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

Issuance of Incidental Harassment Authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to SAExploration, Inc. (SAE) for Marine 3D Ocean Bottom Cable Seismic Activities in the U.S. Beaufort Sea, Alaska, during the 2013 open water season

NMFS Consultation Number: *F/AKR/2013/9283*

Action Agency: *National Marine Fisheries Service's 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
Fin Whale (*Balaneoptera physalus*)	Endangered	Yes	No	N/A
Humpback Whale (*Megaptera novaeangliae*)	Endangered	Yes	No	N/A
North Pacific Right Whale (*Eubalaena japonica*)	Endangered	No	No	No
Ringed Seal, Arctic subspecies (*Phoca hispida hispida*)	Threatened	Yes	No	N/A
Bearded Seal, Beringia DPS (*Erignathus barbatus barbatus*)	Threatened	Yes	No	N/A
Steller Sea Lion, Western DPS (*Eumatopias jubatus*)	Endangered	No	No	No

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By:

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

Date:

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TERMS AND ABBREVIATIONS

µPa	Micro Pascal
2D	Two-Dimensional
3D	Three-Dimensional
AGL	Above Ground Level
ARBO	Arctic Biological Opinion
ASL	Above Sea Level
ATOC	Acoustic Thermometry of the Ocean Climate
BCB	Bering, Chukchi, and Beaufort Seas
BE	Biological Evaluation
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BSAI	Bering Sea/Aleutian Island
BSEE	Bureau of Safety and Environmental Enforcement
BWASP	Bowhead Whale Aerial Survey Project
CFR	Code of Federal Regulations
CI	Confidence Interval
COMIDA	Chukchi Offshore Monitoring in Drilling Area
CPUE	Catch Per Unit Effort
CTS	Compound Threshold Shift
CV	Coefficient of Variation
CWA	Clean Water Act
dB	Decibels
DEA	Draft Environmental Assessment
DP	Dynamic Positioning
DPS	Distinct Population Segment
DQA	Data Quality Act
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EP	Exploration Plan
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FR	Federal Register
ft	Feet
g	Gallons

GPS	Global Positioning System
Hz	Hertz
IHA	Incidental Harassment Authorization
In^3	Cubic inch(es)
IPCC	Intergovernmental Panel on Climate Change
ITS	Incidental Take Statement
IWC	International Whaling Commission
kHz	Kilohertz
km	Kilometers
km^2	Square Kilometers
kn	Knots
L	Liter
LOA	Letter of Authorization
m	Meter
mi	Mile
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
ms	Milliseconds
MSY	Maximum Sustainable Yield
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NRC	National Research Council
NSB	North Slope Borough
NSR	Northern Sea Route
NWMB	Nunavut Wildlife Management Board
NWP	Northwest Passage
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OBC	Ocean Bottom Cable
OC	Organochlorine
OCS	Outer Continental Shelf
Opinion	Biological Opinion
Pa	Pascals
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PR1	Office of Protected Resources- Permits and

	Conservation Division
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
Re	Relative To
RMS	Root Mean Square
RPA	Reasonable and Prudent Alternative
s	Second
SEL	Sound Exposure Level
SAE	SAExploration, Inc.
Shell	Shell Offshore Inc.
SONAR	SOund Navigation And Ranging
SPLASH	Structure of Populations, Level of Abundance and Status of Humpback Whales
SSL	Steller Sea Lion
TGS	TGS-NOPEC Geophysical Company ASA
TTS	Temporary Threshold Shift
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Services
VMS	Vessel Monitoring System

1. INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1536(a)(2)) requires each Federal agency to ensure that any action it authorizes, funds, or carries 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 or its critical habitat, that agency is required to consult formally 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 comply with this general requirement 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' 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 cable (OBC) seismic surveys in U.S. waters and international waters of the Beaufort Sea by SAExploration, Inc. (SAE) between July 15, 2013 and October 31, 2013. The consulting agency for this proposal is NMFS' Alaska Regional Office – Protected Resources Division. This document represents NMFS' final biological opinion (opinion) on the effects of this proposal on endangered and threatened species and 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 authorization of an IHA to take marine mammals by harassment under the MMPA incidental to open-water seismic surveys to SAE in the nearshore waters of the Colville River Delta in the U.S. Beaufort Sea from July 15 to October 31, 2013. These actions have the potential to effect the endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered humpback whale (*Megaptera novaeangliae*), endangered right whale (*Eubalaena japonica*), endangered western Steller sea lion (*Eumatopias jubatus*) distinct population segment (DPS), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), and threatened Beringia DPS of bearded seal (*Erignathus barbatus barbatus*), as well as the designated critical habitats for North Pacific Right whale and Steller sea lion. NMFS PR1 is the federal action agency that issues IHAs and is responsible for ensuring compliance with the terms and conditions of the IHA activities.

This biological opinion is based on information provided in the May 2013, Draft Environmental Assessment; April 2013, Revised Incidental Harassment Application by SAE; March 2013, ESA Additional Information Request Response by SAE; March 2013, Effects of Oil and Gas Activities in the Arctic Ocean Supplemental Draft Environmental Impact Statement; and the updated project proposals, email and telephone conversations between NMFS PRD 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 March 11, 2013, NMFS' PR1 submitted a request to initiate Section 7 consultation to the NMFS Protected Resources Division for the proposed issuance of three IHAs to take marine mammals by harassment incidental to open-water seismic and marine surveys by Shell, TGS, and SAE that would occur from July 1, 2013 through October 31, 2013 in the Beaufort and Chukchi Seas (NMFS 2013a).

On December 11, 2012, NMFS' PR1 provided the Alaska Region with a copy of the IHA application for SAE (SAE 2012). SAE provided revisions to the IHA on April 4, 2013 (SAE 2013a).

NMFS PR1 requested additional information from SAE for the ESA consultation on March 13, 2013. SAE responded to this additional information request on March 15, 2013 (SAE 2013b), March 22, 2013 (SAE 2013c), and June 3, 2013 (SAE 2013d).

1.3 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 15, 2013 and October 31, 2013.

Project Purpose

The purpose of this action is for PR1 to issue an IHA to SAE to take marine mammals by harassment under the MMPA incidental to open-water marine seismic surveys in the Beaufort Sea in accordance with applicable law.

1.3.1 SAE's Proposed Open-Water Activities

SAE proposes to conduct 3D seismic surveys in the nearshore waters of the Colville River Delta. The receiver area represents a total area of 1,225 square kilometers (km^2) (473 square miles). The exact location of the receiver area is shown in Figure 1.

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 nodes. There will also be additional boat activity associated with crew transfer, recording support, and additional monitoring for marine mammals (SAE 2013a).

SAE plans to conduct the surveys between July 15 and October 31, 2013. Actual data acquisition is expected to take approximately 70 days (July 25 to September 30), dependingon 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 1,176 hours). If required in the Conflict Avoidance Agreement (CAA, see below), surveys will temporarily cease during the fall bowhead whale hunt to avoid interference with the Cross Island, Kaktovik, or Barrow based hunts. Seismic surveys will begin in the more offshore areas first with the intention of completing surveys of the fall bowhead whale migration area (waters >15 meters deep) prior to their arrival.

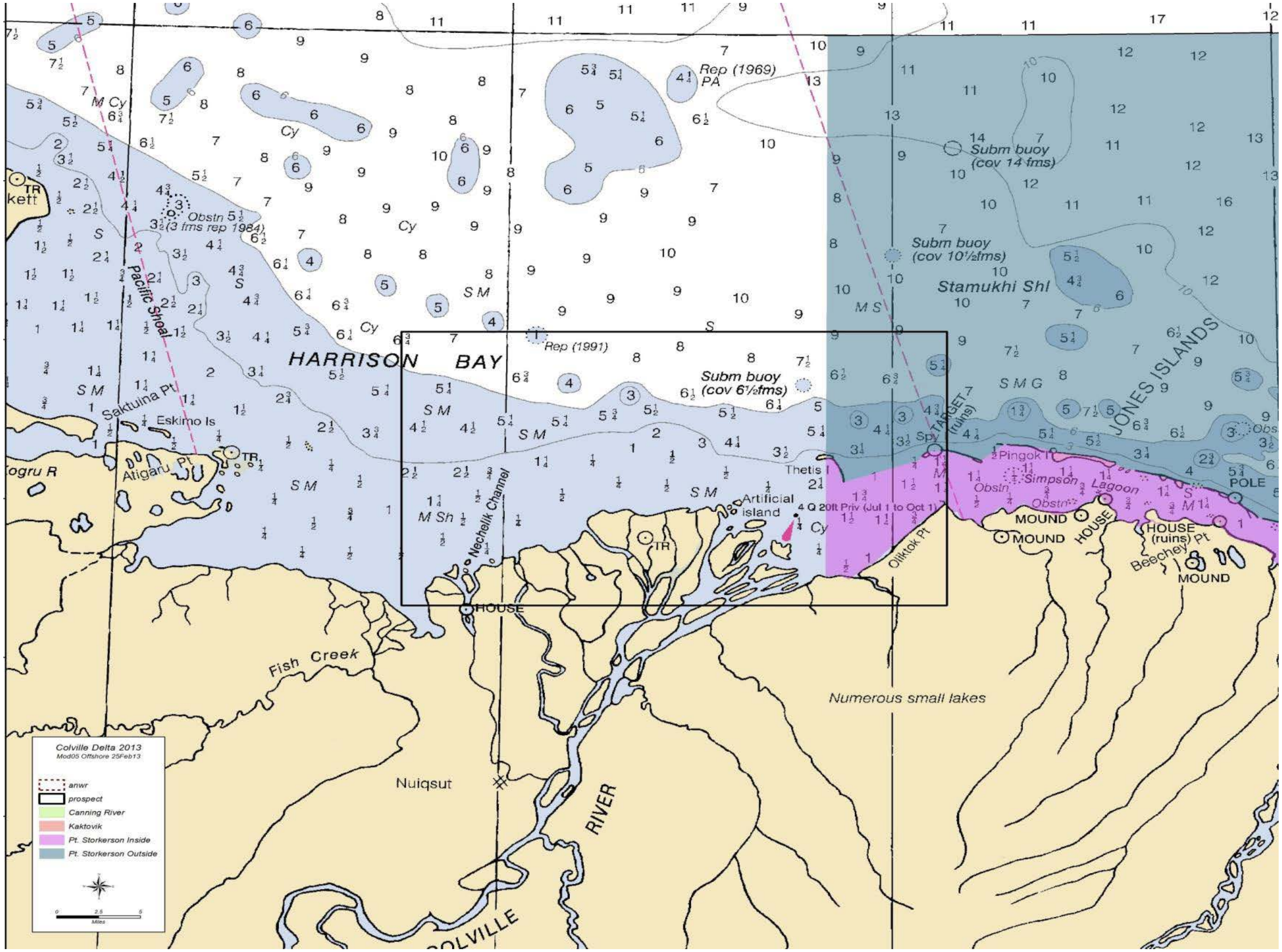

Figure 1. Proposed seismic survey area for SAE's 3D OBC operations during the 2013 open-water season in the U.S. Beaufort Sea (SAE 2013a).

The following text provides a brief description of the seismic operations (laying nodal recording sensors, operating seismic source vessels towing active airgun arrays, and retrieving nodes), the support vessels and crew transfer operations, and finally, a description of the active acoustic systems routinely used for seismic surveys.

1.3.1.1 SAE's Seismic Surveys

Two-hundred-ten nodal (receiver) lines will be laid perpendicular from the shoreline spaced 200 to 268 meters (660 to 880 feet) apart. Receiver line lengths range between 20 and 32 kilometers (13 and 20 miles) long. The total receiver area is 1,225 square kilometers (473 square miles). Sixty-five source (shot) transect lines will run perpendicular to the receiver nodal lines, each spaced 300 to 335 meters (990 to 1,100 feet) apart. These lines will be approximately 51 kilometers (32 miles) long. The total source survey area is 995 square kilometers (384 square miles).

The receiver layout and seismic survey data will be acquired using the stroke technique--multiple strokes with 6 receiver lines per stroke. Source lines will be acquired perpendicular to the receiver lines for each stroke, only 6 receiver lines will be laid at a time, with enough associated source survey to fully acquisition data for that stroke. Once data is acquired for a given stroke, the nodal lines (strings of individual nodes tethered together by rope) will be retrieved and repositioned into a second 6 line stroke, and the seismic survey operations begin anew. This will allow the most rapid acquisition of data using the minimum number of active nodes (SAE 2013a).

Seismic Source Array

SAE will use 880 and 1,760 cubic inch (cui) sleeve airgun arrays for use in the deeper waters, and a 440 cubic inch array in the very shallow (<1.5 meter deep) water locations. The arrays will be towed approximately 15 to 22 meters (50 to 75 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 8 to 10 seconds for each array resulting in an overall shot interval of 4 to 5 seconds considering the two arrays. Operations are expected to occur 24 hours a day.

Pingers and Transponders

An acoustical pinger system will be used to position and interpolate the location of the nodes. Pingers will be positioned at predetermined intervals throughout the shoot patch and signals transmitted by the pingers will be received by a transponder mounted on a recording and retrieving vessel. The pingers and transponder communicate via sonar and, therefore, each generates underwater sounds potentially disturbing to marine mammals (SAE 2013a).

The geophysical surveys planned by SAE are industry-standard, scientific surveys that have been routinely conducted in the Beaufort and Chukchi Seas since the early 1980s.

1.3.1.2 SAE's Vessel and Aircraft 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 2013a).

Vessel	Operation	Size (feet)	Gross Tonnage	No. of Berths	Main Activity/Frequency	Source Levels[1] (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 vessels expected to be used during this survey (SAE 2013a).

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 are the *Peregrine* and *Miss Diane*.

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.

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), but this vessel is mostly anchored up once it gets on site. The crew transfer vessel also travels only infrequently relative to other vessels, and is usually operated at different speeds.

Mitigation Vessel

To facilitate marine mammal monitoring of the Level B harassment zone, one dedicated vessel will be deployed a few kilometers northeast of the active seismic source vessels to provide a survey platform for 2 or 3 Protected Species Observers (PSOs). These PSOs 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 2013a).

1.3.1.3 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 2013a).

Active Acoustic Source	Frequency (kHz)	Maximum Source Level (dB re 1 µPa at 1m)
1760 cui airgun array	<1	237
880 cui airgun array	<1	227
440 cui airgun array	<1	221

Pinger	19-55	193
Transponder	7-50	193
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 2013a).

SONAR

Sound Navigation And Ranging, (SONAR), is a technique that uses sound propagation to navigate, communicate, or detect objects on or under the surface of the water. The proposed action anticipates the use of pingers and transponders which communicate via sonar.

Pinger and Transponder System

The exact model of pinger system to be used is yet to be determined, but available pingers transmit short pulses at between 19 to 55 kHz and have published source levels between 185 and 193 dB re 1 μPa @ 1 m (rms). Available transponders generally transmit at between 7 and 50 kHz, with similar source levels also between 185 and 193 dB re 1 μPa @ 1 m. Aerts et al. (2008) measured the sound source signature of the same pingers and transponders to be used in this survey and found the pinger to have a source level of 185 dB re 1 μPa and the transponder at 193 dB re 1 μPa.

SEISMIC

Seismic reflection profiling uses high-intensity sound to image the earth's crust. It is the primary technique used by the energy industry for finding and monitoring reserves of oil and natural gas.

Seismic surveys can be characterized by the type of data being collected (e.g. 2D, 3D, high-resolution, etc.) or by the type of survey being conducted (e.g. open-water towed marine streamer, ocean-bottom cable, in-ice towed streamer, over ice, etc.). Survey data may be described by the acoustic sound source (e.g. airgun, water gun, sparker, pinger) or by the purpose for which the data are being collected (e.g. speculative shoot, exclusive shoot, site clearance). SAE is proposing to collect 3D data by using an OBC system with an airgun sound source (SAE 2013a).

Seismic Profiling

Seismic reflection profiling systems are used to search for commercially and economically valuable subsurface deposits of crude oil, natural gas, and minerals by the recording, processing, and interpretation of reflected seismic waves from the substrates by introducing controlled source energy (such as seismic air gun impulses and vibratory waves) into the earth.

SAE is proposing to use reflected sound energy from a towed 880 and 1,760 cui sleeve airgun array for use in the deeper waters to produce graphic images of seafloor and subseafloor features

(SAE 2013a). The 440 cui array will be used in very shallow (<1.5 meter deep) water (SAE 2013a). Air guns fire highly compressed air bubbles into the water that transmit seismic wave energy into the subsurface rock layers. Seismic waves reflect and refract off subsurface rock formations and travel back to acoustic receivers called hydrophones. The characteristics of the reflected seismic waves (such as travel time and intensities) are used to locate subsurface geologic formations that may contain hydrocarbon deposits and to help facilitate the location of prospective drilling targets (BOEM 2011a).

Based on the manufacturer's specifications, the 440 cubic inch array has a peak-peak estimated 1-meter sound source of 239.1 dB re 1 µPa (9.0 bar-m; Far-field Signature, Appendix A), and root mean square (rms) at 221.1 dB re 1 µPa. The 880 cubic inch array produces sound levels at source estimated at peak-peak 244.86 dB re 1 µPa @ 1 m (17.5 bar-m; Far-field Signature, Appendix A), and rms at 226.86 dB re 1 µPa. The 1,760 cubic inch array has a peak-peak estimated sound source of 254.55 dB re 1 µPa @ 1 m (53.5 bar-m; Far-field Signature, Appendix A), with an rms sound source of 236.55 dB re 1 µPa. The 1,760 cubic inch array has a sound source level approximately 10 dB higher than the 880 cubic inch array (SAE 2013a).

The arrays will be towed approximately 15 to 22 meters (50 to 75 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.

The pressure output of an airgun array is proportional to (1) its operating pressure, (2) the number of airguns, and (3) the cube root of the total gun volume. For consistency with the underwater acoustic literature, airgun-array source levels are back-calculated to an equivalent source concentrated into a one-meter-radius volume (Greene and Moore 1995). The far field pressure from an airgun array is focused vertically, being about 6 dB stronger in the vertical direction than in the horizontal direction for typical arrays. 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 (SAE 2013a). Airgun arrays have dominant energy at low frequencies, where long-range propagation is likely.

OTHER ACOUSTIC SOURCES

Vessel Noise

SAE's proposed action anticipates employing eight vessels during their open-water operations in 2013. Vessels are anticipated to transit from the staging area through the Bering Strait, into the Chukchi Sea, and finally the Beaufort Sea.

Currently, no particular vessels are under contract with SAE for the project. When contracts for each of these two vessels are secured, SAE will provide NMFS the full vessel specifications. However, this opinion provides the anticipated source levels and frequency ranges of vessel operations (see Tables 1 and 2).

Vessel noises are often at source levels of 165-200 dB re 1 µPa at 1 m (Aerts *et al.* 2008, SAE 2013a), and typically operate at frequencies from 20-200 Hz (Greene 1995). Aerts et al. (2008) found the recording and deployment vessels to have a source level of approximately 165.3 dB re 1 µPa, while the smaller bow pickers produce more cavitation resulting in source levels of 171.8 dB re 1 µPa. In addition, 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), but this vessel is mostly anchored up once it gets on site. 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, while during slower on-site movements the vessel source levels are only 166.4 dB re 1 µPa (Aerts et al. 2008).

1.3.2 Mitigation Measures Proposed by SAE

As required to satisfy the requirements of the MMPA, SAE proposes to implement measures that would allow their survey and maintenance activities to have the least practicable adverse impact on marine mammal species or stocks (which includes considerations of personal safety and practicality of implementation). Those measures are provided below.

Protected Species Observers (PSOs)

PSOs will be placed onboard the seismic and mitigation vessels to minimize exposure to the seismic sound source, monitor the 180 dB and 190 dB safety or exclusion zones, the 160 dB harassment zone (both are explained below), 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 shut-down procedures if a marine mammal is detected approaching or within designated distances from the sound source.

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

- 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

SAE will conduct sound source measurements of the airgun array at the beginning of survey operations in 2013 to verify the size of the various marine mammal exclusion zones and harassment zone. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify and adjust the marine mammal exclusion and harassment zone distances. The field report will be made available to NMFS and the PSOs within 72 hours of completing the measurements. The mitigation measures to be implemented at the 190, 180, and 160 dB (rms) sound levels will include power downs and shut downs as described below.

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:

- With or without seismic operations taking place, SAE will reduce vessel speed when within 1 km of cetaceans, or conduct course alterations, provided that doing so will not compromise safety of the operations;
- The seismic and scout vessel 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 a safety zone for cetaceans and pinnipeds surrounding the airgun array on the source vessel where the received level would be 180 dB and 190 dB;
- PSOs will establish and monitor a harassment zone for marine mammals surrounding the airgun array of the source vessel where the received level would be 160dB;
- Whenever aggregations of cetaceans appear to be engaged in non-migratory significant behavior (e.g. feeding, socializing) are observed during a vessel monitoring program within the 160 dB harassment zone around the seismic activity, the seismic operation will not commence or will shut down; and
- Initiation of the seismic source will occur only after the 180 dB zone is visible for 30-minutes during day or night;

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

- During limited visibility due to fog and/or darkness, the entire 180 dB exclusion zone may not be visible. If the entire zone is not visible for a minimum of 30-minutes, initiation 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.

1.3.3 Mitigation Measures Proposed by PR1

The mitigation measures described below are required per the NMFS IHA stipulations, and will be implemented by SAE to reduce potential impacts to marine mammals from survey activities, vessel movements, and from vessels operating in dynamic positioning.

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

1. Protected Species Observers ([PSOs], formerly referred to as Marine Mammal Observers or [MMOs]) are required on all vessels engaged in activities that may result in an incidental take through acoustic exposure.

