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

Issuance of Incidental Harassment Authorization under Section 101(a)(5)(D) of the Marine Mammal Protection Act to SAExploration, Inc. (SAE) for Marine 3D Ocean Bottom Node Seismic Activities in the U.S. Beaufort Sea, Alaska, during the 2015 Open Water Season

NMFS Consultation Number: *AKR-2015-9451*

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

Affected Species and Determinations:

ESA-Listed 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?
Bowhead Whale (*Balanea mysticetus*)	Endangered	Yes	No	N/A
Ringed Seal, Arctic subspecies (*Phoca hispida hispida*)	Threatened	Yes	No	N/A
Bearded Seal, Beringia DPS (*Erignathus barbatus barbatus*)	Threatened	Yes	No	N/A

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By:

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

Date: 6.29.15

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

TERMS AND ABBREVIATIONS

µPa	Micro Pascal
2D	Two-Dimensional
3D	Three-Dimensional
ATOC	Acoustic Thermometry of the Ocean Climate
BIA	Biologically Important Area
BSAI	Bering Sea/Aleutian Island
BWASP	Bowhead Whale Feeding Ecology Study
CAA	Conflict Avoidance Agreement
CI	Confidence Interval
CNP	Central North Pacific
CPUE	Catch Per Unit Effort
CSEL	Cumulative Sound Exposure Level
cui	Cubic Inches
CWA	Clean Water Act
dB	Decibels
DDT	Dichloro-Diphenyltrichloroethane
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Medium
ESA	Endangered Species Act
ESW	Effective Strip Width
ft	Feet
gal	Gallons
IHA	Incidental Harassment Authorization
ION	ION Geophysical
IPCC	Intergovernmental Panel on Climate Change
IWC	International Whaling Commission
km	Kilometers
km^2	Square Kilometers
L	Liters
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NPRW	North Pacific right whale
OBN	Ocean Bottom Node
OC	organochlorine
Opinion	Biological Opinion
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring
PBDE	Polybrominated Diphenyl
PBR	Potential Biological Removal

PCB	Polychlorinated Biphenyls
PCE	Primary Constituent Element
PR1	Office of Protected Resources- Permits and Conservation Division
PTS	Permanent Threshold Shift
RMS	Root Mean Square
RPA	Reasonable Prudent Alternative
SAE	SAExploration, Inc.
SONAR	Sound Navigation and Ranging
t	Ton
TTS	Temporary Threshold Shift
USFWS	United States Fish and Wildlife Service
VGP	Vessel General Permit

1. INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended, (ESA) 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 with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, 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 conduct this consultation informally if they conclude that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service 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 by harassment under the Marine Mammal Protection Act (MMPA) incidental to three dimensional (3D) ocean bottom node (OBN) seismic surveys in U.S. state and federal waters of the Beaufort Sea by SAExploration, Inc. (SAE) between July 1, 2015 and October 15, 2015. The consulting agency is NMFS's Alaska Regional Office. This document represents NMFS's biological opinion (opinion) on the effects of this proposal on endangered and threatened species and designated critical habitat.

The opinion and incidental take statement were prepared by NMFS in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR 402.

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

This opinion considers the effects of the issuance of an IHA to take marine mammals by harassment under the MMPA incidental to open-water seismic surveys by SAE in the nearshore waters of the the U.S. Beaufort Sea from July 1 to October 15, 2015.
These actions have the potential to affect the endangered bowhead whale (*Balaena mysticetus*), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), and Beringia DPS of bearded seal (*Erignathus barbatus nauticus*).[1] Although the action area overlaps with proposed ringed seal critical habitat, proposed ringed seal critical habitat is not included in this consultation because the designation is not expected to be finalized in 2015.

[1] 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. We include bearded seals in this opinion so that NMFS PR1 has the benefit of our analysis of the consequences of the proposed action on the species, even though the listing is not in effect..

This biological opinion is based on information provided in the January 2015, Revised Incidental Harassment Authorization Application by SAE; March 2015, Draft Environmental Assessment; April 2015, Proposed Incidental Harassment Authorization Federal Register Notice (71 FR 20084), June 2015 Revised Exposure Estimates, the updated project proposals, email and telephone conversations between NMFS Alaska Region and NMFS PR1 staff; and other sources of information. A complete record of this consultation is on file at NMFS's Juneau, Alaska office.

1.2 Consultation History

On November 2014, SAE submitted an IHA application to NMFS for the non-lethal taking of cetaceans and seals in conjunction with its proposed 3D seismic survey in the Beaufort Sea, Alaska during the summer of 2015 (SAE 2014a). In January 2015, SAE submitted a revised IHA application(SAE 2015b). On February 25, 2015, NMFS PR1 submitted a request to initiate section 7 consultation to the NMFS Alaska Region (NMFS 2015a). On June 15, 2015, NMFS PR1 provided revised exposure estimates based on updated density information and daily ensonified area.

2. DESCRIPTION OF THE PROPOSED ACTION

2.1 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 SAE's 3D seismic exploration in nearshore waters of the U.S. Beaufort Sea between July 1, 2015 and October 15, 2015.

The purpose for the proposed seismic survey is for SAE to replace and augment existing datasets by providing better quality, higher resolution seismic data by using autonomous nodal seismic recording equipment. This data will improve operators' understanding of the geology and potential targets for existing production and future lease sales. Previous surveys collected 2D data which can often be distorted leading to inaccurate interpretations of the data. A 3D seismic survey provides more accurate images due to the multiple points of observation. This results in greater accuracy to base business and geologic decisions (SAE 2015b).

2.1.1 SAE's Proposed Open-Water Activities

SAE proposes to conduct 3D seismic surveys in the nearshore waters of the Beaufort Sea between Harrison Bay and the Sagavanirktok River delta. The survey box represents a total area of 4,562 square kilometers (km^2) (1,761 square miles) (see Figure 1). Within this area, SAE plans to survey a maximum of 777 km^2 ($300mi^2$).

The components of the project include laying nodal recording sensors (nodes) on the ocean floor, operating seismic source vessels towing active airgun arrays, and retrieval of the nodes. There will also be additional vessel activity associated with crew transfer, recording support, and additional monitoring for marine mammals (SAE 2015b).

SAE plans to conduct the surveys between July 1 and October 15, 2015. Data acquisition is expected to take approximately 70 days, depending on weather. Based on past similar seismic surveys in the Beaufort Sea, it is expected that effective shooting would occur over about 70% of the 70 days (or about 49 days). The Conflict Avoidance Agreement (CAA) states that surveys will temporarily cease during the fall bowhead whale hunt to avoid interference with the Cross Island (Nuiqsut residents), Kaktovik, or Barrow-based hunts if required by those communities

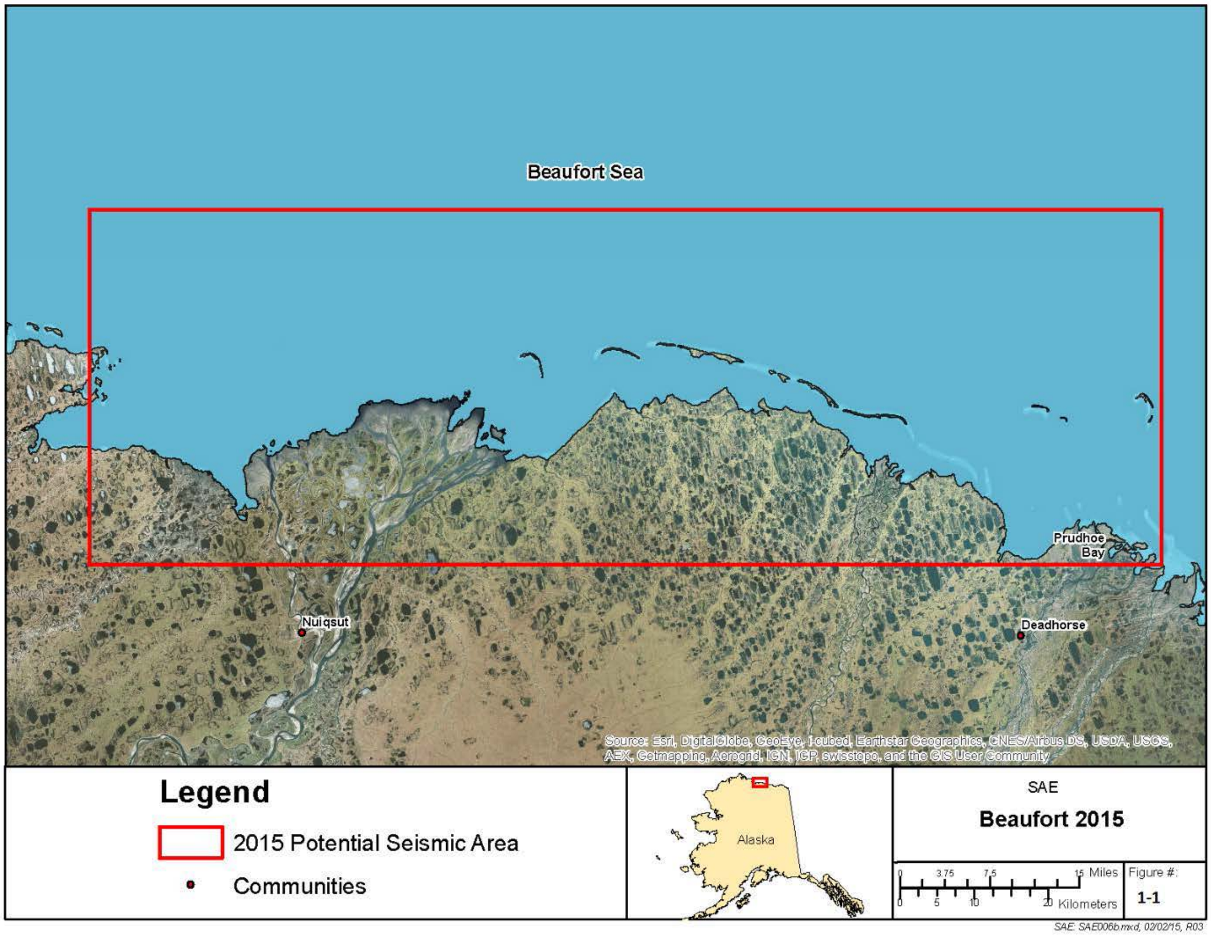

Figure 1. **Maximum Proposed Seismic Survey Box. Only 777 km^2 (300mi^2) would be surveyed in 2015 (SAE 2015b).**

2.1.1.1 SAE's Seismic Surveys

Marine seismic operations will be based on a "recording patch" or similar approach. Patches are groups of six receiver lines and 32 source lines. Each receiver line has submersible marine sensor nodes tethered equidistant (50 meters; 165 feet) from each other along the length of the line. Each node is a multicomponent system containing three velocity sensors and a hydrophone. Each receiver line is approximately 8 kilometers (5 miles) in length, and is spaced approximately 402 meters (1,320 feet) apart. Each receiver patch is 19.4 square kilometers (7.5 square miles) in area. The receiver patch is oriented such that the receiver lines run parallel to the shoreline (see Figure 2).

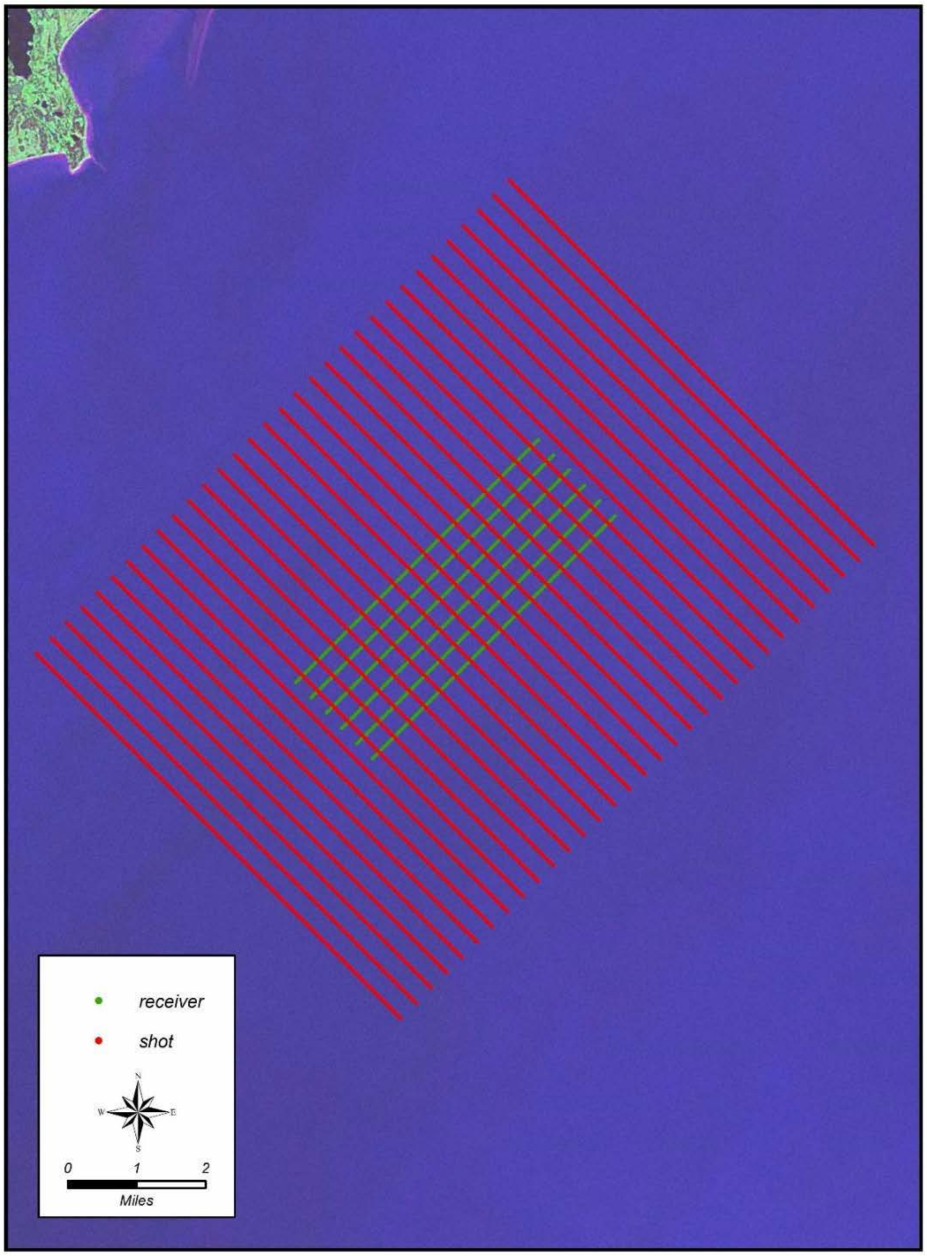

Figure 2. Example of a typical receiver patch (green) and seismic source lines shot (red).

Source lines, 12 kilometers (7.5 miles) long and spaced 502 meters (1,650 feet) apart, run perpendicular to the receiver lines (and perpendicular to the coast) and, where possible, will extend approximately 5 kilometers (3 miles) beyond the outside receiver lines and approximately 4 kilometers (2.5 miles) beyond each of the ends of the receiver lines. The outside dimensions of the maximum shot area during a patch shoot will be 12 kilometers by 16 kilometers (7.5 miles by 10 miles) or 192 km^2 (75 mi^2). It is expected to take three to five days to shoot a patch, or 49 km^2 (18.75 mi^2) per day. All shot areas will be wholly contained within the 4,532 km^2 survey box depicted in Figure 1. Shot intervals along each source line will be 50 meters (165 feet).

During recording of one patch, nodes from the previously surveyed patch will be retrieved, recharged, and data downloaded prior to redeployment of the nodes to the next patch. As patches are recorded, receiver lines are moved side to side or end to end to the next patch location so that receiver lines have continuous coverage of the recording area.

Autonomous recording nodes lack cables but will be tethered together using a thin rope for ease of retrieval. This rope will lay on the seabed surface, as will the nodes, and will have no effect on marine traffic. Primary vessel positioning will be achieved using GPS with the antenna attached to the air gun array. Pingers deployed from the node vessels will be used for positioning of nodes. The geometry/patch could be modified as operations progress to improve sampling and operational efficiency (SAE 2015b).

Seismic Source Array

SAE will use a 620 cubic inch (cui), 8-cluster array, and may use a 2 x 620 cui array, totaling 1,240 cui, in deeper waters. The arrays will be centered approximately 15 meters (50 feet) behind the source vessel stern, at a depth of 4 meters (12 feet), and towed along predetermined source lines at speeds between 4 and 5 knots. Two vessels with full arrays will be operating simultaneously in an alternating shot mode; one vessel shooting while the other is recharging. Shot intervals are expected to be about 16 seconds for each array resulting in an overall shot interval of 8 seconds considering the two alternating arrays. Operations are expected to occur 24 hours a day, with actual daily shooting to total about 12 hours (SAE 2015b).

Based on manufacturer specifications, the 1,240-cubic-inch array has a zero-peak estimated sound source of 249 dB (decibels) re 1 micropascals (μPa) @ 1 m, with a root mean square (rms) sound source of 224 dB re 1 μPa, while for the 620-cubic-inch array the zero-peak is 237 dB re 1 μPa (rms) with an rms source level of 218 dB re 1 μPa (see Table 2). The acoustical broadband energy is concentrated along the vertical axis (focused downward), while there is little energy focused horizontally. The spacing between airguns results in offset arrival timing of the sound energy. These delays “smear” the sound signature as offset energy waves partially cancel each other, which reduces the amplitude in the horizontal direction. Thus, marine mammals near the surface and horizontal to the airgun arrays would receive sound levels considerably less than a marine mammal situated directly beneath the array, and at levels probably less than predicted by the acoustical spreading model (SAE 2015b). As a result, the estimates of the distances to 160 dB re 1 μPa threshold for this IHA request should be considered conservative (see Exposure Analysis, Section 6.2.1).

A 10 cui mitigation airgun will be used during poor visibility conditions, and is intended to (a) alert marine mammals to the presence of airgun activity, and (b) retain the option of initiating a ramp-up to full operations under poor visibility conditions. The mitigation gun will be operated at approximately one shot per minute during these periods. The manufacturer specifications indicate a 214 dB re 1 μPa zero-peak sound source equating to a 195 dB re 1 μPa rms source (see Table 2).

Airgun arrays typically produce most noise energy in the 10 to 120 hertz range, with some energy extending to 1 kilohertz (Richardson et al. 1995).

Pingers and Transponders

An acoustical pinger system will be used to position and interpolate the location of the nodes. A vessel-mounted transceiver calculates the position of the nodes by measuring the range and bearing from the transceiver to a small acoustic transponder fitted to every third node. The transceiver uses sonar to interrogate the transponders, which respond with short pulses that are used in measuring the range and bearing. The system provides a precise location of every node as needed for accurate interpretation of the seismic data (SAE 2015b).

The transceiver to be used is the Sonardyne Scout USBL, while transponders will be the Sonardyne TZ/OBC Type 7815-000-06. Because the transceiver and transponder communicate via sonar, they produce underwater sound levels. The Scout USBL transceiver has a transmission source level of 197 dB re 1 μPa @ 1 m and operates at frequencies between 35 and 55 kilohertz. The transponder produces short pulses of 184 to 187 dB re 1 μPa @ 1 m at frequencies also between 35 and 55 kilohertz (SAE 2015b)(see Table 2).

2.1.1.2 SAE's Vessel Operations

Several offshore vessels will be required to support recording, shooting, and housing in the marine and transition zone environments. The exact vessels that will be used have not yet been determined. However, the types of vessels that will be used to fulfill these roles are found in Table 1.

Table 1. **SAE's seismic program vessels** (SAE 2015b).

Vessel	Operation	Size (feet)	Gross Tonnage	No. of Berths	Main Activity/Frequency	Source Levels1 (dB)
TBD	Source Vessel	120 x 25	100-250	10-20	Seismic data acquisition 24 hour operation	179.0
TBD	Source Vessel	80 x 25	100-250	10-20	Seismic data acquisition 24 hour operation	165.7
TBD	Node equipment deployment and retrieval	80 x 20	50	16	Deploying and retrieving nodes 24 hour operation	165.3
TBD	Node equipment deployment and retrieval	80 x 20	50	16	Deploying and retrieving nodes 24 hour operation	165.3
TBD	Mitigation/Housing Vessel	90 x 20	100	20-30	House crew 24 hour operation	200.1
TBD	Crew Transport Vessel	30 x 20	20-30	3	Transport crew intermittent 8 hours	191.8
TBD	Bow Picker	30 x 20	20-30	3	Deploying and retrieving nodes Intermittent operation	171.8
TBD	Bow Picker	30 x 20	20-30	3	Deploying and retrieving nodes Intermittent operation	171.8

[1] Sound source level from (Aerts et al. 2008) based on empirical measurements of the same types of vessels expected to be used during this survey (SAE 2015b).

Source Vessels

Source vessels will have the ability to deploy two arrays off the stern using large A-frames and winches and have a draft shallow enough to operate in waters less than 1.5 meters (5 feet) deep. On the source vessels the airgun arrays are typically mounted on the stern deck with an umbilical that allow the arrays to be deployed and towed from the stern without having to re-rig or move arrays. A large bow deck will allow for sufficient space for source compressors and additional airgun equipment to be stored. The two marine vessels likely to be used will be the same or similar to those that were acoustically measured (Aerts et al. 2008). The source vessels were found to have sound source levels of 179 dB re 1 μPa (rms) and 165.7 dB re 1 μPa (rms)(see Table 1).

Recording Deployment and Retrieval Vessels

Jet driven shallow draft vessels and bow pickers will be used for the deployment and retrieval of the offshore recording equipment. These vessels will be rigged with hydraulically driven deployment and retrieval squirters allowing for automated deployment and retrieval from the bow or stern of the vessel. These vessels will also carry the recording equipment on the deck in fish totes. Aerts et al. (2008) found the same types of vessels to be used by SAE for recording and deployment to have a source level of approximately 165.3 dB re 1 μPa (rms), while the smaller bow pickers produce more cavitation resulting in source levels of 171.8 dB re 1 μPa (rms)(see Table 1).

Housing and Transfer Vessels

Housing vessel(s) will be larger with sufficient berthing to house crews and management. The housing vessel will have ample office and bridge space to facilitate the role as the mother ship and central operations. Crew transfer vessels will be sufficiently large to safely transfer crew between vessels as needed. Aerts et al. (2008) found the housing vessel to produce the loudest propeller noise of all the vessels in the fleet (200.1 dB re 1 μPa rms), but this vessel is mostly anchored up once it gets on site (see Table 1). The crew transfer vessel also travels only infrequently relative to other vessels, and is usually operated at different speeds. During higher speed runs shore the vessel produces source noise levels of about 191.8 dB re 1 μPa (rms), while during slower on-site movements the vessel source levels are only 166.4 dB re 1 μPa (rms) (Aerts et al. 2008). We expect SAE will use similar vessels to those examined by Aerts et al. (2008).

Mitigation Vessel

To facilitate marine mammal monitoring of the 160 dB re 1 μPa (rms) harassment zone, one dedicated vessel will be deployed a few kilometers northeast of the active seismic source vessels to provide a survey platform for one to two Protected Species Observers (PSOs). This additional mitigation vessel will only be required if SAE is shooting the larger 1,240 cui airgun array due to the extended harassment zone (~5.2 km). The PSOs stationed on the mitigation vessel will work in concert with PSOs stationed aboard the source vessels, and will provide an early warning of the approach of any marine mammal. It is assumed that the vessel will be of similar size and acoustical signature as a bowpicker (SAE 2015b).

2.1.1.3 SAE's Acoustic Equipment

Table 2 provides information on the acoustic equipment SAE anticipates using in the action area including seismic devices (such as airguns), sonar devices (such as pingers) and other acoustic sources (such as vessels).

Table 2. Acoustic equipment SAE anticipates using within the action area (SAE 2015b).

Active Acoustic Source	Frequency (kHz)	Maximum Source Level (dB re 1 µPa at 1m)
1240 cui airgun array	<1	224
620 cui airgun array	<1	218
40 cui airgun array	<1	195
Pinger (Scout USBL)	35-55	197
Transponder	33-55	187
Vessel Noise[1]	<1	200

[1] Vessel Noise includes source vessels, recorder vessels, housing vessel, crew transport vessels, and bow pickers. The loudest vessel is anticipated to be the housing vessel (SAE 2015b).

2.1.2 Mitigation Measures Proposed by SAE

SAE proposes to implement measures that would allow the proposed action to have the least practicable adverse impact on marine mammal species or stocks (which includes considerations of personal safety and practicality of implementation). A summary of those measures is provided below, and a more detailed version can be found in SAE's monitoring and mitigation plan (SAE 2015b). Unless otherwise noted, these measures apply to all marine mammals (not just listed marine mammals).

