pena, Handegard et al. 2013). Any such effects on fish are anticipated to be minimal and temporary and would not be expected to diminish a marine mammal species' or stock's foraging success.

In their detailed review of studies on the effects of airguns on fish and fisheries, Dalen et al. (1996) concluded that airguns can have deleterious effects on fish eggs and larvae out to a distance of 16 ft. (5.0 m), but that the most frequent and serious injuries are restricted to the area within 5.0 ft. (1.5 m) of the airguns. Most investigators and reviewers (Gausland 2003, Thomson and Davis 2001, Dalen et al. 1996) have concluded that even seismic surveys with much larger airgun arrays than are used for shallow hazards and site clearance surveys have no impact to fish eggs and larvae discernible at the population or fisheries level.

Koshleva (1992) reported no detectable effects on the amphipod (*Gammarus locusta*) at distances as close as 0.5 m from an airgun with a source level of 223 dB re 1 μPa rms. A recent Canadian government review of the impacts of seismic sound on invertebrates and other organisms included similar findings; this review noted "there are no documented cases of invertebrate mortality upon exposure to seismic sound under field operating conditions" (CDFO 2004). Some sub-lethal effects (e.g., reduced growth, behavioral changes) were noted (CDFO 2004). Studies on brown shrimp in the Wadden Sea (Webb and Kempf 1998) revealed no particular sensitivity to sounds generated by airguns used in with sound levels of 190 dB re 1 μPa rms at 3.3 ft. (1.0 m) in water depths of 6.6 ft. (2.0 m).

Pinnipeds (ringed and bearded seals)

Ringed and bearded seals vocalize underwater in association with territorial and mating behaviors. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz and make calls between 90 Hz and 16 kHz (Richardson, Greene et al. 1995). A more recent review suggests that the functional hearing range phocids should be considered to be 75 Hz to 100 kHz (Hemila, Nummela et al. 2006, Kastelein, Wensveen et al. 2009, NOAA 2013). The airgun sound sources being proposed for this project are anticipated to be below 1 kHz, and should be within the auditory bandwidth for ringed and bearded seals.

Ringed seals are known to make barks, clicks and yelps with a frequency range between 0.4-16 kHz, and have dominant frequencies <5 kHz (Cummings, Holliday et al. 1986), as cited in (Stirling 1973, Richardson, Greene et al. 1995). Ringed seal sounds are less complex and much lower in source level than bearded seal sounds (Richardson, Greene et al. 1995). Ringed seal sounds include 4 kHz clicks, rub sound with peak energy at 0.5-2 kHz and durations of 0.08-0.3 s, squeaks that are shorter in duration and higher in frequency; quaking barks at 0.4-1.5 kHz and durations of 0.03-0.12 s; yelps; and growls (Schevill, Watkins et al. 1963, Stirling 1973, Cummings, Holliday et al. 1986). Ringed seals may produce sounds at higher frequencies, given their most sensitive band of hearing extends up to 45kHz (Terhune and Ronald 1976) and most equipment used in studies is unsuitable for frequencies >15 kHz (Richardson, Greene et al. 1995). Ringed seals are known to vocalize at source levels of up to 130 dB (Stirling 1973, Cummings, Holliday et al. 1986, Richardson, Greene et al. 1995).

Male bearded seals rely on underwater vocalizations to find mates. As background noise increases, underwater sounds are increasingly masked and uni-directional, deteriorate faster, and are detectable only at shorter ranges (Cameron, Bengtson et al. 2010). Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz (Richardson, Greene et al. 1995), and seismic operations are anticipated to operate as frequencies <1 kHz. The frequency range of the predominant "trill" and "moan" calls (130 Hz-10.6 kHz and 130 Hz-1.3 kHz, respectively) that are broadcast during the mating season, overlaps the range (10 Hz-1kHz) of proposed airgun sources.

Bearded seals are a dominant component of the ambient noise in many Arctic areas during the spring (Thiele 1988). The song is thought to be a territorial advertisement call or mating call by the male (Ray, Watkins et al. 1969, Budelsky 1992). Cummings et al. (1983) estimated source levels of up to 178 dB re 1µ Pa m. Parts of some calls may be detected 25+ km away (Cleator, Stirling et al. 1989). Because bearded seals are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that received levels of up to 178 dB are not likely to damage tissues of this species.

Information on behavioral reactions of pinnipeds in water to multiple pulses involves exposures to small explosives used in fisheries interactions, impact pile driving, and seismic surveys. Several studies lacked matched data on acoustic exposures and behavioral responses by individuals. As a result, the quantitative information on reactions of pinnipeds in water to multiple pulses is very limited (Southall, Bowles et al. 2007). However, based on the available information on pinnipeds in water exposed to multiple noise pulses, exposures in the ~150-180 dB re 1µ Pa range (RMS values over the pulse duration) generally have limited potential to induce avoidance behavior in pinnipeds (Southall, Bowles et al. 2007). We anticipate this would also apply to bearded seals since they are known to make calls with source levels up to 178 dB (Cummings, Holliday et al. 1983). Received levels exceeding 190 dB re 1µ Pa are likely to elicit avoidance responses, at least in some ringed seals (Harris, Miller et al. 2001, Blackwell, Lawson et al. 2004, Miller, Moulton et al. 2005). Harris *et al.* (2001) reported 112 instances when seals were sighted within or near the exclusion zone based on the 190 dB radius (150-250m of the seismic vessel).[11] The results suggest that seals tended to avoid the zone closest to the boat (<150m) (or noise levels greater than 190 dB). However, overall, seals did not react dramatically to seismic operations. Only a fraction of the seals swam away, and even this avoidance appeared

[11] It should be noted that visual observations from the seismic vessel were limited to the area within a few hundred meters, and 79% of the seals observed were within 250m of the vessel Harris, R. E., G. W. Miller and W. J. Richardson (2001). "Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea." Marine Mammal Science **17**(4): 795-812..

quite localized (Harris, Miller et al. 2001). In the case of ringed seals exposed to sequences of airgun pulses from an approaching seismic vessel, most animals showed little avoidance unless the received level was high enough for mild TTS to be likely (Southall, Bowles et al. 2007). We assume that bearded seals will behave in a similar manner to ringed seals when exposed to seismic sounds.

Seals have been noted to tolerate high levels of sounds from airguns (Arnold 1996, Harris, Miller et al. 2001, Moulton and Lawson 2002). In any case, the observable behavior of seals to passing active source vessels is often to just watch it go by or swim in a neutral way relative to the ship rather than swimming away. Seals at the surface of the water would experience less powerful sounds than if they were the same distance away but in the water below the seismic source. This may also account for the apparent lack of strong reactions in ice seals (NMFS 2013).