    - A sufficient number of NMFS-qualified, vessel-based PSOs shall be onboard the survey vessel to meet the following criteria: to visually watch for and monitor marine mammals near the vessels during dynamic positioning or airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night. The vessels' crew shall also assist in detecting marine mammals, when practicable. PSOs shall have access to reticle binoculars (7x50 Fujinon), big-eye binoculars (25x150), and night vision devices. PSO shifts shall last no longer than 4 hours at a time and shall not be on watch more than 12 hours in a 24-hour period. PSOs shall also make observations during daytime periods when active operations are not being conducted for comparison of animal abundance and behavior, when feasible;

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

        - Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from 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 vessel, sea state, ice cover, visibility, and sun glare;
        - The positions of other vessel(s) in the vicinity of the PSO location.
        - The ship's position, speed of support vessels, and water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables;

- 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 observers shall be paired with experienced observers to avoid situations where lack of experience impairs the quality of observations;
- Crew leaders and most other biologist serving as observers in 2013 shall be individuals with experience as observers during recent seismic or shallow hazard monitoring projects in Alaska, the Canadian Beaufort, or other offshore areas in recent years;
- PSOs will complete a two or three-day training session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2013 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;
- If there are Alaska Native PSOs, the PSO training that is conducted prior to the start of the survey activities shall be conducted with both Alaska Native PSOs and biologist PSOs being trained at the same time in the same room. There shall not be separate training courses for the different PSOs;
- 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; and
- PSOs shall use the best available technology to improve detection capability during periods of fog and other types of inclement weather. Such technology might include night-vision goggles or binoculars as well as other instruments that incorporate infrared technology.

2. Establishment of Exclusion and Disturbance 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 or disturbance 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 120-dB, 160-dB, 180-dB, and 190-dB marine mammal harassment zones 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 1 µPa (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; 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.

5. Sound Source Verification (SSV) tests for sound sources and vessels at the start of the season using hydrophones.

Before conducting the activity, SAE shall conduct SSV tests to verify the radii of the exclusion and disturbance zones within real-time conditions in the field, providing for more accurate radii to be used. Using a hydrophone system, SAE is required to conduct SSV tests for all airgun arrays and vessels and, at a minimum, report the following results to NMFS within five days of completing the test:

- The empirical distances from the airgun array and other acoustic sources 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.
- The test results shall be reported to NMFS within 9 days of completing the test.

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

These measures would be required for all vessel operations conducted in support of surveys, equipment recovery, and maintenance activities.

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

    - All vessels shall reduce speed to less than 5 kn 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 three or more whales observed within a 500 m (547 yard) area and displaying behaviors of directed or coordinated activity (e.g., group feeding);
    - Operate the vessel(s) to avoid causing a whale to make multiple changes in direct;
    - 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 accordingly to avoid the likelihood of injury to whales.

C) 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 2013 bowhead whale hunt;

1.4 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) 3D seismic survey sites in nearshore waters of the Colville River Delta in the U.S. Beaufort Sea; (2) a sound propagation buffer of approximately 10 kilometers around the 3D seismic survey sites in the Chukchi Sea; (3) State of Alaska waters between planning areas and the Alaska coastline; and (4) transit areas from Dutch Harbor through the Bering Strait and Chukchi Sea into the Beaufort Sea.

1.4.1 3D Seismic Surveys in the Beaufort Sea

The Beaufort Sea is located on the far edges of the Arctic Ocean, to the north of Alaska and Canada. The Alaskan coast of the Beaufort Sea is about 600 km (373 mi) in length, reaching from the Canadian border in the east, to the Chukchi Sea at Point Barrow in the west. The Beaufort Sea is a semi-enclosed basin with a narrow continental shelf extending 3 to 80 kilometers (km) (19 to 50 mi) from the coast. The Beaufort shelf areas have a larger depth range than the Chukchi shelf. The continental shelf of the Beaufort Sea is relatively shallow, with an average water depth of about 37 m (121 ft). However, bottom depths on the shelf increase gradually to a depth of about 80 m (262 ft), then increase rapidly along the shelf break and continental slope to a maximum depth of around 3,800 m (12,467 ft). Numerous narrow and low relief barrier islands within 1.6 to 32 km (1 to 20 mi) of the coast influence nearshore processes in the Beaufort Sea (BOEM 2011c).

SAE is proposing to conduct 3D seismic surveys in the nearshore waters of the Colville River Delta in the U.S. Beaufort Sea (see Figure 1). The total receiver area is 1,225 km^2 (473 mi^2). The total seismic survey area is 995 km^2 (384 mi^2) (SAE 2013a).

1.4.2 Sound Propagation Buffer

The Beaufort Sea seismic survey area covers a total of approximately 995 km^2 within the Alaskan portion of the Beaufort Sea. SAE provided modeled sound propagation estimates for the Beaufort Sea (SAE 2013c). Based on these estimates, received levels from seismic surveys using a 1760 cui airgun configuration would be expected on average to decline to about 120 dB within 9.57 km of the survey location (SAE 2013c). The 120 dB isopleth was chosen because that's when we anticipate survey seismic noise levels would approach ambient noise levels (i.e. the point where no measurable effect from the project would occur). This 9.57 km sound propagation buffer around the 3D seismic survey area assumes that a source vessel engaged in transmitting seismic occurred on the boundary of the survey area.

1.4.3 Alaska State Waters

The action area includes State of Alaska waters between seismic survey locations and the Alaska coastline. Surveys will occur within the nearshore waters of the Colville River Delta in U.S. Beaufort Sea. However, staging and resupply activities may occur from Alaskan Arctic communities. SAE has indicated that crew changes and resupply may occur out of Oliktok (Green 2013). In addition, some of the 3D seismic surveys will occur within state waters as indicated in Figure 1.

1.4.4 Transit Areas

SAE's seismic surveys will occur within state and federal waters of the Beaufort Sea. At this point in time, SAE has not identified where vessels will start and conclude the 2013 survey season. However, based on previous arctic oil and gas surveys and drilling activities that have occurred in the Chukchi and Beaufort Sea Planning Areas, Dutch Harbor often serves as a major staging area and may be used here. Vessels often transit through the Bering Strait into the Chukchi or Beaufort Sea Planning Areas.[1] For these reasons, the oceanographic area extends along a navigational route from Dutch Harbor on the south through the Bering Strait and Chukchi Sea into the Beaufort Sea. We recognize that staging and resupply may also occur from Alaskan Arctic communities (e.g. Oliktok). These locations and their staging waters are already encompassed in the action area under state waters. In addition, activities could be staged from areas in the Canadian Beaufort (e.g. Tuktoyaktuk) or Russian Arctic, but during our review of IHA applications and 90-day monitoring reports this occurred far less frequently than transits out of Dutch Harbor, and even in those few situations where projects started in the Canadian Arctic waters, they ended in Dutch Harbor.

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[1] NMFS reviewed all of the IHA applications and 90-day monitoring reports from previous seismic and exploratory drilling operations in the Arctic from 2006-2012. Only three reports did not start, finish, or resupply in Dutch Harbor (BP Exploration 2011, IHA Application; Hauser *et al.* 2008, 90-day monitoring report; Aerts *et al*. 2008, 90-day monitoring report). Of these, only one (Aerts *et al*. 2008) did not stage in Arctic waters and instead staged at the Port of Anchorage. ION Geophysical (2012) and Beland and Ireland (2010) both started their projects in Canadian Arctic waters; however, both projects ended in Dutch Harbor.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

Section 7(a)(2) of the ESA requires Federal agencies to consult with the USFWS, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that, at the conclusion of consultation, the consulting agency (NMFS and/or USFWS) provide an opinion stating how the agencies' actions will affect listed species or their critical habitat. If incidental take is expected, Section 7(b)(4) requires the provision of an incidental take statement (ITS) specifying the impact of any incidental taking, and including reasonable and prudent measures to minimize such impacts.

2.1 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 their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts to the conservation value of the designated critical habitat.

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

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

2.1.1 Approach to the Assessment

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

- Identify those aspects of proposed actions that are likely to have direct and indirect

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

effects on the physical, chemical, and biotic environment of the project area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step represent the action area for the consultation.

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

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

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

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

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

- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of survival or 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 2.2). The final steps of our analyses- establishing the risks those responses pose to listed resources- are different for listed species and designated critical habitat (these represent our *risk* analyses) Integration and synthesis with risk analyses occurs in Section 2.6 of this opinion.

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

- 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 in Section 2.8. The RPA must not be likely to jeopardize the continued existence of ESA-listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

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

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

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

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

2.2 Rangewide Status of the Species and Critical Habitat

Seven species of marine mammals listed under the ESA under NMFS's jurisdiction may occur in the action area (Western Arctic Bowhead whale [*Balanea mysticetus*], Northeast Pacific Fin whale [*Balaneoptera Physalus*], North Pacific Humpback whale [*Megaptera novaeangliae*], eastern North Pacific right whale [*Eubalaena japonica*], the western Steller sea lion DPS [*Eumetopias jubatus*]), the Arctic subspecies of the Ringed seal [*Phoca hispida hispida*] and the Beringia DPS of the [*Erignathus barbatus barbatus*] subspecies of the Bearded seal. The action area also includes critical habitat for the North Pacific right whale, and the western Steller sea lion. This opinion considers the effects of the proposed action on these species and designated critical habitats (Table 4).

Table 3. Listing status and critical habitat designation for marine mammal species considered in this opinion.

Species	Stock	Status	Listing	Critical Habitat
Balanea mysticetus	Western Arctic Bowhead Whale	Endangered	NMFS 1970, 35 FR 18319	Not designated

Balaneoptera physalus	Northeast Pacific Fin Whale	Endangered	NMFS 1970, 35 FR 18319	Not designated
Megaptera novaeangliae	North Pacific Humpback Whale	Endangered	NMFS 1970, 35 FR 18319	Not designated
Eubalaena japonica	Eastern North Pacific Right Whale	Endangered	NMFS 2008, 73 FR 12024	NMFS 2008, 73 FR 19000
Phoca hispida hispida	Arctic Ringed Seal	Threatened	NMFS 2012, 77 FR 76706	Not proposed
Erignathus barbatus barbatus	Beringia (DPS), Alaska Bearded Seal	Threatened	NMFS 2012, 77 FR 76740	Not proposed
Eumetopias jubatus	Western (DPS), Steller Sea Lion	Endangered	NMFS 1997, 62 FR 24345	NMFS 1993, 58 FR 45269

2.2.1 Species and Critical Habitat Not Considered Further in this Opinion

As described in the *Approach to the Assessment* section of this opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the activities PR1 proposes to authorize in the action area. The first criterion was *exposure* or some reasonable expectation of a co-occurrence between one or more potential stressor associated with SAE's activities and a particular listed species or designated critical habitat: if we conclude that a listed species or designated critical habitat is not likely to be exposed to SAE's activities, we must also conclude that the listed species or designated critical habitat are not likely to be affected by those activities.

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

We applied these criteria to the species and critical habitat listed at the beginning of this section; this subsection summarizes the results of those evaluations

CRITICAL HABITAT FOR THE NORTH PACIFIC RIGHT WHALE. Critical habitat for the North Pacific right whale (NPRW) was designated in the eastern Bering Sea and in the Gulf of Alaska on April 8, 2008 (73 FR 19000). Only the critical habitat in the eastern Bering Sea overlaps with the proposed action (see Figure 2) The primary constituent elements deemed necessary for the conservation of North Pacific right whales include the presence of specific copepods (*Calanus marshallae*, *Neocalanus cristatus*, and *N. plumchris*), and euphausiids (*Thysanoessa Raschii*) that act as primary prey items for the species.

Figure 2. North Pacific right whale critical habitat shown in both the Bering Sea and Gulf of Alaska. The pentagon area in the Bering Sea is the only section of critical habitat that occurs within the action area, and is located above Dutch Harbor (indicated by a yellow star).

Vessels transiting to and from Dutch Harbor may enter the Bering Sea critical habitat. However, vessel traffic alone is not anticipated to affect aggregations of copepods or euphausiids, and therefore will not affect the PCEs associated with NPRW whale critical habitat. In addition, the critical habitat in the Bering Sea would not be exposed to acoustic signals associated site clearance, shallow hazard, or ice gouge surveys, or equipment recovery or maintenance because those activities are only authorized to occur within the OCS of the Chukchi Sea and the activities will occur far enough away from the critical habitat area that received sound levels within the habitat will not exceed 120 dB re 1 µPa (rms). For these reasons, we do not expect critical habitat for the NPRW whale to be adversely affected by vessel traffic associated with SAE's authorized activities, therefore, we will not consider critical habitat further in this opinion for this species.

The potential impact to NPRW associated with vessel strike and vessel noise will be discussed in the *Effects of the Action* section.

2.2.2 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 now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 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 (IPCC 2007).

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 (IPCC 2001). 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 (IPCC 2001). This becomes particularly important in the Arctic, where oil and gas exploration, development, and production is related to large-scale energy production and an increase in combustion of fossil fuels.[3]

Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001). These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 5).

The strongest warming is expected in the north, exceeding the estimate for mean global warming

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[3] Information provided by BOEM in climate change comments. Email dated 10-4-2012.

by a factor or 3, due in part to the "ice-albedo feedback," whereby as the reflective areas of arctic ice and snow retreat, the earth absorbs more heat, accentuating the warming (NRC 2003). Observed decreases in snow and ice extent are also consistent with warming (IPCC 2007). Satellite date since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% (2.1-3.3) per decade, with larger decreases in summer of 7.4% (5.0-9.8) per decade (IPCC 2007).

Changes in sea level, snow cover, ice extent, and precipitation are consistent with a warming climate near the Earth's surface. The IPCC (2001) noted "Examples include…increases in sea level and ocean-heat content, and decreases in snow cover and sea-ice extent and thickness" and consider their statement that "rise in sea level during the 21st century that will continue for further centuries" to also be a "robust finding." However, they highlight the uncertainty of understanding the probability distribution associated with both temperature and sea-level projections.

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 *et al.* 2001; McCarthy *et al.* 2001; Parry *et al.* 2007). The direct effects of climate change would result in increases in atmospheric temperatures, changes in sea surface temperatures, changes in patterns of precipitation, and changes in sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown.

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for calving and rearing calves, 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. Although the IPCC (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20% since the 1950s.

Table 4. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from IPCC 2001).

Phenomenon	**Confidence in Observed Changes (observed in latter 20th Century)**	**Confidence in Projected Changes (during the 21st Century)**
Higher max temperatures and greater number of hot days over almost all land areas	Likely	Very likely
Higher min temperatures with fewer cold days and frost days over almost all land areas	Very likely	Very likely

Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increased heat index over most land areas	Likely over many areas	Very likely over most areas
More intense precipitation events	Likely over many mid-to-high latitude areas in Northern Hemisphere	Very likely over most areas
Increased summer continental drying and associated probability of drought	Likely in a few areas	Likely over most mid-latitude continental interiors (projections are inconsistent for other areas)
Increase in peak wind intensities in tropical cyclones	Not observed	Likely over some areas
Increase in mean and peak precipitation intensities in tropical cyclones	Insufficient data	Likely over some areas

2.2.3 Status of Listed Species

The remainder of this section of our opinion 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 geophysical surveys and equipment recovery and maintenance activities. In each narrative, we present a summary of information on the population structure and distribution of each species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

After the *Status* subsection of each narrative, we present information on the feeding and prey selection, and diving and social behavior of the different species because those behaviors help us determine how certain activities may impact each species, and helps 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 because that background information lays the foundation for our assessment of how the different 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 (2013), and recovery plans for fin whales (NMFS 2010d), humpback whales (NMFS 1991), right whales (NMFS 2005), and Steller sea lions (NMFS 2008c). Cameron *et al.* (2010) and Kelly *et al.* (2010b) provided status reviews of bearded and ringed seals. Richardson *et al.* (1995) and Tyack (2000) provided detailed analyses of the functional aspects of cetacean communication and their responses to active sonar and 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 and sonar on the marine animals considered in this opinion.

2.2.3.1 Bowhead Whale

Population Structure

The International Whaling Commission (IWC) historically recognized five stocks of bowhead whales for management purposes (IWC 1992; Rugh *et al.* 2003). Three of these stocks occur in the North Atlantic: the Spitsbergen, Baffin Bay-Davis Straight, and Hudson Bay-Foxe Basin stocks. The remaining two stocks occur in the North Pacific: the Sea of Okhotsk and Western Arctic (Bering-Chukchi-Beaufort seas) stocks. The current working hypothesis is that the Davis Strait and Hudson Bay bowhead whales comprise a single Eastern Arctic stock. Confirmation of stock structure awaits further scientific analyses. Out of all of the stocks, the Western Arctic stock is the largest (also known as the Bering-Chukchi-Beaufort stock), and the only stock to inhabit U.S. waters (Allen and Angliss 2013). It is also the only bowhead stock within the action area.

Distribution

Bowhead whales have a circumpolar distribution in high latitudes in the Northern Hemisphere, and ranges from 54º to 85ºN 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, Moore and Reeves 1993). 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 largest population of bowhead whales can be found in the Bering Sea in winter, migrating north through the Chukchi Sea in the spring to summer in the Beaufort Sea before returning to the Bering Sea in the fall (Allen and Angliss 2011) (see Figure 3). Some of the animals remain in the eastern Chukchi and western Beaufort seas during the summer (Clarke *et al.* 2011a, Ireland *et al.* 2009). The Okhotsk population has been observed in summertime along the western and northern portion of the Sea of Okhotsk, notably around the Shantar Islands.

Fall migrating whales typically reach Cross Island in September and October (Brower 1996), although some whales might arrive as early as late August. Most bowheads fall migrate through the Alaskan Beaufort in water depths between 15 and 200 meters (50 and 656 feet) deep (Miller et al. 2002), with annual variability depending on ice conditions (whales traveling farther offshore during heavy ice cover years). 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.

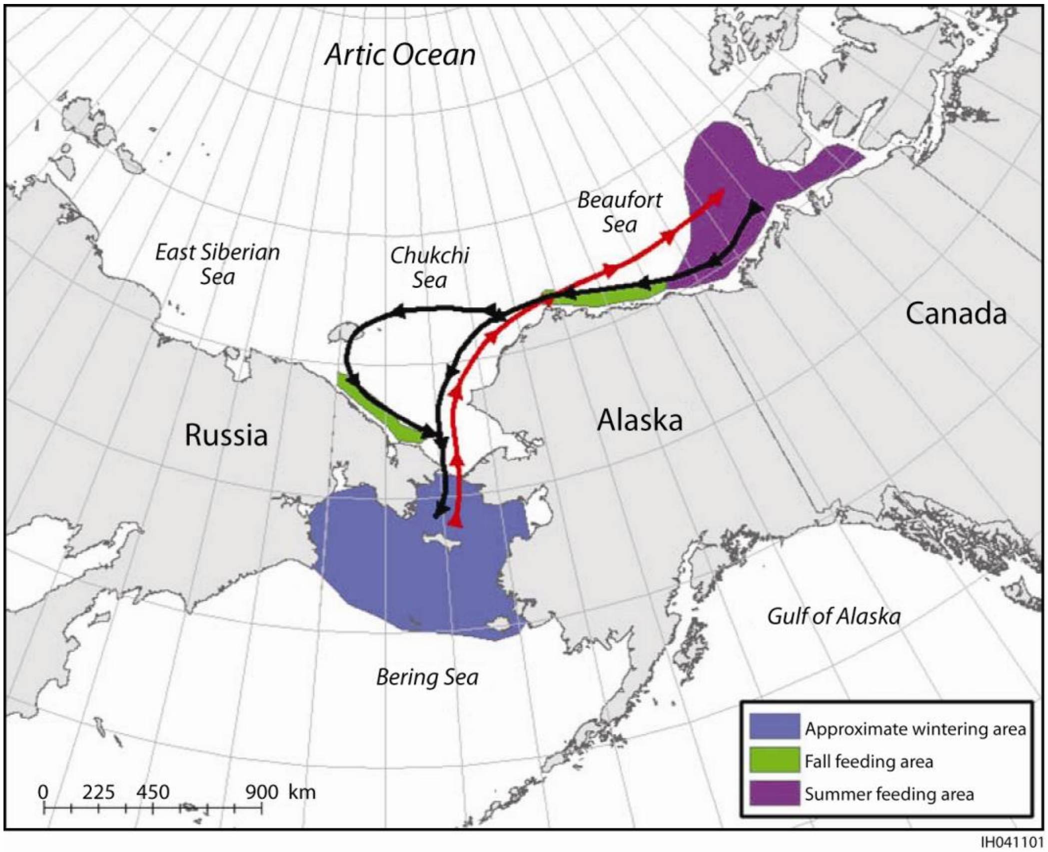

Figure 3. Generalized Migration Route, Feeding Areas, and Wintering Area for the Western Arctic Bowhead Whale (Source: Moore and Laidre 2006).

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. The Hudson Bay-Foxe Basin population is believed to overwinter in Hudson Strait. In the spring some migrate west until they reach northwestern Hudson Bay around Roes Welcome Sound, and Frozen Strait, and others move north into northern Foxe Basin.

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 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. Three human activities are known to threaten bowhead whales: whaling, commercial fishing, and shipping. Historically, bowhead whales were severely depleted by commercial harvesting, which ultimately led to the listing of bowhead whales as an endangered species. They were targeted by hunters because they are slow and big, with large amounts of blubber. 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). For 2008-2012, a block quota of 280 bowhead strikes has been allowed, of which 67 (plus up to 15 unharvested in the previous year) could be taken each year. This quota includes an allowance of 5 animals to be taken by Chukotka Natives in Russia (Allen and Angliss 2013). At the end of the 2012 harvest, there were 15 strikes available for carry-forward, so the combined strike quota for 2013 is 82 (67 +15). The annual average subsistence take (by Natives of Alaska, Russia, and Canada) during the 5-year period from 2005-2009 was 39.6 bowhead whales (Allen and Angliss 2012).

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 2013). 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 (Suydam *et al.* 2011). The minimum average annual entanglement rate in U.S. commercial fisheries for the five year period from 2006-2010 is 0.2; however, the overall rate is currently unknown (Allen and Angliss 2013).

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. Exposure to manmade noise and contaminants may have short- and long-term effects (Bratton *et al.* 1993, Richardson and Malme 1993) that 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 Marine Mammal Protection Act (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 (2004) 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.

From 1978-2001, the Western Arctic stock of bowhead whales has increased at a rate of 3.4% (95% Confidence Interval (CI) = 1.7-5%) during which time abundance doubled from approximately 5,000 to approximately 10,000 whales (George *et al.* 2004). Similarly, Schweder *et al.* (2009) estimated the yearly growth rate to be 3.2% between 1984 and 2003 using a sight-resight analysis of aerial photographs. The most recent abundance estimate, based on surveys conducted in 2001, is 10,545 (Coefficient of Variation (CV) = 0.128) (updated from George *et al.* 2004 by Zeh and Punt 2004). See Table 6 for summary of population abundance estimates (Allen and Angliss 2013). Using the 2004 population estimate of 12,631 and its associated CV= 0.2442, the minimum population estimate for the Western Arctic stock of bowhead whales is 10,314 (Allen and Angliss 2013). The population may be approaching carrying capacity despite showing no sign of a slowing in the population growth rate (Brandon and Wade 2006).