Protected Species Observers (PSOs)

Two PSOs will be placed onboard the seismic source vessels and two to three PSOs on mitigation vessels to minimize exposure to the seismic sound source, monitor the 180 dB and 190 dB exclusion zones and the 160 dB harassment zone (Table 3), and provide early warning of approaching marine mammals. Other vessel-based mitigation measures include ramp-up procedures while initiating seismic operations and power-down or a shut-down procedure if a marine mammal is detected approaching or within designated distances from the sound source.

Table 3. Anticipated distances to Exclusion Zones (180 dB for cetaceans, and 190 dB for pinnipeds) and Harassment Zone (160 dB) (SAE 2014b).

		Exclusion Zone (Pinnipeds)	Exclusion Zone (Cetaceans)	Harassment Zone (All Marine Mammals)
Source	Source Level	190 dB	180 dB	160 dB
10 cubic inch airgun array	195 dB re 1 μPa (rms)	54 m	188 m	1.05 km
620 cubic inch airgun array	218 dB re 1 μPa (rms)	195 m	635 m	1.82 km
1,240 cubic inch airgun array	224 dB re 1 μPa (rms)	250 m	910 m	5.2 km

PSOs will be required onboard seismic source vessels and mitigation vessel to meet the following criteria:

- 2-3 PSOs will be stationed on the large seismic source vessel, 1-2 PSOs will be stationed on the smaller seismic source vessel, and 1-2 PSOs will be used on mitigation vessel (if shooting the 1240 cui array);
- 100% monitoring coverage during all periods of survey operations in daylight;
- PSOs will be aboard both seismic and mitigation vessels to document the occurrence of marine mammals, implement mitigation requirements, and record the reactions of marine mammals to survey activities;
- Maximum of 4 consecutive hours on watch per PSO; and
- Maximum of ~12 hours of watch time per day per PSO.

Sound Source Verification

If SAE uses the 1,240 cui airgun arrays, sound source verification (SSV) tests on these arrays will be required at the beginning of the survey operations. The results of the SSV will be submitted to NMFS within five days after completing measurements. A report on the preliminary results of the SSV measurements, including the measured 190, 180, 170, and 160 dB (rms) radii of the 1,240 cui airgun array, would be submitted within 14 days after collection of those measurements at the start of the field season. This report will specify the distances of the exclusion zones that will be adopted for the survey.

Weekly Reports

SAE will submit weekly reports to NMFS no later than the close of business (Alaska Time) each Thursday during the weeks when seismic surveys take place. The field reports will summarize species detected, in-water activity occurring at the time of the sighting, behavioral reactions to in-water activities, and the number of marine mammals exposed to harassment level noise (≥ 160 dB rms).

Monthly Reports

SAE will submit monthly reports to NMFS for all months during which seismic surveys take place. The monthly reports will contain and summarize the following information:

- Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort Sea state and wind force), and associated activities during the seismic survey and marine mammal sightings.
- Species, number, location, distance from the vessel, and behavior of any sighted marine mammals, as well as associated surveys (number of shutdowns), observed throughout all monitoring activities.
- An estimate of the number (by species) of: (i) pinnipeds that have been exposed to the seismic surveys (based on visual observation) at received levels greater than or equal to 160 dB re 1 µPa (rms) and/or 190 dB re 1 µPa (rms) with a discussion of any specific behaviors those individuals exhibited; and (ii) cetaceans that have been exposed to the geophysical activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 µPa (rms) and/or 180 dB re 1 µPa (rms) with a discussion of any specific behaviors those individuals exhibited.

Passive Acoustic Monitoring

SAE proposes to conduct Passive Acoustical Monitoring (PAM) using specialized autonomous passive acoustical recorders. These recorders will be deployed on the seabed and will record continuously at 64 kHz sample rate and 24-bit samples. The recorders will be calibrated using piston phone calibrators immediately before and after each deployment. These calibrations are accurate to less than 0.5 dB absolute.

The recorders will be configured with a single channel using a sensitive hydrophone and will be configured with an appropriate duty cycle to record at 64 kHz for up to 80 days. The recorders will sit directly on the seabed and will be attached to a ground line with a small weight at its end. Each recorder will be retrieved by using a grapple to catch the ground line and recover the unit.

Four recorders will be deployed in an arrangement surrounding the survey area for the purposes of PAM. These data would be used for post-season analysis of marine mammal vocalization detections to help inform an assessment of potential disturbance effects. They will measure ambient soundscape throughout the Beaufort Sea coast. The PAM data will also provide information about the long-range propagation of the airgun noise.

Vessel Related Mitigation Measures

These mitigation measures apply to all vessel that are part of SAE's Beaufort Sea seismic survey activities, including supporting vessels during seismic operations, when mobilizing to the project area, when demobilizing from the project area, and in the performance of any other operations in support of the 3D seismic program:

- Avoid concentrations of 5 or more whales. Operators of vessels should, at all times, conduct their activities at the maximum distance possible from such concentrations or groups of whales.
- If any vessel approaches within 1.6 km (1 mi) of observed whales, except when providing emergency assistance to whalers or in other emergency situations, the vessel operator will take reasonable precautions to avoid potential interaction with the whales by taking one or more of the following actions, as appropriate:
  - Reducing vessel speed to less than 5 knots within 300 yards (900 feet or 274 m) of the whale(s);
  - Steering around the whale(s) if possible;
  - Operating the vessel(s) in such a way as to avoid separating members of a group of whales from other members of the group;
  - Operating the vessel(s) to avoid causing a whale to make multiple changes in direction; and
  - Checking the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the propellers are engaged.
- Reduce vessel speed, not to exceed 5 knots, when weather conditions require, such as when visibility drops (such as fog and/or darkness), to avoid the likelihood of injury to whales. This applies to any transits occurring from July 1 through October 15th within the action area.

Marine Mammal Mitigation during Operations

SAE will adhere to the following mitigation measures during seismic operations, when mobilizing to the project area, when demobilizing from the project area, and in the performance of any other operations in support of the 3D seismic program:

- The seismic and mitigation vessels will be staffed with PSOs who will alert the crew to the presence of marine mammals so that vessel crews can initiate appropriate mitigation measures, including power-down, shut-down, and ramp-up procedures;
- PSOs will establish and monitor an exclusion zone for cetaceans and pinnipeds surrounding the airgun array on the source vessels where the received level would be 180 dB and 190 dB. The anticipated distances to these isopleths is described in Table 3;
- PSOs will establish and monitor a harassment zone for marine mammals surrounding the airgun array of the source vessels where the received level would be 160dB. The anticipated distances to these isopleths is described in Table 3;
- Whenever aggregations of 12 or more bowhead or gray whales appear to be engaged in non-migratory behavior (e.g. feeding, socializing), or bowhead whale cow/calf pairs are observed within the 160 dB harassment zone around the seismic activity, the seismic operation will not commence or will shut down if operating; and
- Initiation of the seismic source will occur only after the 180 dB zone is visible and clear of cetaceans or pinnipeds for 30 minutes during day or night;

- If a marine mammal is sighted within the exclusion zone during the 30-minute watch prior to ramp up, ramp up will be delayed until the marine mammal is sighted outside of the exclusion zone or the animal is not sighted for at least 15 minutes, for pinnipeds, or 30 minutes, for baleen whales; and
- Throughout the seismic survey, during turning movements and short transits, SAE will employ the use of the smallest-volume airgun (10 cui) to deter marine mammals from entering the immediate area of seismic operations.

During periods of poor visibility or nighttime, SAE will adhere to the following:

- During limited visibility due to foggy conditions, heavy snow or rain, and/or darkness (which may be encountered starting in late August), the entire 180 dB exclusion zone may not be visible. If the entire zone is not visible for a minimum of 30-minutes, ramp-up from full shut-down of the seismic source will not occur;
- If a single airgun seismic source or a seismic source array has been operational before visibility decreased or nightfall, the seismic source operations may continue even though the entire exclusion zone may not be visible. Ramp-up procedures can be initiated, even though the exclusion zone may not be visible, on the assumption that marine mammals will be alerted by the sound from the single airgun and have moved away.

2.1.3 Mitigation Measures Proposed by NMFS PR1

The mitigation measures described below are required per the NMFS's IHA stipulations, and will be implemented by SAE to reduce potential impacts to marine mammals from survey activities, pinger and transponder operations, and vessel movements. Unless otherwise noted, these measures apply to all marine mammal species.

Detection-based measures intended to reduce near-source acoustic exposures and impacts on marine mammals under NMFS's authority within a given distance of the source

Monitoring and Mitigating the Effects of Seismic Survey

1. Protected Species Observers are required on all seismic source and mitigation vessels.

    - 2-3 PSOs will be stationed on the large source vessel, two PSO will be stationed on the smaller source vessel, and an additional 1-2 PSOs on the mitigation vessel. PSOs on the mitigation vessel will work in concert with PSOs aboard the source vessel, and will provide an early warning of the approach of any marine mammal. The mitigation vessel plans to conduct zig-zag transects from 2 to 6 km ahead of the source vessel (based on water depth and weather conditions) to effectively monitor the 160 dB harassment zone, and the edge of the 180 dB exclusion zone.

- PSOs will visually watch for and monitor marine mammals near the vessels during airgun operation or pinger and transponder operations (from nautical twilight-dawn to nautical twilight-dusk) and 30 minutes before, during, and after start-ups of airguns and pingers. The vessels' crew shall also assist in detecting marine mammals, when practicable. PSOs shall have access to reticle binoculars (e.g., 7x50 and 16-40x80). Laser range finders (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation. Night-vision equipment (Generation 3 binocular image intensifiers or equivalent units) will be available for use when/if needed. PSO shifts shall last no longer than 4 hours at a time and PSOs 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.

- PSO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the survey operations; and documenting "take by harassment".

- PSOs will give particular attention to the areas within the marine mammal exclusion zones around the source vessels. These zones are the maximum distances with which received levels may exceed 180 dB (rms) re 1 µPa (rms) for cetaceans, or 190 dB (rms) re 1 µPa for pinnipeds. When a marine mammal is seen approaching or within the exclusion zone applicable to that species, the seismic survey crew will be notified immediately so that mitigation measures can be implemented.

- When a mammal sighting is made, the following information about the sighting will be recorded:

    - Species, group size, age/size/sex categories (if determinable); physical description of features observed or determined not to be present in the case of unknown or unidentified animals; 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 state;
    - Time, location, speed, activity of the source and mitigation vessels, sea state, ice cover, visibility, and sun glare; and
    - The positions of other vessel(s) in the vicinity of the PSO location.

- PSO teams shall consist of Inupiat observers and experienced field biologists. An experienced field crew leader will supervise the PSO team onboard the survey vessel. New PSOs will be paired with experienced PSO or experienced field biologist so that the quality of marine mammal observations and data recording is kept consistent;
- Crew leaders and most PSOs in 2015 shall be individuals with experience as observers during recent seismic or shallow hazard monitoring projects in Alaska, or other offshore areas in recent years;

- Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring and mitigation projects;
- Inupiat observers will be experienced in the region and familiar with marine mammals of the area;
- All 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;
- 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;
- 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);
- PSOs should be instructed to identify animals as unknown where appropriate rather than strive to identify a species if there is significant uncertainty;
- 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;
- SAE will collaborate with other industrial operators in the area to integrate and synthesize monitoring results as much as possible (such as submitting sightings from their monitoring projects to an online data archive like OBIS-SEAMAP), and archiving and making the complete database available upon request; and

2. Establishment of Exclusion and Harassment Zones.

    - Establish and monitor a preliminary exclusion zone surrounding the airgun array on the source vessel where the received level would be at or above 180 dB for cetaceans and 190 dB for pinnipeds with trained PSOs. The radius for the zone will vary based on the configuration of the airgun array, water depth, temperature, salinity, and other factors related to the water and seafloor properties. Immediately reduce the size of the Exclusion Zone (180 or 190 isopleth) by reducing the power level of the array whenever any cetaceans are sighted approaching or within the area delineated by the 180 dB, or pinnipeds are sighted approaching or within the area delineated by the 190 dB isopleth.
    - If the power-down operation cannot reduce the sound pressure level received by any cetacean or pinniped to less than 180 dB or 190 dB, respectively, then SAE must immediately shutdown the seismic airgun array.
    - Establish a harassment zone for cetaceans and pinnipeds surrounding the airgun array on the source vessel where the received level would be 160 dB (rms) re 1 μPa. Immediately upon completion of data analysis of the field verification measurements, the new 160-dB, 180-dB, and 190-dB marine mammal harassment and exclusion zones shall be established based on the sound source verification.

3. Use of start-up and ramp-up procedures for airgun arrays.

- PSOs will monitor the entire exclusion zone for at least 30 minutes prior to starting the airgun array (day or night). If PSO finds a marine mammal within the exclusion zone, the operator must delay the start-up of seismic airguns until the marine mammal(s) has left the exclusion zone. If the PSO sees a marine mammal that surfaces then dives below the surface, the PSO shall continue the watch for 30 min. If the PSO sees no marine mammals during that time, the PSO can assume that the animal has moved beyond the exclusion zone. If for any reason the entire exclusion zone cannot be seen for the entire 30 minute period (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be started;
- 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. 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.
- The seismic operator and PSOs shall maintain records of the times when ramp-ups start and when the airgun arrays reach full power;
- If one airgun (mitigation) is already running at a source level of at least 180 dB re 1µPa (rms), the operator may start the second airgun, provided no marine mammals are known to be near the exclusion zone;
- After shut-down, additional airguns may be added in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per above ambient (~120dB) 5 min period. During ramp-up, the PSOs shall monitor the exclusion zone, and if marine mammals are sighted, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of start-up procedures from shutdown requires that the PSOs be able to view the full exclusion zone;
- Power-down or shutdown the airgun(s) will be implemented if a marine mammal is detected within, approaches, or enters the relevant exclusion zone. A power-down procedure means reducing the number of operating airguns to as low as a single operating mitigation gun, which reduces the exclusion zone to the degree that the animal(s) is no longer in or about to enter it. A shutdown means all operating airguns are shutdown (i.e., turned off);
- If the marine mammal approaches the exclusion zone of the mitigation gun, the airguns must then be completely shut down. Airgun activity shall not resume until the PSO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the exclusion zone for 15 min for species with shorter dive durations (small odontocetes and pinnipeds) or 30 min for species with longer dive duration (mysticetes);
- Following a power-down or shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described above;
- Seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored;

- 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;
- The exclusion zone will also be monitored for 30 min after seismic operations have ceased; and

4. Use of small-volume airgun during turns and transits

   - Throughout the seismic survey, particularly during turning movements, and short transits, SAE will employ the use of a small-volume airgun to deter marine mammals from being within the immediate area of the seismic operations. The mitigation airgun would be operated at approximately one shot per minute and would not be operated for longer than three hours in duration (turns may last two to three hours for the proposed project).
   - During turns or brief transits (e.g., less than three hours) between seismic tracklines, one mitigation airgun will continue operating. The ramp-up procedure will still be followed when increasing the source levels from one airgun to the full airgun array. However, keeping one airgun firing will avoid the prohibition of a "cold start" during darkness or other periods of poor visibility. Through use of this approach, site clearance and shallow hazards surveys using the full array may resume without the 30 minute observation period of the full exclusion zone required for a "cold start". PSOs will be on duty whenever the airguns are firing during daylight, during the 30 minute periods prior to ramp-ups, and the 30 minute period after airguns have ceased firing.

5. Sound Source Verification (SSV) tests for 1,240 cui airgun array at the start of the season using hydrophones.

   Before conducting the seismic survey with the 1,240 cui airgun array, SAE will conduct SSV tests to verify the radii of the exclusion and harassment zones within real-time conditions in the field, providing for more accurate radii to be used. SAE will submit the results to NMFS within five days after completing the measurements, followed by a report submitted within 14 days after the completion of the measures:

   - The empirical distances from the airgun arra utilized during the effectiveness of the IHA to broadband received levels of 190 dB down to 120 dB in 10 dB increments and the radiated sounds vs. distance from the source vessel. 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.

Measures intended to reduce/lessen non-acoustic impacts on marine mammals

These measures would be required for all vessel operations conducted in support of the proposed action.

1. Specified procedures for vessels to avoid collisions with whales.

   - All vessels shall reduce speed to less than 5 knots prior to coming within 274 m (300 yards) of whales. The reduction in speed will vary based on the situation but must be sufficient to avoid interfering with the 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 this opinion, a group is defined as being five or more whales observed within a 500 m (547 yard) area;
   - Operate the vessel(s) to avoid causing a whale to make multiple changes in direction;
   - Check the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the vessel's propellers are engaged;
     - When visibility is reduced, such as during inclement weather (rain, fog) or darkness, adjust vessel speed to 5 knots accordingly to avoid the likelihood of injury to whales. This applies to any transits occurring from July 1 through October 15th within the action area.
   -

Measures intended to ensure no unmitigable adverse impact to subsistence uses

These measures would be required for all activities that occur during the open-water season.

- Before initiating marine surveys, coordinate activities with local subsistence users and Village Whaling Associations in order to minimize the risk of interfering with subsistence hunting activities;

- Participate in the Com Center Program. The Com Centers shall operate 24 hours/day during the 2015 bowhead whale hunt;

2.2 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 will include: (1) the 3D seismic survey area in nearshore waters of the U.S. Beaufort Sea between Harrison Bay and the Sagavanirktok River delta; and (2) a sound propagation buffer of 5.2 km around the 3D seismic survey area.

We define the action area for this consultation to include the area within which project-related noise levels are ≥160 dB. The action area encompasses the 4,562 km^2 survey box, comprised of approximately 777 km^2 of seismic survey area and 686 km^2 sound propagation buffer, including vessel transits within these areas (Figure 3).

Based on SAE's modeled sound propagation estimates, received levels from seismic surveys using a 1,240 cui airgun configuration would be expected on average to decline to about 160 dB within 5.2 km of the survey location (SAE 2015b). Adding the sound propagation buffer around the 777 km^2 survey area results in a total ensonified area of 1,463 km^2 (SAE 2015b). Since we do not know where within the survey box the surveys will occur, we define the action area to include the entire survey box with the sound propagation buffer.

The action area includes transit areas for mobilization, demobilization, and support activities. Vessels will be brought up the Dalton Hwy, and mobilization and demobilization are anticipated to occur at Oliktok Point. Equipment staging and onshore support will primarily occur at Oliktok Point, but may also take place at West Dock (Figure 3).

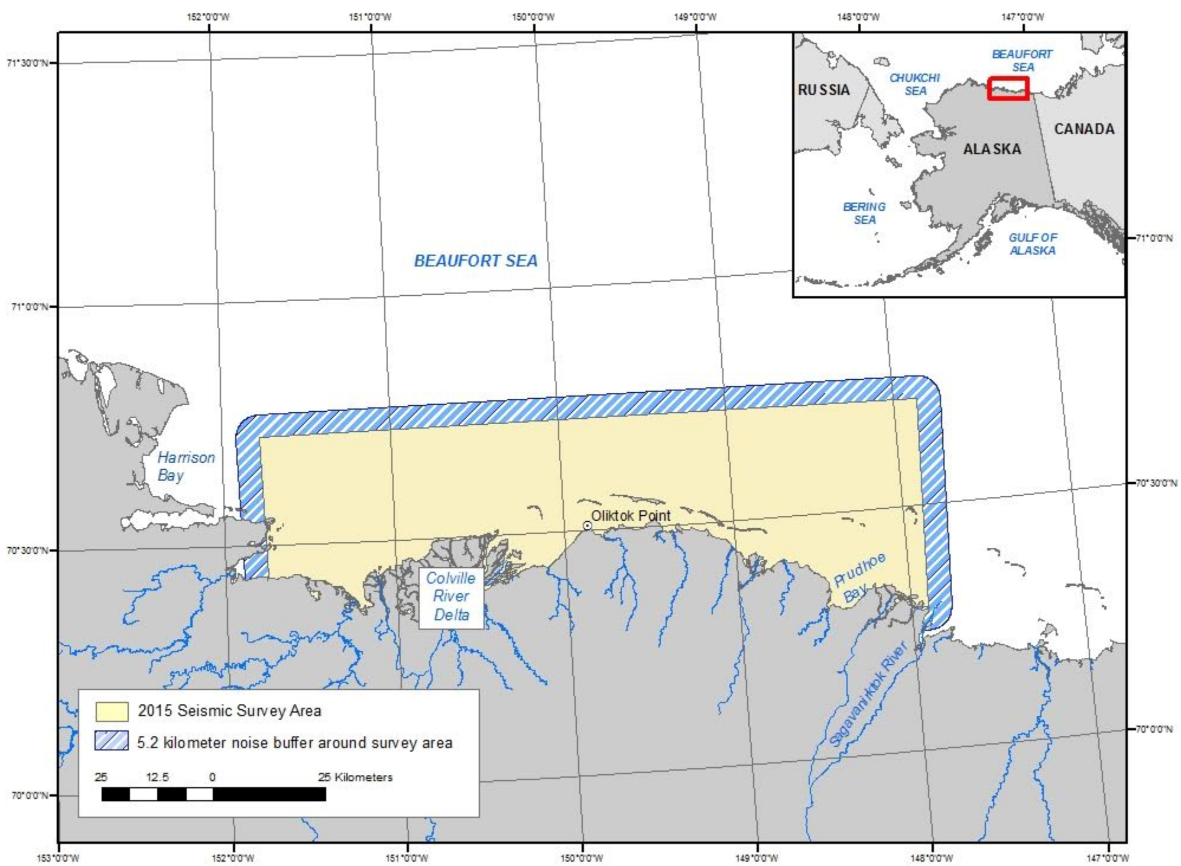

Figure 3. Action area map for SAE's proposed 3D seismic operations in the Beaufort Sea. Transit to survey area may occur from Prudhoe Bay or Oliktok Point. Action area includes a 5.2 km noise buffer around survey area.

3. APPROACH TO THE ASSESSMENT

3.1 Introduction to the Biological Opinion

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

"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 the survival or 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).

For purposes of this opinion, NMFS interprets this definition consistent with the court's opinion in *National Wildlife Federation v. NMFS*, 524 F.3d 917 (9th Cir. 2008). NMFS's jeopardy analysis considers how the proposed action may affect the likelihood of survival of the species and how it may affect the likelihood of recovery of the species.

3.1.1 Approach to the Assessment

We will use the following approach to determine whether the proposed action described in Section 2 is likely to jeopardize listed species:

- 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 action area – the spatial extent of these direct and indirect effects.

- 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 4.

- 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 5 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 6 of this opinion with the exposure analysis described in Section 6.2 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 6.3 of this opinion.

- Describe any cumulative effects. Cumulative effects, as defined in NMFS's 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 7 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 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) 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 4). Integration and synthesis with risk analyses occurs in Section 8 of this opinion.

- Reach jeopardy and adverse modification conclusions. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 9. These conclusions flow from the logic and rationale presented in the Integration and Synthesis section 8.

- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, 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 (RPA) to the action.

3.1.2 Exposure Analyses

Exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects 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. When it is impossible or impracticable to estimate the number of individuals likely to be exposed, we try to estimate the proportion of a population that is likely to be exposed. If we cannot estimate this proportion, we will rely on a surrogate or index.

Given the many uncertainties in predicting the quantity and types of impacts of sound on marine mammals, it is common practice to estimate how many animals would be present within a particular distance of human activities and/or exposed to a particular level of anthropogenic sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner. One of the reasons for this is that the selected distances/isopleths are based on limited studies indicating that some animals exhibited short-term reactions at this distance or sound level, whereas the calculation assumes that all animals exposed to this level would react in a biologically significant manner.

Another scenario we considered but did not use assumed marine mammals would try to avoid exposure to seismic transmissions (See *Response Analysis* Section 6.1.4), but the data necessary on the rate at which cetacean and pinniped densities would change in response to initial or continued seismic exposure were not available for this consultation so we could not reach conclusions based on this scenario. As a result, although we considered an alternative exposure scenario for this consultation, we only report the results of one exposure scenario.

3.1.3 Response Analyses

Once we identify which listed resources are likely to be exposed to stressors associated with the proposed action, and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how (1) endangered or threatened species are likely to respond following exposure and the set of physical, physiological, behavioral, or social responses that are likely and (2) the action is likely to affect the quantity, quality, or availability of one or more of the physical or biological features of critical habitat.