ZVSP would occur in the fall season when ringed seals are anticipated to be making short and long distance foraging trips (Smith 1973, Smith 1976, Smith and Stirling 1978, Teilmann, Born et al. 1999, Gjertz, Kovacs et al. 2000, Harwood and Smith 2003). Bearded seals are anticipated to occur at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Burns 1981, Nelson, Burns et al. 1984). Bearded seals are less likely to encounter ZVSP during the open water season than ringed seals because of the bearded seals preference for sea ice habitat (BOEM 2015). However, bearded seals are often spotted by PSOs during surveys so there is still the potential for exposure.

While the potential instances of exposure derived from ringed and bearded seal density multiplied by the area potentially ensonified by ZVSP (898 km^2 Table 9) estimate a high number of exposures, the majority of these are anticipated to occur at received levels $\leq$ 160 dB. Even if exposure occurred at higher received levels, the tendency of pinnipeds such as ringed and bearded seals to raise their heads above water, or haul out (during the in-ice period) to avoid exposure to sound fields, as well as mitigation measures being in place, reduce the potential for harassment of these species. Ringed and bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because seals seem rather tolerant of low frequency noise.

Based on this information, we would not expect ringed and bearded seals that are more than 11 kilometers from the seismic sound source to devote attention to that stimulus, even though received levels might be as high as 160 dB. Similarly, we would not expect ringed and bearded seals that find themselves more than 2 km from ZVSP to change their behavioral state, despite being exposed to received levels ranging up to 189 dB; these seals might engage in low-level avoidance behavior or short-term vigilance behavior. Ringed and bearded seals that occur within 0.7 kilometers of equipment employed during ZVSP are likely to change their behavioral state to avoid slight TTS, although this avoidance is anticipated to be localized. In addition, if ringed or bearded seals are spotted within the 190 dB isopleth a power down of seismic operations would occur.

Responses to Oil and Gas Spills

The empirical evidence available did not allow us to estimate the number of listed marine mammals that are likely to be exposed to oil spills associated Shell's proposed action. Nevertheless, we assume that any individuals that overlap in time and space with a potential spill may be exposed.

There are different probabilities of potential occurrence between the various sized oil spills (small, large, and VLOS). It is more likely that a small oil spill could occur during Shell's planned drilling activities than a large oil spill or a VLOS. The size of the spill determines the number of individuals that will be exposed and duration of exposure. However, the general responses of individual animals to exposure to oil do not differ with the size of a spill.

Toxic substances can impact animals in two major ways. First, the acute toxicity caused by a major point source of a pollutant (such as an oil spill or hazardous waste) can lead to acute mortality or moribund animals with a variety of neurological, digestive and reproductive problems. Second, toxic substances can impair animal populations through complex biochemical pathways that suppress immune functions and disrupt the endocrine balance of the body, causing poor growth, development, reproduction and reduced fitness. Toxic substances come in numerous forms, with the most-recognized being the organochlorines (OCs; mainly PCBs and DDTs), heavy metals and polycyclic aromatic hydrocarbons (PAHs). There are also a number of "emerging" contaminants, e.g., flame retardant polybrominated diphenyl ethers (PBDEs), which could also be impacting marine mammals.

If an oil spill were to occur, marine mammals and their habitats may be adversely impacted. Marine mammals could experience adverse effects from contact with hydrocarbons, including:

- Inhalation of liquid and gaseous toxic components of crude oil and gas;
- Ingestion of oil and/or contaminated prey;
- Fouling of baleen (bowhead, fin, and humpback whales);
- Oiling of skin, eyes, and conjunctive membranes causing corneal ulcers, conjunctivitis, swollen nictitating membranes and abrasions.

Available evidence suggests that mammalian species vary in their vulnerability to short-term damage from surface contact with oil and ingestion. While vulnerability to oil contamination exists due to ecological and physiological reasons, species also vary greatly in the amount of information that has been collected about them and about their potential oil vulnerability.

Ingestion of hydrocarbons can irritate and destroy epithelial cells in the stomach and intestine of marine mammals, affecting motility, digestion, and absorption, which may result in death or reproductive failure (Geraci and St. Aubin 1990). Direct ingestion of oil, ingestion of contaminated prey, or inhalation of volatile hydrocarbons transfers toxins to body fluids and tissues causing effects that may lead to death, as suspected in dead gray and harbor seals found with oil in their stomachs (Engelhardt 1982, Geraci and St. Aubin 1990, Frost, Manen et al. 1994, Spraker, Lowry et al. 1994, Jenssen 1996). Additionally, harbor seals observed immediately after oiling appeared lethargic and disoriented, which may be attributed to lesions observed in the thalamus of the brain (Spraker, Lowry et al. 1994).

Baleen Whales (bowhead, fin, and humpback)

Depending on the timing of the spill, bowhead, fin, and humpback whales could briefly be exposed to small spills of refined oil. The rapid dissipation of toxic fumes into the atmosphere from rapid aging of fresh refined oil and disturbance from response related noise and activity limits potential exposure of whales to prolonged inhalation of toxic fumes. Surface feeding whales could ingest surface and near surface oil fractions with their prey, which may be contaminated with oil components. Ingestion of oil may result in temporary and permanent damage to whale endocrine function and reproductive system function, but is not likely for small oil spills.

Research has shown that while cetaceans are capable of detecting oil, they do not seem to be able to avoid it. For example, during the spill of Bunker C and No. 2 fuel oil from the *Regal Sword*, researchers saw humpback and fin whales, and a whale tentatively identified as a right whale, surfacing and even feeding in or near an oil slick off Cape Cod, Massachusetts (Geraci and St. Aubin 1990).

The greatest threat to cetaceans is likely from the inhalation of the volatile toxic hydrocarbon fractions of fresh oil which can damage the respiratory system (Hansen 1985, Neff 1990), cause neurological disorders or liver damage (Geraci and St. Aubin 1990), have anaesthetic effects (Neff 1990), and cause death (Geraci and St. Aubin 1990). However, for small spills there is anticipated to be a rapid dissipation of toxic fumes into the atmosphere from rapid aging of fresh refined oil which limits potential exposure of whales to prolonged inhalation of toxic fumes.

Whales could be exposed to a multitude of short and longer term additional human activity associated with initial spill response, cleanup and post event human activities that include primarily increased and localized vessel and aircraft traffic associated with reconnaissance and monitoring. These activities would be expected to be intense during the spill cleanup operations and continue at reduced levels for potentially decades. Specific cetacean mitigation would be employed as the situation requires and would be modified as needed to meet the needs of the response effort. The response contractor would be expected to work with NMFS and state officials on wildlife management activities in the event of a spill. We will not evaluate the potential effects associated with spill response and cleanup as part of this consultation. However, oil spill response activities have been previously consulted on by NMFS as part of the *Unified Plan* (AKR-2014-9361).