Table 5. Summary of population abundance estimates for the Western Arctic stock of bowhead whales. The historical estimates were made by back-projecting using a simple recruitment model. All other estimates were developed by corrected ice-based census counts. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George et al. (2004) and Zeh and Punt (2004).

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)		

The current estimate for the rate of increase for this stock of bowhead whales is 3.2-3.4% (George *et al.* 2004, Schweder *et al.* 2009). However, it is recommended that the cetacean maximum theoretical net productivity rate (R_{max}) of 4% be used for the Western Arctic stock of bowhead (Wade and Angliss 1997).[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.* 2004). The calf count provides corroborating evidence for a healthy and increasing population.

The potential biological removal (PBR) for this stock is 103 animals (10,314 x 0.02 x 0.5) (see Allen and Angliss 2013). 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. At the end of the 2012 harvest, there were 15 strikes available for carry-forward, so the combined strike quota for 2013 is 82 (67 +15). This quota is shared between the United States and Russia. For 2013, the U.S. receives 75 strikes and Russia 7 (Allen and Angliss 2013).

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).

NORTH ATLANTIC. The estimated abundance of the Spitsbergen stock was 24,000 prior to

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[4] The R_{max} value of 3.2-3.4% should not be used because the population is currently being harvested and because the population has recovered to population levels where the growth is expected to be significantly less than R_{max} (Allen and Angliss 2013).

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.* 2001). The conception date and length of gestation suggests that calving is likely to occur in mid-May to mid-June, when whales are between the Bering Strait and Point Barrow (BOEM 2011a). 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).

Feeding and Prey Selection

Bowheads are filter feeders, filtering prey from the water through baleen fibers in their mouth. 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 and conversely 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.* 2010). Laidre *et al.* (2007) and others have identified krill concentrated near the sea bottom and bowhead whales have been observed with mud on heads and bodies and streaming from mouths (Mocklin 2009). Food items most commonly found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, and amphipods (Moore *et al.* 2010; Lowry, Sheffield, and George 2004). 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 1993). It is estimated that a 60 ton (t) bowhead whale eats 1.5 t of krill each day; that 1.5 t of krill will have consumed 5.5 trillion phytoplankton. Estimated rate of consumption is 50,000 individual copepods, each weighing about 0.004 g, per minute of feeding time (BOEM 2011a).

Available data indicate that Western Arctic bowhead whales feed in both the OCS of the

Chukchi and Beaufort Seas and that 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., Ljungblad *et al.* 1987; Carroll *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 Lloyd 1984; Carroll *et al.* 1987; Shelden and Rugh 1995). The stomach contents of the 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 Lloyd 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 (1993) reported that the stomachs of 13 out of 36 spring-migrating bowheads harvested near Point Barrow between 1979 through 1988 contained food. Lowry 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 (1993). 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 (Clarke *et al*. 2011b, NMFS 2010a). 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 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, Sheffield, and George 2004; summarized in Richardson and Thomson 2002; Ashjian *et al.* 2010; Okkonen *et al.* 2011; Clarke *et al.* 2011a, b, c, d; Clarke *et al.*2012). Available information indicates it is likely there is considerable interannual 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. 2003).Thomas *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, as reported in NMFS 2001). 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 at the Nuiqsut Public Hearing on March 19, 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

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

Bowhead whale calls might help maintain social cohesion of groups (Würsig and Clark 1993). Würsig *et al.* (1985) 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.

Bowhead whales sometimes feed cooperatively. They take efficient advantage of dense swarms of invertebrates.

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). 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 and Bishop 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 2002a). 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, Würsig and Clark 1993; Cummings and Holliday 1987 in Erbe 2002a).

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 (Noongwook *et al.* 2007). In addition, whalers wear white parkas on the ice so that they are not visible to the whales when they surface (Rexford 1997).

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

2.2.3.2 Fin whale

Population Structure

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

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

In the North Pacific Ocean, the IWC recognizes two “stocks”: (1) East China Sea and (2) rest of the North Pacific (Donovan 1991). However, Mizroch *et al.* (1984) concluded that there were five possible “stocks” of fin whales within the North Pacific based on histological analyses and tagging experiments: (1) East and West Pacific that intermingle around the Aleutian Islands; (2) East China Sea; (3) British Columbia; (4) Southern-Central California to Gulf of Alaska; and (5) Gulf of California. Based on genetic analyses, Bérubé *et al.* (1998) concluded that fin whales in the Sea of Cortez represent an isolated population that has very little genetic exchange with other populations in the North Pacific Ocean (although the geographic distribution of this population and other populations can overlap seasonally). They also concluded that fin whales in the Gulf of St. Lawrence and Gulf of Maine are distinct from fin whales found off Spain and in the Mediterranean Sea**.**

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

Distribution

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

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

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

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

Individual and small groups of fin whales seasonally inhabit areas within and near the Chukchi Sea during the open water period (BOEM 2011a). Based on observations and passive acoustic detection (Delarue *et al.* 2010; Crance *et al.* 2011; Hannay *et al.* 2011) and direct observations from monitoring and research projects of fin whales from industry (Funk *et al.* 2010, Ireland *et al.* 2009) and government (Clarke *et al.* 2011d, Berchok *et al.* 2012), fin whales are considered to be in low densities, but regular visitors to the Alaska Chukchi Sea.

Threats to the Species

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

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

As its legacy, whaling has reduced fin whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push fin whales closer to extinction. Otherwise, whaling currently does not threaten every fin whale population, although it may threaten specific populations. There is no authorized subsistence take of fin whales in the Northeast Pacific stock (Allen and Angliss 2011). In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit. The Japanese whalers plan to kill 50 fin whales per year starting in the 2007-2008 season and continuing for the next 12 years.

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

Despite anecdotal observations from fishermen which suggest that large whales swim through their nets rather than get caught in them, fin whales have been entangled by fishing gear off Newfoundland and Labrador in small numbers: a total of 14 fin whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994, Perkins and Beamish 1979). Of these 14 fin whales, 7 are known to have died as a result of that capture, although most of the animals that died were less than 15 meters in length (Lien 1994). Between 1999 and 2005, there were 10 confirmed reports of fin whales being entangled in fishing gear along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, Fin whales were injured in 1 of the entanglements and killed in 3 entanglements. Between 2002 and 2006, there was one observed incidental mortality of a fin whale in the Bering Sea/Aleutian Island (BSAI) pollock trawl fishery with a mean annual mortality rate of 0.23 (CV – 0.34) (Allen and Angliss 2011). These data suggest that, despite their size and strength, fin whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries. However, between 2007 and 2010, there were no observed incidental mortalities of fin whales in any of the Alaska commercial fisheries (Allen and Angliss 2013).

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

There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 3 involved fin whales (Neilson *et al.* 2012). This results in an annual mean mortality rate of 0.6 fin whales in Alaska waters (Allen and Angliss 2013). However, this source of mortality does not exceed the PBR level for the stock (11.4) (Allen and Angliss 2013).

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

Status

Fin whales were listed as endangered under the ESA in 1970. In 1976, the IWC protected fin whales from commercial whaling (Allen 1980). Fin whales are listed as endangered on the IUCN

Red List of Threatened Animals (IUCN 2012). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for fin whales. A Final Recovery Plan for the Fin Whale (*Balaenoptera physalus*) was published on July 30, 2010 (NMFS 2010d).

It is difficult to assess the current status of fin whales because (1) there is no general agreement on the size of the fin whale population prior to whaling and (2) estimates of the current size of the different fin whale populations vary widely. We may never know the size of the fin whale population prior to whaling. Sergeant (1977) suggested that between 30,000 and 50,000 fin whales once populated the North Atlantic Ocean based on assumptions about catch levels during the whaling period. Sigurjónsson (1995) estimated that between 50,000 and 100,000 fin whales once populated the North Atlantic, although he provided no data or evidence to support that estimate. More recently, Palumbi and Roman (2006) estimated that about 360,000 fin whales (95% confidence interval = 249,000 - 481,000) populated the North Atlantic Ocean before whaling based on mutation rates and estimates of genetic diversity.

Ohsumi and Wada (1974) estimated that the North Pacific fin whale population ranged from 42,000-45,000 before whaling began. Of this, the "American population" (i.e., the component centered in waters east of 180º W longitude), was estimated to be 25,000-27,000. From a crude analysis of catch statistics and whaling effort, Rice (1974) concluded that the population of fin whales in the eastern North Pacific declined by more than half, between 1958 and 1970, from about 20,000 to 9,000 "recruited animals" (*i.e.,* individuals longer than the minimum length limit of 50 ft). Chapman (1976) concluded that the "American stock" had declined to about 38% and the "Asian stock" to 36% below their maximum sustainable year (MSY) levels (16,000 and 11,000, respectively) by 1975. As pointed out by Barlow (1994), citing IWC (1989) catch per unit effort (CPUE) techniques for estimating abundance are not certain, therefore, the absolute values of the cited abundance estimates should not be relied upon. Based on visual surveys, Moore *et al.* (2002) estimated 3,368 (CV=0.29) and 683 (CV=0.32) fin whales in the central eastern Bering Sea and southeastern Bering Sea, respectively, during summer surveys in 1999 and 2000. However, these estimates are considered provisional because they were never corrected for animals missed on the track line or that may have been submerged when the ship passed. Dedicated line transect cruises were conducted in coastal waters of western Alaska and the eastern and central Aleutian Islands in July-August 2001-2003 (Zerbini et al. 2006). Over 9,053 km of tracklines were surveyed in coastal waters (as far as 85 km offshore) between the Kenai Peninsula (150^{o}W) and Amchitka Pass (178^{o}W). Fin whale sightings (n = 276) were observed from east of Kodiak Island to Samalga Pass, with high aggregations recorded near the Semidi Islands. Zerbini et al. (2006) estimated that 1,652 (95% CI: 1,142-2,389) whales occurred in the area.

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

Zerbini *et al.* (2006) estimated rates of increase of fin whales in coastal waters south of the Alaska Peninsula (Kodiak and Shumagin Islands). An annual increase of 4.8% (95% CI: 4.1–

5.4%) was estimated for the period 1987–2003. This estimate is the first available for North Pacific fin whales and is consistent with other estimates of population growth rates of large whales. It should be used with caution, however, due to uncertainties in the initial population estimate for the first trend year (1987) and due to uncertainties about the population structure of the fin whales in the area. Also, the study represented only a small fraction of the range of the northeast Pacific stock.

Although the full range of the northeast Pacific stock of fin whales in Alaskan waters has not been surveyed, a rough estimate of the size of the population west of the Kenai Peninsula could include the sums of the estimates from Moore *et al.* (2002) and Zerbini *et al.* (2006). Using this approach, the provisional estimate of the fin whale population west of the Kenai Peninsula would be 5,700 (Allen and Angliss 2013). This is a minimum estimate for the entire stock because it was estimated from surveys which covered only a small portion of the range of this stock.

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

The East Greenland-Iceland fin whale population was estimated at 10,000 animals (95 % confidence interval = 7,600- 14,200), based on surveys conducted in 1987 and 1989 (Buckland *et al.* 1992). The number of eastern Atlantic fin whales, which includes the British Isles-Spain-Portugal population, has been estimated at 17,000 animals (95% confidence interval = 10,400 - 28,900; Buckland *et al.* 1992). These estimates are both more than 15 years old and the data available do not allow us to determine if they remain valid. Forcada *et al.* (1996) estimated the fin whale population in the western Mediterranean numbered 3,583 individuals (standard error = 967; 95% confidence interval = 2,130-6,027). This is similar to a more recent estimate published by Notarbartolo-di-Sciara *et al.* (2003). Within the Ligurian Sea, which includes the Pelagos Sanctuary for Marine Mammals and the Gulf of Lions, the fin whale population was estimated to number 901 (standard error = 196.1) whales. (Forcada *et al.* 1995).

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

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

Feeding and Prey Selection

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

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

Fin whales in the Gulf of California prey mainly on zooplankton such as *Nyctiphanes simplex* (Tershy 1992).

Diving and Social Behavior

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

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

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

Vocalizations and Hearing

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

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

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

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

2.2.3.3 Humpback whale

Population Structure

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

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

These stocks are based on where these humpback whales winter: California-Oregon-Washington-Mexico stock winters along coasts of Central America and Mexico, and migrate to the coast of California to southern British Columbia in the summer/fall, whereas the central North Pacific stock winters in the waters around Hawai'i, and migrates primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands. The western North Pacific stock winters off of Asia and migrates primarily to Russia and the Bering Sea/Aleutian Islands. However, Calambokidis *et al.* (1997) identified humpback whales from Southeast Alaska (central North Pacific), the California-Oregon-Washington (eastern North Pacific), and Ogasawara Islands (Japan, Western Pacific) groups in the Hawai'ian Islands during the winter; humpback whales from the Kodiak Island, Southeast Alaska, and British Columbia groups in the Ogasawara Islands; and whales from the British Columbia, Southeast Alaska, Prince William Sound, and Shumagin-Aleutian Islands groups in Mexico- indicating that while wintering grounds appear to be separate, there may be considerable overlap in summer feeding grounds.

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

Between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis *et al.* 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches.

NORTH ATLANTIC OCEAN. In the Atlantic Ocean, humpback whales aggregate in four feeding areas in the summer months: (1) Gulf of Maine, eastern Canada, (2) west Greenland, (3) Iceland and (4) Norway (Katona and Beard 1990, Smith *et al.* 1999). The principal breeding range for these whales lies from the Antilles and northern Venezuela to Cuba (Winn *et al.* 1975, Balcomb and Nichols 1982, Whitehead and Moore 1982). The largest contemporary breeding aggregations occur off the Greater Antilles where humpback whales from all of the North Atlantic feeding areas have been identified from photographs (Katona and Beard 1990, Clapham *et al.* 1993, Mattila *et al.* 1994, Palsbøll *et al.* 1997, Smith *et al.* 1999, Stevick *et al.* 2003). Historically, an important breeding aggregation was located in the eastern Caribbean based on the important humpback whale fisheries this region supported (Reeves *et al.* 2001, Smith and Reeves 2003). Although sightings persist in those areas, modern humpback whale abundance appears to be low (Winn *et al.* 1975, Levenson and Leapley 1978, Swartz *et al.* 2003). Winter aggregations also occur at the Cape Verde Islands in the Eastern North Atlantic (Reiner *et al.* 1996, Reeves *et al.* 2002, Moore *et al.* 2003). In another example of the “open” structure of humpback whale populations, an individual humpback whale migrated from the Indian Ocean to the South Atlantic Ocean and demonstrated that individual whales may migrate from one ocean basin to another (Pomilla and Rosenbaum 2005).

INDIAN OCEAN. As discussed previously, a separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

Distribution

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

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Nemoto 1957; Tomlin 1967; Johnson and Wolman 1984 as cited in Allen and Angliss 2013). Humpback whales have also been observed during the summer in the Chukchi and Beaufort Seas (Allen and Angliss 2013).

In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen *et al.* 2009). Additionally, Ireland *et al.* (2008) reported three humpback sightings in 2007 and one in 2008 during surveys of the eastern Chukchi Sea. Humpback whales have been seen and heard with some regularity in recent years (2009-2011) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Hashagen *et al.* 2009; Anonymous 2010; Goetz *et al.* 2010; Clarke *et al.* 2011a; Crance *et al.* 2011; NMML and PMEL 2011). A single humpback was observed between Icy Cape and Wainwright feeding near a group of gray whales during aerial surveys of the northeastern Chukchi Sea in July 2009 as part of Chukchi Offshore Monitoring in Drilling Area (COMIDA) (Clarke *et al.* 2011a). This may be a recent phenomenon as no humpback whales were sighted during the previous COMIDA surveys in the Chukchi Sea from 1982 through 1991 (Clarke *et al.* 2011a). Additional sightings of four humpback whales occurred in 2009 south of Point Hope, while transiting to Nome (Brueggeman 2010). The approximate distribution of humpback whales in Alaskan waters is provided in Figure 4 below.

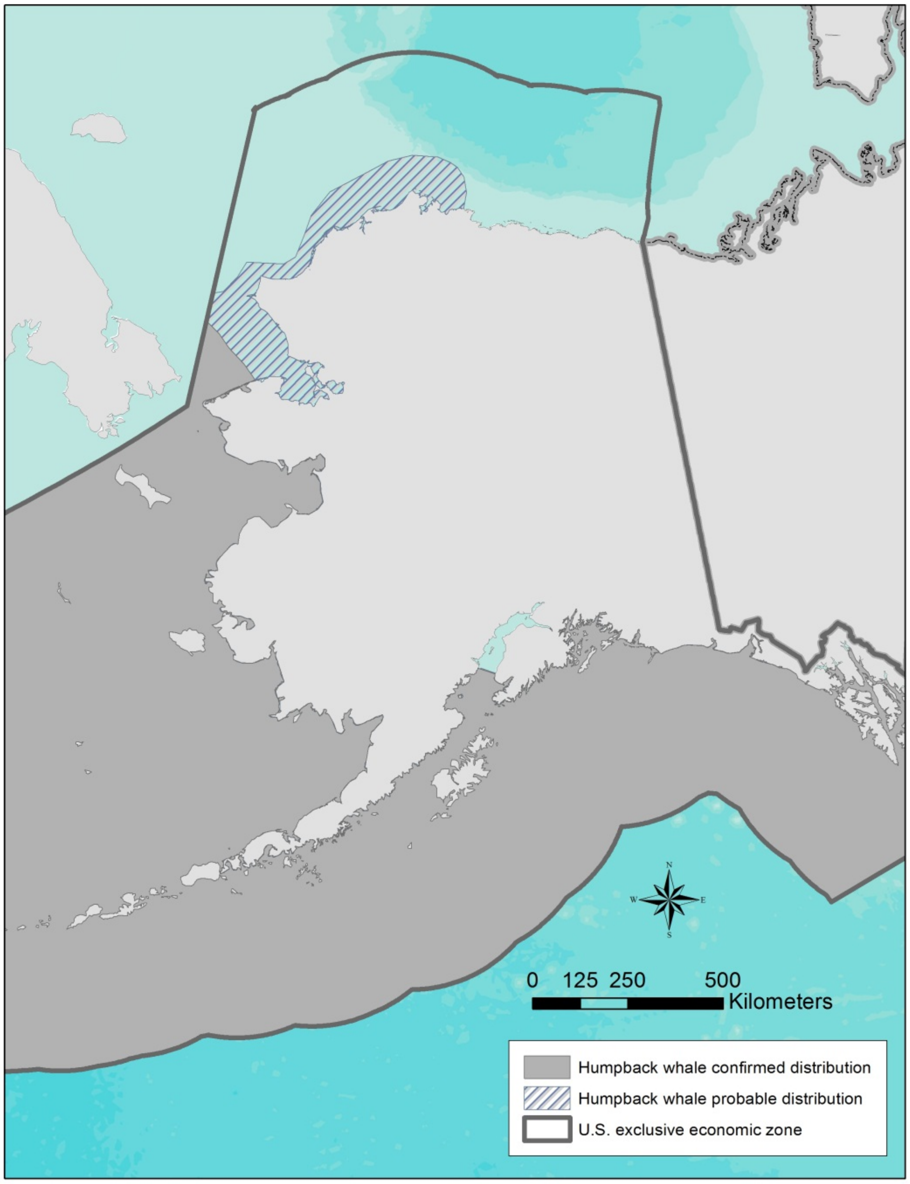

Figure 4. Approximate distribution of humpback whales in the Alaskan waters of the western North Pacific (shaded area). Area within the hash lines is a probable distribution based on sightings in the Beaufort Sea (Hashagen *et al.* 2009) (Source: Allen and Angliss 2013).

In the Atlantic Ocean, humpback whales range from the mid-Atlantic bight, the Gulf of Maine, across the southern coast of Greenland and Iceland, and along coast of Norway in the Barents Sea. These humpback whales migrate to the western coast of Africa and the Caribbean Sea during the winter.

In the Southern Ocean, humpback whales occur in waters off Antarctica. These whales migrate to the waters off Venezuela, Brazil, southern Africa, western and eastern Australia, New Zealand, and islands in the southwest Pacific during the austral winter. A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

Threats to the Species

NATURAL THREATS. There is limited information on natural phenomena that kill or injure humpback whales. Humpback whales are killed by orcas (Whitehead and Glass 1985; Dolphin 1987; Florez-González *et al.* 1994; Perry *et al.* 1999; Naessig *et al.* 2004) and are probably killed by false killer whales and sharks. Because seven female and seven male humpback whales stranded on the beaches of Cape Cod and had died from toxin produced by dinoflagellates between November 1987 and January 1988, we also know that adult and juvenile humpback whales can be killed by naturally-produced biotoxins (Geraci *et al.* 1990). Entrapments in ice have been documented in the spring ice pack in Newfoundland (Merdsoy *et al.* 1979 in NMFS 1991) with up to 25 entrapped in the same event (Lien and Stenson 1986 in NMFS 1991) and some reported mortalities. No humpback ice entrapments have been reported in the Chukchi Sea.

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

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

Subsistence hunters in Alaska have reported one subsistence take of a humpback whale in South Norton Sound in 2006. There have not been any additional reported takes of humpback whales from this stock by subsistence hunters in Alaska or Russia. The average annual mortality rate from subsistence takes for the 2003- 2007 period is 0.2 (Allen and Angliss 2011).

Humpback whales are also killed or injured during interactions with commercial fishing gear, although the evidence available suggests that these interactions on humpback whale populations may not have significant, adverse consequence for humpback whale populations. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada: a total of 595 humpback whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994, Perkins and Beamish 1979). Of these whales, 94 are known to have died as a result of that capture, although, like fin whales, most of the animals that died were smaller: less than 12 meters in length (Lien 1994).

In recent years, an increasing number of entangled humpback whales have been reported to NMFS Alaska Region stranding program. One hundred eighteen humpback whales were reported (96 confirmed) entangled in Alaska from 1997-2009; the majority of these occurred in southeast Alaska (NMFS Alaska Region Unpublished Stranding Data 2010). For many of these reports, it is not possible to identify the gear involved in the entanglement to a specific fishery. This is based on a general lack of data in reports received, the difficulty in accurately describing gear at a distance, and the fact that most entanglements are not re-sighted for follow-up analysis (NMFS 2010c). Between 2007 and 2010, there was one mortality of a Western North Pacific humpback whale in the Bering Sea/Aleutian Islands pollock trawl fishery, and one mortality in the Bering Sea/Aleutian Islands flatfish trawl (Allen and Angliss 2013). Average annual mortality from observed fisheries was 0.37 humpbacks from this stock (Allen and Angliss 2013).