Conceptual Model for Response Analyses

To guide our response analyses, we use a conceptual model of responses to noise (which is the principal stressor included in the proposed action). The model is based on animal behavior and behavioral decision-making (Figure 4) although we continue to recognize the risks presented by physical trauma and noise-induced losses in hearing sensitivity (threshold shift). This model is also based on a conception of "hearing" that includes cognitive processing of auditory cues, rather than focusing solely on the mechanical processes of the ear and auditory nerve. Our model incorporates the primary mechanisms by which behavioral responses affect the longevity and reproductive success of animals: changing an animal's energy budget, changing an animal's time budget (which is related to changes in an animal's energy budget), forcing animals to make life history trade-offs (for example, engaging in evasive behavior such as deep dives that involve short-term risks while promoting long-term survival), or changes in social interactions among groups of animals (for example, interactions between a cow and her calf).

This conceptual model begins with the specific acoustic stimuli that we focus on in an assessment (Box 1 in Figure 4). Although we generally considered different acoustic stimuli separately, we considered a single source of multiple acoustic stimuli as a complex “acoustic object” that has several acoustic properties. For example, we treat pulses produced by seismic sound sources and sounds produced by the source vessel as a single “acoustic object” that produced continuous sounds (engine- noise, propeller cavitation, hull displacement, etc.) and periodic impulsive pulses. Because animals would be exposed to this complex of sounds produced by a single, albeit moving, source over time, we assumed they would generally respond to the acoustic stream associated with this single acoustic object moving through their environment. Multiple ships associated with a particular type of survey, for instance 3D seismic surveys, are expected to also represent a single acoustic object as all vessels are moving in formation at the same speeds while alternating shots. Multiple ships associated with drilling operations, such as support ships that move independently of the survey formation would represent different acoustic objects in the acoustic scene of endangered and threatened marine animals.

Acoustic stimuli can represent two different kinds of stressors: *processive stressors*, which require high-level cognitive processing of sensory information, and *systemic stressors*, which usually elicit direct physical or physiological responses and, therefore, do not require high-level cognitive processing of sensory information (Herman and Cullinan 1997, Anisman and Merali 1999, de Kloet et al. 2005, Wright et al. 2007). Disturbance from surface vessels and airguns would be examples of processive stressors while ship strikes would be an example of a systemic stressor. The proposed action may result in two general classes of responses:

1. responses that are influenced by an animal’s assessment of whether a potential stressor poses a threat or risk (see Figure 4: Behavioral Response).

2. responses that are not influenced by the animal’s assessment of whether a potential stressor poses a threat or risk (see Figure 4: Physical Response).

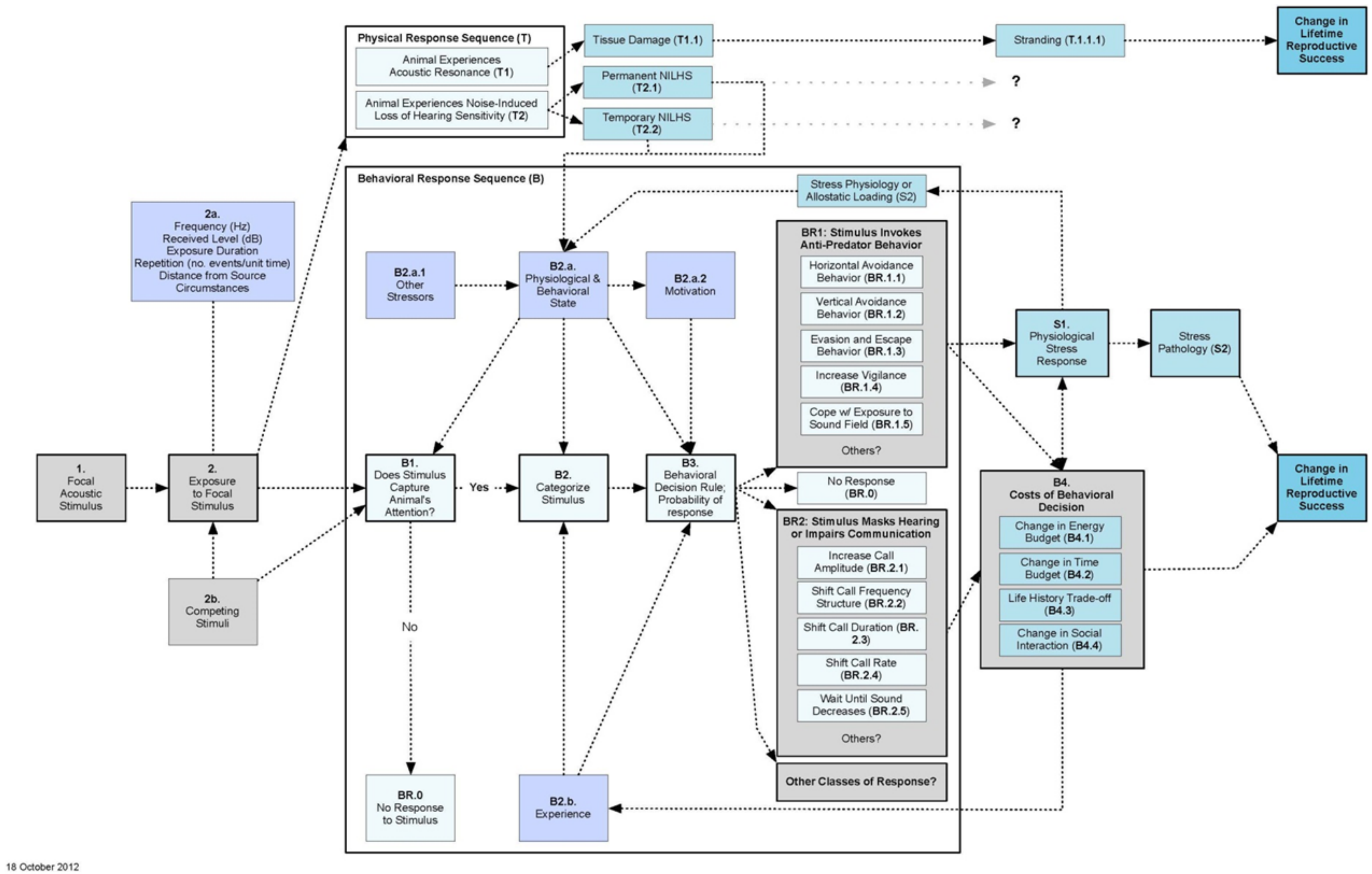

Figure 4. **Conceptual model of the potential responses of listed species upon exposure to an active acoustic sources, and the pathways by which those responses might affect the fitness of individual animals that have been exposed.**

Our conceptual model explicitly recognizes that other acoustic and non-acoustic stimuli that occur in an animal's environment might determine whether a focal stimulus is salient to a focal animal (the line connecting Box 2b to Box 2 in Figure 4). The salience of an acoustic signal will depend, in part, on its signal-to-noise ratio and, given that signal-to-noise ratio, whether an animal will devote attentional resources to the signal or other acoustic stimuli (or ambient sounds) that might compete for the animal's attention (the line connecting Box 2b to Box B1 in Figure 4).[2] That is, an acoustic signal might not be salient (1) because of a signal-to-noise ratio or (2) because an animal does not devote attentional resources to the signal, despite its signal-to-noise ratio. Absent information to the contrary, we generally assume that an acoustic stimulus that is "close" to an animal (within 10 – 15 kilometers) would remain salient regardless of competing stimuli and would compete for an animal's attentional resources. By extension, we also assume that any behavioral change we might observe in an animal would have been caused by a focal stimulus (the stimulus most immediately confronting the animal) rather than competing stimuli. However, as the distance between the source of a specific acoustic signal and a receiving animal increases, we assume that the receiving animal is less likely to devote attentional resources to the signal.

If we assume that an acoustic stimulus, such as a seismic or drilling source, was salient to an animal or population of animals, we would then ask how an animal might classify the stimulus as a cue about its environment (Box B2 in Figure 4) because an animal's response to a stimulus in its environment depends upon whether and how the animal converts the stimulus into information about its environment (Blumstein and Bouskila 1996, Yost 2007). For example, if an animal classifies a stimulus as a "predatory cue," that classification will invoke a suite of candidate physical, physiological, or behavioral responses that are appropriate to being confronted by a predator (this would occur regardless of whether a predator is, in fact, present).

By incorporating a more expansive concept of "hearing," our conceptual model departs from earlier models which have focused on the mechanical processes of "hearing" associated with structures in the ear that transduce sound pressure waves into vibrations and vibrations to electro-chemical impulses. That conception of hearing resulted in assessments that focus almost exclusively on active acoustic sources while discounting other acoustic stimuli associated with activities that marine animals might also perceive as relevant. That earlier conception of hearing also led to an almost singular focus on the intensity of the sound (its received level in decibels) as an assessment metric and noise-induced hearing loss as an assessment endpoint.

[2] See Blumstein and Bouskila (1996) for more of a review of the literature on how animals process and filter sensory information, which affects the subjective salience of sensory stimuli. See Clark and Dukas (2003), Dukas (2002), and Roitblat (1989) for more extensive reviews of the literature on attentional processes and the consequences of limited attentional resources in animals.

Among other considerations, the earlier focus on received level and losses in hearing sensitivity failed to recognize several other variables that affect how animals are likely to respond to acoustic stimuli:

1. "hearing" includes the cognitive processes an animal employs when it analyzes acoustic impulses (see (see Bregman 1990, Blumstein and Bouskila 1996, Hudspeth 1997, Yost 2007), which includes the processes animals employ to integrate and segregate sounds and auditory streams and the circumstances under which they are likely to devote attentional resources to an acoustic stimulus.

2. animals can "decide" which acoustic cues they will focus on and their decision will reflect the salience of a cue, its spectral qualities, and the animal's physiological and behavioral state when exposed to the cue.

3. animals not only perceive the received level (in dB) of a sound source, they also perceive their distance from a sound source. Further, animals are more likely to devote attentional resources to sounds that are close than sounds that are distant.

4. both received levels and the spectral qualities of sounds degrade over distance so the sound perceived by a distant receiver is not the same sound at the source.

As a result of this shift in focus, we have to consider more than the received level of a particular low- or mid-frequency wave form and its effects on the sensitivity of an animal's ear structure. We also have to distinguish between different auditory scenes; for example, animals will distinguish between sounds from a source that is moving away, sounds produced by a source that is approaching them, sounds from multiple sources that are all approaching, sounds from multiple sources that appear to be moving at random, etc.

Animals would then combine their perception of the acoustic stimulus with their assessment of the auditory scene (which include other acoustic stimuli), their awareness of their behavioral state, physiological state, reproductive condition, and social circumstances to assess whether the acoustic stimulus poses a risk and the degree of risk it might pose, whether it is impairing their ability to communicate with conspecifics, whether it is impairing their ability to detect predators or prey, etc. We assume that animals would categorize an acoustic source differently if the source is moving towards its current position (or projected position), moving away from its current position, moving tangential to its current position, if the source is stationary, or if there are multiple acoustic sources it its auditory field.

This process of "categorizing a stimulus" (Box B2 in Figure 4) lends meaning to a stimulus and places the animal in a position to decide whether and how to respond to the stimulus (Blumstein and Bouskila 1996). How an animal categorizes a stimulus will determine the set of candidate responses that are appropriate in the circumstances. That is, we assume that animals that categorizes a stimulus as a "predatory cue" would invoke candidate responses that consisted of anti-predator behavior rather than foraging behavior (Blumstein and Bouskila 1996, Bejder et al. 2009).

We then assume that animals apply one or more behavioral decision rules to the set of candidate responses that are appropriate to the acoustic stimulus as it has been classified (Box B3 in Figure 3). Our use of the term "behavioral decision rule" follows Blumstein and Bouskila (1996), and Lima and Dill (1990b), and is synonymous with the term "behavioral policy" of McNamara and Houston (1986b): the process an animal applies to determine which specific behavior it will select from the set of behaviors that are appropriate to the auditory scene, given its physiological and behavioral state when exposed and its experience. Because we would never know the behavioral policy of an individual, free- ranging animal, we treat this policy as a probability distribution function that matches a particular response in the suite of candidate behavioral responses.

Once an animal selects a behavioral response from a set of candidate behaviors, we assume that any change in behavioral state would represent a shift from an optimal behavioral state (or behavioral act) to a sub-optimal behavioral state (or behavioral act) as the animal responds to a stimulus such as acoustic sound sources. That selection of the sub-optimal behavioral state or act could be accompanied by *canonical costs*, which are reductions in the animal's expected future reproductive success that would occur when an animal engages in suboptimal behavioral acts (McNamara and Houston 1986b).

Specifically, canonical costs represent a reduction in current and expected future reproductive success (which integrates survival and longevity with current and future reproductive success) that would occur when an animal engages in a sub-optimal rather than an optimal sequence of behavioral acts; given the pre-existing physiological state of the animal in a finite time interval (McFarland and Sibly 1975, McNamara and Houston 1982, McNamara and Houston 1986a, Houston et al. 1993, McNamara 1993, McNamara and Houston 1996, Nonacs 2001, Crone et al. 2013). Canonical costs would generally result from changes in animals' energy budgets (Sapolsky 1997, Moberg 2000, McEwen and Wingfield 2003, Wingfield and Sapolsky 2003, Romero 2004), time budgets (Sutherland 1996, Frid and Dill 2002a), life history trade-offs (Cole 1954, Stearns 1992b), changes in social interactions (Sutherland 1996), or combinations of these phenomena (see Box B4 in Figure 4). We assume that an animal would not incur a canonical cost if they adopted an optimal behavioral sequence (see McNamara and Houston 1986a for further treatment and discussion).

This conceptual model does not require us to assume that animals exist in pristine environments; in those circumstances in which animals are regularly or chronically confronted with stress regimes that animals would adapt to by engaging in sub-optimal behavior, we assume that a change in behavior that resulted from exposure to a particular stressor or stress regime would either contribute to sub-optimal behavior or would cause animals to engage in behavior that is even further from optimal.

3.1.4 Risk Analysis

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 defined by the ESA. 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.
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 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.

The effects analyses of biological opinions consider the impacts on listed species and designated critical habitat that result from the incremental impact of an action by identifying natural and anthropogenic stressors that affect endangered and threatened species throughout their range (the *Status of the Species*) and within an action area (the *Environmental Baseline*, which articulates the pre-existing *impacts* of activities that occur in an action area, including the past, contemporaneous, and future *impacts* of those activities). We assess the effects of a proposed action by adding the direct and indirect effects to the *impacts* of the activities we identify in an *Environmental Baseline* (50 CFR 402.02), in light of the impacts of the status of the listed species and designated critical habitat throughout their range. As a result, our effects analyses are similar to those contained in the "cumulative impact" sections of NEPA documents.

3.1.5 Brief Background on Sound

Sound is a wave of pressure variations propagating through a medium (for this consultation, the sounds generated by seismic and electromechanical equipment propagates through marine water as its medium). Pressure variations are created by compressing and relaxing the medium. Sound measurements can be expressed in two forms: *intensity* and *pressure*. Acoustic intensity is the average rate of energy transmitted through a unit area in a specified direction and is expressed in watts per square meter. Acoustic intensity is rarely measured directly, it is derived from ratios of *pressures*; the standard reference pressure for underwater sound is 1 µPa; for airborne sound, the standard reference pressure is 20 µPa (Richardson et al. 1995).

Acousticians have adopted a logarithmic scale for sound intensities, which is denoted in decibels (dB). Decibel measurements represent the ratio between a measured pressure value and a reference pressure value (in this case 1 µPa or, for airborne sound, 20 µPa.). The logarithmic nature of the scale means that each 10 dB increase is a ten-fold increase in power (e.g., 20 dB is a 100-fold increase, 30 dB is a 1,000- fold increase). The term "sound pressure level" implies a decibel measure and a reference pressure that is used as the denominator of the ratio. Throughout this opinion, we use 1 µPa as a standard reference pressure unless noted otherwise.

It is important to note that decibels underwater and decibels in air are not the same and cannot be directly compared. Because of the different densities of air and water and the different decibel standards in water and air, a sound with the same intensity (i.e., power) in air and in water would be approximately 63 dB quieter in air.

Sound frequency is measured in cycles per second, or Hz, and is analogous to musical pitch; high-pitched sounds contain high frequencies and low-pitched sounds contain low frequencies. Natural sounds in the ocean span a huge range of frequencies: from earthquake noise at 5 Hz to harbor porpoise clicks at 150,000 Hz. These sounds are so low or so high in pitch that humans cannot hear them; acousticians call these infrasonic and ultrasonic sounds, respectively. A single sound may be made up of many different frequencies together. Sounds made up of only a small range of frequencies are called "narrowband," and sounds with a broad range of frequencies are called "broadband;" airguns are an example of a broadband sound source and sonars are an example of a narrowband sound source.

When considering the influence of various kinds of noise on the marine environment, it is necessary to understand that different kinds of marine life are sensitive to different frequencies of sound. Most dolphins, for instance, have excellent hearing at very high frequencies between 10,000 and 100,000 Hz. Their sensitivity at lower frequencies below 1000 Hz, however, is quite poor. On the other hand, the hearing sensitivity of most baleen whales appears to be best at frequencies between about between 20 Hz-5 kHz, with maximum sensitivity between 100-500 Hz (Erbe 2002b). As a result, baleen whales might be expected to suffer more harmful effects from low frequency noise than would dolphins.

When sound travels away from its source, its loudness decreases as the distance traveled by the sound increases. Thus, the loudness of a sound at its source is higher than the loudness of that same sound a kilometer distant. Acousticians often refer to the loudness of a sound at its source as the *source level* and the loudness of sound elsewhere as the *received level*. For example, a humpback whale 9 kilometers from an airgun that has a source level of 230 dB may only be exposed to sound that is 160 dB loud. As a result, is important not to confuse source levels and received levels when discussing the loudness of sound in the ocean.

As sound moves away from a source, its propagation in water is influenced by various physical characteristics, including water temperature, depth, salinity, and surface and bottom properties that cause refraction, reflection, absorption, and scattering of sound waves. Oceans are not homogeneous and the contribution of each of these individual factors is extremely complex and interrelated. Sound speed in seawater is generally about 1,500 meters per second (5,000 feet per second) although this speed varies with water density, which is affected by water temperature, salinity (the amount of salt in the water), and depth (pressure). The speed of sound increases as temperature and depth (pressure), and to a lesser extent, salinity, increase. The variation of sound speed with depth of the water is generally presented by a "sound speed profile," which varies with geographic latitude, season, and time of day.

Sound tends to follow many paths through the ocean, so that a listener may hear multiple, delayed copies of transmitted signals (Richardson et al. 1995). Echoes are a familiar example of this phenomenon in air. In order to determine what the paths of sound transmission are, one rule is to seek paths that deliver the sound to the receiver the fastest. If the speed of sound were constant throughout the ocean, acoustic rays would consist of straight-line segments, with reflections off the surface and the bottom. However, because the speed of sound varies in the ocean, most acoustic rays do not follow a straight path.

As sound travels through the ocean, the intensity associated with the wave front diminishes, or attenuates. In shallow waters of coastal regions and on continental shelves, sound speed profiles become influenced by surface heating and cooling, salinity changes, and water currents. As a result, these profiles tend to be irregular and unpredictable, and contain numerous gradients that last over short time and space scales. This decrease in intensity is referred to as propagation loss,

also commonly called transmission loss. In general, in a homogeneous lossless medium, sound intensity decreases as the square of the range due to simple spherical spreading. In other words, a source level of 235 dB will have decreased in intensity to a received level of 175 dB after about 914 meters (1,000 yards).

4. RANGEWIDE STATUS OF THE SPECIES AND CRITICAL HABITAT

Three species of marine mammals listed under the ESA under NMFS's jurisdiction may occur in the action area (Table 4).[3] The action area does not include designated critical habitat. Although the action area overlaps with proposed ringed seal critical habitat, proposed ringed seal critical habitat is not included in this consultation because the designation is not expected to be finalized in 2015.

Table 4. 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
Phoca hispida hispida (Arctic Ringed Seal)	Threatened	NMFS 2012, 77 FR 76706	Proposed designation, 79 FR 73010
Erignathus barbatus nauticus (Beringia DPS Bearded Seal)	Threatened	NMFS 2012, 77 FR76740	Not proposed

4.1 Climate Change

One threat is or will be common to all of the species we discuss in this opinion: global climate change. Because of this commonality, we present this narrative here rather than in each of the species-specific narratives that follow.

There is widespread consensus within the scientific community that atmospheric temperatures on earth are increasing and that this will continue for at least the next several decades (Watson and Albritton 2001, Oreskes 2004). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat waves, floods, storms, and wet-dry cycles. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average seal level (Pachauri and Reisinger 2007).

[3] On July 25, 2014, the US District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of bearded seals under the ESA (Alaska Oil and Gas Association v. Pritzker, Case NO. 4:13-cv-00018-RPB). The decision vacated NMFS's listing of the Beringia DPS of bearded seals as a threatened species. NMFS is appealing that decision. In the interim, our biological opinions under section 7 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 the proposed action on this DPS, even though the listing of the species is not in effect.

The Intergovernmental Panel on Climate Change (IPCC) estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). The IPCC reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the IPCC concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (Stocker et al. 2013).

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century (Watson and Albritton 2001). According to the IPCC (Stocker et al. 2013), it is likely that there has been an anthropogenic contribution to the very substantial Arctic warming over the past 50 years. In addition, anthropogenic forcings are very likely to have contributed to Arctic sea ice loss since 1979 (Stocker et al. 2013).

The rate of decline of Arctic sea ice thickness and September sea ice extent has increased considerably in the first decade of the 21st century (Stocker et al. 2013). It is estimated that three quarters of summer Arctic sea ice volume has been lost since the 1980s (Stocker et al. 2013). There was also a rapid reduction in ice extent, to 37% less in September 2007 and 49% less in September 2012 relative to the 1979-2000 climatology (Stocker et al. 2013). All recent years have ice extents that fall at least two standard deviations below the long-term sea ice trend (Stocker et al. 2013).

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Houghton 2001, McCarthy 2001, Parry 2007). Climate change would result in increases in atmospheric temperatures, changes in sea surface temperatures, changes in patterns of precipitation, and changes in sea level (Stocker et al. 2013).

The indirect effects of climate change for listed marine mammals would result from changes in the distribution of temperatures suitable for many stages of their life history, the distribution and abundance of prey, and the distribution and abundance of competitors or predators. For example, variations in the recruitment of krill (*Euphausia superba*) and the reproductive success of krill predators have been linked to variations in sea-surface temperatures and the extent of sea-ice cover during the winter months. Thinning and reduced coverage of Arctic sea ice are likely to substantially alter ecosystems that are in close association with sea ice (Loeng et al. 2005). A decrease in the availability of suitable sea ice conditions may not only lead to high mortality of ringed seal pups but may also produce behavioral changes in seal populations (Loeng et al. 2005). Changes in snowfall over the 21st century were projected to reduce ringed seal habitat for lairs by 70% (Hezel et al. 2012). Bowhead whales are dependent on sea-ice organisms for feeding and polynyas for breathing, so the early melting of sea ice may lead to an increasing mismatch in the timing of these sea-ice organisms and secondary production (Loeng et al. 2005).

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).

4.2 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 seismic surveys. 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 as a starting point for our analysis of whether 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). Cameron et al. (2010) and Kelly *et al.* (2010b) 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 on the marine animals considered in this opinion.

4.2.1 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 range 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 et al. 2003b). 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 5). 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 et al. 2009, Clarke et al. 2011c).

In the Chukchi Sea, bowheads are generally found in waters between 50 and 200 m deep (Clarke and Ferguson. 2010b). However, individuals in the Beaufort Sea appear to strongly favor shallower areas less than 50 m and preferably shallower than 20 m (Clarke and Ferguson. 2010a). Feeding appears to preferentially occur in 154-157º longitude in the Beaufort Sea (Clarke and Ferguson. 2010a). Hauser et al. (2008) conducted surveys for bowhead whales near the Colville River Delta during August and September 2008, and found most bowheads between 25 and 30 kilometers (15.5 and 18.6 miles) north of the barrier islands (Jones Islands), with the nearest in 18 meters (60 feet) of water about 25 kilometers (16 miles) north of the Colville River Delta. No bowheads were observed inside the 18-meter (60-foot) isobath.