Based on the localized nature of small oil spills, the relatively rapid weathering expected for <1,000 bbl of oil, the small number of refueling activities in the proposed action, and the safeguards in place to avoid and minimize oil spills, we conclude that the probability of Shell's drilling activities causing a small oil spill and exposing bowhead, fin, or humpback whales is sufficiently small as to be considered discountable. If exposure were to occur, due to the ephemeral nature of small, refined oil spills, NMFS does not expect detectable responses from whales and would consider the exposure insignificant.

Pinnipeds (ringed and bearded seals)

In the event of a small oil spill, ice seals could be briefly exposed depending on habitat use, densities, season, and various spill characteristics. Oil tends to concentrate in ice leads and in breathing holes, and will be held closer to the surface against ice edges where seals tend to travel (Engelhardt 1987). Floating sea ice also reduces wave action and surface exchange thus delaying the weathering and dispersion of oil and increasing the level and duration of exposure to seals. It also reduces evaporation of volatile hydrocarbons, lessening the acute levels of toxins in the air but lengthening the period of exposure (Engelhardt 1987).

Both bearded and ringed seals closely associate with sea ice throughout the year. Both species prefer to forage in proximity to the southern ice edge during the summer months, although some may be found in the open ocean away from areas of sea ice. Bearded seals feed on benthic organisms on the relatively shallow Chukchi continental shelf, while ringed seals forage for fishes and some invertebrates in the water column. These differences in food selection and foraging behavior help determine the presence or absence of each of these species in an area. Bearded seals are essentially restricted to areas over the continental shelf and the ice front where they can reach the seafloor to feed on benthic organisms. Ringed seals may be found under areas of solid ice as well as in the ice front where they prey upon fishes such as Arctic and saffron cod.

Surface contact with petroleum hydrocarbons, particularly the low-molecular-weight fractions, can cause temporary damage of the mucous membranes and eyes (Davis, Schafer et al. 1960) or epidermis (Walsh, Scarpa et al. 1974, Hansbrough, Zapata-Sirvent et al. 1985, St. Aubin 1988) of ice seals. Researchers have suggested that pups of ice-associated seals may be particularly vulnerable to fouling of their dense lanugo coat (Geraci and St. Aubin 1990, Jenssen 1996). Though bearded seal pups exhibit some prenatal molting, they are generally not fully molted at birth, and thus would be particularly prone to physical impacts of contacting oil. Adults, juveniles, and weaned young of the year rely on blubber for insulation, so effects on their thermoregulation are expected to be minimal. Other acute effects of oil exposure which have been shown to reduce seal health and possibly survival include skin irritation, disorientation, lethargy, conjunctivitis, corneal ulcers, and liver lesions. Direct ingestion of oil, ingestion of contaminated prey, or inhalation of hydrocarbon vapors can cause serious health effects including death (Geraci and Smith 1976, Geraci and St. Aubin 1990). However, rapid dissipation of toxic fumes into the atmosphere from rapid aging of fresh refined oil is anticipated after small spills, which limits potential exposure of seals to prolonged inhalation of toxic fumes

Based on the localized nature of small oil spills, the relatively rapid weathering expected for <1,000 bbl of oil, the small number of refueling activities in the proposed action, and the safe guards in place to avoid and minimize oil spills, we conclude that the probability of Shell's drilling activities causing a small oil spill and exposing ringed and bearded seals is sufficiently small as to be considered discountable. If exposure were to occur, due to the ephemeral nature of small, refined oil spills, NMFS does not expect detectable responses from seals and would consider exposure insignificant.

6.0 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

NMFS reviewed recent environmental reports, NEPA compliance documents, Shell's IHA application, and other source documents to evaluate and identify actions that were anticipated to occur within the analytical timeframe of this opinion (July 2015-October 2015). Reasonably foreseeable future state, tribal, local or private actions include:oil and gas exploration, development, and production activities; military training exercises; air and marine transportation; and tourism.

Oil and Gas Projects

State of Alaska: The State of Alaska has a Five–Year Oil and Gas Leasing Program (submitted to the Alaska State Legislature each January). The program outlines a stable and predictable schedule of proposed lease sales, which could result in the further development of Alaska's petroleum resources. The State of Alaska has no scheduled lease sale in the Chukchi Sea nearshore areas in the most recent Program (BOEM 2015).

Activities related to natural gas development are not expected in the Chukchi Sea for at least the next several years (BOEM 2015).

Russia: Oil and gas exploration has also occurred in offshore areas of the Russian Arctic and in areas around Sakhalin Island to the south of the Bering Straits. These activities are anticipated to continue into the future. There is little information on specific plans, but the effects of these activities are expected to be similar to those resulting from activities occurring in the U.S Arctic (BOEM 2015).

Mining

While the majority of mining activities take place onshore, marine and air transportation could contribute to potential cumulative effects through the disturbance of marine mammals. The world's largest known zinc resources are located in the western Brooks Range. As much as 25 million tons of high-grade zinc is estimated to be present near Red Dog Mine, approximately 40 mi from the southwest corner of the NPR-A (Schoen and Senner 2002). In 2012 Red Dog produced approximately 958,000 tons of zinc concentrate and 175,000 tons of lead concentrate (AK DNR 2013). All concentrates are exported to world markets via the DeLong Mountain Transportation System that connects the mine to port facilities on the Chukchi Sea.

Transportation

Reductions in sea ice cover will likely lead to increased activity from shipping and resource extraction industries, with associated increased threat of marine accidents and pollution discharge. It is also reasonable to assume that trends associated with transportation to facilitate the maintenance and development of coastal communities and Red Dog Mine will continue. In some specific cases, described below, transportation and associated infrastructure in the action area may increase as a result of increased industrial and commercial activity in the area (BOEM 2015).

Aircraft Traffic: Existing air travel and freight hauling for local residents is likely to continue at approximately the same levels. Air traffic to support mining is expected to continue to be related to exploration because there are no new large mining projects in the permitting process. Tourism air traffic will not likely change much because there are no reasonably foreseeable events that would draw large numbers of visitors to travel to or from the area using aircraft. Sport hunting and fishing demand for air travel will likely continue at approximately the same levels. Use of aircraft for scientific and search and rescue operations is likely to continue a present levels.

Vehicle Traffic: None of the anticipated future activities propose to construct permanent roads to the communities in the area. Construction of ice roads could allow industry vehicles access to community roads, and likewise allow residents vehicular access to the highway system (BOEM 2015).