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

Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, 95 entanglements were confirmed resulting in the injury of 11 humpback whales and the death of 9 whales. No information is available on the number of humpback whales that have been killed or seriously injured by interactions with fishing fleets outside of U.S. waters.

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

The number of humpback whales killed by ship strikes is exceeded only by fin whales (Jensen and Silber 2004). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow *et al.* 1997). There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales (Neilson *et al.*2012). There was a significant increase in the number of reports over time between 1978 and 2011 ($r^2 = 0.6999$; $p < 0.001$). The majority of strikes were reported in southeastern Alaska, where the number of humpback whale collisions increased 5.8% annually from 1978 to 2011 (Neilson *et al.* 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010c). However, no vessel collisions or prop strikes involving humpback whales have been documented in the Chukchi Sea (BOEM 2011a)

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

The humpback whale calf that was found stranded on Oahu with evidence of vessel collision (propeller cuts) in 1996 suggests that ship collisions can kill calves (NMFS unpublished data). Of 123 humpback whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist *et al.* 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 7 humpback whales.

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

Status

Humpback whales were listed as endangered under the ESA in 1973. Humpback whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for humpback whales. A final recovery plan for the humpback whale was completed in November of 1991 (NMFS 1991).

It is difficult to assess the current status of humpback whales for the same reasons that it is difficult to assess the status of fin whales: (1) there is no general agreement on the size of the humpback whale population prior to whaling and (2) estimates of the current size of the different humpback whale populations vary widely and produce estimates that are not always comparable to one another, although robust estimates of humpback whale populations in the western North Atlantic have been published. We may never know the size of the humpback whale population prior to whaling.

Winn and Reichley (1985) argued that the global population of humpback whales consisted of at least 150,000 whales in the early 1900s, with the largest population historically occurring in the Southern Ocean. Based on analyses of mutation rates and estimates of genetic diversity, Palumbi and Roman (2006) concluded that there may have been as many as 240,000 (95% confidence interval = 156,000 – 401,000) humpback whales in the North Atlantic before whaling began. In the western North Atlantic between Davis Strait, Iceland and the West Indies, Mitchell and Reeves (1981) estimated there were at least 4,685 humpback whales in 1865 based on available whaling records (although the authors note that this does not represent a "pre-exploitation estimate" because whalers from Greenland, the Gulf of St. Lawrence, New England, and the Caribbean Sea had been hunting humpback whales before 1865).

NORTH PACIFIC OCEAN. Estimates of the number of humpback whales occurring in the different populations that inhabit the Northern Pacific have risen over time. In the 1980s, estimates ranged from 1,407 to 2,100 (Baker 1985; Darling and Morowitz 1986; Baker and Herman 1987), while recent estimates place the population size at about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis *et al.* 1997; Cerchio 1998; Mobley *et al.* 1999). Based on data collected between 1980 and 1983, Baker and Herman (1987) used a capture-recapture methodology to produce a population estimate of 1,407 whales (95% confidence interval = 1,113 - 1,701). More recently, (Calambokidis *et al.* 1997) relied on resightings estimated from photographic records of individuals to produce an estimate of 6,010 humpback whales occurred in the North Pacific Ocean. Because the estimates produced by the different methodologies are not directly comparable, it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,000 individuals results from a real increase in the size of the humpback whale population, sampling bias in one or both studies, or assumptions in the methods used to produce estimates from the individuals that were sampled. Since the last of these estimates was published almost 20 years ago, we do not know if the estimates represent current population sizes.

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

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

Central North Pacific (CNP) Stock- Intial mark-recaputure estimates have been calculated from the SPLASH data with point estimates of abundance for the Central North Pacific stock of humpback whales which winter in Hawaii ranging from 7,469 to 10,103 (Allen and Angliss 2013). The SPLASH abundance estimates ranged from 2,889 to 13,594 combined for the Aleutian Islands and Bering Sea for the Central North Pacific stock in their summer feeding areas (Allen and Angliss 2013).

Although there is no estimate of the maximum net productivity rate (R_{max}) for the Central North Pacific stock, the R_{max} for this stock is assumed to be at least 7% (Allen and Angliss 2013). Using the smallest SPLASH study abundance estimate for 2004-2005 for Hawaii of 7,469 with an assumed CV of 0.300 and its associated N_{min} of 5,833, potential biological removal (PBR) was calculated to be 61.2 animals (5,833 x 0.035 x 0.3) (Allen and Angliss 2013).[5] For the Aleutian Islands and Bering Sea, PBS is calculated to be 7.9 (2,256 x 0.035 x 0.1) (Allen and

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[5] This is considered the PBR for the entire CNP stock (Allen and Angliss 2013).

Angliss 2013).

Western North Pacific (WNP) Stock- Point estimates of abundance for the Western North Pacific stock which winters in Asia (combined across three areas) for 2004 to 2006 were relatively consistent across models, ranging from 938 to 1,107 (Allen and Angliss 2013). On the summer feeding grounds, ranged from 6,000 to 14,000 for the Bering Sea and Aleutian Islands (Allen and Angliss 2013).

Similar to the Centeral North Pacific stock, there is no estimate of the maximum net productivity rate (R_{max}) for the Western North Pacific stock. However, the R_{max} for this stock is assumed to be at least 7% (Allen and Angliss 2013). Using the smallest SPLASH abundance estimate calculated for 2004-2006 of 938 animals with an assumed CV of 0.300 for the entire Western North Pacific stock of humpback whale, PBR is calculated to be 2.6 animals (732 x 0.035 x 0.1) (Allent and Angliss 2013).

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

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

Reproduction and Growth

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

Feeding and Prey Selection

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

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

Diving and Social Behavior

In Hawai'ian waters, humpback whales remain almost exclusively within the 1820 m isobath and usually within waters depths less than 182 meters. Maximum diving depths are approximately 150 m (492 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton *et al.* 1997). They may remain submerged for up to 21 min (Dolphin 1987). Dives on feeding grounds ranged from 2.1-5.1 min in the north Atlantic (Goodyear unpublished manuscript). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0min for non-feeding whales, and 4.3 min for resting whales, with the deepest dives to 148m (Dolphin 1987), while whales observed feeding on Stellwagon Bank in the North Atlantic dove <40m (Hain *et al.* 1995). Because most humpback prey is likely found above 300 m depths most humpback dives are probably relatively shallow. Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

In a review of the social behavior of humpback whales, Clapham (1996) reported that they form small, unstable social groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long-periods of times. There is good evidence of some territoriality on feeding (Clapham 1994, 1996), and calving areas (Tyack 1981). In calving areas, males sing long complex songs directed towards females, other males or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Intermale competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds which may be as high as 2.4:1. Humpback whales observed in the Alaska Chukchi Sea have been single animals and one cow calf pair was observed in the U.S. Beaufort Sea (Hashagen *et al.* 2009).

Vocalizations and Hearing

No studies have directly measured the sound sensitivity of humpback whales. Humpback whales are grouped among low frequency functional hearing baleen (mysticete) whales (Southall *et al.* 2007). In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Humpback whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970, Winn *et al.* 1970, Thompson *et al.* 1986). Source levels average 155 dB and range from 144 to 174 dB (Thompson *et al.* 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Tyack 1981; Silber 1986).

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

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

1. Complex songs with components ranging from at least 20 Hz–5 kHz with estimated source levels from 144– 174 dB; these are mostly sung by males on the breeding grounds (Winn *et al.* 1970; Richardson *et al.* 1995; Frazer and Mercado 2000; Au et al. 2000, 2006);

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and

3. Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels in excess of 175 dB re 1 Pa at 1m (Thompson *et al.* 1986; Richardson *et al.* 1995).

A general description of the anatomy of the ear for cetaceans is provided in the description of the fin whale above; that description is also applicable to humpback whales. Houser *et al.* (2001) produced a mathematical model of a humpback whale’s hearing sensitivity based on the anatomy of the whale’s ear. Based on that model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7kHz to 10kHz, with a maximum sensitivity between 2 and 6kHz, and good sensitivity between 700 Hz-10kHz (Houser *et al.* 2001).

2.2.3.4 North Pacific Right Whale

Population Structure

Genetic data now provide unequivocal support to distinguish three right whale lineages as separate phylogenetic species (Rosenbaum *et al.* 2000). Rosenbaum *et al.* (2000) concluded that the right whale should be regarded as three separate species as follows:

1. The North Atlantic right whale (*Eubalaena glacialis*) ranging in the North Atlantic Ocean;

2. The North Pacific right whale (*Eubalaena japonica*), ranging in the North Pacific Ocean; and;

3. The southern right whale (*Eubalaena australis*), historically ranging throughout the southern hemisphere's oceans.

The North Pacific right whale (*Eubalaena japonica*) is the only species that occurs in the action area. The North Pacific right whale is comprised of two populations (eastern and western). The eastern population occurs in the Bering Sea portion of the action area.

Very little is known about right whales in the eastern North Pacific, which were severely depleted by commercial whaling in the 1800s (Brownell *et al.* 2001). In the last several decades there have been markedly fewer sightings due to the drastic reduction in number, caused by illegal Soviet whaling in the 1960s (Doroshenko 2000). Additional information on illegal Soviet harvests in the 1960's are in Ivashchenko *et al.* (2007).

The western population is also small and at risk of extinction; however, while no reliable published estimate of abundance exists, survey data suggest it is much larger than the eastern population, numbering in the several hundred or more animals (Brownell *et al.* 2001).

Distribution

NMFS determined that the geographic area occupied by the North Pacific right whale at the time of ESA listing extends over a broad areas of the North Pacific Ocean, between 120ºE and 123ºW longitude and 20ºN and 60ºN latitude.

North Atlantic (*E. glacialis*) and Southern Hemisphere (*E. australis*) right whales calve in coastal waters during the winter months. However, in the eastern North Pacific no such calving grounds have been identified (Scarff 1986). Migratory patterns of North Pacific right whales are unknown, although it is thought they migrate from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly well offshore (Braham and Rice 1984, Scarff 1986, Clapham *et al.* 2004).

Information on the current seasonal distribution of right whales is available from dedicated vessel and aerial surveys, bottom-mounted acoustic recorders, and vessel surveys for fisheries ecology and management which have also included dedicated marine mammal observers. Right whales have been detected in the southeastern Bering Sea around the localized area of the designated critical habitat (Moore *et al.* 2000, 2002; Clapham *et al.* 2004; Zerbini *et al.* 2006, 2009, 2010; Rone *et al.* 2010). Of the 184 recent right whale sightings reported north of the

Aleutian Islands, 182 occurred within the specific area designated as critical habitat in the Bering Sea. Since 1996, right whales have been consistently sighted in this area over a period of years during the spring and summer feeding seasons. For example, NMFS surveys alone recorded between two and four sightings in 1996 (Goddard and Rugh 1998), 13 sightings in 2000 (LeDuc *et al.* 2001) and over 23 sightings in 2004. A minimum of 17 individuals were identified in the Bering Sea by photo-id and by genotyping from skin biopsies. Among these, at least one male had been previously photographed and four animals biopsied in other years; the latter included the only female seen prior to this encounter (Wade *et al.* 2006). This concentration also included two probable calves. During a NMFS survey in 2008, a second right whale, last sighted in 2002, was satellite-tagged. The animal remained inside the Bering Sea critical habitat providing further indication of this area's importance as foraging habitat for eastern North Pacific right whales. Similarly, three other whales that were tagged in July and August 2009 remained within the critical habitat for periods of days to weeks (Phil Clapham, AFSC-NMML, pers. comm., 9, October 2009).

The eastern North Pacific right whales are observed consistently in this area, although it is clear from historical and Japanese sighting survey data that right whales often range outside this area and occur elsewhere in the Bering Sea (Clapham *et al.* 2004; LeDuc *et al.* 2001; Moore *et al.* 2000; Moore *et al.* 2002). Bottom mounted acoustic recorders were deployed in the southeastern Bering Sea and the northern Gulf of Alaska starting in 2000 to document the seasonal distribution of right whale calls (Mellinger *et al.* 2004). Analysis of the data from those recorders deployed between October 2000 and January 2006 indicates that right whales remain in the southeastern Bering Sea from May through December with peak call detection in September (Munger and Hildebrand 2004). Data from recorders developed between May 2006 and April 2007 show the same trends (Stafford and Mellinger 2009). Use of this habitat may intensify in mid-summer through early fall based on higher monthly and daily call detection rates (Allen and Angliss 2013).

Threats to the Species

There are a number of factors that put the North Pacific right whale at considerable risk of extinction. These include but are not limited to the following: (1) life history characteristics such as slow growth rate, long calving intervals, and longevity; (2) distorted age, size or stage structure of the population and reduced reproductive success; (3) strong depensatory or Allee effects; (4) habitat specificity or site fidelity; and (5) habitat sensitivity (NMFS 2006b).

Ship strikes may affect the continued existence of North Pacific right whales. Little is known of the nature or extent of this problem in the North Pacific. Other species of right whales are highly vulnerable to ship collisions, and North Pacific right whales cross a major Trans-Pacific shipping lane when traveling to and from the Bering Sea (e.g. Unimak Pass); their probability of ship-strike mortalities may increase with the likely future opening of an ice-free Northwest Passage (Evlin and Taggart 2008; Wade *et al.* 2011). Because of the rarity of right whales, the impact to the species from even low levels of interaction could be significant (NMFS 2006b).

Entanglements of North Pacific right whales in fishing gear appear to be uncommon. Only one case of entanglement is known from the western North Pacific (Brownell *et al.* 2001) though the occurrence of right whales near pot fisheries in the Bering Sea indicates a potential for conflict. Given the low population size of North Pacific right whales, the impact of even low levels of interactions could be significant (NMFS 2006b).

Climate change may have a dramatic effect on survival of North Pacific right whales. Right whale life history characteristics make them very slow to adapt to rapid changes in their habitat (see Reynolds et al. 2002). They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate. 2003). Zooplankton abundance and density in the Bering Sea has been shown to be highly variable, affected by climate, weather, and ocean processes and in particular ice extent (Baier and Napp 2003; Napp and G. L. Hunt 2001). The largest concentrations of copepods occurred in years with the greatest southern extent of sea ice (Baier and Napp 2003). It is possible that changes in ice extent, density and persistence may alter the dynamics of the Bering Sea shelf zooplankton community and in turn affect the foraging behavior and success of right whales.

Based on an analysis of the best scientific and commercial data available and after taking into consideration current population trends and abundance, demographic trends and life history traits affecting the continued survival of the species and ongoing conservation efforts, it is clear that the North Pacific right whale remains in significant danger of extinction throughout its range (NMFS 2006b).

Status

On March 6, 2008, NMFS re-listed the North Pacific right whale as endangered as a separate species (*Eubalaena japonica*) from the North Atlantic species, *E. glacialis* (73 FR 12024). Critical habitat was designated for the North Pacific Right whale on April 8, 2008 (73 FR 19000). We designated the same two areas that we had previously designated as critical habitat for the northern right whale in the North Pacific Ocean (71 FR 38277, July 6, 2006).

The eastern North Pacific right whale is arguably the most endangered stock of large whale in the world (Allen and Angliss 2011). Wade *et al.* (2011) provided photographic estimates = 31 individuals (95% CL 23-54), and genotyping estimates = 28 individuals (95% CL 24-42). These estimates strongly support the recent IUCN ‘critically endangered’ designation for eastern North Pacific right whales (defined as less that 50 mature individuals) (Wade *et al.* 2011). Further, these estimates are confirmed via genetic analysis and indicate this population is in immediate risk of extirpation (LeDuc *et al.* 2012).

No estimate of trend in abundance is currently available. Due to insufficient information, the default cetacean maximum net productivity rate (R_{max}) of 4% is used for this stock (Wade and Angliss 1997). However, given the small apparent size and low observed calving rate of this population, this rate may be unrealistically high (Allen and Angliss 2013). A reliable estimate of minimum abundance for this stock is 25.7 based on the mark-recapture estimate of 31 (CV = 0.226; Wade *et al.* 2011). The PBR level for this stock is therefore 0. Regardless of the PBR level, because this species is listed under the ESA and no negligible impact determination has been made, no human-caused takes of this population are authorized (Allen and Angliss 2013). Though reliable numbers are not known, the abundance of this stock is considered to represent only a small fraction of its pre-commercial whaling abundance (i.e., the stock is well below its Optimum Sustainable Population size) (Allen and Angliss 2013).

In its review of the status of right whales worldwide, the International Whaling Commission expressed "considerable concern" over the status of this population (IWC 2001), which is arguably the most endangered stock of large whales in the world (Allen and Angliss 2013).

Reproduction and Growth

Little is currently known about the rate of reproduction for North Pacific right whales. There have been very few confirmed sightings of calves in the eastern North Pacific this century. The only available reports are of: (1) a relatively small whale in a group of four in the Bering Sea in 1996 (Goddard and Rugh 1998); (2) the sighting of a calf in the Bering Sea in summer 2002 (LeDuc 2004); and (3) a sighting of three calves among a group of 24 whales in the Bering Sea in the summer of 2005 (Wade *et al.* 2006). Several of the right whales seen in the past few years appear to be subadults (Shelden and Clapham 2006) which indicate they were probably born after the last of the Soviet takes in the early 1960s. Calves have been reported in the western North Pacific (Omura 1986; Brownell *et al.* 2001), but calculation of meaningful reproduction rates remains impracticable. Right whales elsewhere in the world are known to calve every three to four years on average, although in recent years an increase in the inter-birth interval to more than five years has been reported for the North Atlantic right whale (Kraus *et al.* 2001).

Diving, Feeding, and Prey Selection

Right whales are large, slow moving whales which tend to congregate in coastal areas (Allen and Angliss 2011). Right whales are skimmers; they feed by continuously filtering prey through their baleen while moving, mouth agape, through a patch of zooplankton. Several species of large copepods and other zooplankton constitute the primary prey of the North Pacific right whale. They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate 2003, Baumgartner *et al.* 2003).The few existing records of right whale feeding habits indicate that right whales feed almost entirely on copepods (IWC 1986). Analyses of stomachs from whales caught in 1956 along the Japanese coast revealed concentrations of copepods *Neocalanus plumchrus, N. cristatus* and *C. finmarchicus* with a small quantity of euphausiid larvae *Euphausia pacifica* (Omura 1958). It should be noted that *C. finmarchicus* in the North Pacific is now recognized as C. *marshallae* (see Shelden *et al.* 2005). The copepods *Calanus marshallae*, Neocalanus cristatus, and *N. plumchrus*, and a euphausiid, *Thysanoessa raschii*, whose very large size, high lipid content, and occurrence in high concentrations in the region likely makes it a preferred prey item for right whales, and were designated as primary constituent elements for feeding (73 FR 19000).

Vocalizations and Hearing

While no information is available on the North Pacific right whale hearing range, it is anticipated that they are low-frequency specialists similar to other baleen whales. Thickness and width measurements of the basilar membrane have been conducted on North Atlantic right whale and suggest and estimated hearing range of 10 Hz-22 kHz based on established marine mammal models (Parks *et al.* 2007a).

In right whales, the level of sensitivity to noise disturbance and vessel activity appears related to the behavior and activity in which they are engaged at the time (Watkins 1986; Mayo, Watkins, and Kraus personal communication, as cited in NMFS 1991; Kraus and Mayo unpubl. data as cited in NMFS 1991). In particular, feeding or courting right whales may be relatively unresponsive to loud sounds and, therefore, slow to react to approaching vessels or even oblivious to them. In general, the impact of noise from shipping or industrial activities on the communication, behavior and distribution of right whales remains unknown (NMFS 2006b).

2.2.3.5 Arctic Ringed Seal

Population Structure

A single Alaskan stock of ringed seal is currently recognized in U.S. waters. This stock is part of the Artic ringed seal subspecies. The genetic structuring of the Arctic subspecies has yet to be thoroughly investigated, and Kelly *et al.* (2010b) cautioned that it may prove to be composed of multiple distinct populations.

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 1958a). 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 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 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 in 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

Current 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.* 1976; Fay *et al.* 1990; Sipliä 2003; 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, and is under investigation. 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.

<u>Climate Change: Loss of Sea Ice and Snow Cover</u>. Diminishing sea ice and snow cover were identified as 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. Ocean acidification could further exacerbate the stress regime species are already facing. The 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 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 this is the best estimate currently available (Allen and Angliss 2013). 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 to be sustainable.

Commercial Fisheries Interactions. Commercial fisheries may impact ringed seals through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations. Based on data from 2007 and 2009, there have been an average of 1.75 (CV=0.01) mortalities of ringed seals incidental to commercial fishing operations per year (Allen and Angliss 2013).

For indirect interactions, 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 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 purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice. This necessarily mitigates many of the risks of shipping to populations of 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 or very large oil spill. Within the range of the Arctic ringed seal, offshore oil and gas exploration and production activities are currently underway in the United States, Canada, Greenland, Norway, and Russia. In the United States, oil and gas activities have been conducted off the coast of Alaska since the 1970s, with most of the activity occurring in the Beaufort Sea. Although five exploratory wells have been drilled in the past, no oil fields have been developed or brought into production in the Chukchi Sea to date.

Status

NMFS listed the Arctic ringed seals as threatened under the ESA on December 28, 2012 (77 FR 76706). Critical habitat for the Arctic ringed seal in U.S. waters will be proposed in future rulemaking.

There are no specific estimates of population size available for the Arctic subspecies of the ringed seal, but most experts would postulate that the population numbers in the millions. Based on the available abundance estimates for study areas within the Chukchi-Beaufort Sea region and extrapolations for pack ice areas without survey data, Kelly *et al.* (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). The estimates from 1999 and 2000 in the Chukchi Sea only covered a portion of this stocks range and were conducted over a decade ago (Allen and Angliss 2013). 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.

As these surveys represent only a fraction of the stock's range and occurred more than a decade ago, current and reliable data on trends in population abundance for the Alaska stock of ringed seals are considered unavailable. PBR for this stock is also unknown at this time (Allen and Angliss 2013).

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.* (2011a) 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 4 summarizes the approximate annual timing of reproduction and molting for Arctic ringed seals.