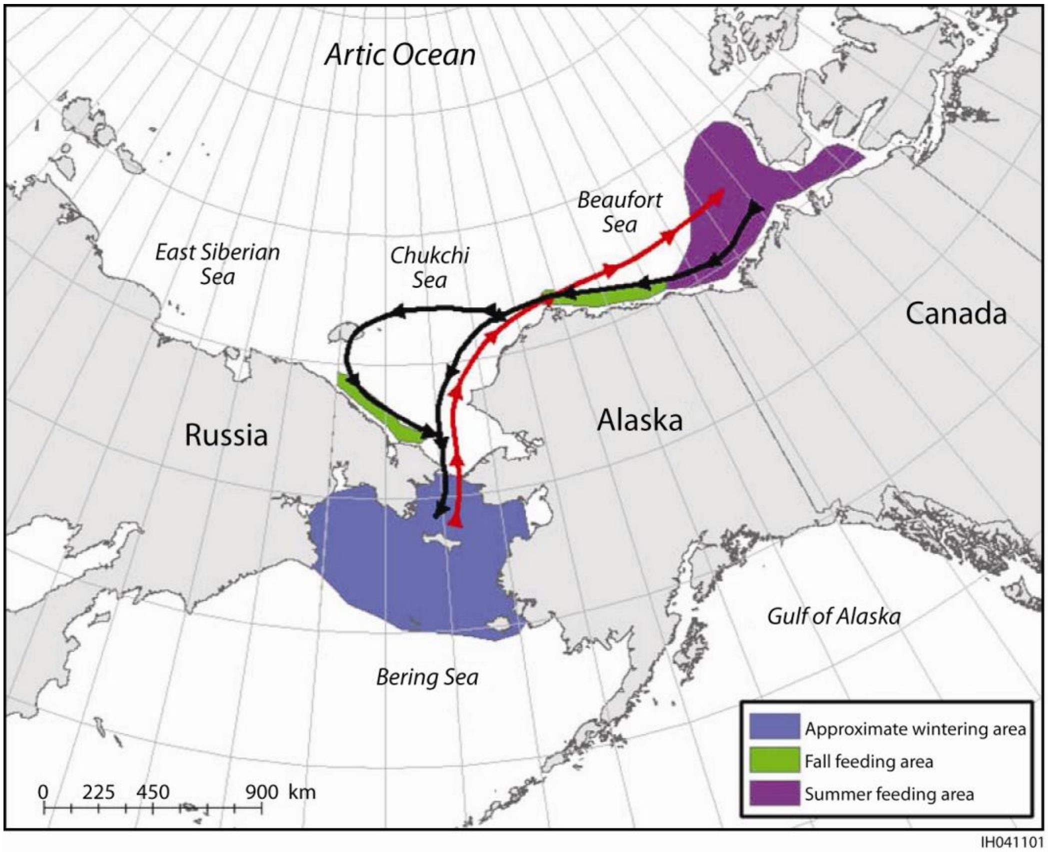

Figure 5. Generalized Migration Route, Feeding Areas, and Wintering Area for Western Arctic Bowhead Whale

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 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 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 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 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 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 also been targeted by subsistence whaling. Subsistence harvest is regulated by quotas set by the International Whaling Commission (IWC) and is allocated and enforced 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 ten Alaska communities(Philo et al. 1993, Suydam et al. 2011).

Canadian and Russian Natives also 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 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 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 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 et al. 1993). Several cases of rope or net entanglement have been reported from whales taken in the subsistence hunt (Philo 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 2013). During the 2011 spring aerial survey of bowhead near Point Barrow, one entangled bowhead was photographed (Mocklin 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 et al. 2001). About 1% of the bowhead whales taken by Alaskan Inupiat bore scars from ship strikes (George 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 et al. 1993, Richardson and Malme 1993, Richardson 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 (2006b) 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 et al. 2013) Similarly, Schweder et al. (2010a) 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 et al. 2004a) 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 et al. 2013). See Table 5 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 2006a).

Table 5. 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 annual rate of increase for this stock of bowhead whales is 3.2-3.4% (George et al. 2004a, Schweder et al. 2010a). (Wade and Angliss 1997) recommend using the cetacean maximum theoretical net productivity rate (R_{max}) of 4% for the Western Arctic stock of bowhead.[4]

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 et al. 2004a). 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 reliable 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).

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[4] The estimate for the current rate of increase for this stock (3.2-3.4%) should not be used as an estimate of R_{max} 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 and Angliss 2013).

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) 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 et al. 1993), and recovery is described as “at best, exceedingly slow” (Davis and Koski 1980). No reliable 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 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 et al. 1993, Reese et al. 2001b). 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 et al. 1984). Growth for both sexes slows markedly at about 40 to 50 years of age (George 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). 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 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, 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. et al. 2013).

Feeding and Prey Selection

Bowheads are filter feeders, filtering prey from the water through baleen (Lowry 1993a). They feed throughout the water column, including bottom feeding as well as surface skim feeding (Würsig et al. 1989). Skim feeding can occur when animals are alone or may occur in coordinated echelons of over a dozen animals (Würsig 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 et al. 2010a). 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 et al. 2004, Moore 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 et al. 1986, Lowry 1993b). 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 et al. 1987, Ljungblad 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 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 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 et al. 2010, Moore et al. 2010, Okkonen et al. 2011). Lowry (1993b) reported that the stomachs of 13 out of 36 spring-migrating bowheads harvested near Point Barrow between 1979 through 1988 contained food. Lowry (1993b) estimated total volumes of contents in stomachs ranged from less than 1 to 60 liters (L), with an average of 12.2 L in eight specimens. Shelden and Rugh (1995) concluded that “In years when oceanographic conditions are favorable, the lead system near Barrow may serve as an important feeding ground in the spring (Carroll et al. 1987).” Richardson and Thomson (2002) concluded that some, probably limited, feeding occurs in the spring.

The area near Kaktovik appears to be one of the areas important to bowhead whales primarily during the fall (NMFS 2010b). BOEM-funded Bowhead Whale Feeding Ecology Study (BWASP) surveys show areas off Kaktovik as areas that are sometimes of high use by bowhead whales (NMFS 2010a, Clarke et al. 2011a)). Data recently compiled by Clarke *et al.* (2012) further illustrate the frequency of use of the area east of Kaktovik by bowhead mothers and calves during August, September, and October.

Industry funded aerial surveys of the Camden Bay area west of Kaktovik reported a number of whales feeding in that region in 2007 and 2008 (Christie et al. 2009); however, more recent Aerial Surveys of Arctic Marine Mammals (ASAMM) surveys have not noted such behavior in Camden Bay. While data indicate that bowhead whales might feed almost anywhere in the Alaskan Beaufort Sea within the 50-m isobath, feeding in areas outside of the area noted between Smith Bay and Point Barrow and/or in Barrow Canyon are ephemeral and less predictable (J. Clarke, pers. comm. 2013).

Bowhead whales feed in the Canadian Beaufort in the summer and early fall (e.g., (Würsig et al. 1989), and in the Alaskan Beaufort in late summer/early fall, (Lowry and Frost 1984, Ljungblad et al. 1986, Schell and Saupe 1993, Lowry et al. 2004, Ashjian et al. 2010, Clarke et al. 2011c, a, b, Clarke et al. 2011d, Okkonen et al. 2011, Clarke et al. 2012). Available information indicates it is likely there is considerable inter-annual variability in the locations where feeding occurs during the summer and fall in the Alaska Beaufort Sea, in the length of time individuals spend feeding, and in the number of individuals feeding in various areas in the Beaufort Sea.

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 et al. 2003a). Ireland et al. (2009) also reported bowhead sightings in 2006 and 2007 during summer aerial surveys in the Chukchi Sea.

The Inupiat believe that whales follow the ocean currents carrying food organisms (e.g., (Napageak 1996). Bowheads have been observed feeding not more than 1,500 feet (ft) offshore in about 15-20 ft of water near Point Barrow (Rexford 1997). Nuiqsut Mayor Nukapigak testified in 2001 that he and others saw a hundred or so bowhead whales and gray whales feeding near Northstar Island (MMS 2002). Some bowheads appear to feed east of Barter Island as they migrate westward (Thomson and Richardson 1987).

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 et al. 2011b). During this survey, a group of 180 bowhead whales were seen feeding and milling (Clarke et al. 2011b).

Bowhead whale calls might help maintain social cohesion of groups (Wursig and Clark 1993). (Würsig 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 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 et al. 1987, George 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 et al. 2012). Their skull morphology allows them to break through ice up to 18 cm thick to breathe in ice covered waters (George et al. 1989).

Bowhead whales are grouped among low frequency functional hearing baleen whales (Southall 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 2002b). Vocalization bandwidths vary. Tonal FM modulated vocalizations have a bandwidth of 25 to 1200 Hz with the dominant range between 100 and 400 Hz and lasting 0.4- 3.8 seconds. 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 2002b). 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 1986b, Au et al. 2006, Southall et al. 2007, Ciminello 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 et al. 2012). Given background noise, this allows bowheads whales an active space of 40-130 km (Roulin 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 et al. 2007b). 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 et al. 2011). The authors suggest that bowheads may use their sense of smell to find dense aggregations of krill upon which to prey.

4.2.2 Arctic Ringed Seal

Population Structure

A single Alaskan stock of ringed seal is 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 et al. 1988, Kelly et al. 2010b). 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 et al. 2003, Freitas 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 et al. 2004, Kelly et al. 2010a).

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 et al. 2008, Kelly et al. 2010b). 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 the species' Status Review (Kelly et al. 2010b) 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.

<u>Predation.</u> 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 et al. 1976b, Fay et al. 1990, Derocher 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).

<u>Parasites and Diseases.</u> 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. Kelly *et al.* (2010b) 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 are the greatest challenges to the persistence of Arctic ringed seals. Within this century, snow cover was 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 et al. 2010b).

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 et al. 2010b).

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 Alaska Natives in 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 being collected and no new annual harvest estimates exist. Kelly *et al.* (2010b) concluded that although subsistence harvest of Arctic ringed seals is currently substantial in some parts of their range, harvest levels appear 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).

Kelly et al. (2010b) 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 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, since they are closely associated with ice throughout the year. 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 and in State waters. 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 been documented from research to ringed seals (Allen and Angliss 2014).

The large range and population size of the Arctic subspecies make it less vulnerable to other perturbations, such as hunting, fisheries interactions, and research takes. Therefore, at the time of listing, ESA Section 4(d) protective regulations and Section 9 prohibitions were deemed unnecessary for the conservation of the species (77 FR 76706).

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).

There are no precise 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.* (2010b) indicated that a reasonable estimate for the Chukchi and Beaufort Seas is 1 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 252,000 seals in 1999 and 208,000 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 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 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 et al. 1980, Holst 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 et al. 1980, Smith 1987, Holst et al. 2001, Labansen et al. 2007). Quakenbush *et al.* (2011b) 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 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 6 summarizes the approximate annual timing of reproduction and molting for Arctic ringed seals.

Arctic Ringed Seals

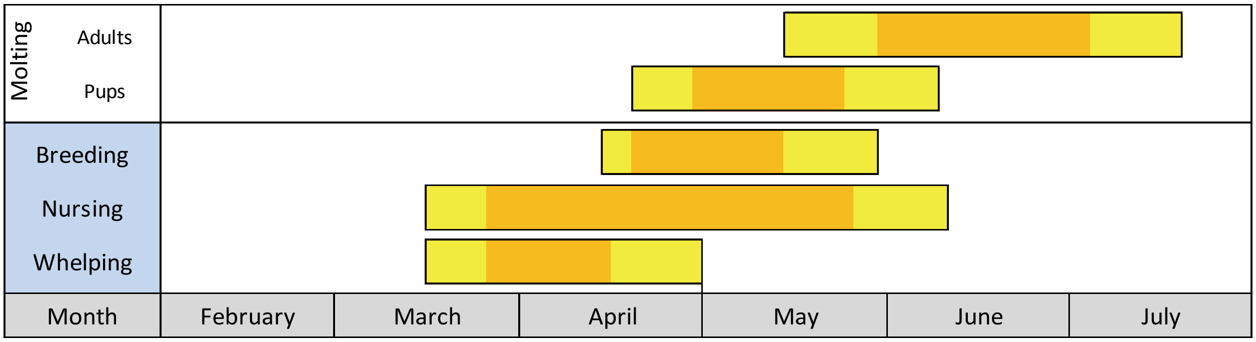

Figure 6. **Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicated the "peak" timing of each event (source: (Kelly et al. 2010b).**

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 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 et al. 1999) and to depths of over 500 m (Born 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 et al. 1999, Gjertz et al. 2000a). 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 et al. 1999, Carlens et al. 2006, Kelly et al. 2010b). 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 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 et al. 2006, Kastelein et al. 2009, NOAA 2013). The airgun sound sources being proposed for this action are anticipated to be 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 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 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 et al. 2010b). 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 et al. 2010b).

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. There is a direct coupling through the vestibule of the vestibular and auditory systems; therefore, 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 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). 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 et al. 1997). 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 et al. 1998). Sound waves could be received by way of the blood sinuses and by tissue conduction through the vibrissae (Riedman 1990).

4.2.3 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 et al. 1976a). Geographic boundaries for the divisions between the two subspecies are subject to the caveat that distinct boundaries do not appear to exist (Cameron 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 et al. 1966, Burns 1967, Burns and Frost 1979, Frost et al. 1979, Burns 1981, Smith 1981, Kelly 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 et al. 1976a, Fedoseev 1984, Nelson 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 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, 1981, Nelson 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 et al. 1976a, Burns 1981).

Threats to the Species

Threats to the Beringia DPS of bearded seal are described in detail the species' Status Review (Cameron 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.

Predation. 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 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. 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 will be 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 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 Alaska Natives in northern communities (Hart and Amos 2004, ACIA 2005, Hovelsrud 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. There is currently no commercial harvest of bearded seals and significant harvests seem unlikely in the foreseeable future.

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 et al. 1988). Allen and Angliss (2013)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 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 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 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 2009, 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, since they are closely associated with ice throughout the year. 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 2003-2007, there was 1 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, and Conservation 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 currently 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 the decision.

The present population of the Beringia DPS is highly uncertain, it has been estimated to be about 155,000 individuals (Cameron et al. 2010). Based on extrapolation from existing aerial survey data, Cameron et al. (2010) considered the current population of bearded seals in the Bering Sea to be about double the 63,200 estimate reported by Ver Hoef et al. (2010); corrected for seals in the water) for U.S. waters, or approximately 125,000 individuals. In addition, Cameron et al. (2010) derived crude estimates of: 3,150 bearded seals for the Beaufort Sea (uncorrected for seals in the water), which was noted as likely a substantial underestimate given the known subsistence harvest of bearded seals in this region; and about 27,000 seals for the Chukchi Sea based on extrapolation from limited aerial surveys (also uncorrected for seals in the water).

Reliable 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, and 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 et al. 1988, Reeves et al. 1992, Hjelset et al. 1999, Cameron et al. 2010). They primarily feed on or near the bottom, diving is 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 et al. 2000b). 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 et al. 2006, Marshall 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 et al. 1988).

Quakenbush et al. (2011a) 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 et al. 2011a). 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.

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 et al. 2000b, Krafft 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 et al. 2000b). Adult females spent most of their dive time (47-92%) performing U-shaped dives, believed to represent bottom feeding (Krafft et al. 2000); U-shaped dives are also common in nursing pups (Lydersen et al. 1994b).

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 et al. 1976a). 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.1 This is similar to both male and female young-of-year bearded seals instrumented in Kotzebue Sound, Alaska (Frost 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 et al. 2008) while adults favored afternoon.[5]

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 (Holsvik 1998, Krafft et al. 2000), while dependent pups spent about 50% of their time in the water, split between the surface (30%) and diving (20%) (Lydersen et al. 1994b, Lydersen et al. 1996, Watanabe et al. 2009). The time spent in water during the nursing period is remarkable when compared to most other sympatric phocids, such as harp (*Pagophilus groenlandica)*; (71%:0%), grey (*Halichoerus grypus)*; (28%:0%), and hooded seals (0%:0%); however, it is similar to that of ringed seals (*Phoca hispida)*; (mothers 82% : pups 50%) (Lydersen and Hammill 1993, Lydersen et al. 1994b, a, Lydersen 1995, Lydersen and Kovacs 1999, Krafft et al. 2000). 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 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 et al. 2000). This diurnal pattern also coincides with the timing of underwater mating calls by breeding

[5] M. Cameron, Unpubl. data, National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, as cited in (Cameron et al. 2010).

males (Cleator et al. 1989, Van Parijs 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 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 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 et al. 1983, Atkinson 1997, Risch 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 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 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 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 et al. 1997).

The facial whisker pads of bearded seals have 1300 nerve endings associated with each whisker, making them among the most sensitive in the animal kingdom (Marshall 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. Harbor seals have the known ability to detect and follow hydrodynamic trails out to 180 meters away (Dehnhardt et al. 2001) and research data supports the position that pinniped vibrissae are sensitive active-touch receptor systems enabling seals to distinguish between different types of trail generators (i.e. prey items, currents) (Supin et al. 2001, Marshall et al. 2006, Wieskotten et al. 2010). Mills and Renouf (1986) determined harbor seal vibrissae are least sensitive at lower frequencies (100, 250, and 500 Hz), and more sensitive at higher frequencies (750+ Hz) where the smallest detectable vibration occurred at 1000 Hz. Bearded seal vibrissae may prove to be sensitive at similar frequencies as harbor seals.

Most phocid seals spend greater than 80% of their time submerged in the water (Gordon 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 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 et al. 1989, Van Parijs et al. 2001, Van Parijs 2003, Van Parijs et al. 2003, Van Parijs 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 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 et al. 2006, Kastelein et al. 2009, NOAA 2013).

5. 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 may continue to affect populations of endangered whales and threatened ice seals.

5.1 Stressors for Species in the Action Area

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

5.1.1 Targeted Hunts

Historical Commercial Hunting

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 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.

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.

<u>Subsistence Harvest</u>

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 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 each landed only one. Alaska Natives landed 37 bowheads in 2004 (Suydam et al. 2005, 2006), 55 in 2005 (Suydam et al. 2006), 31 in 2006 (Suydam et al. 2007), 41 in 2007 (Suydam et al. 2008), and 38 in 2008 (Suydam et al. 2009), 31 in 2009 (Suydam et al. 2010), 45 in 2010 (Suydam et al. 2011), and 38 in 2011 (Suydam 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 et al. 2011), and in 2011 it was 76% (Suydam 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.

Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. Repulse Bay has had four successful harvests since 1996, the latest occurring August 2012. Eight whales were harvested by Russian subsistence hunters between 1999-2005 (Borodin 2005, IWC 2007). No catches were reported by either Canadian or Russian hunters for 2006-2007 (IWC 2008) or by Russia in 2009 (IWC 2010), but two bowheads were taken in Russia in 2008 (IWC 2009), and in 2010 (IWC 2011). The annual average subsistence take (by Natives of Alaska, Russia, and Canada) during the 5-year period from 2006 to 2010 was 38 bowhead whales (Allen and Angliss 2013).

Ringed Seal

Ringed seals are an important species for Alaska Native subsistence hunters. The estimated annual subsistence harvest in Alaska dropped from 7,000 to 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 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. (2010b) concluded that although subsistence harvest of Arctic ringed seals is currently substantial in some parts of their range, harvest levels appear 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 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 has been compiled for 129 villages from reports from the Division of Subsistence (Coffing et al. 1998, Georgette 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). Data on community subsistence harvests are no longer being collected and no new annual harvest estimates exist.

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 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 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).

5.1.2 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).

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 et al. 1969b, Stirling 1983, Richardson 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 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.

<u>Anthropogenic Noise</u>. 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 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 et al. 1995, NRC 1996, NRC 2000, NRC 2003, Jasny 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).

<u>Sounds from Vessels</u>. 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 Sea, 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 et al. 2015). Broadband source levels for icebreaking operations are anticipated to be ~198 dB re 1 µPa at 1m (Austin 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 et al. 2015).

<u>Sound from Oil and Gas Activities</u>. Anthropogenic noise levels in the Beaufort Sea region 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, on-ice, and in-ice seismic surveys in the 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/3D seismic survey with multiple guns would emit sound at frequencies at about 10 Hz-3 kHz (Austin 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, 1999, Thode et al. 2010). While seismic energy does have the capability of propagating for long distances it generally decreases to a level at or below the ambient noise level at a distance of 10 km from the source (Richardson 1998, 1999, Thode et al. 2010). The shelf region in the Beaufort Sea (water depths 10-250m) has similar depth and acoustic properties to the Chukchi shelf environment. Recent seismic surveys have been performed on the Beaufort Sea shelf in Camden and Harrison Bays that have generated exploration noise footprints similar to those produced by exploration over the Chukchi Sea lease areas.

Since July 2010, NMFS issued an IHA to Shell to take 8 species of marine mammals by Level B behavioral harassment incidental to conducting site clearance and shallow hazards surveys in the Beaufort Sea on August 6, 2010 (75 FR 49710; August 13, 2010). No seismic surveys were conducted in the Beaufort Sea in 2011. In 2012, NMFS issued an IHA to BP Exploration (Alaska), Inc. (BPXA) and ION Geophysical (ION) to take small numbers of marine mammals by harassment incidental to conducting open-water 3D OBC seismic surveys in the Simpson Lagoon of the Beaufort Sea (77 FR 40007; July 6, 2012) and in-ice 2D seismic surveys in the Beaufort and Chukchi Seas (77 FR 65060; October 24, 2012), respectively. NMFS issued two IHAs to BPXA for 3D seismic operations in Prudhoe Bay (79 FR 36730) and 2D seismic geohazard surveys in Foggy Island Bay in the Beaufort Sea (79 FR 36769) in 2014. The Prudhoe Bay IHA allowed for up to 6 instances of seismic exposure to bowhead whales, 87 instances of seismic exposure to bearded seals, and 324 instances of seismic exposure to ringed seals associated with 3D seismic surveys. The Foggy Island Bay IHA allowed for up to one instance of exposure to bowhead whales, 19 instances of exposure to bearded seals, and 71 instances of exposure to ringed seals associated with 2D seismic geohazard surveys. In addition in 2014, NMFS issued an IHA to SAE for 3D seismic operations in the Coleville River delta (79 FR 51963). The Coleville River IHA allowed for up to 131 instances of seismic exposure to bowhead whales, 32 instances of seismic exposure to bearded seals, and 638 instances of seismic exposure to ringed seals associated with 3D seismic surveys. The proposed action is similar to activities conducted previously in the Beaufort Sea.

The Arctic Regional Biological Opinion (ARBO) issued in 2013, was a programmatic incremental step consultation with BOEM/BSEE that covered oil and gas leasing and exploration activities in the Beaufort and Chukchi Sea Planning Areas over a 14-year period. ARBO covered on and off lease deep penetration marine seismic and geohazard surveys as well exploration drilling in the Chukchi and Beaufort Sea Planning Areas. Under ARBO (NMFS 2013a), annual takes by harassment associated with marine seismic and geohazard surveys in the Beaufort Sea is anticipated to be (368) bowhead whales, (3,740) ringed seals, and (1,516) bearded seals.

Oil and gas exploration has also occurred in the eastern Beaufort Sea, off the Mackenzie River Delta and in the Arctic Islands. Characteristics are similar to exploration activities in Alaska (shallow hazards, site clearance, 2D and 3D seismic surveys, exploratory drilling), except that the majority of support is provided by road access and coastal barges. 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 (NMFS 2013c).

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 et al. 2005). NMFS is not aware of data that indicate that such avoidance is long-lasting after cessation of the activity (NMFS 2013b).

Sound levels produced by drillships were modeled based on measurements from *Northern Explorer II*. The modeled sound-level radii 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). The area estimated to be exposed to ≥160 dB at the modeled drill sites would be ~0.01 km^2 (0.004 mi^2). 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 (Greene and Moore 1995). There currently are no oil-production facilities in the Chukchi Sea. However, in state waters of the Beaufort Sea, there are three operating oil-production facilities (Northstar, Oooguruk, Nikaitchug) and two production facilities on a man-made peninsula/causeway. Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km (2.5 mi) and often not detectable beyond 9.3 km (5.8 mi) away. Studies conducted as part of a monitoring program for the Northstar project (a drilling facility located on an artificial island in the Beaufort Sea) indicate that in one of the 3 years of monitoring efforts, the southern edge of the bowhead whale fall migration path may have been slightly (2-3 mi) farther offshore during periods when higher sound levels were recorded; there was no significant effect of sound detected on the migration path during the other two monitored years (Richardson et al. 2004). Evidence indicated that deflection of the southern portion of the migration in 2001 occurred during periods when there were certain vessels in the area and did not occur as a result of sound emanating from the Northstar facility itself (BOEM 2011).

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 transien sounds that vary widely in intensity and frequency (BOEM 2011).

5.1.3 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) (see Figure 7).

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. 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). In addition, some of this nearshore traffic in the Beaufort is likely attributable to the ongoing construction by Exxon at Point Thompson for a gas condensate facility, which has required barge deliveries from Prudhoe Bay (ICCT 2015).