Vessel Traffic: Vessel traffic through the Bering Strait has risen steadily over recent years according to USCG estimates, and Russian efforts to promote a Northern Seas Route for shipping may lead to continued increases in vessel traffic adjacent to the western portion of the Action Area. Between 2008 and 2012, vessel activity in the U.S. Arctic went from 120 vessels to 250, an increase of 108 percent (ICCT 2015). This includes only the northern Bering Sea, the Bering Strait, Chukchi Sea and Beaufort Sea to the Canadian border. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the near-shore Prudhoe Bay from oil and gas exploration activity is particularly pronounced (ICCT 2015). The U.S. Coast Guard also estimated that one million adventure tourists may have visited the region in 2013 (BOEM 2015).

A site-specific analysis done by Shell Oil as part of a Revised Outer Continental Shelf Lease Exploration Plan for the Chukchi Sea indicated that barge traffic passing through the Chukchi Sea during July through October increased from roughly 2000 miles of non-seismic vessel traffic in 2006 to roughly 11,500 miles of non-seismic vessel traffic in 2010. In comparison, the same analysis estimated that vessel miles associated with seismic surveys in 2006 were roughly 70,000 miles, compared to roughly 30,000 miles in 2010 (BOEM 2015).

Vessel traffic within the action area can currently be characterized as traffic to support oil and gas industries, barges or cargo vessels used to supply coastal villages, smaller vessels used for hunting and local transportation during the open water period, military vessel traffic, and recreational vessels such as cruise ships and a limited number of ocean-going sailboats. Barges and small cargo vessels are used to transport machinery, fuel, building materials and other commodities to coastal villages and industrial sites during the open water period. Additional vessel traffic supports the Arctic oil and gas industry, and some activity is the result of emergency-response drills in marine areas.

In addition, research vessels, including NSF and USCG icebreakers, also operate in the action area. USCG anticipates a continued increase in vessel traffic in the Arctic. Cruise ships and private sailboats sometimes transit through the action area. Changes in the distribution of sea ice, longer open water periods, and increasing interest in studying and viewing Arctic wildlife and habitats may support an increase in research and recreational vessel traffic in the proposed action area regardless of oil and gas activity.

Spill records indicate most petroleum spills in Alaska occur in harbors and from groundings. Vessel-related spills on the high seas are considered infrequent. The ADEC (ADEC 2014) reports the highest probability of spills of refined petroleum products occurs during bulk-fuel transfer operations at remote North Slope villages.

Community Development

Community development projects in Arctic communities involve both major infrastructure projects such as construction of airports and response centers, as well as smaller projects. These projects could result in construction noise in coastal areas, and could generate additional amounts of marine and aircraft traffic to support construction activities. Marine and air transportation could contribute to potential cumulative effects through the disturbance of marine mammals. No major community development projects are foreseeable at the present time (BOEM 2015).

Recreation and Tourism

Marine and coastal vessel and air traffic could contribute to potential cumulative effects through the disturbance of marine mammals. With the exception of adventure cruise ships that transit the Chukchi Sea coasts in small numbers, much of the U.S. Arctic sightseeing traffic is concentrated in the Arctic National Wildlife Refuge and should not impact species in the action area. In addition, future sport hunting and fishing, or other recreation or tourism-related activities are anticipated to continue at current levels and in similar areas in the project area (BOEM 2015).

Subsistence Hunting

The take of ice seals by Alaska Native hunters represents the largest known human-related cause of mortality and is likely to remain so for the foreseeable future. The subsistence take is small and ringed and bearded seal populations are likely to have the capacity to absorb it. Subsistence hunting of bowhead whales is covered via ESA section 7 consultations due to required federal actions to set harvest quotas.

Research Activities

International and domestic entities are devoting more and more attention towards studying the Arctic. While generally authorized under scientific permits and MMPA authorizations, these studies are not without impact. Aircraft surveys often drop below levels specified to minimize disturbance effects and circle groups of marine mammals in order to count and photograph them. Aircraft activities associated with any one project can include hundreds of hours of flight time. Incidental and direct take associated with research permitting was discussed in the Environmental Baseline section. While federal projects undergo consultation under the ESA, there are often similar State or local governmental projects that contribute to vessel or aircraft traffic in the action area.

Oil and gas exploration is not the only source of seismic surveying in the Action Area. For example, the University of Alaska Fairbanks conducted a 2D survey in the fall of 2011 in the Chukchi borderland region using the NFS-owned R/V *Marcus G. Langseth*, a 235 ft, 3,834 gross ton research vessel. This vessel can tow up to four seismic hydrophone cables. The UAF team surveyed a grid of 2D seismic lines over the Chukchi borderland, to obtain images of the stratification of the rocks in the borderland continental shelf, then, ran seismic lines south into the northern Chukchi Sea.

7.0 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS's assessment of the risk posed to the species as a result of implementing the proposed action. As we discussed in the *Approach to the Assessment* section of this opinion, we begin our risk analyses by asking whether the probable physical, physiological, behavioral, or social responses of endangered or threatened species are likely to reduce the fitness of endangered or threatened individuals or the growth, annual survival or reproductive success, or lifetime reproductive success of those individuals. If we would not expect individuals of the listed species exposed to an action's effects to experience reductions in the current or expected future survivability or reproductive success (that is, their fitness), we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Stearns 1977; Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). Therefore, if we conclude that individuals of the listed species are not likely to experience reductions in their fitness, we would conclude our assessment because we would not expect the effects of the action to affect the performance of the populations those individuals represent or the species those population comprise. If, however, we conclude that listed species are likely to experience reductions in their fitness as a result of their exposure to an action, we then determine whether those reductions would reduce the viability of the population or populations the individuals represent and the "species" those populations comprise (which the ESA defines to include subspecies and distinct populations segments of vertebrate taxa).

As part of our risk analyses, we consider the consequences of exposing endangered or threatened species to the stressors associated with the proposed actions, individually and cumulatively, given that the individuals in the action areas for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range. These stressors or the response of individual animals to those stressors can produce consequences — or cumulative impacts— that would not occur if animals were only exposed to a single stressor.

As we discuss in the narratives that follow, our analyses led us to conclude that endangered or threatened individuals that are likely to be exposed to stressors from drilling activities NMFS PR1 proposes to permit in the Chukchi Sea are likely to experience disruptions in their normal behavioral patterns, but they are not likely to be killed, injured, or experience measurable reductions in their current or expected future reproductive success as a result of that exposure.

NMFS acknowledges the extremely low risk of exposure to spilled oil and gas for all of the species included in this opinion and the advanced preparation of an Oil Spill Reponse Plan. No take is authorized by oil and gas spills.

Bowhead Whale Risk Analysis

Based on the results of the exposure analysis, NMFS anticipates up to 1,083 bowhead whales will be exposed to vessel noise from drilling, MLC construction, dynamic positioning, anchor handling, transit, aircraft flight, ice management, and ZVSP associated with this action at received levels sufficiently high that might result in behavioral harassment. No bowhead whales are anticipated to be exposed to sound levels that could result in TTS or PTS. Exposure to vessel strike and oil and gas spills is considered extremely unlikely to occur, and such takes therefore would not be authorized in this action. Mitigation measures are designed to avoid or minimize adverse impacts to bowhead whales associated with seismic operations, drilling, and aircraft and vessel traffic. Also, the Final Drilling Safety Rule (77 FR 50856) reduces the risk of exposure to oil and gas spills.