Arctic Ringed Seals

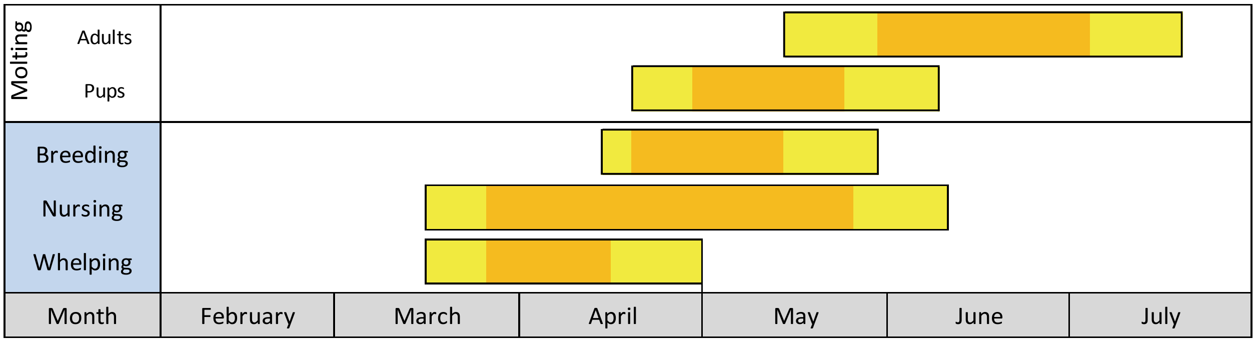

Figure 5. Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the “normal” range over which each event is reported to occur and orange bars indicated the “peak” timing of each event (source: Kelly *et al.* 2010b).

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 1993b). 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 *et al.* 1991, Lydersen and Hammill 1993b).

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.* 2000,). Based on three-dimensional tracking, Simpkins *et al.* (2001) categorized ringed seal dives as either travel, exploratory, or foraging/social dives. Ringed seals tend to come out of the water during the daytime and dive at night during the spring to early summer breeding and molting periods, while the inverse tended to be true during the late summer, fall, and winter (Kelly and Quakenbush 1990, Lydersen 1991, Teilmann *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 auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall *et al.* 2007). The airgun sound source being proposed for this project is anticipated to be between 100 Hz to 3 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, in themselves, 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 only 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).

2.2.3.6 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.* 1976). The geographic distributions of these subspecies are not separated by conspicuous gaps. There are regions of intergrading generally described as somewhere along the northern Russian and central Canadian coasts (Burns 1981, Kelly 1988, Rice 1998). Consequently, geographic boundaries for the divisions between the two subspecies are subject to the strong caveat that distinct boundaries do not appear to exist in the actual populations; and therefore, there is considerable uncertainty about the best locations for the boundaries. Two distinct population segments (DPS) 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; Burns 1981; Smith 1981; Kelly 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 DOSs), 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.* 1976, 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. Based on the best available data, Cameron *et al.* (2010) therefore 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; Burns 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.* 1976, Burns 1981).

Threats to the Species

Current 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).

The range of plausible scenarios is large, making it impossible to predict the direction or magnitude of the net impact on bearded seal mortality.

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

Climate Change: Sea Ice Loss. For at least some part of the year, bearded seals rely on the presence of sea ice over the productive and shallow waters of the continental shelves where they have access to food–primarily benthic and epibenthic organisms–and a platform for hauling out of the water. Further, 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 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 significant 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 1988). Allen and Angliss (2013) reported that based on subsistence harvest data maintained by ADF&G primarily for the years 1990 to 1998, the mean estimated annual harvest level in Alaska averaged 6,788 bearded seals as of August 2000 (Coffing *et al.* 1998, Georgette *et al.* 1998, Wolfe and Hutchinson-Scarbrough 1999, Allen and Angliss 2013). The estimate of 6,788 bearded seals is considered by Allen and Angliss (2013) to be the best estimate of the subsistence harvest level in Alaska. Data on community subsistence harvests are no longer being collected and no new annual harvest estimates exist (Allen and Angliss 2013). 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 *et al.* 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. Thes estimated minimum mortality rate incidental to commercial fisheries is 2.70 (CV= 0.21) bearded seals per year, based exclusively on observer data (Allen and Angliss 2013). 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 purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice. This necessarily mitigates many of the risks of shipping to populations of 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, Conservation, and Educaiton Division, Office of Protected Resources, pers comm. as cited in Allen and Angliss 2013).

Contamination. Research on contaminants and bearded seals is limited compared to the extensive information available for ringed seals. Pollutants such as organochlorine compounds (OC) 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, but are not limited to: 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 or very 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). Critical habitat for the Beringia DPS in U.S. waters will be proposed in future rulemaking.

Although 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).

At present, 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 (Allen and Angliss 2013). Because a reliable estimate of minimum abundance is currently not available, the PBR for this stock is unknown (Allen and Angliss 2013).

In the East Siberian Sea, sightings were rare, with sighting typically one bearded seal during every 200-250 km of travel. Geller (1957) described the zone between the Kola Peninsula and Chukotka as comparatively poor in marine mammals relative to the more western and eastern portions of the northern Russian coasts. The BRT was not aware of any other information about bearded seal abundance in the East Siberian Sea (Cameron *et al.* 2010).

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 (Kelly 1988; Reeves *et al.* 1992; ADFG 1994; Cameron *et al.* 2010; Burns 1981; Hjelset *et al.* 1999). 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.* 2000). Unlike walrus that root in the soft sediment for benthic organisms, bearded seals are believed to scan the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall *et al.* 2006, 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 1988).

Quakenbush *et al.* (2011b) 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.* 2011b). The majority of invertebrate prey items identified in the 2000s were mysids, isopods, amphipods, and decapods. Decapods were the most dominant class of invertebrates, and were strongly correlated with the occurrence of shrimp and somewhat correlated with the occurrence of crab. Mollusks were also common prey, occurring in more than half of the stomachs examined throughout the years of the study.

Diving, Hauling out, and Social Behavior

The diving behavior of adult bearded seals is closely related to their benthic foraging habits and in the few studies conducted so far, dive depths have largely reflected local bathymetry (Gjertz *et al.* 2000, 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.* 2000). 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.* 1976). From July to April, three males (2 subadults and 1 young adult) tagged as part of a study in the Bering and Chukchi Seas rarely hauled out at all, even when occupying ice covered areas.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.[6]

Other studies using data recorders and telemetry on lactating females and their dependent pups showed that, unlike other large phocid seals, they are highly aquatic during a nursing period of about 3 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.* 1994a, 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*

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

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 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 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 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.

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). According to Southall *et al.* (2007), bearded seals (as with other pinnipeds) have an estimated auditory bandwidth of 75 Hz to 75 kHz in water, and 75 Hz to 30 kHz in air.

Masking of biologically important sounds by anthropogenic noise could be considered a temporary loss of hearing acuity. Brief, small-scale masking episodes might, in themselves, have few long-term consequences for individual marine mammals. There are few situations or circumstances where low frequency sounds could mask biologically important signals. While seismic surveys can contain sounds up to 1 kHz, most of the emitted sound is <200 Hz. Seismic surveys generate periodic sounds that have little potential to mask sounds important to seals.

2.2.3.7 Steller Sea Lion (Western DPS)

Population Structure

Analysis of mitochondrial DNA provided information leading to the conclusion that distinct population segments of Steller sea lions were identifiable (Bickam *et al.* 1996). Furthermore based on phylogeographical analysis (Dizon *et al.* 1992) using Steller sea lion population dynamics, data from tagging, branding and radio-telemetry studies, phenotypic data, and genetics, NMFS has been able to delineate two discrete population segment of Steller sea lions within their geographic range (62 FR 24345).

The eastern DPS Steller sea lions are distributed from California to Alaska and the population includes all rookeries east of Cape Suckling, Alaska (144°W) south to Año Nuevo Island, which is the southernmost extant rookery (55 FR 49204). The western DPS of Steller sea lions includes animals located west of Cape Suckling, Alaska (144°W; 62 FR 24345). However, individuals move between rookeries and haul out sites regularly, and occasionally transit over long distances between eastern and western DPS locations (Calkins and Pitcher 1982, Raum-Suryan *et al.* 2002, Raum-Suryan *et al.* 2004). The western DPS of Steller sea lion is the only population anticipated to be in the Bering Sea section of the action area with the potential to be exposed to project related stressors.

Distribution

Steller sea lions are distributed around the rim of the North Pacific Ocean from the Channel

Islands off Southern California to northern Hokkaido, Japan (Loughlin *et al.* 1984, Nowak 2003). In the Bering Sea, the northernmost major rookery is on Walrus Island in the Pribilof Island group. The northernmost major haulout is on Hall Island off the northwestern tip of St. Matthew Island. Their distribution also extends northward from the western end of the Aleutian chain to sites along the eastern shore of the Kamchatka Peninsula. Their distribution is probably centered in the Gulf of Alaska and the Aleutian Islands (NMFS 1992).

Land sites used by Steller sea lions are referred to as rookeries and haulouts. Rookeries are used by adult sea lions for pupping, nursing, and mating during the reproductive season (generally from late May to early July). Haulouts are used by all age classes of both genders but are generally not where sea lions reproduce. Sea lions move on and offshore for feeding excursions. At the end of the reproductive season, some females may move with their pups to other haulout sites and males may migrate to distant foraging locations (Spalding 1964). Sea lions may make semi-permanent or permanent one-way movements from one site to another (Chumbley *et al.* 1997; Loughlin 1997; Burkanov *et al.* 2005) Calkins and Pitcher (1982) reported movements in Alaska of up to1,500 km. They also describe wide dispersion of young animals after weaning, with the majority of those animals returning to the site of birth as they reach reproductive age.

Most adult Steller sea lions occupy rookeries during the pupping and breeding season, which extends from late May to early July (Pitcher and Calkins 1981, Gisiner 1985), and exhibit high site fidelity (Sandegren 1970). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts (Rice 1998; Ban 2005; Call and Loughlin 2005).

Threats to the Species

NATURAL THREATS. Killer whales and sharks prey on Steller sea lions, and given the reduced abundance of sea lions at multiple sites these successful predators may exacerbate the decline in local areas (e.g., Barrett-Lennard *et al.* 1995). Research suggests that the transient (migratory) killer whales may rely on marine mammal prey to a greater extent than resident and offshore killer whales (Barrett-Lennard *et al.* 1995; Heise 2003; Krahn *et al.* 2004). According to observations in the Gulf of Alaska, Steller sea lions may be a preferred prey in this region where researches observed 79 percent of the killer whale attacks were on Steller sea lions.

Causes of pup mortality include drowning, starvation caused by separation from the mother, crushing by larger animals, disease, predation, and biting by females other than the mother (Edie 1977; Orr and Poulter 1967).

Changes in sea-surface temperatures in the North Pacific Ocean and changes in the structure and composition of the fish fauna on the North Pacific is also believed to place limits on the size of the Steller sea lion population. A shift from a cold to a warm regime that occurred in 1976-1977 was associated with dramatic changes in the structure and composition of the invertebrate and fish communities as well as the distribution of individual species in the North Pacific ocean and Bering Sea (Brodeur and Ware 1992; Beamish 1993; Francis and Hare 1994; Hollowed and Wooster 1992, 1995; Wyllie-Echeverria and Wooster 1998). Many populations of groundfish, particularly pollock, Atka mackerel, cod and various flatfish species increased in abundance as a result of strong year-classes spawned in the mid- to late 1970s. These changes in the abundance of prey resources are believed to have reduced the carrying capacity of the North Pacific Ocean for Steller sea lions (NMFS 2010c).

ANTHROPOGENIC THREATS. Historically, Steller sea lions and other pinnipeds were seen as nuisances to the fishing industry and management agencies because they damaged catch and fishing gear and were thought to compete for fish (Mathisen 1959). Sea lion numbers were reduced through bounty programs, controlled hunts, and indiscriminate shooting (Bigg 1988; Atkinson *et al.* 2008; NMFS 2008c). Steller sea lions were also killed for bait in the crab fishery. Government sanctioned control measures and harvests stopped in the U.S. in 1972 with the passage of the MMPA.

The minimum estimated mortality rate incidental to U.S. commercial fisheries is 33.8 sea lions per year based on observer data (32.8) and stranding data (1.0) where observer data was not available (Allen and Angliss 2013). No observers have been assigned to serveral fisheries that are known to interact with the western Steller sea lion stock making the estimated mortality a minimum estimate (Allen and Angliss 2013).

Commercial fisheries for groundfish (including fisheries for Atka mackerel, walleye pollock, and Pacific cod), herring, crab, shrimp, and Pacific salmon interact with Steller sea lions in a wide variety of ways, including operational conflicts (e.g., incidental kill, gear conflicts, sea lion removal of catch) and biological conflicts (e.g., competition for prey). Several parties and several biological opinions issued by NMFS have asserted that these fisheries compete with Steller sea lions for food, although some reviewers have vigorously disputed this claim. One side of this dispute asserts that the fisheries adversely affect Steller sea lions by (a) competing with sea lions for prey, and (b) affecting the structure of the fish community in ways that reduce the availability of alternative prey (see for examples: Alaska Sea Grant 1993, NRC 1996). The other side of this dispute asserts that the fisheries are not the primary or a contributing cause of the Steller sea lion's decline at all; instead, they point to environmental changes (the regime shift that was discussed previously), increased predation (primarily by killer whales), or other factors as the causative agents (for example, see Saulitis *et al.* 2000).

The mean annual subsistence take from the western stock over the 5-year period from 2004 through 2008, combined with the mean take over the 2005-2009 period from St. Paul, was 198 Steller sea lions per year (Allen and Angliss 2013).

Contaminant burdens are also a considerable issue for Steller sea lions. Roughly 30 individuals died as a result of the Exxon Valdez oil spill and contained particularly high levels of PAH contaminants, presumably as a result of the spill. Subsequently, premature birth rates increased and pup survival decreased (Calkins *et al.* 1994). Organochlorines, including PCBs and DDT (including its metabolites), have been identified in Steller sea lions in greater concentrations than any other pinniped during the 1980s, although levels appear to be declining (Barron *et al.* 2003, Hoshino *et al.* 2006). Contaminant burdens are lower in females than males, because contaminants are transferred to the fetus in utero as well as through lactation (Lee *et al.* 1996, Myers *et al.* 2008).

Mortalities may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. However, between 2006-2010, there were zero mortalities resulting from research on the western stock of Steller sea lions (Tammy Adams, Permits Conservation and Education Division, Office of Protected Resources, NMFS, pers. comm. as cited in Allen and Angliss 2013).

Status

The Steller sea lion was initially listed as a threatened species under the ESA on April 5, 1990 (55 FR 12645). In 1997, the species was split into two separate populations based on demographic and genetic differences (Bickham *et al.* 1996, Loughlin 1997), the western population was reclassified as endangered while the eastern population remained threatened (62 FR 30772). Critical habitat for both of these species was designated on August 27, 1993 (58 FR 45269). On April 18, 2012, NMFS published a proposed rule to delist the eastern DPS of the Steller sea lion (77 FR 23209) based upon a draft status review indicating that the population no longer fits the definition of threatened under the ESA.

Numbers of Steller sea lions declined dramatically throughout much of the species’ range, beginning in the mid- to late 1970s (Braham *et al.* 1980, Merrick *et al.* 1987, NMFS 1992, NMFS 1995). For two decades prior to the decline, the estimated total population was 250,000 to 300,000 animals (Kenyon and Rice 1961, Loughlin *et al.* 1984). The population estimate declined by 50-60 percent to about 116,000 animals by 1989 (NMFS 1992), and by an additional 15 percent by 1994, with the entire decline occurring in the range of the western DPS.

The decline has generally been restricted to the western population of Steller sea lions which had declined by about 5 percent per year during the 1990s. Counts for this population have fallen from 109,880 animals in the late 1970s to 22,167 animals in 1996, a decline of 80% (NMFS 1995). This decline continued into the 1990s as Fritz and Stinchcomb (2005) estimated that from 1991-2000, the number of adults and juvenile sea lions in the western DPS declined by about 38 percent. The 2008-2011 aggregate total count of non-pups (34,314) plus the number of pups in 2009-2011 (11,602) is 45,916, which is used as the minimum population estimate for the U.S. portion of the western stock of Steller sea lion (Wade and Angliss 1997, Allen and Angliss 2013). While the entire western DPS appeared to be in decline throughout the 1980s and 1990s, the population increased at a rate of approximately 3 percent per year from 2000-2004 (Fritz and Stinchcomb 2005). Despite incomplete surveys conducted in 2006 and 2007, the available data indicate that the western Steller sea lion DPS has at least been stable since 2004 (when the last complete assessment was done), although declines continue in the western Aleutian Islands.

The PBR for the western stock is 275 animals (45,916 x 0.06 x 0.1) (Allen and Angliss 2013).

Feeding and Prey Selection

Steller sea lions are generalist predators that eat various fish (arrowtooth flounder, rockfish, hake, flatfish, Pacific salmon, Pacific herring, Pacific cod, sand lance, skates, cusk eel, lamprey, walleye pollock, and Atka mackerel), squids, octopus, and occasionally birds and other mammals. Diet is likely strongly influenced by local and temporal changes in prey distribution and abundance (McKenzie and Wynne 2008; Sigler *et al.* 2009). Haulout selection appears to be driven at least in part by local prey density (Winter *et al.* 2009).

Mothers with newborn pups will make their first foraging trip about a week after giving birth, but trips are short in duration and distance at first, then increase as the pup gets older. Females attending pups tend to stay within 37 kilometers of the rookery (Calkins 1996; Merrick and Loughlin 1997). Young individuals generally remain within 480 kilometers of rookeries their first year before moving further away in subsequent years (Raum-Suryan *et al.* 2004).

Diving, Hauling out, and Social Behavior

Steller sea lions tend to make shallow dives of less than 250 meters (820 feet) but are capable of deeper dives (NMFS 2008c). Female foraging trips during winter tend to be longer (130 kilometers) and dives are deeper (frequently greater than 250 meters). Summer foraging dives, on the other hand, tend to be closer to shore (about 16 kilometers) and shallower (100-250 meters) (Merrick and Loughlin 1997; Loughlin 1997). Adult females stay with their pups for a few days after birth before beginning a regular routine of alternating foraging trips at sea with nursing their pups on land. Female Steller sea lions use smell and distinct vocalizations to recognize and create strong social bonds with their newborn pups.

Steller sea lions do not migrate, but they often disperse widely outside of the breeding season (Loughlin 1997). Because of their polygynous breeding behavior, in which individual, adult male sea lions will breed with a large number of adult females, Steller sea lions have clearly-defined social interactions. Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple, 2002). At sea, groups usually consist of females and subadult males as adult males are usually solitary (Loughlin, 2002). King (1983) reported rafts of several hundred Steller sea lions adjacent to haulouts.

Vocalizations and Hearing

Gentry (1970) and Sandegren (1970) described a suite of sounds that Steller sea lions form while on their rookeries and haulouts. These sounds include threat displays, vocal exchanges between mothers and pups, and a series of roars and hisses. Poulter and DelCarlo (1971) reported that Steller sea lions produce clicks, growls, and bleats underwater.

On land, territorial male Steller sea lions usually produce low frequency roars (Loughlin *et al.*, 1987). The calls of females range from 30 Hz to 3 kHz, with peak frequencies from 150 Hz to 1 kHz for 1.0 to 1.5 seconds.

Kastelein *et al.* (2005) also described the underwater vocalizations of Steller sea lions, which include belches, barks, and clicks. The underwater audiogram of the male Steller sea lion in their study had a maximum hearing sensitivity at 77 dB RL at 1kHz. His range of best hearing, at 10dB from the maximum sensitivity, was between 1 and16 kHz. His average pre-stimulus responses occurred at low frequency signals. The female Steller sea lion’s maximum hearing sensitivity, at 73 dB RL, occurred at 25 kHz. These authors concluded that low frequency sounds are audible to Steller sea lions. However, because of the small number of animals tested, the findings could not be attributed to individual differences in sensitivity or sexual dimorphism (Kastelein *et al.* 2005).

Due to the scarcity of information relating to hearing in Steller sea lions and other pinnipeds, Southall *et al.* (2007) estimated the functional underwater hearing range of all pinnipeds to be between 75 Hz and 75 kHz.

2.2.4 Status of Critical Habitat

That status of critical habitat is focused primarily on the presence of ESA-listed species and the physical and biological features that are essential to their conservation. The only critical habitat that occurs in the action area and has the potential to be impacted by stressors associated with the proposed action is critical habitat for the Steller sea lions.

2.2.4.1 Critical Habitat for the Steller Sea Lion

Critical habitat was designated for Steller sea lions (SSL) on August 27, 1993 (58 FR 45269) based on the location of terrestrial rookery and haulout sites, spatial extent of foraging trips, and availability of prey items (see Figure 5). The areas designated as critical habitat for the Steller sea lion were determined using the best information available at the time (see regulations at 50 CFR part 226.202), including information on land use patterns, the extent of foraging trips, and the availability of prey items (NMFS 2008c). Particular attention was paid to life history patterns and the areas where animals haul out to rest, pup, nurse their pups, mate, and molt.