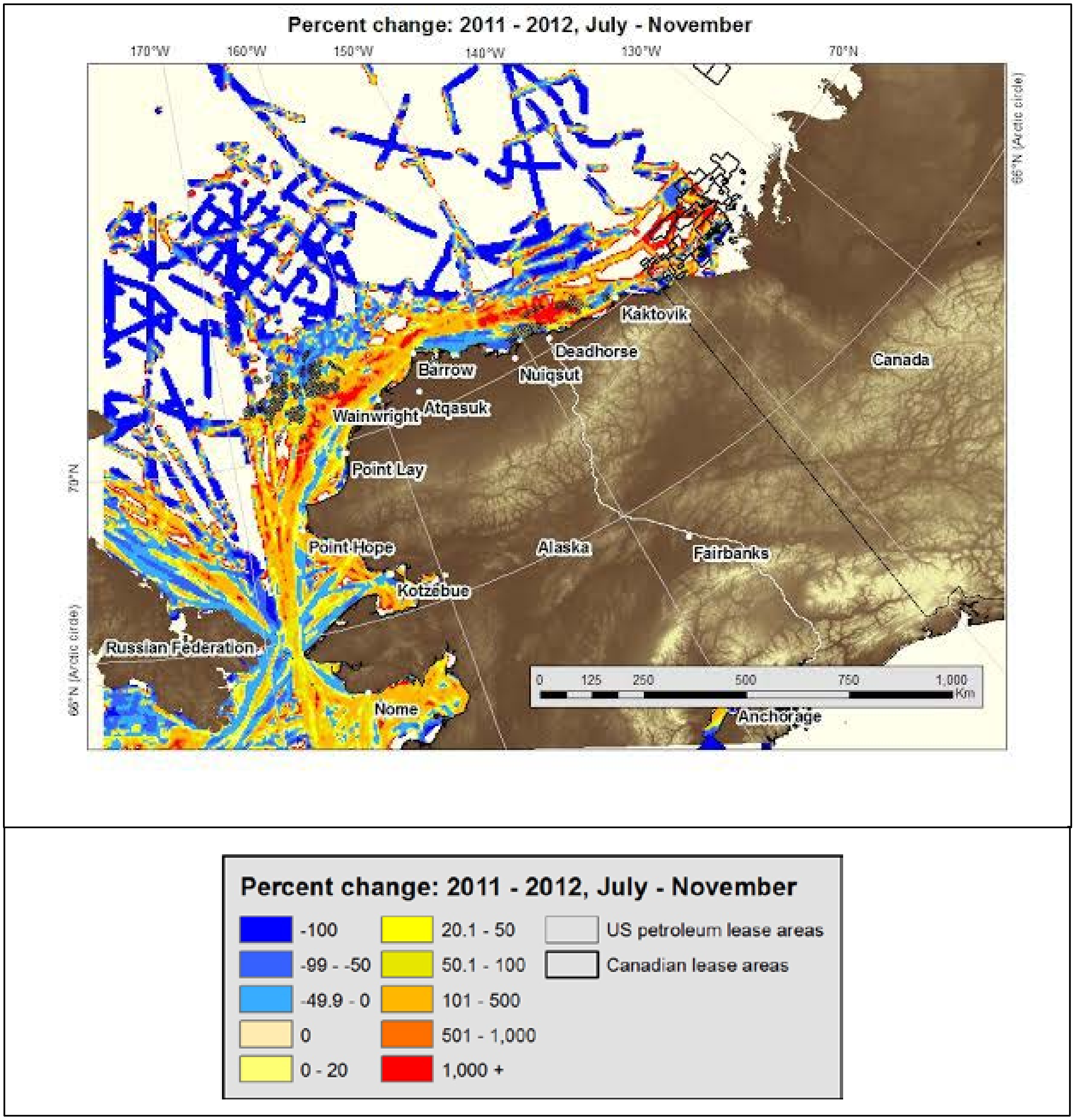

Figure 7. **Percent difference in vessel activity from 2011 to 2012 using 5 km grid cells (ICCT 2015).**

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 2010c). 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.

The frequency of observations of vessel-inflicted injuries suggests that the incidence of ship collisions with bowhead whales is 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 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.

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 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 single 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. However, no icebreakers are associated with the proposed action.

5.1.4 Commercial Fishing Interaction

While currently no commercial fishing is authorized in the Beaufort 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 Beaufort Sea.

Bowhead Whale

Several cases of rope or net entanglement have been reported from bowhead whales taken in the subsistence hunt (Philo 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 et al. 2011). During the 2011 spring aerial photographic survey of bowhead whales near Point Barrow, one entangled bowhead was photographed (Mocklin 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.

Ringed Seal

Until 2003, 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 2003, changes in fishery definitions in the List of Fisheries have resulted in separating these three fisheries into 12 fisheries (69 FR 70094, 2 December 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 (see Table 6) (Allen and Angliss 2014).

Table 6. Summary of incidental mortality of ringed seals (Alaska stock) due to commercial fisheries from 2007 to 2011 and calculation of the mean annual mortality rate (Allen and Angliss 2014).

Fishery name	Years	Data type	Observer coverage	Observed mortality (in given yrs.)	Estimated mortality (in given yrs.)	Mean annual mortality
BSAI flatfish trawl	2007 2008 2009 2010 2011	obs data	72 100 100 100 100	0 2 1 0 6 (+1)*	0 2.0 1.0 0 6.0 (7)**	2.0 (CV = 0.02)
BSAI pollock trawl	2007 2008 2009 2010 2011	obs data	85 85 86 86 98	0 1 1 0 3	0 1.0 1.0 0 3.0	1.0 (CV = 0.04)
BSAI Pacific cod trawl	2007 2008 2009 2010 2011	obs data	53 59 63 66 60	0 0 0 0 1	0 0 0 0 1.0	0.2 (CV = 0.01)
BSAI Pacific cod longline	2007 2008 2009 2010 2011	obs data	63 63 60 64 57	0 0 0 0 1	0 0 0 0 1.6	0.32 (CV = 0.06)
Total estimated annual mortality						3.52 (CV = 0.06)

*Total mortalities observed in unsampled hauls
** Total mortalities observed in sampled and unsampled hauls. Since the total known mortality (7) exceeds the estimated mortality (6.0) for 2011, the sum of actual mortalities observed (7) will be used as a minimum for that year.

Bearded Seal

Similar to ringed seals, the monitoring of incidental serious injury or mortality of bearded seals changed as of 2004, and provided managers a better insight into how each fishery in Alaska was potentially impacting the species (Allen and Angliss 2014). As of 2004, changes in fishery definitions in the List of Fisheries have resulted in separating the three fisheries that could have interacted with bearded seals into 12 fisheries (69 FR 70094).

Between 2007 and 2011, there were incidental serious injuries and mortalities of bearded seals in the BSAI pollock trawl and the BSAI flatfish trawl (Table 7). 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).

Table 7. Summary of incidental mortality of bearded seals (Alaska stock) due to commercial fisheries from 2007-2011 and calculation of the mean annual mortality rate. Details of how percent observer coverage is measured is included in (Allen and Angliss 2014).

Fishery Name	Year	Data Type	Observer Coverage	Observed Mortality	Estimated Mortality	Mean Annual Takes (CV in parentheses)
BSAI Pollock Trawl	2007 2008 2009 2010 2011	Obs. data	85 85 86 86 98	1 4 1 0 (+1)* 0	1.0 4.1 1.0 0 (1)** 0	1.4 (CV=0.06)
BSAI Flatfish Trawl	2007 2008 2009 2010 2011	Obs. data	72 100 100 100 100	0 1 0 0 1	0 1.0 0 0 1.0	0.4 (CV= 0.03)
Total Estimated Annual Mortality						1.8 (CV= 0.05)

*Total mortalities observed in unsampled hauls.
**Total mortalities observed in sampled and unsampled hauls. Since the total known mortality (1) exceeds the estimated mortality (0) for 2010, the sum of actual mortalities observed (1) will be used as a minimum estimate for that year.

5.1.5 Pollutants and Contaminants

Authorized Discharges

Existing development in the action area provides multiple sources of contaminants that may be bioavailable (NMFS 2013c). 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 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 et al. 2010).

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) issued an NPDES Vessel General Permit (VGP) for “Discharges Incidental to the Normal Operation of a Vessel” for Alaska was finalized in February, 2009. 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.

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.

NMFS consulted on the issuance of the new 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 2012a, b).

Accidental Discharges- Oil Spills and Gas Releases

Offshore petroleum exploration activities have been conducted in State of Alaska waters and the OCS of the Beaufort and Chukchi Sea Planning Areas since the late 1960s. Small oil spills have occurred with routine frequency and are considered likely to occur during the first incremental step as well as subsequent stages (BOEM 2015b). Small spills during exploration activities are expected to be small and consist of refined oils because crude and condensate oil would not be produced during exploration (BOEM 2015a).

From 1971-2010 industry drilled 84 exploration wells in the entire Alaska OCS (BOEM 2011). Within the action area of 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).

No exploratory drilling blowouts have occurred on the Alaskan OCS. However, one exploration drilling blowout of shallow gas occurred on the Canadian Beaufort Sea out of the 85 exploratory wells that were drilled in the Canadian Beaufort Sea (BOEM 2011).

Contaminants in Bowhead Whales, Ringed Seals, and Bearded Seals

Bowhead Whale

Some environmental contaminants, such as chlorinated pesticides, are lipophilic and can be found in the blubber of marine mammals (Becker et al. 1995). Tissues collected from whales landed at Barrow in 1992 (Becker et al. 1995) indicate that bowhead whales have very low levels of mercury, polychlorinated biphenyls (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.

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.

Heavy metals such as mercury, cadmium, lead, selenium, arsenic, and nickel accumulate in ringed seal vital organs, including liver and kidneys, as well as in the central nervous system (Kelly et al. 2010b). 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) report 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 Artic (Tynan and DeMaster 1997).

5.1.6 Research

The NMFS Permits Division has issued scientific research permits, for activities that 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.

5.1.7 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 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 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 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. 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.

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 man-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 et al. 2010b).

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. 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.

5.2 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 in the 19^{th} and early 20^{th} centuries 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 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 can 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 estimations 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 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.

6. EFFECTS OF THE ACTION

"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.

This biological opinion relies on the best scientific and commercial information available. We try to make 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).

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 SAE's proposed activity.

We conclude this section 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.

The ESA does not define "harassment" nor has NMFS defined this term, pursuant to the ESA, through regulation. 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" 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." For the purposes of this consultation, "harassment" is assumed to occur when marine mammals are exposed to certain sound levels described above.

6.1 Project Stressors

Seismic surveys have been conducted in the Chukchi and Beaufort Seas since the late 1960s and early 1970s, resulting in extensive coverage over the area. NMFS 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 seismic surveys since the early 1990s. The seismic surveys SAE plans to conduct during the open water season in 2015 are similar to the data acquisition programs conducted in the Beaufort Sea by Shell beginning in 2006, and BP beginning in 2008, and ION Geophysical beginning in 2012, and BPXA and SAE in 2014. Thus, the potential stressors associated with the activities NMFS PR1 may authorize have occurred previously in the action area.

During our assessment, we considered several potential stressors associated with the proposed action. Based on our review of the data available, 3D OBN seismic surveys and vessel activities may cause these primary stressors:

1. sound fields produced by continuous noise sources such as: source vessels, equipment deployment and retrieval vessels, housing and transport vessels, and mitigation vessel;

2. pulsed sounds from 3D OBN seismic surveys, pingers, and transponders; and

3. risk of collisions associated with proximity to the vessels involved in those exploration activities.

6.2 Acoustic Thresholds and Definitions of Harassment

Since 1997, NMFS has used generic sound exposure thresholds to determine whether an activity produces underwater and in-air sounds that might result in impacts to marine mammals (70 FR 1871). NMFS is currently developing comprehensive guidance on sound levels likely to cause injury and behavioral disruption to marine mammals (NOAA 2013). However, until formal guidance is available, NMFS uses conservative thresholds of sound pressure levels from broad band sounds that cause behavioral disturbance (160 dB rms re: 1μPa for impulse sound and 120 dB rms re: 1μPa for continuous sound) and injury (180 dB rms re: 1μPa for whales and 190 dB rms re: 1μPa for pinnipeds). These "disturbance" and "injury" thresholds correlate with the "Level A" harassment and "Level B" harassment thresholds as those terms are defined pursuant to the MMPA (16 U.S.C. § 1362(18)(A)(i) and (ii)).

The MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) 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 [Level B harassment].

As described below, we anticipate that exposures to listed marine mammals from seismic noise associated with the proposed action may result in disturbance and potential onset of injury. However, no mortalities or permanent impairment to hearing is anticipated with the proposed action.

6.3 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 these effects 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.

6.3.1 Exposure to Active Seismic Surveys

Noise sources from the proposed action include: seismic survey equipment (1,240, 620, and 10 cui airgun arrays), and sonar devices (pingers and transponders), and source and support vessels associated with these surveys (see Table 1 for full list). All of the source types have operated in the project area environments for commercial oil and gas exploration projects since 2006. Most of these projects operated under IHAs that required acoustic measurements of underwater noise sources, and the results are cataloged in a series of monitoring reports submitted to NMFS (Austin and Laurinolli 2007, Blackwell 2007, MacGillivray and Hannay 2007, Aerts et al. 2008, Warner et al. 2008, Hannay et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Chorney et al. 2011, Warner and McCrodan 2011, Beland et al. 2013, Lomac-MacNair 2014). The reports dating back to 2006 are publicly available on NMFS' ITA website: http://www.nmfs.noaa.gov/pr/permits/incidental/oilgas.htm.

Airgun arrays are the most common source of seismic survey noise. For the proposed action, airguns will be operating July 1st through October 15th.

Mitigation Measures to Minimize the Likelihood of Exposure to Active Seismic

Mitigation measures are described in detail in Sections 2.1.2 and 2.1.3. The following mitigation measures will be required through the MMPA permitting process to reduce the adverse effects of seismic exposure on marine mammals from the proposed oil and gas exploration activities.

1. PSOs are required on all seismic source and mitigation vessels engaged in activities that may result in an incidental take through acoustic exposure;

2. Establishment of radii associated with received sound level thresholds for 180 dB shutdown/power down for cetaceans and 190 dB shutdown/power down for pinnipeds;

3. Establishment of radii associated with received sound level thresholds for 160 dB harassment zone. Whenever aggregations of 12 or more cetaceans engaged in non-migratory significant behavior (e.g. feeding, socializing), or bowhead whale cow/calf pairs are observed within the 160 dB harassment zone around the seismic activity, seismic operation will not commence or will shut down;

4. Use of start-up and ramp-up procedures for airgun arrays.

Approach to Estimating Exposures to Active Seismic

We relied on exposure estimates provided by NMFS PR1 (NMFS 2015b) which revised the estimates provided by SAE in its IHA application (SAE 2015b), and incorporated a time vector. NMFS PR1's revised estimates incorporate survey days into the exposure estimates by multiplying animal density and daily ensonified area and the number of survey days. However, this method only provides the value of daily exposure incidences, i.e., the number of exposures an individual receives on a daily basis. Since the same animal is very likely to be taken multiple times on different days, this method may over-count the number of unique animals from a given population that is harassed. To address this issue, NMFS PR1 applied a correction factor to incorporate the daily turn-over rate.

NMFS PR1's estimates assume: (1) marine mammals would not try to avoid being exposed to the stressor (loud noise); (2) mean densities of marine mammals would be constant over time within the action area; (3) ASAMM data from 2014 are representative, despite including high nearshore bowhead densities in comparison to previous years, and a relatively small survey block; and (4) the SAE surveys will be fully completed, despite the fact that inclement weather and equipment failure are likely to cause delays and may limit the number of seismic operations that can be undertaken. Overall, this approach is very conservative and likely results in an overestimate of exposure.

The narratives that follow present the approach NMFS PR1 used to estimate the number of marine mammals that might be "taken" during seismic activities.

The instances of exposure for each species to received levels of pulsed sound ≥160, 180, and 190 dB rms were estimated by multiplying:

- the expected bowhead whale, ringed seal, and bearded seal densities during the summer and fall seasons, by
- the daily survey area by water depth[6] and percentage of operation using 640 and 1240 cui airgun arrays, plus an ensonified buffer out to the 160, 180, and 190 dB isopleths, by
- the number of survey days per season.

Anticipated Densities of Listed Species in the Beaufort Sea

To estimate summer bowhead whale densities, NMFS PR1 used data from the 2008 and 2014 ASAMM aerial surveys flown in the Beaufort Sea between 0 to 20°W (Ferguson, pers. comm., 2015; www.asfc.noaa.gov/nmml/). Between 2008 and 2014, a total of 35 bowhead whales were recorded along 1,300 kilometers of transect line, or 0.0269 whales per kilometer of transect line. To convert the number of individuals per line transect (ind/km) to a density per area (ind/km^2), NMML used the effective strip half-width (ESW) of 1.15 km for bowheads (Ferguson and Clarke 2013). Applying availability bias (0.870) (Ferguson and Clarke 2013) and observer bias (0.07) (Thomas et al. 2002) correction factors results in a corrected summer density estimate of 0.1674 (Ferguson, pers. comm., 2015) (see Table 8).[7]

NMFS PR1 determined fall density estimates for bowhead whales from September and October ASAMM data collected from 2008 to 2014. During this time period, 206 bowhead whales were recorded along 2,650 kilometers of transect line, or 0.0777 per kilometer. Using an ESW of 1.15, and applying the availability (0.870) and observer bias (0.07) correction factors from (Thomas et al. 2002, Ferguson and Clarke 2013) derives a corrected fall density estimate of 0.4828 (Ferguson, pers. comm., 2015) (see Table 8).

[6] For pinnipeds, which occupy all water depths, this includes the entire ensonified area (113 km^2 for 640 cui array, and 303 km^2 for 1240 cui array). For bowhead whales water depths include >5m depth (73.5 km^2 for 640 cui array, and 197 km^2 for 1240 cui array), and are anticipated to be even smaller during fall migration as described below.
[7] This is a much higher density than previous estimates (e.g., Brandon et al. 2011) due to relatively high numbers of whales recorded in the Beaufort Sea in nearshore areas during 2013 and 2014 over a smaller transect area.

Surveys for ringed seals have been conducted in the Beaufort Sea by Kingsley (1986), Frost et al. (2002), Moulton and Lawson (2002), and Green et al. (2007). The shipboard monitoring surveys by Green et al. (2007) were not systematically based, but are useful in estimating the general composition of pinnipeds in the Beaufort nearshore. Frost et al.'s (2002) aerial surveys were conducted during ice coverage and do not fully represent the late summer and fall conditions under which the Beaufort surveys will occur. Moulton and Lawson (2002) conducted summer shipboard surveys for pinnipeds along the nearshore Beaufort coast and developed seasonal average and maximum densities representative of SAE's Beaufort summer seismic project, while Kingsley (1986) conducted surveys along the ice margin representing fall conditions (see Table 8) (SAE 2015b).

Bearded seals were also recorded in Harrison Bay and the Colville River Delta by Green et al. (2007), but at lower proportions to ringed seals than spotted seals. However, estimating bearded seal densities based on the proportion of bearded seals observed during the barge-based surveys results in density estimates that appear unrealistically low given density estimates from other studies, especially given that nearby Thetis Island is used annually as a base for hunting this seal (densities are seasonally high enough for focused hunting). Therefore, the bearded seal density values used in the IHA application were derived from Stirling et al.'s (1982) observations (the proportion of eastern Beaufort Sea bearded seals is anticipated to be 5 percent that of ringed seals) (SAE 2015b) (Table 8).

Table 8 shows the reported average density estimates (#/km^2) for bowhead whales, ringed seals, and bearded seals during the summer and fall seasons (SAE 2015b).

Table 8. Average densities (#/km^2) of listed marine mammals in the Beaufort Sea for the planned (July-Oct) survey period (NMFS 2015b).

Species	Summer Avg. Density	Fall Avg. Density
Bowhead Whale	0.1674	0.4828
Ringed Seal	0.3547	0.2510
Bearded Seal	0.0177	0.0125

Daily Survey Area and Ensonified Buffer

The daily survey area is anticipated to be 48.56 km^2 (18.75 mi^2).[8] The daily ensonified area associated with the various threshold levels was determined by placing a 160, 180, and 190 dB re 1 μPa (rms) isopleth buffer (associated with the 620 cui and 1,240 cui airgun arrays) around the daily survey area (48.56 km^2). The ensonified area will vary depending on the size of the airgun array being shot. SAE anticipates using the 620 cui array the majority of the time (e.g. 80% of the time), and only using the 1,240 cui array occasionally (e.g., 20% of the time) (SAE 2015c). As an example, the estimated distance to the 160 dB isopleth associated with the largest array

[8] SAE anticipates that the daily survey area would total 48.56 km^2 and the total number of survey days may total 49. However, they only anticipate surveying a total area of 777 km^2. The reason for this low total survey area is because they anticipate up to 70% overlap with previous survey patches (SAE 2015a).

(1,240 cui) was based on SSV measurements from a 1,200 cui array in the nearshore Beaufort (Heath et al. 2014). The measured distance to the 160 dB isopleth was 5.2 km. However, the anticipated distance to the 160 dB isopleth associated with the 620 cui airgun array is 1.82 km (see Table 9).

Table 9. Distance (in meters) to various received rms SPLs (in dB re 1 µPa) for discharge volumes of 1,240, 620, and 10 cui (SAE 2015b).

Sound Source	Source Level	190dB	180dB	160dB
1,240 cui Airgun	224 dB re 1 µPa (rms)	250m	910m	5.2 km
620 cui Airgun	218 dB re 1 µPa (rms)	195m	635m	1.82 km
10 cui Airgun	195 dB re 1 µPa (rms)	54m	188m	1.05 km

NMFS PR1 assumes that the daily survey area would be approximately 48.56 km^2 and the dimensions of the survey area are anticipated to be 8 x 6 km (NMFS 2015b). Placing a 5.2 km buffer (from the 1,240 cui array) around the 48.56 km^2 daily survey area results in a daily ensonified area of 303 km^2 for both vessels (see Table 10). Alternatively, placing a 1.82 km buffer from the 620 cui array around the 48.56 km^2 daily survey area results in a daily ensonified area of 113 km^2 (see Table 10).

The estimated distances to the 190 and 180dB isopleths associated with the 1,240 cui array were 250m and 910m respectively (see Table 9). Placing these buffers around the daily survey area results in a daily ensonified area of 56 km^2 and 77.5 km^2 for the 190 and 180 dB re 1 µPa (rms) received levels (Table 10).

Table 10. Daily ensonified area estimates associated with various received sound levels (dB re 1 µPa (rms)) from the 1,240 cui and 640 cui airgun arrays during SAE's 2015 anticipated summer 3D OBN survey (ensonified area is provided in km^2)(NMFS 2015b, SAE 2015b).

Sound Source		190	180	160
1,240 cui Airgun	Ensonified Area (km^2)	56	77.5	303
640 cui Airgun	Ensonified Area (km^2)	54	68	113

Habitat Usage and Zone of Influence

Within the 303 km^2 ensonified area for the 1,240 cui array, 19 percent (57.57 km^2) falls within the 0 to 1.5 meter depth range, 16 percent (48.48 km^2) falls within the 1.5 to 5 meter range, 36 percent (109 km^2) falls within the 5 to 15 meter range, and 29 percent (87.87 km^2) falls within waters greater than 15 meters deep (bowhead migration corridor). Since bowhead whales are only anticipated to occur in waters greater than 5 meters deep, the daily zone of influence for bowhead whales is anticipated to be approximately 197 km^2 for the 1,240 cui array (NMFS 2015b) (see Table 11).

Similarly, for the 640 cui array the total daily ensonified area of 113 km^2 could be divided up where 19 percent (21.47 km^2) falls within the 0 to 1.5 meter depth range, 16 percent (18.08 km^2) falls within the 1.5 to 5 meter range, 36 percent (40.68 km^2) falls within the 5 to 15 meter range, and 29 percent (32.77 km^2) falls within waters greater than 15 meters deep (bowhead migration corridor). The daily zone of influence for bowhead whales is anticipated to be approximately 73.45 km^2 (NMFS 2015b) (see Table 11).

Pinnipeds are anticipated to occupy all water depths so the zone of influence for ringed and bearded seals is the total daily ensonified areas listed in Table 10 (113 – 330 km^2 dependent on airgun size).

Table 11. Daily zone of influence estimates for bowhead whales per season associated with various received sound levels from the 1240 and 640 cui airgun arrays during SAE's 2015 anticipated 3D seismic surveys (ZOI is provided in km^2) (NMFS 2015b).

Sound Source		190dB	180dB	160dB
1240 cui Airgun	Bowhead Habitat Summer ZOI Area (km^2)	36 km^2	50 km^2	197 km^2
1240 cui Airgun	Bowhead Habitat Fall ZOI Area (km^2)	16 km^2	23 km^2	88 km^2
640 cui Airgun	Bowhead Habitat Summer ZOI Area (km^2)	35 km^2	44 km^2	73 km^2
640 cui Airgun	Bowhead Habitat Fall ZOI Area (km^2)	16 km^2	20 km^2	33 km^2

Number of Survey Days

Data acquisition is expected to take ~70 days dependent on weather and ice. Based on past seismic operations in the Beaufort Sea, SAE anticipates shooting 70% of the time or ~49 days (SAE 2015b). NMFS PR1 anticipates that the survey may consist of 28 days in the summer (July-Aug) and 21 days in the fall (Sept-Oct) (NMFS 2015b). For this reason the estimated instances of exposures result from multiplying seasonal density by daily ensonified area per season by number of survey days per season (see Table 12).