Probable Risk to Bowhead Whales

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of listed whales. As a result, the whales' probable responses from potential exposures to active seismic and drilling noise are not likely to reduce the current or expected future reproductive success of listed whales or reduce the rates at which they grow, mature, or become reproductively active. No serious injuries or mortalities are expected or authorized. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

Although the drilling activities and ZVSP are likely to cause some individual whales to experience changes in their behavioral states that might have energy-cost consequences (Frid and Dill. 2002), NMFS expects that these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual whales in ways or to a degree that would reduce their fitness. This action takes place in a very small area of the overall distribution of these whales, and the whales are actively foraging in waters around the activities or migrating through the action area for a short time period compared to their overall migration.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise. As a result, since the take levels associated with drilling activities and ZVSP are not likely to negatively affect the fitness of individual bowhead whales, they are not likely to appreciably reduce the bowhead whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that the action will likely have minimal impact on bowhead whales is the estimated growth rate of the bowhead whale population in the Arctic. The Western Arctic stock of bowhead whales has been increasing at approximately 3.2-3.4 percent per year (George, Zeh et al. 2004, Schweder and Sadykova. 2009), despite exposure to oil and gas exploration activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2015). Given the life history of bowhead whales and gestational constraints on minimum calving intervals (e.g., (Reese, Calvin et al. 2001), and assuming that adult survival rates based on aerial photo-ID data (Zeh, Poole et al. 2002, Schweder, Sadykova et al. 2010) and age-at-maturity have remained stable, the trend in abundance implies that the population has been experiencing relatively high annual calf and juvenile survival rates. This is consistent with documented observations of native whalers around St. Lawrence Island, who have reported not only catching more pregnant females but also seeing more young whales than during earlier decades (Noongwook, Huntington et al. 2007). While the sample size was small, that the pregnancy rate from the 2012 Alaskan harvest data indicate that 2013 calf production could be higher than average (George, Zeh et al. 2004, George, Givens et al. 2011, Suydam, George et al. 2013). This increase in the number of bowhead whales suggests that the stress regime these whales are exposed to has not prevented these whales from increasing their numbers.

As discussed in the *Environmental Baseline* section of this opinion, bowhead whales have been exposed to active seismic and drilling activities in the Arctic, including vessel traffic, aircraft traffic, and seismic and drilling noise, for more than a generation. Although we do not know if more bowhead whales might have used the action area or the reproductive success of bowhead whales in the Arctic would be higher absent their exposure to these activities, the rate at which bowhead whales occur in the Arctic suggests that bowhead whale numbers have increased substantially in these important migration and feeding areas despite exposure to oil and gas exploration activities. The proposed action in conjuction with other ongoing and foreseeable actions is not likely to affect the rate at which bowhead whale counts in the Arctic are increasing.

A change in either calf production or survival rates (or age-at-sexual maturation) of young whales in the future could be indicative of a population level response to anthropogenic stressors, or alternatively, a signal of the seemingly inevitable event that this population approaches the carrying capacity of its environment (Eberhardt 1977). Since the late 1970s and the initiation of surveys for abundance, the estimates of population size do not indicate that either anthropogenic (offshore oil and gas activities, subsistence whaling, etc.) or natural factors (e.g., prey availability) have resulted in any negative influence on the bowhead whale trends in abundance (LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc. et al. 2014).

Fin and Humpback Whale Risk Analysis

Based on the results of the exposure analysis, NMFS anticipates up to 14 fin and 14 humpback whales will be exposed to vessel noise from drilling, MLC construction, dynamic positioning, anchor handling, transit, aircraft flight, ice management, and ZVSP associated with this action in the Chukchi Sea OCS, at received levels sufficiently high that might result in behavioral harassment. No fin or humpback whales are anticipated to be exposed to sound levels that could result in TTS or PTS. Exposure to vessel noise from transit and aircraft noise may occur but is considered insignificant and would not rise to the level of take. Exposure to vessel strike and oil and gas spills is considered extremely unlikely to occur and therefore not authorized. Mitigation measures are designed to avoid or minimize adverse impacts to fin and humpback whales associated with seismic operations, drilling, and aircraft and vessel traffic. Also, the Final Drilling Safety Rule (77 FR 50856) reduces the risk of exposure to oil and gas spills. Because of their similarly low occurrence in the action area and anticipated similar response to stressors, risk that is common to both species is discussed only once below.

Probable Risk to Fin and Humpback Whales

Although drilling activities and ZVSP are likely to cause some individual whales to experience changes in their behavioral states that might have energy-cost consequences (Frid and Dill. 2002), these responses are not likely to alter the physiology, behavioral ecology, or social dynamics of individual whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters around the activities or migrating through the action area.

Humpback and fin whale reactions to noise sources may also be dependent on whether the whales are feeding or migrating. In most circumstances, humpback and fin whales are likely to avoid exposure to continuous noise sources or are likely to avoid certain ensonified areas. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a), and it is anticipated that humpback and fin whales may react similarly. The open water season (July through October) during which the proposed activities would occur, overlaps with summer feeding and late-summer/fall westward/southern migration across the Chukchi Sea down into the Bering Strait.[12] Therefore, the potential for exposure to continuous noise sources is relatively high during this time period, although humpback and fin whales densities are low in the Chukchi Sea. Humpback whales have been seen and heard with some regularity in recent years (2009-2011) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback and fin whales are present earlier than September (Hashagen *et al.* 2009; Anonymous 2010; Goetz *et al.* 2010; Clarke *et al.* 2011a; Crance *et al.* 2011; NMML 2011). A single humpback was observed between Icy Cape and Wainwright feeding near a group of gray whales during aerial surveys of the northeastern Chukchi Sea in July 2009 as part of COMIDA (Clarke *et al.* 2011a). In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen *et al.* 2009).

Considering the low density of these species in the Arctic and the likely avoidance of certain ensonified areas, we anticipate few instances in which humpback or fin whales would be exposed continuous noise sources, and would not expect those whales to devote resources to that stimulus, even though received levels might be higher than 120 dB. Similarly, we would not expect exposure to those sources to cause humpback or fin whales to change their behavioral state. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those humpback and fin whales that do not avoid the sound field might experience interruptions in their vocalizations. In either case, humpback and fin whales that avoid these sound fields or stop vocalizing are not likely to experience significant disruptions of their normal behavior patterns because the ensonified area represents only a small portion of their feeding range. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the

[12] This is primarily based on migration timing of bowhead whales since the timing of humpback whale migration in the Arctic is unknown. However, if we assume that humpback and fin whale feeding and migration timing is similar to other baleen whales in the area then we would anticipate overlap with project activities from July-October.

fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities associated with NMFS PR1's permitted activities in the Chukchi Sea would not be expected to appreciably reduce the humpback or fin whales' likelihood of surviving or recovering in the wild.