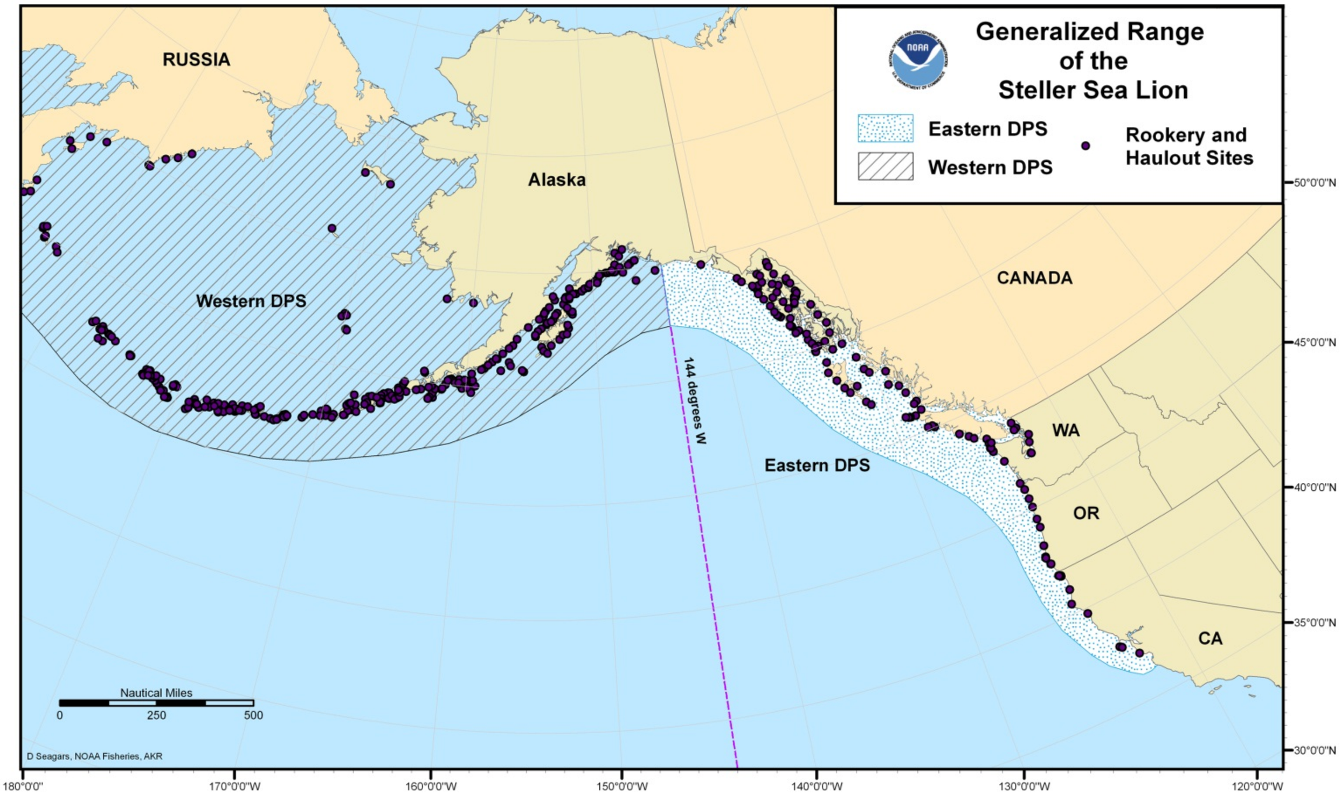

Figure 6. Steller sea lion range map and rookery and haulout locations for the western DPS and eastern DPS. The border for the eastern DPS occurs east of 144° W longitude, outside of the action area.

Designated critical habitat for Steller sea lions includes 1) a terrestrial zone that extends 3,000 ft (0.9 km) landward from the baseline or base point of each major rookery and major haulout, 2) an air zone that extends 3,000 ft (0.9 km) above the terrestrial zone, measured vertically from sea level, 3) an aquatic zone that extends 20 nm (37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144° W long, and 5) three special aquatic foraging areas in Alaska; the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area. (Specific coordinates for these protected areas can be found in the regulations at 50 CFR § 226.202).

Essential features of Steller sea lion critical habitat include the physical and biological habitat features that support reproduction, foraging, rest, and refuge, and include terrestrial, air and aquatic areas. Specific terrestrial areas include rookeries and haul-outs where breeding, pupping, refuge and resting occurs. The principal, essential aquatic areas are the nearshore waters around rookeries and haulouts, their forage resources and habitats, and traditional rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas.

Factors that influence the suitability of a particular area include substrate, exposure to wind and waves, the extent and type of human activities and disturbance in the region, and proximity to prey resources (Mate 1973).

Terrestrial Habitats

Rookeries are occupied by breeding animals and some sub-adults throughout the breeding season, which extends from late May to early July throughout the range. Rookeries are defined as those sites where males defend territory and where pupping and mating occurs.

The SSL Recovery Team identified 121 major haulout sites.[7] Haulouts are areas of rest and refuge by all ages and both sexes of sea lions during the non-breeding season and by non-breeding adults and sub-adults during the breeding season.

Aquatic Habitats

These aquatic zones around rookeries and haulout sites were chosen based on evidence that many foraging trips by lactating adult females in summer may be relatively short (20 km or less; Merrick and Loughlin 1997). Also, mean distances for young-of-the-year in winter may be relatively short (about 30 km; Merrick and Loughlin 1997, Loughlin *et al.* 2003). These young animals are just learning to feed on their own, and the availability of prey in the vicinity of rookeries and haulout sites may be crucial to their transition to independent feeding after weaning. Similarly, haulouts around rookeries are important for juveniles, because most juveniles are found at haulouts not rookeries. Evidence indicates that decreased juvenile survival may be an important proximate cause of the sea lion decline (York 1994, Chumbley *et al.* 1997). Therefore, the areas around rookeries and haulout sites must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect (NMFS 2008c).

Three “special aquatic foraging areas in Alaska” were chosen based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. These areas include the Shelikof Strait, Bogoslof Island, and Seguam Pass. The Bogoslof Foraging Area is the only foraging area designated as critical habitat which occurs in the action area. This site has historically supported large aggregations of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for SSLs (Fiscus and Baines 1966, Kajimura and Loughlin 1988).

Disturbance

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. Terrestrial habitat has been protected throughout the range by a variety of agencies, and by the fact that sea

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[7] A major haulout is defined as a site where more than 200 animals have been counted. There are many more haulout sites throughout the range that are used by fewer animals or used irregularly (58 FR 17181).

lions generally inhabit remote, unpopulated areas. Many haulouts and rookeries used by the western DPS are afforded protection from disturbance because they are located on land where access is regulated by the Alaska Maritime National Wildlife Refuge and other agencies (NMFS 2008c). However, in the region near Dutch Harbor, large commercial ship traffic is concentrated in and near Unimak Pass, and the local fishing fleet, tugs and barges, ferries, and other small vessels often transit in the area as well, so overlap with vessels and Steller sea lions is anticipated.

Vessels transiting to and from Dutch Harbor in association with SAE's authorized activities will pass through designated critical habitat SSLs. Dutch Harbor sits within the Bogoslof designated foraging area and is within the 20 nm aquatic zone associated with rookery and haulout locations (Figure 6). In addition, depending on the routes vessels take to transit through the Bering Strait, they may also overlap with Steller sea lion critical habitat designated on the Pribilof Islands, St. Matthew Island, or St. Lawrence Island.

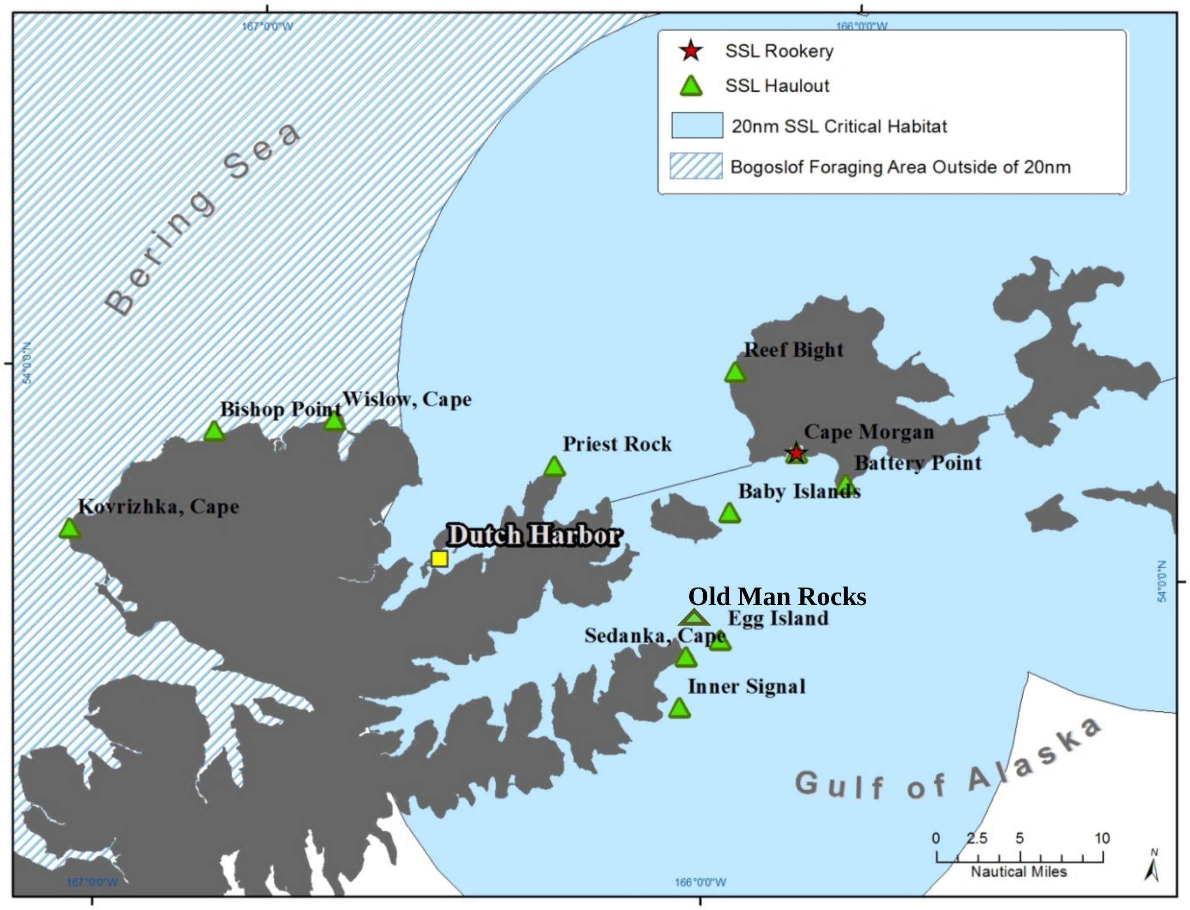

Figure 7. Haulout and rookery locations for the western DPS of Steller sea lions near Dutch Harbor. This list is not meant to be exclusive, there are additional haulout and rookery locations that may not be shown here. However, it does highlight the overlap in the 20nm designated critical habitat, and the nearby designated

Bogoslof foraging area and the location of Dutch Harbor to and from which SAE authorized vessels may be transiting.

No transit zones for vessels within 3 nm of listed rookeries were implemented under the ESA during the initial listing of the species as threatened under the ESA in 1990. These 3 nm buffer zones around all Steller sea lion rookeries west of 150°W were designed to prevent shooting of sea lions at rookeries. Today, these measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

2.3 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, ended, and no longer appear to affect these whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect populations of endangered whales and threatened ice seals.

2.3.1 Stressors for Species in the Action Area

The following discussion summarizes the principal stressors that are known to affect the likelihood that these endangered and threatened species will survive and recover in the wild. The stressors that will be covered in this discussion include:

1. Targeted Hunts
2. Acoustic Noise
3. Ship Strike
4. Commercial Fishing Interactions
5. Pollutants and Contaminants
6. Research Activities
7. Climate Change

1. Targeted Hunts

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

Historical Commercial Whaling.

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 of the fishery (1850-1870), over 60% of the estimated pre-whaling abundance was harvested, although effort remained high into the 20th century (Braham 1984). It is estimated that the pelagic whaling industry harvested 18,684 whales from this stock (Woodby and Botkin 1993). During 1848-1919, shore-based whaling operations (including landings as well as struck and lost estimates from U. S., Canada, and Russia) took an additional 1,527 animals (Woodby and Botkin 1993). An unknown percentage of the animals taken by the shore-based operations were harvested for subsistence and not commercial purposes. Estimates of mortality likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost animals. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution.

Fin Whale

Between 1925 and 1975, 47,645 fin whales were reported killed throughout the North Pacific (International Whaling Commission, BIWS catch data, February 2003 version, unpublished, as cited in Allen and Angliss 2011)), although newly revealed information about illegal Soviet catches indicates that the Soviets over-reported catches of about 1,200 fin whales, presumably to hide catches of other protected species (Doroshenko 2000). There are no reports of direct human-related injuries or mortalities to fin whales in Alaska waters included in the Alaska Region stranding database for 2001-2005 (NMFS AKR, unpublished data, as cited in Allen and Angliss 2011).

Humpback Whale

Much of the information provided in the *Alaska Marine Mammal Stock Assessments* by Allen and Angliss (2013), does not include reliable data differentiating the number of Western North Pacific stock taken by commercial whaling from the number of Central North Pacific stocks taken by commercial whaling. However, it is the best information available.

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

Ogaswara Islands. On the feeding grounds, substantial catches occurred around the Commander Islands and western Aleutian Islands, as well as in the Gulf of Anadyr (Springer *et al.* 2006).

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

North Pacific Right Whale

Right whales are large, slow-swimming whales which tend to congregate in coastal areas. Their thick layer of blubber causes them to float when killed. These attributes made them an easy and profitable species for early (pre-modern) whalers (Allen and Angliss 2011). Intensive nineteenth-century whaling, primarily by American whalers, may have killed more than 23,000 North Pacific right whales and drastically reduced these populations by the 1850s (Scarff 2001, Clapham *et al.* 2004). Despite the international protection agreement in 1949, the USSR killed 372 right whales in the Gulf of Alaska and Bering Sea in the 1960s (Doroshenko 2000). These catches, which were part of a massive 30 year campaign of illegal whaling by the USSR (Yablokov 1994, Clapham and Ivashchenko 2009), decimated what was probably a small but slowly increasing eastern population (Brownell *et al.* 2001, Wade *et al.* 2011).

Ringed and Bearded Seals

While there was substantial commercial harvest of both ringed and bearded seals in the late 19th and 20th Centuries which 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 as discussed below.

Steller Sea Lions (western DPS)

Steller sea lions were commercially harvested prior to 1973. A total of 616 adult males and 45,178 pups of both sexes were harvested in the eastern Aleutian Islands and Gulf of Alaska between 1959 and 1972 (Thorsteinson and Lensink 1962; Havens 1965; Merrick *et al.* 1987). The pup harvests, which sometimes reached 50% of the total pup production from a rookery, could have depressed recruitment in the short term and may partially explain the declines at some sites through the mid-1970s. However, these harvests do not explain why numbers declined in regions where no harvest occurred, or why in some regions declines occurred approximately 20 years after harvests ceased (Merrick *et al.* 1987, Atkinson *et al.* 2008). A comparative analysis of the ecology and population status of four species of pinnipeds in similar environments (Steller sea lions in the Gulf of Alaska, Cape fur seals in the Benguela Current, harp seals in the Barents Sea, and California sea lions in the California Current) indicates that directed commercial harvest was not a major factor in the Gulf of Alaska Steller sea lion decline (Shima *et al.* 2000).

Subsistence Harvest.

Bowhead Whale

Alaska Natives have been taking bowhead whales for subsistence purposes for at least 2,000 years (Marquette and Bockstoce 1980, Stoker and Krupnik 1993). Subsistence takes have been regulated by a quota system under the authority of the IWC since 1977. This harvest represents the largest known human-related cause of mortality in the Western Arctic stock. Alaska Native subsistence hunters take approximately 0.1-0.5% of the population per annum, primarily from eleven Alaska communities (Philo *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 (2004) summarize Alaskan subsistence harvests of bowheads from 1974 to 2003 reporting a total of 832 whales landed by hunters from 11 villages with Barrow landing the most whales (n = 418) while Little Diomede and 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). 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). Available evidence indicates that subsistence hunting has caused disturbance to the other whales, changed their behavior, and sometimes temporarily affects habitat use, including migration paths (NMFS 2008a).

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 (Allen and Angliss 2013). At the end of the 2012 harvest, there were 15 strikes available for carry-forward, so the combined strike quota for 2013 is 82 (67 +15). This quota is shared between the United States and Russia. For 2013, the U.S. receives 75 strikes and Russia 7.

Canadian and Russian Natives are also known to take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. 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 2004, 2005; IWC 2007a). 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 2011a,b). 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).

Fin Whale

Subsistence hunters in Alaska and Russia have not been reported to take fin whales from this stock (Allen and Angliss 2013).

Humpback Whale

Subsistence hunters in Alaska have reported one illegal take of a humpback whale in South Norton Sound in 2006. There have not been any additional reported takes of humpback whales from this stock by subsistence hunters in Alaska or Russia (Allen and Angliss 2013). The average annual mortality rate from subsistence takes for the 2003- 2007 period is 0.2 (Allen and Angliss 2011).

North Pacific Right Whale

Subsistence hunters in Alaska and Russia have not reported taking animals from this stock (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 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 2013). At this time, there are no efforts to quantify the level of harvest of ringed seals by all Alaska communities. 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 to be sustainable.

Bearded Seal

Bearded seals are an important species for Alaska subsistence hunters, with estimated annual harvests of 1,784 (SD = 941) from 1966 to 1977 (Burns 1981). Between August 1985 and June 1986, 791 bearded seals were harvested in five villages in the Bering Strait region based on reports from the Alaska Eskimo Walrus Commission (Kelly 1988).

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 2013). 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 *et al.* 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.

Western Steller Sea Lion

Alaska Natives were exempted from the 1972 MMPA and ESA ban on taking marine mammals. This exemption allows Alaska Natives to continue taking marine mammals for subsistence or handicraft purposes. As of 2009, data on community subsistence harvests are no longer being collected. Therefore, the most recent 5-year data (2004-2008) will be retained and used for estimating an annual mortality estimate for all areas except St. Paul. Data from St. Paul are still being collected and will be updated with the most recent 5-year period available (Table 7).

Table 6. Summary of the subsistence harvest data for the western U.S. stock of Steller sea lions, 2004-2008 (Allen and Angliss 2013).

	All areas except St. Paul Island			**St. Paul Island**	
Year	**Number harvested**	**Number struck and lost**	**Total**	**Number harvested + struck and lost**	**Total take**
2004	136.8	49.1	185.9[a]	18[f]	204
2005	153.2	27.6	180.8[b]	22[g]	203
2006	114.3	33.1	147.4[c]	26[h]	173
2007	165.7	45.2	210.9[d]	34[i]	245
2008	114.7	21.6	136.3[e]	22[j]	158
2009	N/A	N/A	N/A	26[k]	N/A
Mean annual take (2004-2008)	136.9	35.3	172.3	26	198

[a]Wolfe *et al.* 2005; [b]Wolfe *et al.* 2006; [c] Wolfe *et al.* 2008; [d]Wolfe *et al.* 2009a; [e]Wolfe *et al.* 2009b; [f]Zavadil *et al.* 2005; [g]Lestenkof and Zavadil 2006; [h]Lestenkof *et al.* 2007; [i]Lestenkof *et al.* 2008; [j]Jones; [k] Zavidil 2010.

Based on retrospective surveys, the annual subsistence harvest (including struck and loss) decreased substantially from about 550 sea lions in 1992 to about 200 in 1996 followed by annual takes between 165 and 215 from 1997 to 2004. The greatest numbers of sea lions harvested were in the Pribilof Islands and the Aleutian Islands. Factors that may be responsible for this decreased take include fewer hunters, fewer animals to hunt in the communities' hunting areas, and voluntary restraint from hunting because of perceived problems with the sea lion population (Wolfe and Hutchinson-Scarbrough 1999).

The Recovery Plan for Steller Sea Lion (NMFS 2008c) rated subsistence harvest as low for its impact on the species recovery.

2. Acoustic Noise

Ambient Noise. Ambient noise is background noise in the environment absent *obvious* human influence. For example, close approaches by vessels will likely result in higher sound levels and these are considered obvious human influences. When one considers the distance from its source that a signal can be detected, the intensity and frequency characteristics of ambient noise are important factors to consider in combination with the rate at which sound is lost as it is transmitted from its source to a receiver (Richardson *et al.* 1995). 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 and waves, ice, rain and hail; sounds produced by living organisms; seismic 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 2011a). 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 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 and Chukchi Seas. 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.* 1969, as cited in Richardson *et al.* 1995; Stirling *et al.* 1983; 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.* 1984 as cited in 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, the gray whale, walrus, ringed seal, beluga whale, spotted seal, fin whale (in the southwestern areas) and, potentially but less likely, the humpback whale. Walrus, seals, and seabirds (especially near breeding colonies) all produce sound that can be heard above water.

Anthropogenic Noise. Levels of anthropogenic (human-caused) sound can vary dramatically depending on the season, type of activity, and local conditions. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson *et al.* 1995).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny *et al.* 2005; NRC 1994, 1996, 2000, 2003, 2005; Richardson *et al.* 1995). 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). Sources of anthropogenic sounds in the Chukchi Seas include vessels and aircraft, scientific and military equipment, oil and gas exploration and development, and human settlements. Vessels include motor boats used for subsistence and local transportation, commercial shipping, research vessels, etc. Aircraft includes airplanes and helicopters. Levels of anthropogenic sound can vary dramatically depending on the season, local conditions and size of a community, and the type of activity.

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

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

Shipping sounds are often at source levels of 150-190 dB re 1 µPa at 1m (BOEM 2011a). Shipping traffic is mostly at frequencies from 20-300 Hz (Greene 1995). Sound produced by smaller boats typically is at a higher frequency, around 300 Hz (Greene 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 (10-10,000 Hz) noise levels of 5-10 dB are caused by propeller cavitation (Greene and Moore 1995). Greene and Moore (1995) reported estimated source levels for icebreakers to range from 177-191 dB re 1 µPa-m. Even with rapid attenuation of sound in heavy ice conditions, the elevation in noise levels attributed to icebreaking can be substantial out to at least 5 km (3 mi) (Greene and Moore 1995). In some instances, icebreaking sounds are detectable from more than 50 m (31 mi) away.

Sound from Oil and Gas Activities. 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/three-dimensional (3D) seismic survey with multiple guns would emit sound at frequencies at about 10-120 Hz, and pulses can contain sound at frequencies up to 500-1,000 Hz (Greene and Moore 1995). Seismic airgun sound waves are directed towards the ocean bottom, but can propagate horizontally for many kilometers (Greene and Richardson 1988, Hall *et al.* 1994 as cited in 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. Because the Chukchi Sea continental shelf has a highly uniform depth of 30-50m, it strongly supports sound propagation in the 50-500 Hz frequency band (Funk *et al.* 2008). This is of particular interest because most of the industrial sounds from large vessels, seismic sources, and drilling are in this band and this likely overlaps with the greatest hearing sensitivity of listed cetacean species under consideration in this opinion.

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. (BPXI) and ION Geophysical (ION) to take small numbers of marine mammals by harassment incidental to conducting open-water 3D ocean bottom cable (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. Recently in 2013, NMFS issued a proposed rule for Shell to take small numbers of marine mammals by harassment incidental to conducting site clearance and shallow hazard surveys and equipment recovery and maintenance activities in the Chukchi Sea OCS (78 FR 28412; May 14, 2013).