Turnover Rate of Listed Marine Mammals

"Turnover" is the rate at which the individual marine mammals present in a given area leave and are replaced by other individuals. For instance, a turnover rate of 24 hours means that every 24 hours we would expect, on average, an entirely new group of individuals to be present. The turnover rate is relevant for calculating how many animals may be exposed to localized stressors.

Bowhead Whales

It is difficult to determine an appropriate average turnover time for individual bowhead whales in a particular area of the Beaufort Sea. Reasons for this include differences in residency time between migratory and non-migratory periods, changes in distribution of food and other factors such as behavior that influence animal movement, variation among individuals, etc. Complete turnover of individual bowhead whales in the survey area each 24-hour period is possible during distinct periods within the fall migration when bowheads are traveling through the area. Even during the fall migration, however, bowheads often move in pulses with one to several days between major pulses of whales (Richardson and Thomson 2002). Gaps between groups of traveling whales during fall migration result in days when no bowhead whales would be expected to be present in the activity area. The absence of bowhead whales during periods of the fall migration can likely be attributed to individuals stopping to feed opportunistically when food is encountered, which is known to occur annually around Barrow Canyon (Citta et al. 2014). Mapping locations of bowhead whales revealed that 91% of individuals that appeared to be feeding were located in shelf waters, predominantly along the 20-m isobath (Shelden and Mocklin 2013).

Bowhead whales are often observed feeding between Point Barrow and Smith Bay during the summer period into early fall (Aug-Oct) (Clarke and Ferguson 2010b, a, Clarke et al. 2011c, Clarke et al. 2012, 2013) and this region has been identified as a biologically important area (BIA) for feeding (Clarke et al. 2015). Later in the fall (Sept-Oct), other areas in the western Beaufort Sea (including the action area), have been identified as feeding BIAs shoreward of the 50-m isobath (Clarke et al. 2015) (see Figure 8).

Traveling was the most commonly recorded behavior (45% for all years combined 2007-2011) but direction of travel was highly variable suggesting animals were not necessarily migrating through the area. The paucity of individual re-sightings (based on photography) between survey days (3 matches out of 762 identified whales) suggested very low residence times off of Barrow (Shelden and Mocklin 2013). However, satellite tagging information indicated that bowheads do not move across the Beaufort Sea in a continuous stream. Three of the 19 tagged whales left the Barrow area only to return and spend 13-32 days in the waters off Barrow (Quakenbush et al. 2010b).

Due to the biological importance of the action area for feeding and as a migration corridor, we would not anticipate broad deflection around the seismic survey area by bowhead whales. However, we would anticipate pulses of whales moving through due to opportunistic feeding opportunities. For these reasons, we selected an assumed turnover rate of 48 hours to account for intermittent periods of migrating and feeding bowheads.

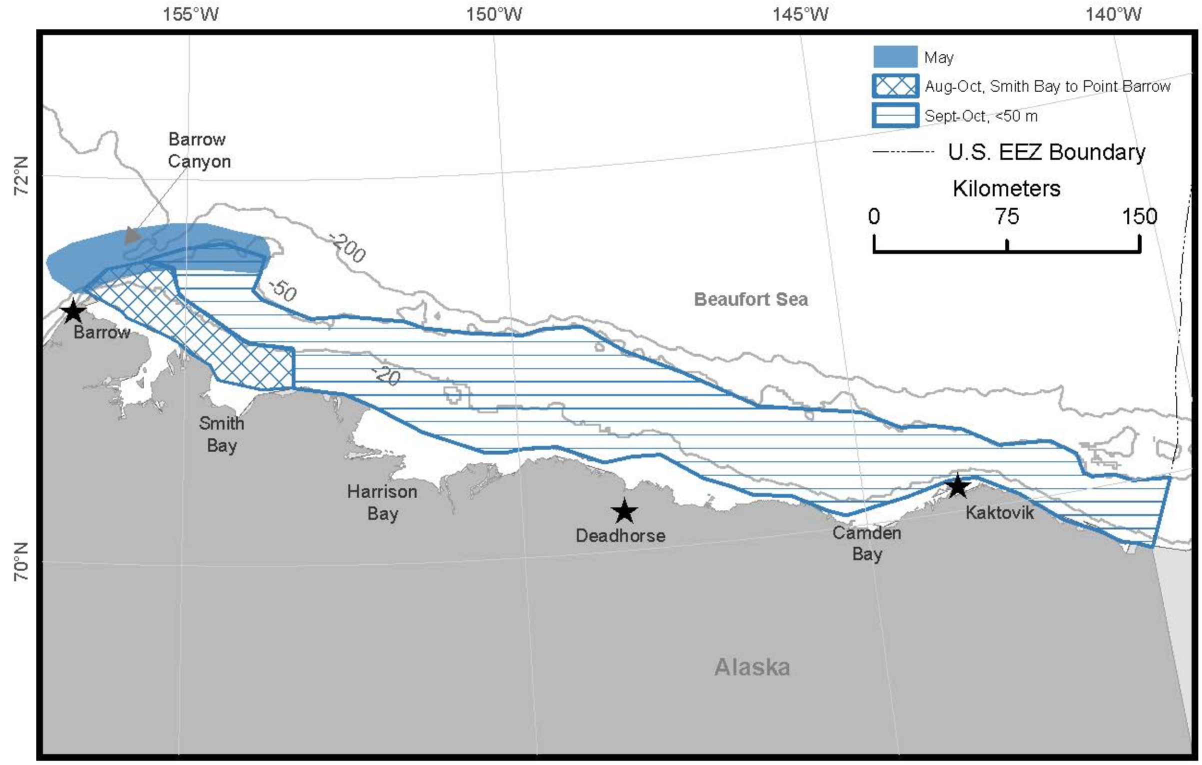

Figure 8. Bowhead whale feeding Biologically Important Areas during eastward spring migration in May near Barrow Canyon; from Point Barrow to Smith Bay in August through October, generally shoreward of 20-m isobaths; and during westward fall migration from September through October, generally shoreward of the 50-m isobaths (Clarke et al. 2015).

Ringed and Bearded Seals

Based on the available information on pinnipeds in water exposed to impulsive noise sources, 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 et al. 2007). 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).

Recent evidence from monitoring conducted in support of Shell's 2012 exploration drilling program in the Beaufort indicated a low turnover rate of ringed seals associated with an active drilling unit (Bisson et al. 2013). PSOs 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). 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 individuals that remain in the area for longer periods. The lower turnover rate of ringed seals associated with drilling operations may also be indicative of turnover rates associated with seismic programs, especially considering the recorded limited avoidance of pinnipeds with previous seismic operations as described above (Harris et al. 2001, Moulton and Lawson 2002, Miller et al. 2005).

During the open-water foraging period, ringed seals are known to make short and long distance movements based on annual observations (Smith 1973) and recoveries of tagged seals (Kelly et al. 2010a, ADFG 2014).

ADFG has conducted satellite tagging and tracking of ringed seals in the Arctic. During the 2014 tagging season, four ringed seals were tagged (two males and two females) in Kotezebue Sound. Some of these seals spent time in the action area. Figure 9 presents one of their weekly tagging map archives from the 2014 open water season, indicating that seals may occupy a relatively small area (particularly when actively foraging), as well as travel long distances to other foraging locations.

Kelly et al. (2010a) attached satellite-linked transmitters to the hindflippers of seals (instead of gluing to the pelage) in order to extend tracking beyond the subsequent molt. They captured 25 ringed seals at four sites in the shorefast ice of the Chukchi and Beaufort Seas. The seals were captured in March to early June and tracked for up to 14 months. After the ice broke up in July, the seals moved offshore to moving ice. Nine seals were tracked throughout the year and – in July through December – six of those moved to pack ice within 200 km of their tagging sites and 3 to pack ice 800 km or more from their tagging sites (including one that ranged almost 1,800 km).

In the Canadian Beaufort satellite-linked time-depth recorders were deployed on 17 ringed seals immediately following spring break up during 1999, 2000, and 2010 near Ulukhaktok, NT, Canada. Tags performed well on 16 of 17 tagged seals, with average tracking periods of 254 days, and four lasting >300 days. The seals were highly mobile, travelling constantly during the open water period, the furthest being 2,200 km from the tagging site. The average size of the home range for the open water period was 122,854 km^2 for subadults, 76,658 km^2 for adult females, and 21,649 km^2 for adult males. During winter, 5 of 5 adult females, 5 of 7 adult males, and 3 of 4 subadults returned, using home ranges that were, on average, 6.6 times smaller than during open water (Harwood et al. 2012).

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 100s or 1,000s of kilometers to forage in highly productive areas and along the pack ice edge (Freitas et al. 2008, Kelly et al. 2010b). At the end of the foraging period, adult Arctic ringed seals return to the same sites used during the previous subnivean period (Smith and Hammill 1981, Kelly et al. 2010b).

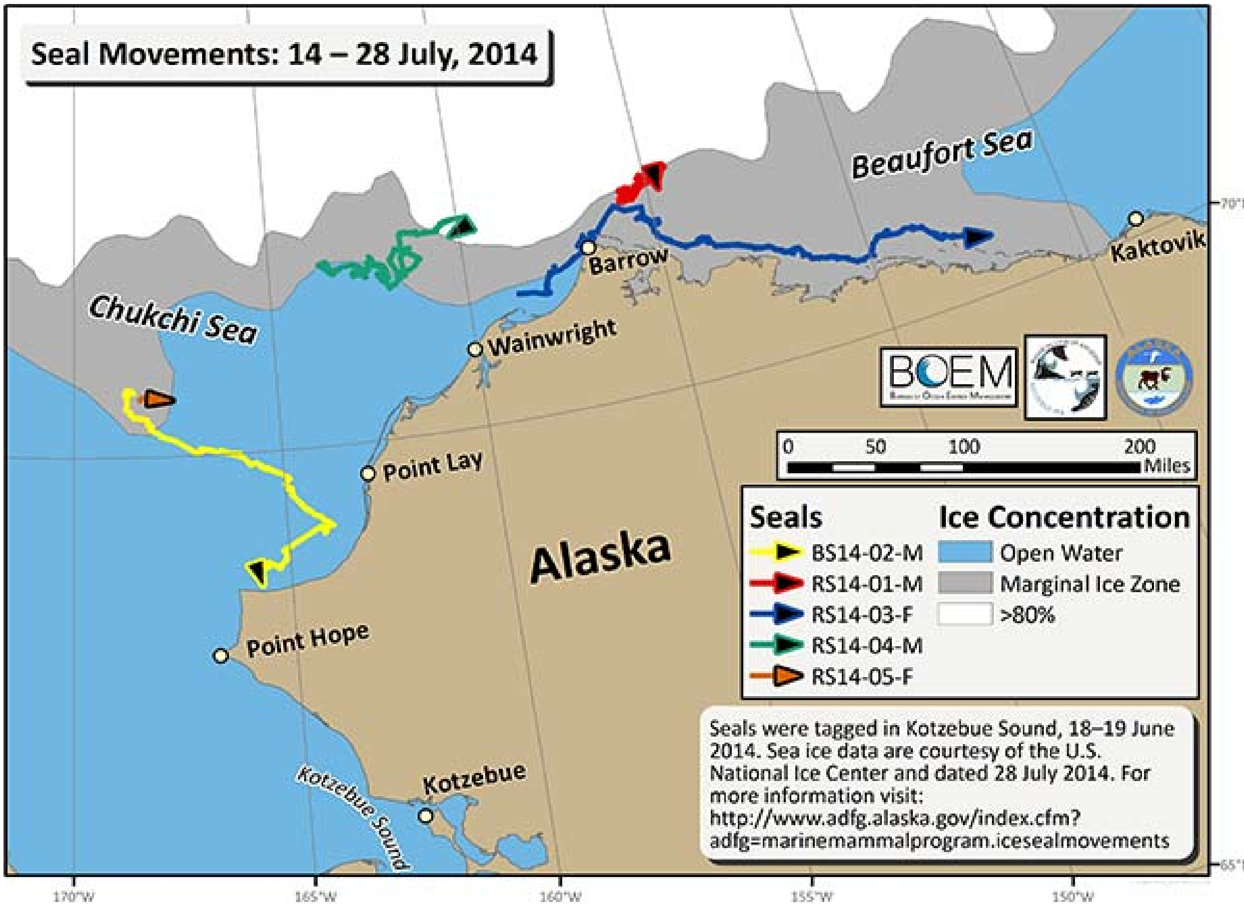

Figure 9. Ringed seal satellite tracking map archive July 14-28 2014, indicates that seals can occupy a relatively small area over a 2 week period (e.g. RS14-01), as well as traveling long distances (e.g. RS14-03). Female RS14-03 transited through the action area in the Beaufort (ADFG 2014).

We consider a 24-hr turnover rate and zero avoidance to be an overestimate of instances of exposure to ringed seals. Although evidence exists to indicate a turnover period of a week or more for individual seals near a drilling operation in the Alaskan Arctic (Patterson et al. 2014), more data and analysis are necessary to determine an accurate extended turnover rate for seal populations in areas associated with seismic operations. Similarly, studies have investigated potential avoidance of anthropogenic activities and associated underwater sounds by ice seals. However, these studies have not yielded a clear understanding of how ice seals react to underwater sound (Harris et al. 2001, Moulton and Lawson 2002, Blackwell et al. 2004, Miller et al. 2005, Moulton et al. 2005, Bain and Williams 2006, Reiser et al. 2010). For this consultation, we assumed a 48-hour turnover rate and zero avoidance based on repeated ringed seal re-sights during previous drilling operations, tolerance of pinnipeds associated with previous seismic operations, and tagging data indicating two foraging strategies for long foraging trips and short confined trips in the Beaufort Sea. This results in a 50% reduction in estimated exposures to ringed seals, similar to what was presented for bowhead whales (i.e., pulses of migration and feeding, and tolerance of anthropogenic noise while feeding) (see Table 21).

We 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 action area were not available. Instead, we used the 24-hour turnover rate for bearded seals. Although this may be overly conservative (i.e., it assumes a high turnover rate in the vicinity of the seismic activities), it is difficult to scale variables more precisely without additional data.

The final column in Table 12 represents the total potential instances of exposure.

Results of Exposure Analysis (Seismic Surveys)

The estimated instances of exposure (see Table 12) are likely overestimates for the following reasons (SAE 2015b):

- The estimates assume that marine mammals would not avoid seismic or vessel noise, yet some degree of avoidance is likely;
- The estimates assume that the full seismic source array will operate continuously along the entire survey area. However, this is unlikely to occur due to adverse weather and ice conditions, potential equipment delays, conflict avoidance agreements, and SAE's efforts to balance the needs of multiple clients for seismic data;
- The proportion of time that the seismic array will be operating is very small compared to the proportion of time that SAE will be in the project area. This is because each pulse with the full seismic array lasts only about 3 milliseconds, and is repeated at an interval of approximately 10 seconds, resulting in a shot every 5 seconds due to shots alternating between two vessels;
- Exposure estimates include the daily survey area plus an ensonified buffer zone around the survey area that represents the total ensonified area out to the 160, 180, and 190 dB isopleths. Thus, marine mammals within the far edge of this isopleth are actually expected to be exposed to sounds < 160, 180, or 190 dB re 1 μPa (rms); and
- Mitigation measures will be employed if any marine mammal is sighted within or near the designated (180/190 dB) exclusion zones, and will result in the shut down or power down of seismic operations. In addition, whenever aggregations of 12 bowhead or more are observed engaging in non-migratory behavior (e.g. feeding, socializing), or cow/calf pairs are observed within the 160dB isopleth (harassment zone), shutdown or power down of seismic operations will occur further reducing instances of exposure (see Sections 2.1.2 and 2.1.3).

SAE and NMFS PR1 estimated bowhead whales, ringed seals, and bearded seals might be exposed to received levels ≥160, 180, and 190 dB (rms) from seismic operations during the 2015 open water season (Tables 12-13). Estimates assume the 620 cui array will operate 80% of the time and the 1,240 cui array will operate 20% of the time. The single mitigation airgun would be operating on turns and transits between survey lines. Estimates multiply daily ensonified area, animal density, number of survey days, and season; adjusted by turnover rate, different airgun usage, and different habitat usage.

Table 12. Potential instances of exposure of listed marine mammals to received sound levels ≥160 dB 1 µPa (rms) to airgun pulses during SAE's planned 3D seismic surveys in the Beaufort Sea during the 2015 open-water season (SAE 2015b).

Airgun array volume: 620 in^3											
	Summer				Fall				All seasons		
Species (habitat)	ZOI (km^2)	Days	Density (km^{-1})	Summer exposure	ZOI (km^2)	Days	Density (km^{-1})	Fall exposure	Turn-over	Airgun usage	**Total adjusted exposure**
Bowhead whale	113			344	113			332.2	50%	80%	**271**
(0.0 – 1.5m)	*21.47*	*28*	*0*	*0*	*21.47*	*21*	*0*	*0*			
(1.5 – 5.0m)	*18.08*	*28*	*0*	*0*	*18.08*	*21*	*0*	*0*			
(5.0 – 15.0m)	*40.68*	*28*	*0.1674*	*190.6*	*40.68*	*21*	*0*	*0*			
(> 15.0m)	*32.77*	*28*	*0.1674*	*153.6*	*32.77*	*21*	*0.4828*	*332.2*			
Ringed seal	113	28	0.3547	1122.3	113	21	0.2510	595.6	50%	80%	**687**
Bearded seal	113	28	0.0177	56	113	21	0.0125	29.7	100%	80%	**69**
Airgun array volume: 1,240 in^3											
	Summer				Fall				All seasons		
Species (habitat)	ZOI (km^2)	Days	Density (km^{-1})	Summer exposure	ZOI (km^2)	Days	Density (km^{-1})	Fall exposure	Turn-over	Airgun usage	**Total adjusted exposure**
Bowhead whale	303			923	303			891	50%	20%	**181**
(0.0 – 1.5m)	*57.57*	*28*	*0*	*0*	*57.57*	*21*	*0*	*0*			
(1.5 – 5.0m)	*48.48*	*28*	*0*	*0*	*48.48*	*21*	*0*	*0*			
(5.0 – 15.0m)	*109.1*	*28*	*0.1674*	*511.2*	*109.1*	*21*	*0*	*0*			
(> 15.0m)	*87.87*	*28*	*0.1674*	*411.8*	*87.87*	*21*	*0.4828*	*890.8*			
Ringed seal	303	28	0.3547	3009.3	303	21	0.2510	1597.1	50%	20%	**461**
Bearded seal	303	28	0.0177	150.2	303	21	0.0125	79.5	100%	20%	**46**

The estimated instances of exposure to listed marine mammals to received levels ≥180 dB and 190 dB 1 µPa (rms) provided in Table 13, assume mitigation measures are not in place. While we do not anticipate that these exposures will occur (animals exposed at lower received levels will most likely avoid these higher received levels, and mitigation measures will be instituted if animals continue to approach), they have been included to account for faulty mitigation, or animals that may be missed by the PSOs.

Table 13. **Potential instances of exposure of listed marine mammals to received sound levels ≥180 dB 1 μPa (rms)(cetaceans) and ≥190 dB 1 μPa (rms)(pinnipeds) to airgun pulses during SAE's planned 3D seismic surveys in the Beaufort Sea during the 2015 open-water season (SAE 2015b).**

Airgun array volume: 620 in^3											
	Summer				Fall				All seasons		
Species (habitat)	ZOI (km^2)	Days	Density (km^{-1})	Summer exposure	ZOI (km^2)	Days	Density (km^{-1})	Fall exposure	Turn-over	Airgun usage	**Total adjusted exposure**
Bowhead whale	67.8			206	67.8			199	50%	80%	**162**
(0.0 – 1.5m)	*12.88*	*28*	*0*	*0*	*12.88*	*21*	*0*	*0*			
(1.5 – 5.0m)	*10.85*	*28*	*0*	*0*	*10.85*	*21*	*0*	*0*			
(5.0 – 15.0m)	*24.41*	*28*	*0.1674*	*114.4*	*24.41*	*21*	*0*	*0*			
(> 15.0m)	*19.66*	*28*	*0.1674*	*92.2*	*19.66*	*21*	*0.4828*	*199.4*			
Ringed seal	54.2	28	0.3547	538	54.2	21	0.2510	285.5	50%	80%	**329**
Bearded seal	54.2	28	0.0177	26.8	54.2	21	0.0125	14.2	100%	80%	**33**
Airgun array volume: 1,240 in^3											
	Summer				Fall				All seasons		
Species (habitat)	ZOI (km^2)	Days	Density (km^{-1})	Summer exposure	ZOI (km^2)	Days	Density (km^{-1})	Fall exposure	Turn-over	Airgun usage	**Total adjusted exposure**
Bowhead whale	78			237	78			229	50%	20%	**47**
(0.0 – 1.5m)	*14.77*	*28*	*0*	*0*	*14.77*	*21*	*0*	*0*			
(1.5 – 5.0m)	*12.44*	*28*	*0*	*0*	*12.44*	*21*	*0*	*0*			
(5.0 – 15.0m)	*27.99*	*28*	*0.1674*	*131.1*	*27.99*	*21*	*0*	*0*			
(> 15.0m)	*22.54*	*28*	*0.1674*	*105.6*	*22.54*	*21*	*0.4828*	*228.6*			
Ringed seal	55.84	28	0.3547	554.6	55.84	21	0.2510	294.3	50%	20%	**85**
Bearded seal	55.84	28	0.0177	27.7	55.84	21	0.0125	14.7	100%	20%	**8**

However, since marine mammals are known to avoid high received levels of noise, and monitoring and mitigation for power down/shutdown are required when animals are spotted within or approaching the 180/190 dB zones, the estimates presented in Table 13 are not reasonably likely to occur. For these reasons, NMFS PR1 assumed only a small subset of the exposures listed in Table 13 might occur based on mitigation measures and avoidance behavior. Table 14 provides the maximum instances of exposure.

Table 14. Instances of Exposure Incorporating Turnover Rate Assumptions for Bowhead Whale and Ringed Seal, and Application of Power down/Shutdown Zones at 180 dB 1 µPa rms for Cetaceans and 190 dB 1 µPa rms for Pinnipeds.

Species	≥160 dB 1 µPa (rms)	≥180 dB (cetaceans) or 190 dB 1 µPa (rms) (pinnipeds)	**Total Instances of Exposure**
Bowhead whale	452	1	**453**
Ringed seal	1,148	20	**1,168**
Bearded seal	115	10	**125**

The final column in Tables 14 represents the total instances of exposure to marine mammals from pulsed sound associated with seismic airgun use during SAE's 3D seismic surveys (453 instances of exposure to bowhead whales, 1,168 instances of exposure to ringed seals, and 125 instances of exposure to bearded seals).

In the *Response Analysis* (Section 6.4.1) we apply the best scientific and commercial data available to describe the species' expected responses to these exposures.

6.3.2 Exposure to Vessel Noise

Mitigation Measures to Minimize the Likelihood of Exposure to Vessel Noise

Mitigation measures are described in detail in Sections 2.1.2 and 2.1.3. The following mitigation measures will be implemented through the MMPA permitting process to reduce the adverse effects of other acoustic sources on marine mammals from the proposed 3D seismic activities.

1. Two to three PSOs are required on each seismic source vessel, and two PSOs are required on the mitigation vessel and will implement mitigation measures and record marine mammal observations.

2. Vessels in transit shall be operated at speeds necessary to ensure no physical contact with whales occurs.
   - **a)** Transiting vessels will avoid approaching within 1 mile (1.6 km) of observed whales
   - **b)** Vessel speed will be reduced to less than 5 knots when within 300 yards of whales
   - **c)** Avoid concentrations or groups of whales by all vessels under the direction of SAE.

Approach to Estimating Exposures to Vessel Noise

SAE proposed to utilize approximately eight vessels. The noise associated with vessel operation is considered a continuous noise source. The housing vessel is anticipated to produce the loudest propeller noise of all the vessels in the fleet (200.1 dB re 1 µPa)(Aerts et al. 2008, SAE 2015b).