In addition, mitigation measures are designed to avoid or minimize adverse impacts associated with seismic operations, drilling, aircraft and vessel traffic to marine mammals and result in a negligible level of effect to fin and humpback whales.

The strongest evidence supporting the conclusion that drilling activities will likely have minimal impact on fin whales is the estimated growth rate of the fin whale population in the North Pacific. While there is not a precise estimate of the maximum productivity rate for the Northeast Pacific fin whale stock, NMFS estimates that rate to be 4% (Wade and Angliss 1997, Allen and Angliss 2014). Zerbini et al.(2006) estimated the rate of increase for fin whales in coastal waters south of the Alaska Peninsula to be around 4.8% (95% CI: 4.1-5.4%) for the period 1987-2003. Recent passive acoustic detections (Delarue, Mellinger et al. 2010, Crance, Berchok et al. 2011, Hannay, Delarue et al. 2011, Delarue, Martin et al. 2013) and direct observations from monitoring and research projects of fin whales from industry (Ireland, Rodrigues et al. 2009, Funk, Rodrigues et al. 2010, Bisson, H.J. Reider et al. 2013, Funk, Ireland et al. 2013) and government(Clarke, Christman et al. 2011, Clarke, Stafford et al. 2013), indicate that fin whales are considered to be in low densities, but regular visitors to the Alaska Chukchi Sea, despite intermittent exposure to exploration activities in the Chukchi Seas since the late 1960s. Despite the small numbers fin whales that are entangled in fishing gear in the Bering Sea section of the action area, this increase in the number of fin whales suggests that the stress regime these whales are exposed to in the action area has not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, fin whales have been exposed to active seismic and sonar activities in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, including vessel traffic, aircraft traffic, and active sonar and seismic, for more than a generation. Although we do not know if more fin whales might have used the action area or the reproductive success of fin whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which fin whales occur in the North Pacific, and the increasing number of sightings of fin in the Arctic and sub-Arctic suggests that fin whale numbers have increased substantially in these important feeding areas despite exposure to earlier oil and gas exploration operations. We do not expect the proposed action in conjuction with other ongoing and foreseeable actions to affect the rate at which the fin whale population is increasing in the action area are increasing.

Likewise, the strongest evidence supporting the conclusion that drilling operations will likely have minimal impact on humpback whale survival and recovery is the estimated growth rate of the humpback whale population in the North Pacific. Although there is no estimate of maximum net productivity rate for the western or central stocks, NMFS recommends that 7% be used as the maximum net productivity rate until additional data becomes available (Wade and Angliss 1997, Allen and Angliss 2013). Despite small numbers of humpback whales that are entangled in fishing gear in the Bering Sea section of the action area, the single subsistence take of a humpback in 2006, and past oil and gas activities, this increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, humpback whales have been exposed to active seismic and sonar activities in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, including vessel traffic, aircraft traffic, and active sonar and seismic, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which humpback whales occur in the North Pacific, and the increasing number of sightings of humpback in the Arctic and sub-Arctic suggests that humpback whale numbers have increased substantially in these important feeding areas despite exposure to earlier oil and gas exploration operations. We do not expect the proposed action in conjuction with other ongoing and foreseeable actions to affect the rate at which humpback whale populations in the Arctic are increasing.

Pinniped Risk Analysis

Based on the results of the exposure analysis, NMFS anticipates up to 25,217 ringed seals and 1,722 bearded seals will be exposed to vessel noise from drilling, MLC construction, dynamic positioning, anchor handling, transit, aircraft flight, ice management, and ZVSP associated with this action in the Chukchi Sea OCS, at received levels sufficiently high that might result in behavioral harassment. No bearded or ringed seals are anticipated to be exposed to sound levels that could result in TTS or PTS. Exposure to vessel strike and oil and gas spills is considered extremely unlikely and therefore discountable. Mitigation measures are designed to avoid or minimize adverse impacts to pinnipeds associated with seismic operations, drilling, and aircraft and vessel traffic. Also, the Final Drilling Safety Rule (77 FR 50856) reduces the risk of exposure to oil and gas spills. Because of their similar responses to stressors, risk that is common to both species is discussed only once below.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Fall and early winter periods, prior to the occupation of breeding sites, are important in allowing female ringed seals to accumulate enough fat stores to support estrus and lactation (Kelly, Bengtson et al. 2010). The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of ringed and bearded seals because the action area in the Chuckchi Sea is a small area compared to the overall proposed ringed seal critical habitat, and these seals are in the action area of the Chuckchi Sea for a short amount of time compared to their overall migration. As a result, the ringed and bearded seal's probable responses to close approaches by drill ships and associated support vessels and their probable exposure to ZVSP pulses are not likely to reduce the current or expected future reproductive success or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

Probable Risk to Ringed Seals and Bearded Seals

Although these activities are likely to cause some individual ringed and bearded seals to experience changes in their behavioral states that might have energy-cost consequences (Frid and Dill. 2002), these responses are not likely to alter the physiology, behavioral ecology, or social dynamics of individual seals in ways or to a degree that would reduce their fitness. In addition, the implementation of mitigation measures including ramp-up, power-down, and shut-down procedures will further reduce the instances of exposure and minimize the effects on the species. As a result, the proposed action would not appreciably reduce the ringed or bearded seals' likelihood of surviving or recovering in the wild.

8.0 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered humpback whale (*Megaptera novaeangliae*), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), or the Beringia DPS of bearded seal (*Erignathus barbatus barbatus*). In Section 3.1 NMFS concluded that this action is not likely to adversely affect North Pacific right whales, Western DPS of gray whales, sperm whales or Western DPS of Steller sea lion or the designated critical habitats of Western DPS of Steller sea lion or the North Pacific right whale.

9.0 Incidental Take Statement

Section 9 of the ESA prohibits the take of endangered species without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. The ESA, however, does not define harassment.

In this opinion and incidental take statement, we have considered potential exposures to certain sound sources and the effects these sources may have on the marine environment and estimated the total number of potential exposures (Table 13). For any given exposure, it is impossible to predict the exact impact to the individual marine mammal(s) because an individual's reaction depends on a variety of factors (the individual's sex, reproductive status, age, activity engaged in at the time, etc.). Therefore, as a precautionary measure, we assume that each estimated instance of exposure constitutes a take by harassment under the MMPA. We find this approach conservative for evaluating jeopardy under the ESA since the exposure estimates are likely over-estimates, and since an instance of exposure may not actually result in any measurable or consequential change in behavior. Notwithstanding that fact, the exposure estimates reflect the best scientific and commercial data currently available.

Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement (ITS).

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by Section 101(a)(5) of the MMPA. Accordingly, **the terms of this incidental take statement and the exemption from Section 9 of the ESA (which does not apply to ringed or bearded seals) become effective only upon the issuance of MMPA authorization to take the marine mammals identified here**. Absent such authorization, this statement is inoperative.

The terms and conditions described below are nondiscretionary. NMFS PR1 has a continuing duty to regulate the activities covered by this incidental take statement. In order to monitor the impact of incidental take, NMFS PR1 must monitor the progress of the action and its impact on the species as specified in the incidental take statement (50 CFR 402.14(i)(3)). If NMFS PR1 (1) fails to require permittees to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take

The section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or the extent of land or marine area that may be affected by an action, if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 Fed. Reg. 19926, 19953-54 (June 3, 1986)).

This is the first project-specific Section 7 consultation that falls under NMFS AKR's programmatic Biological Opinion on BOEM's Lease Sale 193. This tiered process enables NMFS to track the overall take occurring from multiple oil and gas projects occurring in the Arctic, and to issue Incidental Take Statements that more accurately estimate the level of take anticipated to occur.

These estimates include whales and pinnipeds that are likely to be exposed and respond to activities that are likely to result in behavioral changes that we would classify as harassment. The results of our estimates are presented in Table 13, and repeated below.

Table13 (repeated). The Total Number of Potential Instances of Exposure of Marine Mammals to Sound Levels ≥120 dB re 1 µPa rms or ≥160 dB re 1 µPa rms During the Planned Drilling Activities in the Chukchi Sea, Alaska, 2015. Estimates are also shown as a Percentage of Each Population

Species	Abundance Estimate*	Exposures**	% of Population
Mysticetes			
Bowhead whale	19,534[5]	1,083	5.5
Fin whale	1,652[6]	14	0.8
Humpback whale	20,800[8]	14	0.1
Pinnipeds			
Bearded seal	155,000[10]	1,722	1.1
Ringed seal	300,000[12]	25,217	8.4

*With the exception of bowhead and gray whale, precise population estimates do not exist and these percentages should be interpreted with care. Additionally, the best available abundance estimates often include only a portion of the known distribution and range for a given population, which tends to overestimate the percent of individuals exposed within those populations.

** Instances of exposure to Continuous Sounds ≥120 dB re 1 µPa (rms) or Pulsed Sounds ≥160 dB e 1 µPa (rms) Assumptions for each species included 100% daily turnover and no avoidance of ensonified areas except that a 48 hour turnover rate was applied to bowhead whales and ringed seals

[5] Givens et al. 2013, projected 2015 population using 2011 census of Bering-Chukchi-Beaufort Stock of 16,892 with annual growth rate of 3.7%

[6] Allen and Angliss 2014, estimate of Northeast Pacific Stock from Zerbini et al. 2006 surveys of Western Alaska conducted during 2001-2003

[8] Allen and Angliss 2014, estimate for entire North Pacific population

[10] Allen and Angliss 2014, estimate from Cameron et al. 2010 sum of bearded seals in Bering and Chukchi Seas

[12] Allen and Angliss 2014, estimate from Kelly et al. 2010 for Chukchi and Beaufort Seas

For purposes of this opinion, the endangered bowhead, fin, and humpback whale are the only species for which the Section 9 take prohibition applies. This incidental take statement, however, also includes limits on taking of ringed and bearded seals to provide guidance to the action agency on its requirement to re-initiate consultation if the take limit for any species covered by this opinion is exceeded.

The instances of potential harassment identified in Table 13generally represent a range of possible behavioral changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent disruptions of the normal behavioral patterns of the animals that have been exposed.

We assume animals would respond to a suite of environmental cues that include sound fields produced by seismic airguns, sounds produced by the engines of surface vessels, sounds produced by dynamic positioning, anchor handling, mudline cellar construction, and other sounds associated with the proposed activities. Further, we assume endangered and threatened marine mammals would recognize cues that suggest that ships are moving away from them rather than approaching them and they would respond differently to both situations.

Effect of the Take

In the accompanying biological opinion, NMFS AKR determined that the instances of exposure of endangered and threatened marine mammals to activities associated with the proposed action are not likely to jeopardize the continued existence of bowhead whales, fin whales, humpback whales, ringed seals, or bearded seals, and are not likely to adversely affect right whales or Steller sea lions. Further, NMFS AKR determined that the proposed action is not likely to result in destruction or adverse modification of critical habitats for the Steller sea lion or the North Pacific right whale.

Reasonable and Prudent Measures (RPM)

The RPMs included below, along with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS concludes that the following RPMs are necessary and appropriate to minimize or to monitor the incidental take of bowhead whales, fin whales, humpback whales, ringed seals, and bearded seals resulting from the proposed action.

1. This ITS is valid only for takes resulting from the activities described in this biological opinion, and which have been authorized under section 101(a)(5) of the MMPA.
2. The taking of bowhead whales, fin whales, humpback whales, ringed seals, and bearded seals shall be by incidental harassment only. The taking by serious injury or death is prohibited and may result in the modification, suspension or revocation of the ITS.
3. NMFS PR1 will implement measures to reduce the probability of exposing bowhead whales, fin whales, humpback whales, ringed seals, and bearded seals to noise from exploration drilling, anchor handling, MLC construction, dynamic positioning, ice management, and ZVSPthat will occur during the proposed activities in the Chukchi Sea during the 2015 open water season.

4. NMFS PR1 will implement a monitoring program that allows NMFS AKR to evaluate the exposure estimates contained in this biological opinion and that underlie this incidental take statement.
5. NMFS PR1 will submit reports to NMFS AKR that evaluate its mitigation measures and report the results of its monitoring program.

Terms and Conditions.

In order to be exempt from the prohibitions of section 9 of the ESA, NMFS PR1 must comply with the following terms and conditions, which implement the reasonable and prudent measures described above, the mitigation measures set forth in this opinion, and reporting/monitoring requirements described in the MMPA permit.

Partial compliance with these terms and conditions may result in more take than anticipated, and invalidate this take exemption. These terms and conditions constitute no more than a minor change to the proposed action because they are consistent with the basic design of the proposed action.

To carry out RPM #1, NMFS PR1 or its permittee must undertake the following:

1. At all times when conducting seismic-related or dynamic positioning activities, NMFS PR1 shall require permitted operators to possess on board drilling, anchor handling, MLC construction, dynamic positioning, ice management, and ZVSP vessels, a current and valid Incidental Harassment Authorization issued by NMFS under section 101(a)(5) of the MMPA. Any take must be authorized by a valid, current, IHA issued by NMFS under section 101(a)(5) of the MMPA, and such take must occur in compliance with all terms, conditions, and requirements included in such authorizations.