Oil and gas exploration has also occurred in the Canadian Arctic, specifically in the eastern Beaufort Sea, off the Mackenzie River Delta, Mackenzie 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 the Russian Arctic, and in areas around Sakhalin Island to the south of the Bering Straits (NMFS 2013b).

Greene and Moore (1995) summarized that typical signals associated with vibroseis sound source used for on-ice seismic surveys sweep from 10-70 Hz, but harmonics extend to about 1.5 kHz.

Available information does not indicate that marine and seismic surveys for oil and gas exploration activities has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of marine mammals species and populations in the Arctic region. For example, data indicate that the BCB 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.* 2002). NMFS is not aware of data that indicate that such avoidance is long-lasting after cessation of the activity (NMFS

2013c).

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 in water about 30 m deep (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) further 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 2011a).

Shell conducted two abbreviated exploratory drilling activities at exploration wells in the Beaufort (77 FR 27284; May 9, 2012) and Chukchi (77 FR 27322; May 9, 2012) Seas, Alaska, during the 2012 Arctic open-water season (July through October). In December 2012, Shell submitted two additional IHA applications to take marine mammals incidental to its proposed exploratory drilling in Beaufort and Chukchi Seas during the 2013 open-water season. However, Shell withdrew its application in February 2013.

Given this information, the duration and frequency of drilling within the action area is anticipated to be relatively minimal and impacts are not expected to be significant (NMFS 2013c).

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

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

3. Ship Strike

Marine vessel traffic can pose a threat to marine mammals because of the risk of ship strikes and the disturbance associated with the presence of 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.

According to the NMFS Catch in Areas database (accessed April 10, 2012), the number of fishing vessels with active vessel monitoring system (VMS) that transited in and out of Dutch Harbor between July 1st and December 31st in 2010 and 2011 totaled between 1,400 and 1,820 transits respectively. This is anticipated to be an underestimate of total fishing vessel activity because it focuses on groundfish vessels with active VMS and may miss halibut, sablefish, salmon, and crab vessels. It also does not reflect the number on non-fishing vessels that utilize the harbor and nearby areas. However, it does show that thousands of vessels are anticipated to transit in and out of Dutch Harbor per year.

Shipping and vessel traffic is expected to increase in the Arctic Region OCS if warming trends continue; however, no substantial increase in shipping and vessel traffic has occurred in the action area. In addition, increases in large vessel traffic in the Russian Chukchi Sea are occurring (although this is outside the action area).

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.

There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales, and 3 involved fin whales (Neilson *et al.*2012). There was a significant increase in the number of reports over time between 1978 and 2011 ($r^2 = 0.6999$; $p < 0.001$). One potential strike of a humpback whale was documented just west of Dutch Harbor in King Cover in 2010. The majority of strikes were reported in southeastern Alaska, where the number of humpback whale collisions increased 5.8% annually from 1978 to 2011 (Neilson *et al.* 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010c). Three ship strikes occurred in the northern portion of the Central North Pacific humpback whale's range. Averaged over the period from 2006 to 2010, these three ship strikes account for 0.6 ship strikes/year for the northern portion of the stock (Allen and Angliss 2013).

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

Vessel collisions are considered the primary source of human-caused mortality of right whales in the Atlantic (Cole *et al.* 2005), and it is possible that right whales in the North Pacific are also vulnerable to this source of mortality (Allen and Angliss 2013). However, due to their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strike to the North Pacific stock of right whales at this time (Allen and Angliss 2013).

For the western DPS of Steller sea lion, the Recovery Plan threats assessment concluded that disturbance from vessel traffic posed a minor threat to current recovery of the species (NMFS 2008c). Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators (NMFS 2008c). However, terrestrial habitat for Stellers has been protected through a no transit zone for vessels within 3nm of listed rookeries. In addition, NMFS has provided “Guidelines for Approaching Marine Mammals” that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

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 singled spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike. Icebreakers pose special risks to ice seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (*e.g.,* tankers and bulk carriers) through ice-covered areas. Reeves (1998) noted that some ringed seals have been killed by ice-breakers moving through fast-ice breeding areas.

4. Commercial Fishing Interaction

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

Bowhead Whale

Several cases of rope or net entanglement have been reported from bowhead whales taken in the subsistence hunt (Philo *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 2013).

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.

NMFS 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. The average annual entanglement rate in U.S. commercial fisheries is currently unknown (Allen and Angliss 2013).

Fin Whale

Between 2002 and 2006, there was one observed incidental mortality of a fin whale in the Bering Sea/Aleutian Island (BSAI) pollock trawl fishery. Estimates of marine mammal serious injury/mortality in observed fisheries are provided in Perez (unpubl. ms., as cited in Allen and Angliss 2011). However, between 2007 and 2009, there were no observed incidental mortalities of fin whales due to commercial fisheries (Allen and Angliss 2013).

Humpback whale

Between 2007 and 2010, there was one mortality of a WNP humpback whale in the Bering Sea/Aleutian Islands pollock trawl fishery, and one mortality in the Bering Sea/Aleutian Islands flatfish trawl (see Table 9) (Allen and Angliss 2013). Average annual mortality from observed fisheries was 0.37 humpbacks from this stock (Allen and Angliss 2013). In recent years, an increasing number of entangled humpback whales have been reported to NMFS Alaska Region stranding program. One hundred eighteen humpback whales were reported (96 confirmed) entangled in Alaska from 1997-2009; the majority of these involved southeast Alaska humpbacks (NMFS Alaska Region Stranding Data 2010). For many of these reports, it is not possible to identify the gear involved in the entanglement to a specific fishery. This is based on a general lack of data in reports received, the difficulty in accurately describing gear at a distance, and the fact that most entanglements are not re-sighted for follow-up analysis (NMFS 2010c).

North Pacific Right Whale

Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989 (Kornev 1994). No other incidental takes of right whales are known to have occurred in the North Pacific (Allen and Angliss 2013). Any mortality incidental to commercial fisheries would be considered significant. Entanglement in fishing gear, including lobster pot and sink gillnet gear, is a significant source of mortality for the North Atlantic right whale stock (Waring *et al.* 2004). NMFS is currently undertaking an analysis of North Pacific right whale photographs to estimate entanglement rate from scarring data.

There are no records of fisheries mortalities of eastern North Pacific right whales. Thus, the estimated annual mortality rate incidental to U.S. commercial fisheries approaches zero whales per year from this stock. Therefore, the annual human-caused mortality level is considered to be insignificant and approaching a zero mortality and serious injury rate (Allen and Angliss 2013).

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 2009, there were incidental serious injuries and mortalities of ringed seals in the Bering Sea/Aleutian Islands flatfish trawl fishery, and the Bering Sea/Aleutian Islands pollock trawl. Based on data from 2007 to 2009, there have been an average of 1.75 (CV = 0.01) mortalities of ringed seals incidental to commercial fishing operations (Allen and Angliss 2013).

Bearded Seal

Similar to ringed seals, the monitoring of incidental serious injury or mortality of bearded seals changed as of 2003, and provided managers a better insight into how each fishery in Alaska was potentially impacting the species (Allen and Angliss 2013).

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 2.70 (CV = 0.21) bearded seals per year, based exclusively on observer data (Allen and Angliss 2013).

Western Steller Sea Lion

Between 2007-2009, there were incidental serious injuries and mortalities of western Steller sea lions in the following fisheries: Bering Sea/Aleutian Islands Atka mackerel trawl, Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands Pacific cod trawl, Bering Sea/Aleutian Islands pollock trawl, Gulf of Alaska Pacific cod trawl, Gulf of Alaska pollock trawl, Bering Sea/Aleutian Islands Pacific cod longline, and Gulf of Alaska Pacific cod longline (Allen and Angliss 2013).

During the 5-year period from 2006 to 2010, there were five confirmed fishery-related Steller sea lion strandings in the range of the western stock (Allen and Angliss 2013). Fishery related strandings during 2006-2010 result in an estimated annual mortality of 1.0 animals from this stock. This estimate is considered a minimum because not all entangled animals strand and not all stranded animals are found or reported (Allen and Angliss 2013).

The minimum estimated mortality rate incidental to U. S. commercial fisheries is 33.8 sea lions per year, based on observer data (32.8) and stranding data (1.0) where observer data were not available (Allen and Angliss 2013). Observer data on state fisheries dates as far back as 1990; however, these are the best data available to estimate takes in these fisheries. No observers have been assigned to several fisheries that are known to interact with this stock, making the estimated mortality a minimum estimate (Allen and Angliss 2013).

5. Pollutants and Contaminants

Authorized Discharges

Existing development in the action area provides multiple sources of contaminants that may be bioavailable (NMFS 2013b). 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 2012b, NMFS 2012c).

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. However, historical data on offshore oil spills for the Alaska Arctic OCS regions consists of all small spills and cannot be utilized to create a distribution for statistical analysis (NMFS 2011). For this reason, agencies use a fault tree model to represent expected frequency and BOEM and NMFS determine the severity of oil spills in these regions (Bercha International Inc. 2006, 2008).

From 1971-2010 industry drilled 84 exploration wells in the entire Alaska OCS (BOEM 2011a). 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 2011a).

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 2011a).

Increasing oil and gas development in the U.S. Arctic has led to an increased risk of various forms of pollution to whale and seal habitat, including oil spills, other pollutants, and nontoxic waste (Allen and Angliss 2013).

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. Based on metal levels reported in the literature for other baleen whales, the metal levels observed in all tissues of the bowhead are similar to levels 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 many times lower than that of beluga whales; northern fur seals from the North Pacific or Arctic Ocean. However, while total levels were low, the combined level of 3 isomers of the hexachlorocyclohexanes chlorinated pesticides was higher in the bowhead blubber tested than in the North Atlantic’s pilot whale, the common dolphin, and the harbor seal. These results were believed to be due to the lower trophic level of the bowhead relative to the other marine mammals tested.

Fin Whale

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

Humpback Whale

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

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

North Pacific Right Whale

The impact of pollution on right whales is debatable (NMFS 2006b). O'Shea and Brownell (1994) conclude that there is currently no evidence for significant contaminant-related problems in baleen whales. Although more research is needed, the existing data on mysticetes support the view that the lower trophic levels at which these animals feed should result in lower levels of contaminant accumulation than would be expected in many odontocetes, which typically show concentrations that differ from those of baleen whales by an order of magnitude (O'Shea and Brownell 1994). However, the manner in which pollutants negatively impact animals is complex and difficult to study, particularly in taxa (such as large whales) for which many of the key variables and pathways are unknown (Aguilar, 1987; O'Shea and Brownell 1994).

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 organochlorine (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.

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. Although this might reflect the localized natural arsenic source (from the food web) for these animals, these arsenic levels are probably of no concern with regard to toxicity.

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).

Steller Sea Lion (western DPS)

Aside from the Exxon Valdez Oil Spill in 1989, which occurred well after the Steller sea lion decline was underway, no other events have been recorded that support the possibility of acute toxicity leading to substantial mortality of Steller sea lions (Calkins *et al.* 1994). However, results from several studies, both published and still being conducted, do not permit the complete rejection of toxic substances as a factor that may currently impact sea lion vital rates (NMFS 2008c).

Relatively low levels of toxic substances, including heavy metals, have been documented in Steller sea lions (with some striking exceptions), and these substances are not believed to have caused high levels of mortality or reproductive failure. However, there are no studies on the effects of toxic substances at the population level to determine their impact on vital rates and population trends. Chronic exposure to toxic substances may result in reactive metabolites that could cause damage to DNA, RNA, and cellular proteins.

Sea lions exposed to oil spills may become contaminated with polycyclic aromatic hydrocarbons (PAHs) through inhalation, dermal contact and absorption, direct ingestion, or by ingestion of contaminated prey. After the Exxon Valdez oil spill, Calkins *et al.* (1994) recovered 12 Steller sea lion carcasses from the beaches of Prince William Sound and collected 16 additional Steller sea lions from haul out sites in the vicinity of Prince William Sound, the Kenai coast, and the Barren Islands. Newer contaminants such as PBDEs have not been measured in Steller sea lions. Thus, overall, there is still some concern that toxic substances may have indirect impacts on individual vital rates, including reproductive potential (NMFS 2008c).

The NMFS Northwest Fisheries Science Center examined blubber samples from 24 Steller sea lions from southeast Alaska and reported PCB levels of 630-9,900 ng/g wet weight and DDT levels of 400-8,200 ng/g wet weight (NMFS unpublished data, as cited in NMFS 2008c). PCB levels at the upper end of this range have been shown to reduce juvenile survival in sea otters (AMAP 2002), but the consequences for Steller sea lions are not known. Castellini (1999) found that the levels of zinc, copper, and metallothionein (a chelating compound) were comparable between Steller sea lion pups sampled from the eastern and western DPS, and were lower than for captive sea lions. Castellini also found that circulating zinc and metallothionein levels were elevated in southeast Alaska sea lion pups during the early 1990s, but returned to values comparable to Aleutian Island pups by 1997. Metallothionein levels are one measure of exposure of sea lions to heavy metal contamination. The similarity of levels in both eastern and western DPSs suggests that heavy metal contamination may be having similar effects on both DPSs**.** Existing studies on Steller sea lions have shown relatively low levels of toxic substances (with few exceptions), as well as heavy metals, and these levels are not believed to have caused high mortality or reproductive failure (Lee *et al.* 1996) and are not considered significant contributors to observed Steller sea lion declines.

Adult females and pups are likely the age-classes most vulnerable to toxic substances, the threat occurs at a high frequency (i.e., toxins are commonly found in the North Pacific), and there is a high level of uncertainty associated with the evidence described above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to toxic substances is ranked medium, with a medium feasibility of mitigation (NMFS 2008c).

6. 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.

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. Between 2006-2010 there were zero mortalities from research on the western stock of Steller sea lions (pers. comm. Tammy Adams, Permits, Conservation and Education Division, Office of Protected Resources, NMFS; as cited in Allen and Angliss 2013). No other mortalities of listed marine mammals were reported in the 2013 stock assessment report.

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 marine 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 in parts of the present-day season sea ice zone 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). These changes in turn result in physical changes such as reduced sea ice, increased coastal erosion, changes in hydrology, depth to permafrost, and carbon availability (ACIA 2005).

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 (IPCC 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 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, and may be as soon as 2013 (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).

The effects of these changes to the marine ecosystems of the Bering Sea, Aleutian Islands, and the Gulf of Alaska, and how they may specifically affect Steller sea lions are uncertain. Warmer waters could favor productivity of certain species of forage fish, but the impact on recruitment dynamics of fish of importance to sea lions is unpredictable (NMFS 2008c).

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

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

The recent observations of humpback and fin whales in the eastern Chukchi and western Beaufort seas may be due to reoccupation of previous habitats following the population's recovery from whaling; however, given the virtual absence of these species in the region in historical data, it is also possible that these sightings reflect a northward range expansion related to the effects of climate change.

2.3.2 Summary of Stressors Affecting Listed Species within the Action Area

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

- Commercial whaling reduced large whale populations in the North Pacific down to a fraction of historic population sizes. However, both the Western Arctic bowhead stock of the bowhead whale, and the North Pacific humpback stock are showing marked recovery with numbers approaching the low end of the historic population estimates. Fin whales, while still recovering, remain at a fraction of historic population numbers. The eastern North Pacific right whale population was decimated by commercial and illegal whaling leaving the population at risk from stochastic perturbations that further reduce the size or health of the population.
- 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. There are no authorized subsistence hunts for fin, humpback, or North Pacific right whales in the action area. Subsistence harvest of the Arctic ringed seals and bearded seals is currently substantial in some regions but is not considered a threat at the population level. Subsistence harvest of the western stock of Steller sea lions (198 animals/yr) is below the PBR level (275 animals) for this stock.
- 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; however, no substantial increase in shipping and vessel traffic has occurred in the U.S. Arctic, and no ship strikes have been documented in the U.S. Arctic.
- 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 seals may cause ringed and bearded seals to abandon their preferred breeding habitats in areas with high traffic, and ice-breaker activities have been known to kill ringed seals when ice breaking occurs in breeding areas.
- Concentrations of organochlorine and metal contaminants in tissues of baleen whales are low, and lower than other marine mammal species, 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.
- Relatively low levels of toxic substances, including heavy metals, have been documented in Steller sea lions (with some striking exceptions), and these substances are not believed to have caused high levels of mortality or reproductive failure. Pollutants such as OC compounds and heavy metals have been found in both bearded and ringed seals in the Arctic.
- Mortalities incidental to marine mammal research activities authorized under MMPA permits appears to be low. There was only one documented mortality resulting from research on the Alaska stock of bearded seals, which results in an average of 0.2 mortalities per year from this stock.
- Currently, there are insufficient data to make reliable predictions of the effects of Arctic climate change on baleen whales. A study reported in George *et al.* (2006) showed that landed bowheads had better body condition during years of light ice cover. This, together with high calf production in recent years, suggests that the stock is tolerating the recent ice-retreat at least at present (Allen and Angliss 2013). The feeding range of fin whales is larger than that of other species and consequently, as feeding generalists, it is likely that the fin whale may be more resilient to climate change, should it affect prey, than a species with a narrower range (i.e. feeding specialists). The recent observations of humpback whales in the Beaufort and Chukchi seas may be indicative of seasonal habitat expansion in response to receding sea ice or increases in prey availability which these whales now exploit. Considering that North Pacific right whales are feeding specialists, changes in zooplankton abundance and distribution from climate change may negatively impact the species.
- 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, on the other hand, 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.

2.4 Effects of the Action on the Species and Critical Habitat

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

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

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

This biological opinion relies on the best scientific and commercial information available. We try to 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), and the action agency must carry its burden to demonstrate that the action will not violate section 7(a)(2) of the ESA.

We organize our effects' analyses using a stressor identification – exposure – response – risk assessment framework for the proposed exploration activities. Then we provide a description of the potential effects that could arise from 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. However, 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." 16 U.S.C. § 1362(18)(A). USFWS has defined harass to mean "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding feeding, or sheltering . . . ." 50 C.F.R. § 17.3.

For the purposes of this consultation and consistentwith the MMPA's and USFWS's definitions and the best scientific and commercial data available, we consider a harassment to occur when cetaceans and pinnipeds are exposed to certain sound levels. These thresholds are described below in section 2.4.1.

2.4.1 Project Stressors

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 geophysical surveys since the early 1990s. The 3D seismic surveys SAE plans to conduct during the open water season in 2013 are similar to the other geophysical data acquisition programs over the past several years. By extension, the potential stressors associated with the activities PR1 may authorize are stressors that have occurred previously in the Beaufort Sea action area as well.

We discuss the potential stressors associated with the activities PR1 proposes to authorize on the in the Federal and international waters of the U.S. Chukchi Sea in greater detail in the narratives that follow this introduction. During our assessment, we considered several potential stressors associated with the proposed action. Based on our review of the data available, 3D seismic surveys may cause these primary stressors:

1. sound fields produced by the pulsed sounds from 3D seismic survey airgun arrays and pingers and transponders;

2. sound fields produced by continuous noise sources such as vessels while conducting seismic surveys and transiting to survey locations; and

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

The narratives that follow describe the stressors associated with the proposed activities in greater detail, describe the probability of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and then describe the probable responses of listed species, given probable exposures, based on the evidence available.

1. Pulsed Acoustic Devices

As discussed in the *Description of the Proposed Action* section of this opinion, PR1 intend to authorize a variety of acoustic systems in the action area (see Table 7). These include devices for seismic reflection profiling, such as airgun arrays; and sonar devices, such as single-beam echosounders.

Table 7. Active Acoustic Sources SAE anticipates using within the Beaufort Sea (SAE 2013a).

Active Acoustic Source	**Frequency (kHz)**	**Maximum Source Level (dB re 1 µPa at 1m)**

1760 cui airgun array	<1	237
880 cui airgun array	<1	227
440 cui airgun array	<1	221
Pinger	19-55	193
Transponder	7-50	193
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 2013a).

Airguns are an impulsive acoustic source that have dominant energy at low frequencies (.1-.120 kHz), and have the potential for long-range propagation (Greene 1995). SAE is proposing to use reflected sound energy from a towed 880 and 1,760 cui sleeve airgun array for use in the deeper waters, and a 440 cui array for very shallow waters (<1.5 meter deep) (SAE 2013a). The sound pressure level (SPL) of this source (source level) is anticipated to be a maximum of 237 decibels reference 1 micro Pascal at 1 meter (dB re 1µPa at 1 m) (SAE 2013a).

Available pingers transmit short pulses at between 19 to 55 kHz and have published source levels between 185 and 193 dB re 1 µPa @ 1 m (rms). Available transponders generally transmit at between 7 and 50 kHz, with similar source levels also between 185 and 193 dB re 1 µPa @ 1 m.

During transmissions, these acoustic sources would be detectable at various distances, with the lower-frequency sources generally being detectable at greater distances and the high-frequency sources being detectable at shorter distances.

2. Continuous Noise Sources

The presence and movement of vessels represent a source of acute and chronic disturbance for marine mammals. The combination of the physical presence of a vessel and the underwater noise generated by the vessel, or an interaction between the two may result in behavioral modifications of animals in the vicinity of the vessel (Lusseau 2003, Goodwin and Cotton 2004). Several authors, however, suggest that the noise generated by vessels is probably an important contributing factor to the responses of marine mammals to the vessels (Evans, Canwell et al. 1992, Evans 1992, Blane and Jaakson 1994, Evans, Carson et al. 1994), so we may not be able to treat the effects of vessel traffic as independent of engine and other sounds associated with the vessel.

Vessel Noise is primarily generated by propeller action, propulsion machinery, and hydraulic flow over the hull (Hildebrand 2004). SAE anticipates that vessel noise will have source levels of 165-200 dB re 1 µPa at 1 m, and typically operate at frequencies of less than 1 kHz (SAE 2013a,c).