The instances of exposure for each listed species to received levels of continuous sound associated with vessel noise ≥120 dB rms were estimated by multiplying:

- the anticipated area to be ensonified to the specified levels in each season (summer and fall), by
- that expected species density

Anticipated Area Ensonified to Specified Levels from Vessel Operation

Vessel operations in the shallower coastal areas of the Beaufort Sea produce smaller noise footprints due to reduced low frequency sound propagation in shallower water. Acoustic measurements of 10 vessels, including source vessels, crew-change/support vessels, bowpickers, recorder vessel, and housing vessel, were made in 6 m water depth during the LGL 2008 OBC project (Aerts et al. 2008). Their 120 dB re 1 µPa threshold distances ranged from 56 m for a bow picker vessel to 176 m for a housing vessel (Aerts et al. 2008). A circle with a radius of 176m results in an estimated area of 0.097 km^2 (.037 mi^2) that may be exposed to continuous sounds ≥120 dB rms (Table 15).

Table 15. Ensonified area estimates associated with various received sound levels for vessel noise during SAE's 2014 3D seismic activities (ensonified area provided in km^2) (Aerts et al. 2008).

Sound Source		140	130	120
Vessel Noise	Ensonified Area (km^2)	0.008	0.027	0.097

Expected Densities of Listed Species in the Beaufort Sea (Summer and Fall Seasons)

The anticipated densities of listed species are the same as those listed in Table 8 above (see Section 6.3.1).

Results of Exposure Analyses (Vessel Noise)

We anticipate that noise associated with vessel operations would drop to 120 dB within 176 m (or less) of the vessel (Aerts et al. 2008). Even if we assume all of the vessels produce as much noise as a housing vessel (which is not anticipated), sum the ensonified area associated with each vessel (which should provide an overestimate since sounds from vessels are anticipated to overlap in many cases), and multiply by summer/fall densities of animals, the estimated number of marine mammal exposures that could be ensonified by vessel noise was zero due to the small anticipated area ensonified to received levels ≥120 dB (rms).[9]

[9] As an example, if we use the fall density of bowhead whales (0.4828), which is anticipated to be the highest density of the listed species, and multiply by the ensonified area out to 120 dB associated with the housing vessel (0.097 km^2), multiply by the number of vessels (8), and finally multiply the percentage of survey days during the summer (43%) we only get 0.16 instances of exposure to bowhead whales in the fall from vessel noise. We would consider the likelihood of this exposure occurring to be discountable.

6.3.3 Exposure to Pinger and Transponder Noise

Mitigation Measures to Minimize the Likelihood of Exposure to Pinger and Transponder Noise

Mitigation measures are described in detail in Sections 2.1.2 and 2.1.3. The following mitigation measure will be implemented through the MMPA permitting process to reduce the adverse effects of other acoustic sources on marine mammals from the proposed pinger and transponder activities.

1. PSOs are required on seismic and mitigation vessels that may result in an incidental take through acoustic exposures.

Approach to Estimating Exposures to Pinger and Transponder Noise

We relied on exposure estimates provided by SAE and NMFS PR1 (NMFS 2015b, SAE 2015b). SAE is anticipating an acoustical pinger system to position and interpolate the location of nodes. Signals transmitted by the pingers will be received by a transponder mounted on a recording and retrieving vessel and pingers and transponder will communicate via sonar. The source levels of these devices range from 185 dB re 1 μPa at 1 m to 193 dB re 1 μPa at 1 m and have frequency ranges from 19 kHz to 55 kHz. Section 2.1.1.1 describes each of these sound sources, with source levels and frequency ranges, in more detail.

SAE indicated that its pinger and transponder's underwater sound propagation would drop to 160 dB rms within 100 m (or less) of the vessel (SAE 2015b).

Similar to the approach SAE used to estimate the potential instances of exposure to marine mammals associated with 3D seismic surveys, the instances of exposure for each listed species to received levels of impulsive sound associated with pingers and transponders ≥160 dB rms were estimated by multiplying: the anticipated area to be ensonified to ≥160 dB rms by that expected species density.

Expected Densities of Listed Species in the Beaufort Sea (Summer and Fall Seasons)

The anticipated densities of listed species are the same as those listed in Table 8 above (see Section 6.3.1).

Results of Exposure Analysis (Pingers and Transponders)

Marine mammals are unlikely to be subjected to repeated pings because of the narrow fore-aft width of the beam and will receive only limited amounts of energy because of the short pings. The beam is narrowest closest to the source, further reducing the likelihood of exposure to marine mammals (NMFS 2015b).

No exposures are anticipated to occur at received levels ≥160 dB. In addition, if marine mammals are exposed, they are not likely to respond to that exposure as described in Section

6.4.2.

Given the directionality, short pulse duration, and small beam widths for pingers and transponders; only a few exposures at low received levels are anticipated for listed species. If exposed, whales and seals would not be anticipated to be in the direct sound field for more than one to two pulses (NMFS 2013c). Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, and pinnipeds generally (Southall et al. 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. We do not anticipate these sources to be operating in isolation, and expect co-occurrence with other acoustic sources including airguns. Many whales and seals would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of whales and seals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Sections 2.1.2 and 2.1.3) would further reduce or eliminate any potential effect from non-airgun acoustic sources.

All of these factors reduce the probability of bowhead whales, ringed seals, and bearded seals being exposed to sound fields associated with pinger and transponder sources to levels that we would consider insignificant.[10]

6.3.4 Exposure to Vessel Strike

Mitigation Measures to Minimize the Likelihood of Exposure to Vessel Strike

Mitigation measures are described in detail in Sections 2.1.2 and 2.1.3. The following mitigation measures will be implemented through the MMPA permitting process to reduce the potential for vessel strike on marine mammals from the proposed action.

1. PSOs required on all seismic source vessels and scout vessels;

2. Vessels in transit shall be operated at speeds necessary to ensure no physical contact with whales occurs;
   - **a)** Transiting vessels will avoid approaching within 1 mile of observed whales
   - **b)** Vessel speed will be reduced to less than 5 knots when within 300 yards of whales
   - **c)** Avoid concentrations or groups of whales by all vessels under the direction of SAE.

3. Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals; and

4. Check waters immediately adjacent to vessels with propellers to ensure that no marine mammals will be injured.

[10] Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. In this situation, exposures may occur to a few whales and pinnipeds at ≥120 dB, but at received levels far below what would be considered "take" for pulsed sounds (≥160 dB).

Approach to Estimating Exposures to Vessel Strike

As discussed in the *Proposed Action* section of this opinion, the activities NMFS PR1 proposes to authorize for SAE's 2015 3D surveys in the Beaufort Sea would increase the number of vessels transiting the area. Additional vessel traffic could increase the risk of exposure between vessels and marine mammals.

Assumptions of increased vessel traffic related to 3D seismic activities in the Beaufort Sea are as follows:

- At the start of a program vessels with be trucked over land to Oliktok Point or Prudhoe Bay where they will mobilize to begin surveys.
- The maximum number of vessels associated with the proposed action is anticipated to be eight vessels.
- Operations would commence on or after approximately July 1 and end by early October 15, 2015.
- At the end of a program, vessels will return to Oliktok Point or Prudhoe Bay where they will demobilize.

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 Taggart 2007), as cited in (Aerts and Richardson 2008). Vessels transiting at speeds >10 knots present the greatest potential hazard of collisions (Jensen and Silber 2004, 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 operations occur at relatively low speeds (4-6 knots), large vessels are capable of transiting up to 16 knots and operate in periods of darkness and poor visibility(BOEM 2015a). In addition, large vessels when traveling cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammals. All of these factors increase the risk of collisions with marine mammals (BOEM 2015a). However, standard mitigation measures discussed above are designed to help avoid potential vessel strikes to marine mammals.

Bowhead Whale Exposure

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

Vessels will transit during open-water periods (July 1 through October 15), and bowhead whales are known to migrate and feed in the Beaufort during open-water periods. Bowhead whales migrate through the Alaskan Beaufort Sea from late August to early October, with a peak in September. However, only 30% of the survey area extends past the 15m depth contour which is recognized as the southern boundary of the primary bowhead migration corridor within the Beaufort, which will help limit potential overlap (SAE 2015b).

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. 2010a). Bowhead foraging dives are twice as long as most fin and humpback whales, even at equivalent depths, their dives are followed by shorter recovery times at the surface (Krutzikowsky and Mate 2000). This behavior may make bowhead whales less likely to encounter a vessel transiting in the action area, and lowers their likelihood of colliding with such vessels. However, calves have shorter dive duration, surface duration, and blow intervals than their mothers (BOEM 2011), which put 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 2011). Most bowhead whales show strong avoidance reactions to approaching ships which may help them avoid collisions with vessels (NMFS 2013c). 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 of 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 observed ship-strike injuries suggests that bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

For bowhead whales, there were no records found of 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.

Vessels would have a transitory presence in any specific location. NMFS is not able to quantify existing traffic conditions across the entire Beaufort Sea to provide context for the addition of eight vessels. 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 activities in the Beaufort Sea, the limited number of sightings of bowhead whales in the nearshore area during the survey time, the slow vessel speeds while shooting seismic, mitigation measures to minimize exposure to vessel activities, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike in the Beaufort, Chukchi or Bering Seas, we conclude that the probability of a SAE vessel striking a bowhead whale in the Beaufort Sea is sufficiently small as to be discountable.

Pinniped Exposure (ringed and bearded seals)
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 2013c). Available information indicates that vessel strikes of seals in the region are low and there is no indication that strikes will become a significant source of injury or mortality (BOEM 2011).

Ringed seals are year round residents in the Chukchi Sea, and are anticipated to be in the action area during any time seismic activities may occur. During the open water foraging period ringed seals are making short and long distance foraging trip and may encounter vessels (Kelly et al. 2010a, ADFG 2014).

Bearded seals spend the summer and early fall 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 et al. 1984), and are anticipated to overlap with seismic activities and vessel operations associated with the proposed action but in lower numbers than ringed seals.

Seals that closely approach larger vessels also have some potential to be drawn into bow-thrusters or ducted propellers (BOEM 2015a). 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 2015a). To date, few incidents such as these have been documented in Alaska, though Sternfield (2004) documented a single spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike (BOEM 2015a). There have been no incidents of ship strike with bearded or ringed seals documented in Alaska (BOEM 2015a) despite the fact that PSOs routinely sight bearded and ringed seals during oil and gas exploration activities.

Ringed seals have routinely been observed during previous seismic surveys in this region and time period (e.g., (Aerts et al. 2008, Funk et al. 2008, Savarese et al. 2010, Reiser et al. 2011), during monitoring from Northstar Island (e.g., (Aerts and Richardson 2008, Aerts 2009, 2010) and during aerial surveys flown for bowhead whales (Clarke et al. 2011a). Based on the data available, ringed seals are likely to be the most abundant marine mammal species encountered in the area of the proposed activities, but the number of seals that we expect to encounter during the proposed survey is low. This is based on seal observation data from recent similar seismic surveys in the central Beaufort Sea (Aerts et al. 2008, Hauser et al. 2008, BPXA 2013, Lomac-MacNair 2014).

Since bearded seals are benthic feeders, they generally associate with seasonal sea ice over shallow water of less than 200m (656 ft) (NMFS 2013c). Bearded seals were commonly sighted during aerial surveys conducted in the Beaufort Sea (Moulton and Lawson 2002, Clarke et al. 2011a, Clarke et al. 2012, 2013). During BPXA's OBC seismic survey in Foggy Island Bay, close to the proposed project area, observers recorded a limited number of seal sightings (18) of which one was a confirmed bearded seal (Aerts et al. 2008). Based on available data, bearded seals are expected to occur in the survey area, but the numbers are expected to be small (SAE 2015b).

Ringed seals molt from around mid-May to mid-July when they spend quite a bit of time hauled out on ice at the edge of the permanent pack, or on remnant land-fast ice along coastlines (Reeves 1998). While ringed seals do not cease foraging entirely during their molting period, the higher proportion of time spent hauled out (Kelly and Quakenbush 1990, Kelly et al. 2010b) may make them less likely to encounter a transiting vessel during the initial survey period.

Vessels would have a transitory presence in any specific location. NMFS is not able to quantify existing traffic conditions across the entire Beaufort Sea to provide context for the addition of eight vessels. However, the absence of collisions involving vessels and ice seals 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 activities in the Beaufort Sea, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike in the Beaufort Sea, Chukchi Sea or Bering Sea for ice seals, the mitigation measures in place to minimize exposure of pinnipeds to vessel activities, we conclude that the probability of a SAE vessel striking a threatened ringed or bearded seal in the Beaufort Sea sufficiently small as to be discountable.

6.4 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. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

6.4.1 Responses to Seismic Noise

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

Bowhead Whales

For this action, we estimated 271 instances (138 in the summer, and 133 in the fall) where bowhead whales might be exposed to seismic activities at received levels between 160 dB and 179 dB using ~620 cui airgun array. An additional 181 instances of exposure (92 in the summer, and 89 in the fall) may occur using the 1,240 cui airgun array at received levels between 160-179 dB in state and federal waters in the Beaufort Sea during the open-water season (see Section 6.3.1., *Exposure to Active Seismic*, Table 12). One additional exposure may occur at received levels ≥ 180 dB.

These instances of exposure are likely to be overestimates because they assume a uniform distribution of animals, do not account for avoidance, and they assume all of the tracklines will be shot during the season (see Section 6.2.1 for full list). It is anticipated that only 33-73% of the seismic survey area will overlap with the bowhead habitat use area (NMFS 2015b).

In total we anticipate 452 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179dB, and 1 instance in which bowhead whales might be exposed to received levels between ≥ 180 and 190 dB during the OBN seismic surveys using ~620-1,240 cui airgun arrays (see Table 14).

Given the large size of baleen whales, and their pronounced vertical blow, it is likely that PSOs would be able to detect bowhead 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, evidence exists that some whales may be exposed to these higher received levels of noise. For example, during seismic survey activities 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 et al. 2010).[11] 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 et al. 2010). Similarly, during ION's 2013 in-ice seismic survey in the Beaufort and Chukchi Seas, 10 bowhead whales were sighted within the ≥180 dB re 1 μPa rms radius. The whales exhibited no overt reaction and either continued swimming alongside or in a direction away from the seismic vessel (Beland et al. 2013).

As discussed in the *Status of the Species* section, we have no data on baleen whale hearing so we assume that baleen whale vocalizations are partially representative of their hearing sensitivities. 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 1986b, Au et al. 2006, Southall et al. 2007, Ciminello et al. 2012, NOAA 2013).

Bowhead whales are among the more vocal of the baleen whales (Clark and Johnson 1984). Vocalization is made up of moans of varying pitch, intensity and duration, and occasionally higher-frequency screeches. Bowhead calls have been distinguished by Würsig and Clark (1993): pulsed tonal calls, pulsive calls, high frequency calls, low-frequency FM calls (upsweeps, inflected, downsweeps, and constant frequency calls). 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 2002a). As previously mentioned, Cumming and Holliday (1987) calculated source level measures for bowhead whales songs to be between 158 and 189 dB.

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

This information leads us to conclude that bowhead whales exposed to sounds produced by seismic airguns are likely to respond if they are exposed to low-frequency (20-5000 Hz) sounds. However, because bowhead 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 whales.

Seismic activity in the Beaufort Sea would likely impact bowhead 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, whether it is habituated to the sound, etc.

Tolerance

While 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, few studies have attempted to address habituation, sensitization, or tolerance (Nowacek et al. 2007). Tolerance is defined as 'the intensity of disturbance that an individual tolerates without responding in a defined way' (Nisbet 2000). Tolerance levels can be measured instantaneously and are, therefore, more readily demonstrated than the longer-term processes of habituation or sensitization. In fact, habituation and sensitization are identified, and distinguished from each other, by the direction of change indicated by repeated measures of tolerance taken over time. Thus, over the course of a habituation process, individual tolerance levels will increase, whereas tolerance levels will conversely decrease as individuals become sensitized to specific stimuli (Bejder et al. 2009).

Despite industry activities occurring at distances of only a few kilometers away, often times marine mammals show no apparent response or tolerance to industry activities of various types (Miller 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 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 (2008) study were larger than the array anticipated for the proposed action (total discharge volumes of 620-1,240 cui). Based on this information regarding marine mammal tolerance of underwater sounds, we anticipate that some baleen whales exposed to low frequency underwater sounds from seismic activities may tolerate seismic noise and show no apparent response. More information is needed in order to determine if the learned processes of habituation or sensitization are occurring over time as animals experience repeated exposures.

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 seismic survey, sound will consist of low frequency (under 500 Hz) pulses with extremely short durations (less than one second). Lower frequency anthropogenic 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 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 et al. 2009) and cause increased stress levels (e.g., (Foote et al. 2004, Holt 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 et al. 1995).

Responses While Feeding

Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011). 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 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 et al. 1986, Ljungblad et al. 1988, Richardson et al. 1995, Miller et al. 2005). Richardson 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 et al. 2005, Harris 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 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 2010a).

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 1990a, Gill and Sutherland 2001, Frid and Dill. 2002, Beale and Monaghan 2004a, b, Bejder et al. 2006, Bejder 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 (1986a) 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, and received levels were below ambient levels. 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 whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, may continue to forage 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 2002b, 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 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 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 et al. 2009, Koski 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.

Studies of bowhead, gray, and humpback whales have determined that received levels of pulses in the 160-170 dB re 1 µPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. It is anticipated that for the airgun arrays (620 and 1,240 cui) that will be used for the planned 3D seismic surveys, the distances to the 160 dB isopleth range from 1.8-5.2 km (SAE 2015b).

Avoidance is one of many behavioral responses bowhead whales may exhibit when exposed to impulsive 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 et al. 1986, Elowson et al. 1991), acquire mates (Ryan 1985), assess other members of their species (Parker 1974, Owings et al. 2002), evade predators (Greig-smith 1980), and defend resources (Zuberbuhler 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 (see (Miller et al. 2000, Melcon 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 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 2002a, Southall et al. 2007, Melcon et al. 2012).

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 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 et al. 2005, Blackwell 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 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 et al. 2013).

In birds, song diversity is an important index for population viability, and is influenced by anthropogenic noise (Laiolo et al. 2008, Slabbekorn and Ripmeester 2008), and in bowhead whales song diversity and complexity may serve as a barometer of the impact of encroaching Arctic oil and gas development (Johnson et al. 2014).

Based on this information, we would not anticipate migrating bowhead to devote attention to a seismic stimulus beyond the 120 dB isopleth, which may be more than 10 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.

Of the bowhead whales that may occur between 0 and 5.2 km for the 1,240 cui array, 1.8 km for the 620 cui array, and 1 km for the 10 cui mitigation gun , some whales are likely to change their behavioral state – 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 et al. 1986, Ljungblad et al. 1988, Richardson and Malme 1993, Greene et al. 1999, Frid and Dill. 2002, Christie et al. 2009, Koski et al. 2009, Blackwell et al. 2010, Funk et al. 2010, Melcon et al. 2012). We assume that these responses are more likely to occur when bowhead whales are aware of multiple vessels in their surrounding area. We anticipate that few (if any) exposures would occur at received levels ≥180 due to avoidance of high received levels, and shut down and power-down mitigation measures.

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

Zooplankton are food sources for bowhead whales. Sound energy generated from seismic operations is not anticipated to negatively impact the diversity and abundance of zooplankton.

Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Beaufort Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Chu 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.

No appreciable adverse impact on zooplankton populations will occur due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortality or impacts on zooplankton as a result of seismic operations is immaterial as compared to the naturally-occurring reproductive and mortality rates of these species. This is consistent with previous conclusions that crustaceans (such as zooplankton) are not particularly sensitive to sound produced by seismic sounds (Wiese 1996).

Fish are not considered a primary prey resource for whales in the Arctic (Lowry et al. 2004), but if fish were exposed to seismic we would anticipate the responses as described below under pinniped prey resources.

Pinnipeds (ringed and bearded seals)

We estimated a total of 1,168 possible instances where ringed seals, and 125 possible instances where bearded seals during summer and fall seasons might be exposed to seismic activities during the SAE's 2015 open water operations (see Section 6.3.1., *Exposure to Active Seismic*, Table 14). All instances of exposure are anticipated to occur at received levels between ≥ 160 dB and 190 dB.

We anticipate 1,148 instances where ringed seals might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179 dB, and 20 instances ringed seals might be exposed at received levels between ≥180 and 190 dB during seismic surveys using

~620-1,240 cui airgun arrays (see Table 14). Bearded seals may experience 115 instances of exposure from seismic airguns at received levels between 160 dB and 179 dB, and 10 instances of exposure at received levels between ≥180 and 190 dB during seismic surveys using ~620-1,240 cui airgun arrays (see Table 14).

These instances of exposure are likely overestimates because they assume a uniform distribution of animals, do not account for avoidance, and assume all of the tracklines will be shot during the season (see Section 6.2.1 for full list).

While a single individual may be exposed multiple times, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS.

Ringed and bearded seals traveling across a broad area may encounter more than one seismic exploration activity in a season and may therefore be disturbed repeatedly by the presence of vessels or seismic survey sound or both. However, seismic operations are required to be at least 24 km from each other which would reduce multiple disturbances. It is not known if multiple disturbances within a certain timeframe add to the stress of an animal and, if so, what frequency and intensity may result in biologically important effects. There is likely to be a wide range of individual sensitivities to multiple disturbances, with some animals being more sensitive than others.

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 et al. 1995). A more recent review suggests that the functional hearing range of phocids should be considered to be 75 Hz to 100 kHz (Hemila et al. 2006, Kastelein et al. 2009, NOAA 2013). The airgun sound sources being proposed for this project are anticipated to be between 50 Hz to 200 Hz, 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 et al. 1986), as cited in (Stirling 1973, Richardson et al. 1995). Ringed seal sounds are less complex and much lower in source level than bearded seal sounds (Richardson 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 et al. 1963, Stirling 1973, Cummings 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 et al. 1995). Ringed seals are known to vocalize at source levels of up to 130 dB (Stirling 1973, Cummings et al. 1986, Richardson 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 et al. 2010). Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz (Richardson 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 et al. 1969a, 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 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 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 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 et al. 1983). Received levels exceeding 190 dB re 1µ Pa are likely to elicit avoidance responses, at least in some ringed seals (Harris et al. 2001, Blackwell et al. 2004, Miller 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).[12] 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 quite localized (Harris 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 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 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 2013c).

[12] 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 et al. 2001).

During the open water season when the proposed activities would occur (July 1 through October 15), ringed seals are anticipated to be making short and long distance foraging trips (Smith 1973, 1976, Smith and Stirling 1978, Teilmann et al. 1999, Gjertz et al. 2000a, 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 et al. 1984). Bearded seals are less likely to encounter seismic surveys during the open water season than ringed seals because of the bearded seals preference for sea ice habitat (BOEM 2015a). 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 densities multiplied by the anticipated ensonified area from seismic operations estimate a high number of exposures, the anticipated received levels would be between ≥160 dB and 189 dB re 1 μPa rms where previous studies have shown limited potential to induce avoidance behavior in pinnipeds (Southall et al. 2007). Even if exposure occurred at higher received levels, the tendency of pinnipeds such as ringed and bearded seals to raise their heads above water, 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 the vessels are transiting and the ensonified area is temporary, and seals seem rather tolerant of low frequency noise.

Based on this information, we would not expect ringed and bearded seals that are more than 2-5 km from the seismic sound source to devote attention to that stimulus, even though received levels might be as high as 160 dB.[13] Similarly, we would not expect ringed and bearded seals that find themselves more than 0.6-0.9 kilometers (SAE 2015b) from seismic surveys 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 between 0 and 0.3 kilometers from the seismic source are likely to change their behavioral state to avoid slight TTS, although this avoidance is anticipated to be localized and temporary as the seismic operations are moving (Harris et al. 2001, Blackwell et al. 2004, Miller et al. 2005). In addition, if ringed or bearded seals are spotted within the 190 dB isopleth a power down/shutdown of seismic operations would occur. [14]

Prey Resources

The types of noises produced by seismic surveys 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).

[13] The distance to the 160 dB isopleth will vary dependent on the size of the airgun array. The range presented is for the 620-1,240 cui airgun array respectively (SAE 2015b).
[14] The distances to received levels presented here are all based on the distances anticipated from the 620-1,240 cui airgun arrays (Heath et al. 2014, SAE 2015b).

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 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 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).

6.4.2 Responses to Vessel Noise and Other Acoustic Sources

Vessel Noise

Based on ensonified area estimates provided by SAE and NMFS PR1, we do not anticipate that listed marine mammals will be exposed to continuous noise ≥120 dB associated with vessel traffic in the Beaufort Sea (see Section 6.3.2., *Exposure to Vessel Noise*).

As discussed in the *Approach to the Assessment* section above, animals that are not exposed to a potential stressor cannot respond to that stressor. An action that is not likely to reduce the fitness of individual whales or pinnipeds 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). For this reason we will not consider this stressor any further in our analysis.