To carry out RPM #2, NMFS PR1 or its permittee must undertake the following:

1. The taking of any marine mammal in a manner other than that described in this ITS must be reported immediately to NMFS AKR, Protected Resources Division at 907-586-7235, and operations must cease.

To carry out RPM #4, NMFS PR1 or its permittee must undertake the following:

1. All mitigation measures as outlined in this biological opinion must be implemented, as appropriate, upon issuance of an IHA under the MMPA.

To carry out RPM #5, NMFS PR1 or its permittees must undertake the following:

1. PR1 must provide reports required by the IHA via email to kristin.mabry@noaa.gov.
2. Regarding injury or lethal take:
    a. In the event that the specified activity causes a take of a marine mammal that results in a serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), or is otherwise not authorized by any MMPA permit issued for the activity, NMFS PR1's permittee shall immediately cease the specified activities and immediately report the incident to the Protected Resources Division, NMFS, Juneau office at 907-586-7012 and/or by email to Jon.Kurland@noaa.gov, kristin.mabry@noaa.gov, Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities. The report must include the following information:

Time, date, and location (latitude/longitude) of the incident; the name and type of the vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24hrs preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS AKR will work with NMFS PR1 and the permittee to determine what is necessary to minimize the likelihood of further prohibited take. The permittee may not resume their activities until notified by NMFS PR1 via letter, email, or telephone.

b. In the event that the permittee discovers an injured or dead ESA-listed marine mammal under NMFS's jurisdiction, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), the permittee will immediately report the incident to the Assistance Regional Administrator, Protected Resources Division, NMFS, at 907-586-7638, and/or by email to Jon.Kurland@noaa.gov, Kristin.Mabry@noaa.gov, Alicia.Bishop@noaa.gov, and the Alaska Regional Stranding Coordinator at 907-586-7248 and/or by email (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities. The report must include the same information identified in Condition 2a above. Activities may continue while NMFS AKR and PR1 review the circumstances of the incident. NMFS will work with the permittee to determine whether modifications in the activities are appropriate.

c. In the event that a NMFS PR1 authorized permittee discovers an injured or dead ESA-listed marine mammal under NMFS' jurisdiction, and the lead PSO determines that the injury or death is not associated with or related to the activities described above (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the permittee shall report the incident to the Assistant Regional Administrator, Protected Resources Division, NMFS, at 907-586-7638, and/or by email to Jon.Kurland@noaa.gov, Kristin.Mabry@noaa.gov, Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 and/or by email (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities within 24 hours of the discovery. The permittee shall provide photographs or video footage (if available) or other documentation of the stranded animal sightings to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

3. Submit a draft project specific report on all activities and monitoring results to NMFS PR1 and the NMFS Assistant Regional Administrator (Jon.Kurland@noaa.gov) within 90 days of the completion of the exploration drilling program. This report must contain the following information:

a. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort Sea State and wind force), and sightings of ESA-listed marine mammals under NMFS's jurisdiction during all drilling, anchor handling, MLC construction, dynamic positioning, ice management, and ZVSP activities;

b. Species, number, location, distance from the vessel, and behavior of any ESA-listed marine mammals, seen in association with drilling, anchor handling, MLC construction, dynamic positioning, ice management, and ZVSP seismic activity (including the number of power-downs and shut-downs), observed throughout all monitoring activities;

c. An estimate of the instances of exposure (by species) of NMFS's ESA-listed marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1µPa (rms), 170 dB re 1 µPa (rms), 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) for cetaceans and pinnipeds with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed to the seismic activity at received levels between 160 dB re 1 µPa (rms) and ≥190 dB µPa (rms) for all listed marine mammals with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed;

d. An estimate of the instances of exposure (by species) of NMFS's ESA-listed marine mammals that: (A) are known to have been exposed to noise associated with co-occurring activities identified in the activity scenarios in this analysis (based on visual observation) at received levels ≥ 190 dB re 1 µPa (rms), down to 120 dB re 1 µPa (rms) in 10 dB increments; and (B) may have been exposed to noise associated with vessels in dynamic positioning at received levels between 120 dB re 1 µPa (rms) and ≥190 dB µPa (rms) for all listed marine mammals with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed;

e. The report should clearly compare authorized takes (as defined under the ESA and identified in the ITS of this opinion) to the level of actual estimated takes ("take" being defined as an ESA-listed mysticete receiving seismic pulses at ≥ 160 dB re 1 µPa (rms), or an ESA-listed pinniped receiving seismic pulses at ≥ 170 dB re 1 µPa (rms), or any ESA-listed marine mammal receiving continuous noise levels ≥ 120 dB re 1 µPa (rms) associated with dynamic positioning).

f. The draft report will be subject for review and comments by NMFS AKR. Any recommendations made by NMFS AKR must be addressed in the final report prior to acceptance by NMFS AKR. The draft report will be considered final for the activities described in this opinion if NMFS AKR has not provided comments and recommendations within 90 days of receipt of the draft report.

g. A description of the implementation and effectiveness of the terms and conditions of the biological opinion's Incidental Take Statement (ITS). The report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe the effectiveness, for minimizing the adverse effects of the action on ESA-listed marine mammals.

10.0 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Request NMFS PR1 authorized operators to alter speed or course during transit operations if a marine mammal, based on its position and relative motion, appears likely to intersect with the transect of the vessels;

2. Request operators to use real-time passive acoustic monitoring while in migratory corridors and other sensitive areas to alert ships to the presence of whales, primarily to reduce the ship strike risk.

3. Cumulative Impact Analysis – NMFS PR1 should work with BOEM and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, and other marine mammals. This analysis includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species;

In order to keep NMFS AKR informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NMFS PR1 should notify NMFS AKR of any conservation recommendations it implements.

11.0 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded in any given year for the duration of this opinion, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act (DQA)) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

Utility

This document records the results of an interagency consultation. The information presented in this document is useful to three agencies of the federal government (NMFS, BOEM and BSEE), and the general public. These consultations help to fulfill multiple legal obligations of the named agencies. The information is also useful and of interest to the general public as it describes the manner in which public trust resources are being managed and conserved. The information presented in these documents and used in the underlying consultations represents the best available scientific and commercial information and has been improved through interaction with the consulting agency.

This consultation will be posted on the NMFS Alaska Region website http://alaskafisheries.noaa.gov/protectedresources/). The format and name adhere to conventional standards for style.

Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

Objectivity

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 et seq.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the literature cited section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA implementation, and reviewed in accordance with Alaska Region ESA quality control and assurance processes.

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