Pinger and Transponder Noise

During the operation of pingers and transponders NMFS PR1 proposes to permit in the Beaufort Sea, some instances of exposure may occur to bowhead whales, ringed seals, and bearded seals at low received levels (see Section 6.3.3, *Exposure to Pinger and Transponder Noise*). However, out of these total exposures during the open water season, NMFS would classify 0 instances where whales and seals might be exposed to sounds at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment.[15]

While the operation of pingers and transponders is likely to expose some whales and seals, these exposures are anticipated to occur at low received levels. In addition, most of the energy created by these potential sources is outside the estimated hearing range of baleen whales and pinnipeds generally (Southall et al. 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. These exposures may cause some individual whales and seals to experience changes in their behavioral states (e.g. slight avoidance), however, these responses are not likely to alter the physiology, behavioral ecology, or social dynamics of individual whales or seals in ways or to a degree that would reduce their fitness.

As a result, the pinger and transponder operations NMFS PR1 plans to permit in the Beaufort Sea during the 2015 open water season would not appreciably reduce the bowhead whale, ringed seal, or bearded seal's likelihood of surviving or recovering in the wild.

In addition to the noise associated with pinger and transponder operations, baleen whales and pinnipeds are anticipated to react to the other noises associated with project operations which will reach much farther (seismic operations). For this reason we will not consider this stressor any further in our analysis.

[15] For the open-water season, behavioral harassment is not anticipated to occur until received levels are ≥160 dB. This is consistent with NMFS's longstanding MMPA permitting thresholds. However, there is some recent evidence indicating that for pinnipeds, behavioral harassment may occur at higher thresholds (Harris et al. 2001, Blackwell et al. 2004, Miller et al. 2005, Southall et al. 2007). NMFS is currently reviewing relevant acoustic criteria, and the relevant thresholds may change in the future (78 FR 78822).

6.4.3 Responses to Vessel Strike

As we indicated in *Section 6.3.4 Exposure to Vessel Strike*, the likelihood of a vessel strike occurring as part of the proposed action to a listed baleen whale or pinniped in the Beaufort Sea is sufficiently small as to be considered discountable.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because listed baleen whales and pinnipeds are not likely to be directly or indirectly exposed to vessels in close enough proximity for a strike to occur in the Beaufort Sea, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. An action that is not likely to reduce the fitness of individual whales or pinnipeds 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).

For this reason we will not consider this stressor any further in our analysis.

7. 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 ESA.

NMFS reviewed recent environmental reports, NEPA compliance documents, and other source documents to evaluate and identify actions that were anticipated to occur within the analytical timeframe of this opinion (open water season of 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.

7.1 Oil and Gas Projects

State of Alaska: There are a number of onshore and nearshore exploration wells being proposed on State oil and gas leases in the Beaufort Sea region. However, these prospects are primarily onshore or inshore with little potential for affecting the proposed area.

In the past, many oil industry applicants have applied for MMPA authorization for proposed activities on State leases creating a federal nexus for ESA consultation. Also depending on the proposed activity and location there may be a nexus through wastewater discharge or federal air permits, or dredge and fill permits.

7.2 Transportation

It is reasonable to assume that trends associated with transportation to facilitate the maintenance and development of coastal communities and Prudhoe Bay area oil and gas facilities will continue. In some specific cases, described below, transportation and associated infrastructure in the proposed activity area may increase as a result of increased commercial activity in the area.

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.

Oil and gas industry use of helicopters and fixed wing aircraft to support routine activities and exploration within the project area is likely to increase as a result of increased interest in North Slope exploration.

Vehicle Traffic: None of the anticipated future activities propose to construct permanent roads to the communities in the North Slope. Construction of ice roads could allow industry vehicles access to community roads, and likewise allow residents vehicular access to the highway system.

Vessel traffic within the project 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. The increase in vessel traffic on the near-shore Prudhoe Bay from oil and gas exploration activity is particularly pronounced (ICCT 2015).

In addition, research vessels, including NSF and USCG icebreakers, also operate in the project area. USCG anticipates a continued increase in vessel traffic in the Arctic. Cruise ships and private sailboats sometimes transit through the proposed 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.

Increased barge traffic would occur if the Point Thomson Project or the Alaska Pipeline Project were constructed during the time period covered under this opinion. Coastal barges would support these projects by delivering fuel, construction equipment, and materials and sea lift barges would deliver modules for processing and camp facilities. If realized, this would result in additional barge traffic transiting through the project area but potential for congestion would only be expected near Prudhoe Bay docks and only during construction. Offshore oil and gas exploration drilling would also result in some additional tug and barge, support, icebreaker, and other vessel traffic (Petroleum News 2011) that could contribute to congestion if they used Prudhoe Bay area docks.

7.3 Community Development

Community development projects in Arctic communities 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.

7.4 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 Beaufort and Chukchi Sea coasts in small numbers, much of the air sightseeing traffic is concentrated in ANWR 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 (NMFS 2013b).

7.5 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 by ESA consultations due to required federal actions to set harvest quotas.

7.6 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. 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.

8. INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step of NMFS's assessment of the risk posed to listed species by the proposed action. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of survival of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) result in appreciable reductions in the likelihood of recovery of the species in the wild by reducing its numbers, reproduction, or distribution. These assessments are made in full consideration of the status of the species (Section 4).

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 1992a, 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 individuals of the 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 (species, subspecies, or 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 action, individually and cumulatively, given that the individuals in the action area for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range.

8.1 Bowhead Whale Risk Analysis

Based on the results of the *Exposure Analysis*, we expect bowhead whales to be exposed to low-frequency active seismic noise. We anticipate no exposure to vessel noise at levels of concern, nor any likelihood of vessel strike; effects from these stressors are considered discountable as they are extremely unlikely to occur. Exposure to noise from pinger and transponder operations is also not anticipated, however if exposure were to occur, it is anticipated that these exposures would be at very low received levels, and outside the hearing range of bowhead whales, and the effects of the exposures would be considered insignificant.[16]

Our consideration of probable exposures and responses of bowhead whales to seismic airgun noise associated with the proposed action is designed to help us assess whether those activities are likely to increase the extinction risks or jeopardize the continued existence of listed 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). Bowhead 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 bowhead whales. As a result, the whales' probable responses to close approaches by seismic vessels (i.e., 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) and their probable exposure to active seismic noise are not likely to reduce the fitness or current or expected future reproductive success of listed whales 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.

8.1.1 Probable Risk to Bowhead Whales

During low-frequency seismic activities from the proposed action, NMFS estimated 453 instances of exposure (see Section 6.3.1, *Exposure to Active Seismic*) at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 6.4.1, *Responses to Seismic Noise*).[17] No bowhead whales are anticipated to be exposed to sound levels that could result in TTS or PTS.

[16] Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. In this situation, exposures may occur to a single bowhead at ≤120 dB, but at received levels far below what would be considered "take" (≥160 dB).

[17] For the open-water season, behavioral harassment is not anticipated to occur until received levels are ≥160 dB.

Although the seismic activities are likely to cause individual whales to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002b), 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 because the whales are actively foraging in waters around the seismic operations or migrating through the seismic operations.

While a single individual may be exposed multiple times over the course the open water season, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS.

These exposures may cause some individual bowhead whales to experience changes in their behavioral states (e.g. slight avoidance), however, these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual bowhead whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters around the seismic operations or migrating through the seismic operations.

We expect zero instances where bowhead whales might be exposed to sounds produced by pingers and transponders at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 6.4.2, *Responses to Vessel Noise and Other Acoustic Sources*).[18]

In addition, our *Exposure Analysis* concluded that bowhead whales were not likely to be exposed to vessel noise or the potential for vessel strike because only eight vessels are anticipated for the proposed action and noise associated with the vessel operations is anticipated to drop to 120 dB within 176 m (or less). The limited number of vessels and small ensonified area reduce the probability of exposure to bowhead whales to levels we would consider discountable.

The implementation of mitigation measures will further reduce the instances of exposure and minimize the effects on this species.

As a result, the activities NMFS PR1 plans to authorize are not likely to appreciably reduce the bowhead whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that seismic operations, vessel noise, and pinger and transponder noise 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 et al. 2004b, Schweder and Sadykova. 2009). The maximum theoretical net productivity rate is 4% for the Western Arctic stock of bowhead (Wade and Angliss 1997). The time series of abundance estimates indicates an approximate 50% increase in total abundance of bowhead whales during

[18] For the open-water season, behavioral harassment is not anticipated to occur until received levels are ≥160 dB.

the last ten years, and a doubling in abundance since the early 1990s (LGL Alaska Research Associates Inc. et al. 2014). Despite exposure to oil and gas exploration activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2015a), this increase in the number of bowhead whales suggests that the stress regime these whales are exposed to in the Arctic has not prevented these whales from increasing their numbers.

Given the life history of bowhead whales and gestational constraints on minimum calving intervals (e.g., (Reese et al. 2001a), and assuming that adult survival rates based on aerial photo-ID data (Zeh et al. 2002, Schweder et al. 2010b) 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. 2007a). While the sample size was small, 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).

As discussed in the *Environmental Baseline* section of this opinion, bowhead whales have been exposed to active seismic activities in the Arctic, including associated vessel and aircraft traffic, for generations. 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 earlier seismic operations. The activities NMFS PR1 proposes to authorize under the proposed action are smaller in magnitude as compared to previous activities in the area, and these permitted activities are not likely to affect the rate at which bowhead whale counts in the Arctic are increasing.

A change in either bowhead whale 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 bowhead whale trend in abundance (LGL Alaska Research Associates Inc. et al. 2014).

8.2 Pinniped Risk Analysis (ringed seal and bearded seal)

Based on the results of the *Exposure Analysis*, we expect ringed and bearded seals to be exposed to low-frequency active seismic noise. Exposure to noise from pingers and transponders is not anticipated, and if it were to occur would be at very low received levels and the effects of the exposures are considered insignificant. No exposure to vessel noise or potential for vessel strike is anticipated for either species.

As we discussed in the narratives for cetaceans listed above, our consideration of probable exposures and responses of pinnipeds to seismic stressors associated with exploration activities in the action area are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing listed pinnipeds.

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 et al. 2010b). This early fall foraging period overlaps with fall seismic activities NMFS PR1 plans to permit. However, 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. As a result, the ringed and bearded seal's probable responses (i.e., tolerance, avoidance, short-term masking, and short-term vigilance behavior) to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce their 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.

8.2.1 Probable Risk to Ringed Seals

We estimated 1,168 instances of ringed seal exposure to seismic activities from the proposed action (see Section 6.3.1, *Exposure to Active Seismic*) at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 6.4.1, *Responses to Seismic Noise*).[19] No ringed seals are anticipated to be exposed to sound levels that could result in TTS or PTS.

These estimates represent the total number of takes that could potentially occur, not necessarily the number of individuals taken, as a single individual may be taken multiple times over the course of the proposed action. These exposure estimates are likely to be overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures, and assume all of the tracklines will be shot.

Although these seismic activities are likely to cause some individual ringed seals to experience changes in their behavioral states that might have adverse consequences (Frid and Dill. 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual ringed seals in ways or to a degree that would reduce their fitness because the seals are actively foraging in waters around the seismic operations, have their heads above water, or hauled out. While a single individual may be exposed multiple times over the course the open water season, the short duration and intermittent transmission of seismic airgun pulses, combined

[19] For the open-water season, behavioral harassment is not anticipated to occur until received levels are ≥160 dB. This is consistent with NMFS's longstanding MMPA permitting thresholds. There is some recent evidence, however, indicating that, for pinnipeds, behavioral harassment may occur at higher thresholds (Harris et al. 2001, Blackwell et al. 2004, Miller et al. 2005, Southall et al. 2007). NMFS is currently reviewing relevant acoustic criteria, and the relevant thresholds may change in the future (78 FR 78822).

with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS. In most circumstances, ringed seals are likely to avoid certain ensonified areas that may cause TTS. Ringed seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and ringed seals seem rather tolerant of low frequency noise. Southall et al. (2007) reviewed literature describing responses of pinnipeds to impulsive noise sources and reported that the limited data suggest exposures between ~150 and 180 dB re 1 μPa generally do not appear to induce avoidance behavior. Received levels exceeding 190 dB re are likely to elicit responses in at least some individual seals (Southall et al. 2007).

Our *Exposure Analysis* concluded that some ringed seals might be exposed to impulsive noise from pinger and transponder operations. However, none of these exposures are anticipated to rise to the level of take under the ESA due to exposures occurring at very low received levels (≤120dB), outside the general hearing range of pinnipeds, and the directionality, short pulse duration, and small beam width of the source. All of these factors reduce the probability of exposure of ringed seals to pinger and transponder noise to levels we consider discountable.

In addition, our *Exposure Analysis* concluded that ringed seals were not likely to be exposed to vessel noise or the potential for vessel strike because only eight vessels are associated with the proposed action and noise associated with the vessel operations is anticipated to drop to 120 dB within 176 m (or less). The limited number of vessels and small ensonified area reduce the probability of exposure to ringed seals to levels we would consider discountable.

The implementation of mitigation measures will further reduce the instances of exposure and minimize the effects on the species.

Ringed seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and ringed seals seem rather tolerant of low frequency noise. 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 a result, the proposed action would not appreciably reduce the ringed seal's likelihood of surviving or recovering in the wild.

8.2.2 Probable Risk to Bearded Seals

In our *Exposure Analysis* we estimated 125 instances of bearded seal exposure to seismic activities at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 6.3.1, *Exposure to Active* Seismic).[20]

[20] For the open-water season, behavioral harassment is not anticipated occur until received levels are ≥160 dB.

While a single individual may be exposed multiple times over the course of a season, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS.

Seals have been noted to tolerate high levels of sounds from airguns (Arnold 1996, Harris 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 2013c).

In most circumstances, bearded seals are likely to avoid certain ensonified areas that may cause TTS or PTS. Bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and bearded seals seem rather tolerant of low frequency noise.

Our *Exposure Analysis* concluded that bearded seals were not likely to be exposed to noise associated with pinger or transponder sources, vessel operations or vessel strike in the Beaufort Sea because the noise associated with pinger and transponder sources is expected to attenuate quickly, is considered outside the hearing range of bearded seals, and bearded seals are anticipated to be in low numbers in the area. All of these factors reduce the probability of being exposed to pinger and transponder sources to levels we would consider discountable. In addition, vessel operations would drop to 120 dB within 176 m (or less) and the proposed action only involves eight vessels. The limited number of vessels, and small ensonified area reduced their probability of being exposed to levels that we would consider discountable.

Mitigation measures are designed to avoid or minimize adverse impacts associated with the proposed action to result in a negligible level of effect to bearded seals.

Bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary. 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 a result, the proposed action would not appreciably reduce the bearded seal’s likelihood of surviving or recovering in the wild.

9. 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 the endangered bowhead whale (*Balaena mysticetus*), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), or the Beringia DPS of bearded seal (*Erignathus barbatus nauticus*)

10. 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. The MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) 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 [Level B harassment] (16 U.S.C. §1362(18)(A)(i) and (ii)).

In this opinion and incidental take statement, we have considered potential exposures of listed species to certain sound sources and the effects these sources may have (see Table 16). 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 rely on the estimated instances of exposure (which are considered to be takes by harassment under the MMPA) as a proxy for the number of animals taken under the ESA. 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 a any measurable adverse effect. Notwithstanding that fact, the exposure estimates reflect the best scientific and commercial data 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 become effective only upon the issuance of MMPA authorization to take the marine mammals identified here (Section 9 of the ESA, however, does not apply to ringed or bearded seals)**. 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 the authorization holder to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the authorization, 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.

10.1 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 (50 CFR § 402.14 (i); see also 51 FR 19926, 19953-54 (June 3, 1986)).

This project-specific Section 7 consultation falls within the scope of the programmatic Arctic Regional Biological Opinion that NMFS issued to BOEM/BSEE in April 2013. 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.

As discussed in the *Approach to the Assessment* section of this opinion, we used the best scientific and commercial information available to determine whether and how listed individuals in the exposed populations might respond given their exposure to the proposed action. To estimate the number of animals that might be "taken" in this opinion, we classified the suite of responses as one or more forms of "take" and estimated the number of animals that might be "taken" by (1) reviewing the best scientific and commercial information available to determine the likely suite of responses given exposure of listed marine mammals to the proposed action at various received levels; (2) classifying particular responses as one or more form of "take" (as that term is defined by the ESA and implementing regulations that further define "harass"); and (3) adding the number of exposure events that could produce responses that we would consider "take." These estimates include whales and pinnipeds that are likely to be exposed and respond to low-frequency seismic airgun pulses at received levels and close approaches to vessels that are likely to result in behavioral changes that we would classify as "harassment." This incidental take statement does not exempt take resulting from vessel strikes. No whales or pinnipeds are likely to die or be wounded as a result of their exposure to the proposed seismic operations.

Based on our *Exposure* and *Response* Analyses, we determined that only certain exposures from 3D seismic operations could rise to the level of "take" (by harassment) as defined under the ESA. The results of our incidental take estimates are presented in Table 16.

For bowhead whales, ringed seals, and bearded seals, based on the best scientific and commercial information available, we would not anticipate responses to impulsive seismic noise at received levels between 120-159 dB would rise to the level of "take" as defined under the ESA. For this reason, the total instances of harassment for these species only considered exposures at received levels ≥ 160 dB.

For purposes of this opinion, the endangered bowhead whale is the only species for which the Section 9 take prohibition applies. This incidental take statement, however, includes limits on taking of ringed and bearded seals since those numbers were analyzed in the jeopardy analysis and 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.

Table 16. Summary of incidental take associated with instances of seismic exposure resulting from the proposed action's 3D seismic survey activities on bowhead whales, ringed seals, and bearded seals.

Species	Estimated Instances of Exposure to ≥160 dB		Estimated Instances of Exposure to ≥180 dB (whales) or ≥190 dB (seals) re 1 µPa	Total Amount of Take Associated with Proposed Action	Anticipated Temporal Extent of Take
	Summer	Fall			
Bowhead Whale	230	222	1	**453**	July 1, 2015 through October 15, 2015
Bearded Seal	75	40	10	**125**	
Ringed Seal	750	398	20	**1,168**	

The instances of harassment identified in Table 16 would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures shifting 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 engine of the source vessels, and other sounds associated with the proposed activities.

10.2 Effect of the Take

Studies of marine mammals and responses to seismic transmissions have shown that bowhead whales, as well as ringed and bearded seals are likely to respond behaviorally upon hearing low-frequency seismic transmissions. Although the biological significance of those behavioral responses remains unknown, this consultation has assumed that exposure to seismic noise might disrupt one or more behavioral patterns that are essential to an individual animal's life history. However, any behavioral responses of these whales and pinnipeds to seismic transmissions and any associated disruptions are not expected to affect the reproduction, survival, or recovery of these species. Exposures to pinger and transponder pulses are not anticipated to rise to the level of "take" as defined under the ESA.

10.3 Reasonable and Prudent Measures (RPM)

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

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, ringed seals, and bearded seals resulting from the proposed action.

1. This ITS is valid only for 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, 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 must implement measures to reduce the probability of exposing bowhead whales, ringed seals, and bearded seals to seismic transmissions that will occur during the proposed activities.

4. NMFS PR1 must 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 shall submit reports to NMFS AKR that evaluate its mitigation measures and report the results of its monitoring program.

10.4 Terms and Conditions

"Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply.

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 Sections 2.1.2 and 2.1.3 of this opinion, and reporting/monitoring requirements described in the MMPA authorization.

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 authorization holder must undertake the following:

A. At all times when conducting seismic-related activities, NMFS PR1 must require the authorization holder to possess on board the seismic source vessel 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 authorization holder must undertake the following:

A. The taking of any marine mammal in a manner other than that described in this ITS must be reported within 24 hours to NMFS AKR, Protected Resources Division at 907-586-7638.

B. In the event that the proposed action causes a take of a marine mammal that results in a serious injury or mortality (e.g. ship-strike, stranding, and/or entanglement), SAE must immediately cease operations and immediately report the incident to NMFS AKR, Protected Resources Division at 907-586-7638 and/or by email to Jon.Kurland@noaa.gov and Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 (Aleria.Jensen@noaa.gov), and NMFS PR1 Shane Guan 301-427-8418 for any MMPA authorization issues. 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); (xi) and photographs or video footage of the animal (if equipment is available).

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

To carry out RPM #3, NMFS PR1 must undertake the following:

A. Require SAE to conduct sound source verification (SSV) tests for the 1,240 cui airgun array prior to commencement of the survey. Before conducting NMFS PR1 permitted activities, the operator (SAE) must conduct SSV tests to verify the radii of the exclusion and harassment zones within real-time conditions in the field, thus providing for more accurate radii to be used. Results of the acoustic characterization and SSV will be used to establish the 190 dB, 180 dB, 170 dB, and 160 dB isopleths for the 1,240 cui airgun array. The results of the SSV will be submitted to NMFS within five days after completing the measurements, followed by a report to be submitted within 14 days after completion of the measurements. A more detailed report will be provided to NMFS as part of the required 90-day monitoring report following completion of the acoustic program.

B. The 180 and 190 dB exclusion radii around operating airguns must be fully observed during daylight hours.

C. Whenever aggregations of 12 or more bowhead whales appear to be engaged in non-migratory behavior (e.g. feeding, socializing), or cow/calf pairs are observed within the 160 dB harassment zone around the seismic activity (which is anticipated to occur out to 5.2 km for the 1,240 cui airgun array, and 1.8 km for the 620 cui airgun array from the source vessel), the seismic operation will not commence or will shut-down airgun operations completely.

To carry out RPM #4, NMFS PR1 or its authorization holder must undertake the following:

A. All mitigation measures as outlined in Sections 2.1.2 and 2.1.3 of this biological opinion, or better or equivalent measures, must be implemented, as appropriate, upon issuance of an IHA under the MMPA.

To carry out RPM #5, NMFS PR1 or its authorization holder must undertake the following:

A. SAE must adhere to all monitoring and reporting requirement as detailed in the IHA issued by NMFS under section 101(a)(5) of the MMPA.

B. Submit a draft project specific report that analyzes and summarizes all of the NMFS PR1 authorized activities SAE conducted during the 2015 open water season (July 1 through October 15) to the Assistant Regional Administrator, Protected Resources Division, NMFS by email to Jon.Kurland@noaa.gov or his designee. This report will be submitted by January 2015. This report must contain the following information:

- Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort Sea State and wind force), and associated activities during all seismic/sonar operations, and vessel transit activities and sightings of ESA-listed marine mammals under NMFS's jurisdiction;

- Species, number, location, distance from the vessel, and behavior of any ESA-listed marine mammals under NMFS's jurisdiction, associated with seismic/sonar activity (number of power-downs and shut-downs), or associated with vessel transit observed throughout all monitoring activities;

- An estimate of the instances of exposure (by species) of ESA-listed marine mammals under NMFS's jurisdiction 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) with a discussion of any specific behaviors those individuals exhibited, [21] 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;

[21] Based on information provided (SAE 2015b), we anticipate that noise associated with the 1240 cui airgun array will reach the 160, 180, and 190 dB isopleths at approximately 5.2 km, 910 m, and 250 m respectively from the source. Similarly, for the 620 cui airgun array the respective distances to the various isopleths are anticipated to be 1.82 km, 635 m, and 195m.

- The report should clearly compare the anticipated takes (i.e. instances of exposure) authorized in the ITS with those observed during seismic operations ("take" being defined as an ESA-listed mysticete or pinniped receiving exposure to seismic pulses at ≥ 160 dB re 1 μPa (rms)).

- The draft report will be subject to 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.

- A description of the implementation and effectiveness of each Term and Condition, as well as any conservation recommendations, for minimizing the adverse effects of the action on ESA-listed marine mammals.

11. 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. To the maximum extent practicable, NMFS PR1 should encourage operators to schedule seismic operations (i.e., shooting airguns) during daylight hours when marine mammals can more easily be sighted (deployment/retrieval of equipment could occur during nighttime hours).

2. To the maximum extent practicable, NMFS PR1 should require survey operators to plan survey tracklines (especially nearshore) starting from the coastline (inshore) and proceeding towards the sea (offshore) to avoid concentrating marine mammals in shallow water.

3. NMFS PR1 should request SAE to monitor ambient sound levels within the action area as well as elevated sound levels due to seismic operations to gain insight into the incremental impact of increasing sound levels on listed species.

4. 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 and pinnipeds. This analysis includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species.

5. NMFS PR1 should require SAE PSOs to complete a protected species observer training course that includes the requirements described in the NOAA Fisheries Service 2013 National Standards for Protected Species Observer and Data Management Program: A model for Seismic Surveys (Baker et al. 2013).

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 implemented in the final action.

12. 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, (2) new information reveals effects of the agency action on listed species 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.

13. 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.

13.1 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.

13.2 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.

13.3 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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