Acoustic Thresholds under the MMPA

NMFS established acoustic thresholds for behavioral disturbance (Level B harassment under MMPA) for pulsed sound at 160 dB re 1 µPa (rms) based mainly on the earlier observations of mysticetes reacting to airgun pulses (e.g., Malme *et al.* 1983, 1984; Richardson *et al.* 1986). Level B behavioral harassment is set at 120 dB re 1 µPa (rms) for continuous sounds (such vessels in dynamic positioning).[8] NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur (Level A harassment under the MMPA), which are 180 and 190 dB re 1 µPa (rms) for cetaceans and pinnipeds, respectively. These exposure limits were intended as precautionary estimates of exposures below which physical injury would not occur in these taxa. There was no empirical evidence as to whether exposure to higher levels of pulsed sound would or would not cause auditory or other injuries. However, given the limited data then available, it could not be guaranteed that marine mammals exposed to higher levels would not be injured. Further it was recognized that behavioral disturbance could, and in some cases likely would, occur at lower received levels (Southall *et al.* 2007). The established 180- and 190-dB re 1 µPa (rms) thresholds are used to develop safety or exclusion zones around a sound source and trigger the necessary power-down or shut-down procedures in the event a marine mammal is observed.

Miller *et al.* (1999) surmise that bowhead deflection may have begun about 35 km (21.7 mi) to the east of the seismic operations, but did not provide SPL measurements to that distance. Corresponding levels at 30 km (18.6 mi) were about 107–126 dB re 1 µPa rms (Miller *et al.* 1999). Therefore, acoustic information will be presented pertaining to the occurrence of sound levels at threshold values of 190 dB down to 120 dB re 1 µPa (in 10dB increments) when possible.

3. Shipstrike

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

Vessel operations are anticipated to occur in Federal and internal waters in the Chukchi Sea as noted above. Vessels could also occur in the Bering Sea and Bering Strait as they transit to the Chukchi survey areas. These vessels would be operating during open-water season of July through October 2013. Vessels and their operations produce effects through a visual presence; traffic frequency and speed; and operating noise of on-board equipment, and engines. Stressors

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[8] 70 FR 2005

associated with presence and noise will be discussed later. This section focuses on the potential for strike associated with vessels. Listed species may be exposed to vessels when seasonal distribution and habitat selection overlaps in time and space with proposed vessel activities.

For offshore oil and gas exploration operations vessels provide the primary platform for the various open water season seismic surveys and secondary support for these surveys such as monitoring, crew transfer; fuel, and equipment and supplies delivery.

Vessel Type and Collision Risk

The frequency and severity of ship strikes is influenced by vessel speed. Laist *et al.* (2001) noted 89% of all collision accounts pertained to whales that were killed or severely injured from vessels moving at 14 knots or faster. None of these collisions occurred at speeds of less than 10 knots. For the activities considered in this proposed action, vessel speeds are anticipated to range from 4 knots when towing seismic gear, up to 20 knots when transiting (NMFS 2013b).

SAE anticipates using eight vessels for their seismic survey operations. It is anticipated that the source vessel will be a will range in size from 30-120 ft (9-37 m) (SAE 2013a). Medium and small vessels (<75m) have the ability to slow down in relatively short distances and make rapid turns to avoid collisions with marine mammals (BOEM 2011a). However, they may operate at speeds greater than 10 knots during operations and in periods of darkness and poor visibility which increases the risk of collision.

2.4.2 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.

Based on the evidence available, the North Pacific right whale and Steller sea lion are not likely to be exposed to active seismic sound sources because these species only occur in the Bering Sea section of the action area, far from the exposure zones of the other stressors in the Chukchi Sea. For this reason we will only consider the potential exposure to vessel traffic as it moves through the Bering Sea for these species.

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

2.4.2.1 Exposure to Active Seismic Surveys

Noise sources from the proposed action include: seismic survey equipment (1,760, 880, and 440 cui airgun arrays), sonar devices (pingers and transponders), and source and support vessels associated with these surveys. All of the source types have operated in the project area environments for commercial oil and gas exploration projects since 2006 (NMFS 2013b). 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; Aerts *et al.* 2008; MacGillivray and Hannay 2008; Hannay *et al.* 2009; Warner *et al.* 2008, 2010; O'Neill *et al.* 2010; Chorney *et al.* 2011; Warner and McCrodan 2011, Beland *et al.* 2013). The reports dating back to 2006 are publicly available on NMFS' ITA website: http://www.nmfs.noaa.gov/pr/permits/incidental.htm.

The non-airgun sources of noise will be discussed below in Section 2.4.2.2. The remainder of this section will focus on airguns, and the potential exposure of marine mammals to noise from airgun operation. Airgun arrays are the most common source of seismic survey noise. For the proposed action, airguns will be operating during the open-water season (July through October).

Mitigation Measures to Minimize the Likelihood of Exposure to Active Seismic

Mitigation measures are described in detail in Sections 1.3.2 and 1.3.4. We anticipate that 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 scout 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 under NMFS authority.

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

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

Approach to Estimating Exposures to Active Seismic (Open-Water Season)

We relied on exposure estimates provided by SAE in its IHA application (SAE 2013a). SAE relied on computer models, simulations, and an algorithm to estimate the number of animals that might be exposed to stressors. Like all models, these approaches are based on assumptions and are sensitive to those assumptions. In reviewing the assumptions SAE incorporated in its models, NMFS concludes that those models would tend to over-estimate the number of marine mammals that might be exposed to geophysical surveys and equipment recovery and maintenance activities because the models assume: (1) marine mammals would not try to avoid being exposed to the stressor; (2) mean densities of marine mammals within any square kilometer area of the action area would be constant over time; and (3) the surveys will be fully completed. As is typical during ship surveys, inclement weather and equipment failure are likely to cause delays and may limit the number of seismic operations that can be undertaken, so it is likely that this is an overestimate of exposure (SAE 2013a).

The narratives that follow present the approach SAE and NMFS' Permits Division (PR1) used to estimate the number of marine mammals that might be "taken" during geophysical surveys and equipment recovery and maintenance activities PR1 plans to permit (which is described in the *Proposed Action* section of this opinion).

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

- the anticipated area to be ensonified to the specified levels in each season (summer and fall) and water depth (>15m, and >5m)[9] to which a density applies, plus a buffer, by
- that expected species density within that area

Anticipated Area Ensonified to Specified Levels from Noise Sources Associated with the Proposed Action

3D Seismic Surveys

SAE is anticipating conducting 3D seismic surveys in the nearshore waters of the Colville River Delta in the U.S. Beaufort Sea (see Figure 1). The area of water (in km^2) ensonified to ≥160 dB re 1 μPa (rms) was determined using the instantaneous area ensonified by the 1,760 cui airgun array plus a buffer area around the survey box corresponding to the distance to the various isopleths (SAE 2013a).[10] For example, the estimated distance to the 160 dB isopleth is 3km based on a sound source of 236.55 dB re 1 μPa (rms) for the 1,760 cubic inch seismic array and a spreading model of 18 log r + 0.0047 estimated for similar Beaufort nearshore waters (BP Liberty) by Aerts et al. (2008). Placing a 3 kilometer buffer around the 995 km^2 seismic source area expands the ensonification (or Zone of Influence [ZOI]) area to approximately 1,476 square kilometers (570 square miles), and represents the ZOI for pinnipeds. Within the 1,476 square kilometer ensonified area, 10 percent (144 km^2) falls within the 0 to 1.5 meter depth range, 25 percent (362 km^2) falls within the 1.5 to 5 meter range, 54 percent (793 km^2) with the 5 to 15 meter range, and 12 percent (177 km^2) within waters greater than 15 meters deep (bowhead migration corridor) (SAE 2013a).

Table 8. Ensonified area estimates associated with various received sound levels and water depths from 1760 cui airgun array during SAE's 2013 anticipated 3D seismic surveys (ensonified area is provided in km^2) (SAE 2013a; Green 2013).

Sound Source	190dB	180dB	170dB	160dB

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[9] For pinnipeds, which occupy all water depths, this includes the entire ensonified area (1,474 km^2). For bowhead whales water depths include >5m depth (970 km^2), and >15m depth (177 km^2) (SAE 2013a,b).

[10] A 319m, 838m, 1.76 km, and 3.0km buffer was applied to the 190, 180, 170, and 160dB isopleths respectively Green 2013).

1760 cui Airgun	Bowhead Habitat Ensonified Area (km^2)	802	865	978	1,144
1760 cui Airgun	Pinniped Habitat Ensonified Area (km^2)	1,055	1,147	1,305	1,476

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

Summer density estimates for bowhead whales are based on surveys conducted by Brandon *et al*. (2011) in Harrison Bay during July and August of 2010. Their estimate, corrected for observer and availability bias (Thomas *et al.* 2002), was 0.004 whales per square kilometer. A maximum density (0.016/square kilometers) was derived by multiplying this value by 4 to account for variability (SAE 2013a) (see Table 9).

Fall density estimates were based on Clarke and Ferguson’s (2010) summarization of the 2000-2009 Bowhead Whale Aerial Survey Program (BWASP) conducted annually by BOEM. The center of the potential survey box occurs between 150^0 and 151^0 longitude, and the survey area occurs in waters between 1 and 20 meters deep. Based on these same locations and water depths, LAMA Ecological and OASIS Environmental (2011) applied Thomas *et al*.’s (2002) bias correction factors to the number of whales and transect survey effort from September (96 animals, 9,933 kilometers) and October (42 animals, 6,143 kilometers) summarized in Clarke and Ferguson (2010) and calculated a September density of 0.1381 whales/square kilometers and an October density of 0.0977 whales/square kilometers. LAMA Ecological and OASIS Environmental (2011) also derived a mean density (0.1226 whales/square kilometers) by averaging the September and October densities, and used the higher September value as the maximum density (SAE 2013a).

Surveys for ringed seals have been recently conducted in the Beaufort Sea by Kingsley (1986), Frost et al. (2002), Moulton and Lawson (2002), Green and Negri (2005), and Green et al. (2006, 2007). The shipboard monitoring surveys by Green and Negri (2005) and Green *et al*. (2006, 2007) were not systematically based, but are useful in estimating the general composition of pinnipeds in the Beaufort nearshore, including the Colville River Delta. Frost *et al*.’s aerial surveys were conducted during ice coverage and don’t fully represent the summer and fall conditions under which the Beaufort surveys will occur. Moulton and Lawson (2002) conducted summer shipboard-based surveys for pinnipeds along the nearshore Beaufort Sea coast and developed seasonal average and maximum densities representative of SAE’s Beaufort summer seismic project, while the Kingsley (1986) conducted surveys along the ice margin representing fall conditions (SAE 2013a).

Bearded seals were also recorded in Harrison Bay and the Colville River Delta by Green and Negri (2005) and Green *et al*. (2006, 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 densities estimates that appear unrealistically low given density estimates from other studies, especially given that nearby Thetis Island is used as a base for annually hunting this seal (densities are seasonally high enough for focused hunting). For conservative purposes, the bearded seal density values used in this application are derived from Stirling *et al*.'s (1982) observations that the proportion of eastern Beaufort Sea bearded seals is 5 percent that of ringed seals (SAE 2013a).

Table 9 shows the reported recent density estimates (#/km^2) for three different listed species during summer and fall time periods. Sightings providing data on observed densities were available for the following species: the bowhead whale, and the bearded, and ringed seal. The other remaining species (humpback whales) occur so rarely in the project area vicinity that reliable densities are not available for them and/or no sightings were made during the reported surveys (Clarke and Ferguson 2010, Brandon *et al.* 2011). However, SAE requested take authorization for humpback whales to address the rare chance of an encounter (SAE 2013a). Similarly, fin whales and North Pacific right whales have been included in this opinion because of their presence in the Bering and/or Chukchi Seas, along the vessel routes accessing the project site.

Table 9. Averaged and maximum densities (#/km^2) of listed marine mammals in the Beaufort Sea for the planned (July-October) period (SAE 2013a).

Species	Summer Avg.	Summer Max.	Fall Avg.	Fall Max.
Bowhead Whale	0.004	0.016	0.1226	0.1381
Ringed Seal	0.3547	1.4188	0.251	1.004
Bearded Seal	0.0177	0.0708	0.0125	0.0502

Results of Exposure Analysis (Seismic Surveys)

The estimated instances of exposure (see Table 10) are considered precautionary, and are likely overestimates for the following reasons (SAE 2013a):

- The estimates assume that marine mammals would not show localized avoidance of seismic or vessel noise;
- The estimates assume that the full seismic source array will operate continuously along all seismic lines. However, this is unlikely to occur due to adverse weather and ice conditions, potential equipment delays, etc.;
- The proportion of time that the seismic array will actually 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 sec. Furthermore, each 3-millisecond pulse by the single mitigation airgun will be s`paced apart by 60 sec.;
- The distances to the 160 dB re 1 μPa (rms) isopleths applied during the project includes a 3 kilometer buffer. Thus, marine mammals within the far edge of this isopleth are actually expected to be exposed to sounds < 160 dB re 1 μPa (rms); and
- Mitigation measures will be employed if any marine mammal is sighted within or near the designated exclusion zone, and will result in the shut down or power down of seismic operations (see Section 1.3.3).

Table 10. Potential instances of exposure of listed marine mammals to various received sound levels in the water to airgun pulses during SAE's planned 3D seismic surveys in the Beaufort Sea. The range of exposures represents the average vs. the maximum number of exposures that are anticipated to occur.

Species	Season	190 dB Estim. Total Exposures	180 dB Estim. Total Exposures	170 dB Estim. Total Exposures	160 dB Estim. Total Exposures	150 dB Estim. Total Exposures	140 dB Estim. Total Exposures	130 dB Estim. Total Exposures	120 dB Estim. Total Exposures	TOTAL[a]
Bowhead Whale	Summer				5-19					**146-177**
	Fall				141-158					
Fin Whale	Summer Fall	--	---	--	--	--	--	--	2	**2**
N.P. right Whale		--	--	--	--	--	--	--	--	**0**
Humpback Whale	Summer	--	--	--	--	--	--	--	-2	**2**
	Fall									
Bearded Seal	Summer				26-105	--	--	--	--	**44-179**

	Fall				18-74					
Ringed Seal	Summer				523-2,094	--	--	--	--	**893-3,576**
	Fall				370-1,482					

[a] Exposures are presented at received levels in 10dB increments. In total exposures we have eliminated overlap to avoid counting exposures more than once. For example 30 exposures are anticipated to occur between the source and 190 dB, and 71 exposures are anticipated to occur between 190 and 180 dB (or 41 exposures at 180 and 30 exposures at 190dB). The Total represents the exposures that are anticipated to occur at isopleths ≥ 120dB.

These numbers represent the total potential instances of exposure to marine mammals from pulsed sound associated with seismic airgun use during SAE's 2013 3D surveys. In the *Response Analysis* (Section 2.4.3) we will discuss what (if any) exposures are anticipated to rise to the level of "take."

2.4.2.2 Exposure to Other Acoustic Sources

Mitigation Measures to Minimize the Likelihood of Exposure to Other Acoustic Sources

Mitigation measures are described in detail in Section 1.3.3. We anticipate that 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 oil and gas exploration activities.

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

2. Avoid concentrations or groups of whales by all vessels under the direction of SAE.

Approach to Estimating Exposures to Vessel Noise

Sources of continuous noise for the proposed action include noise from vessels. Additional non-airgun impulsive noise sources include pingers and transponders.

CONTINUOUS NOISE SOURCES

The empirical information available does not allow us to estimate the number of baleen whales and pinnipeds that might be exposed to the continuous noise of vessel operation during the activities PR1 plans to permit in the Beaufort Sea OCS.

As described in Section 1.3.1.3 (SAE's Acoustic Equipment), most vessel operations produce sounds at relatively low frequencies from 20-200 Hz (Greene 1995) with source levels of 165-200 dB 1 µPa at 1m (Aerts *et al.* 2008).

<u>Vessel operations</u> in the Chukchi and Beaufort Shelf environments may, depending on the type of vessels employed, generate 120 dB re 1 µPa zones extending approximately 1 km to 5.4 km (0.6 to 4 mi) (Chorney *et al.* 2010). 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 nine vessels, including two source vessels, three cable lay vessels, and two crew-change/support vessels were made in 9 m water depth during the Eni/PGS 2008 OBC project (Warner *et al.* 2008). Their 120 dB re 1 µPa threshold distances ranged from 280 m, for a cable lay vessel to 1,300 m (0.8 mi) for a crew change vessel. The average distance was 718 m (0.43 mi), and that value is considered as representative for support vessels in coastal operations.

NON-SEISMIC IMPULSIVE NOISE SOURCES

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 1.3.1.3 describes each of these sound sources, with source levels and frequency ranges, in more detail.

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 the specified levels (summer and fall) to which a density applies , by that expected species density.

Anticipated Area Ensonified to Specified Levels from Dynamic Positioning Associated with the Proposed Action

Table 7. Ensonified area estimates associated with various received sound levels for pingers and transponders during SAE's 2013 seismic operations (ensonified area provided in km^2) (SAE 2013c).

Sound Source		160	150	140	130	120
Pinger	Ensonified Area (km^2)	0.002	0.022	0.229	1.682	7.839
Transponder	Ensonified Area (km^2)	0.014	0.146	1.168	5.980	19.940

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

The anticipated densities of listed species are the same as those listed in Table 9 above (see Section 2.4.2.1).

Results of Exposure Analysis (Other Noise Sources)

Exposure to Continuous Noise Sources. The empirical information available does not allow us to estimate the number of baleen whales that might be exposed to the continuous noise of vessel operation during the activities PR1 plans to permit in the Beaufort Sea OCS. However, bowhead and humpback whales, and bearded and ringed seals are anticipated to occur in the Beaufort Sea during the open water season when these activities are occurring. Ice seals are by far the most commonly observed marine mammals in Beaufort Sea and they are anticipated to be present during these operations. We assume that some listed individuals are likely to be exposed to this continuous noise source.

Exposure to Non-Airgun Impulsive Noise Sources. SAE estimated potential instances of exposure for listed species at received levels ≥160 dB (rms) by multiplying the ensonified area by the densities of animals just one time per season. SAE determined that this approach was appropriate because exposures will occur while vessels are moving throughout the survey area.

SAE's pinger's underwater sound propagation would drop to 160 dB within 25 m (or less), and the transponder's underwater propagation would drop to 160 dB within 66 m (or less) of the vessel (SAE 2013c). 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.

Given the directionality, short pulse duration, and small beam widths for pingers and transponders; it is not anticipated that baleen whales or pinnipeds would be exposed to these sources. If exposed, whales and seals would not be anticipated to be in the direct sound field for more than one to two pulses (NMFS 2013b). 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. As previously mentioned, 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. However, if seismic operations are more concentrated near the pack ice edges where seals are more common, the chances are greater that more seals would experience multiple disturbances in a season than if exploration activities were clustered away from the ice (NMFS 2013b).

Based on the information provided by SAE (2013a, c) there is the potential for a few exposures to marine mammals as low received levels from pinger and transponder sources. If marine mammals are exposed however, they are not likely to respond to that exposure.

2.4.2.3 Exposure to Vessel Strike

Mitigation Measures to Minimize the Likelihood of Exposure to Vessel Strike

Mitigation measures are described in detail in Section 1.3.3. We anticipate that 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. Specified procedures for changing vessel speed and/or direction to avoid collisions with marine mammals.

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

Approach to Estimating Exposures to Vessel Strike

As discussed in the *Proposed Action* section of this opinion, the activities PR1 proposes to authorize for SAE's 2013 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 will transit from Dutch Harbor through the Bering Strait and the Chukchi Sea in order to reach the Beaufort Sea.

- The maximum number of vessels associated with the proposed action is anticipated to be 8 vessels used for OBC seismic surveys the Beaufort Sea.

- There could be partial crew changes every eight hours. This could involve moving crew members and supplies from support vessels to the housing vessel, or moving crew to Oliktok.

- Timing of operations would commence on or after approximately July 15 and end by early October 31, 2013.

- At the end of a program, vessels will exit the Chukchi Sea, down through the Bering Strait, and back to Dutch Harbor.

Evidence suggests that a greater rate of mortality and serious injury to marine mammals correlates with greater vessel speed at the time of a ship strike (Laist *et al.* 2001, Vanderlaan and Taggert 2007, as cited in Aerts and Richardson 2008). Vessels transiting at speeds >10 knots present the greatest potential hazard of collisions (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 20 knots and operate in periods of darkness and poor visibility (BOEM 2011a). In addition, large vessels when traveling cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammals (BOEM 2011a). All of these factors increase the risk of collisions with marine mammals (BOEM 2011a).

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

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 2011a).

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

Vessels transiting to the Beaufort Sea from Dutch Harbor at the start of the open water season, or returning across these areas to the Bering Strait at the end of the season, transiting between sites, or for resupply in and out of coastal communities along the Beaufort Sea have the highest chance of encountering migrating bowheads or aggregations feeding in more coastal regions of the Beaufort Sea (Clarke *et al*. 2011a,b,c).

Several behavioral factors of bowhead whales help determine whether transiting vessels may be able to detect the species or whether bowhead would be at depths to avoid potential collision. Bowhead whales typically spend a high proportion of time on or near the ocean floor when feeding. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush *et al.* 2010). Bowhead foraging dives are twice as long as most fin and humpback whales, even at equivalent depths, their dives are followed by shorter recovery times at the surface (Kruzikowsky and Mate 2000). This behavior may make bowhead whales less likely to encounter a vessel transiting in the action area, and lowers their likelihood of colliding with such vessels. However, calves have shorter dive duration, surface duration, and blow intervals than their mothers (BOEM 2011a), 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 2011a). Most bowhead whales show strong avoidance reactions to approaching ships which may help them avoid collisions with vessels (NMFS 2013b). However, Alaska Native hunters report that bowheads are less sensitive to approaching boats when they are feeding (George *et al.* 1994), leaving them more vulnerable to vessel collisions. In addition, bowhead whales are also among the slowest moving 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 observation of 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.

Around the world, fin whales are killed and injured in collisions with vessels more frequently than any other whale (Douglas *et al.* 2008; Jensen and Siber 2004; Laist *et al.* 2001). Differences in frequency of injury types among species may be related to morphology. The long, sleek, fin whale tends to be caught on the bows of ships and carried into port where they are likely found and recorded in stranding databases (Laist *et al.* 2001). There have been 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 3 involved fin whale

(Neilson *et al.* 2012). None of the reported fin whale ship strikes occurred in Arctic waters. Even if vessel-related deaths of fin whales in the waters south of the action area where strike of fin whales has been known to occur were several times greater than observed levels, it would still be a small fraction of the total fin whale population (Laist *et al.* 2001).

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

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

The high proportion of calves and juveniles among stranded ship-struck right whales and humpback whales indicates that young animals may be more vulnerable to being hit by ships (Laist *et al.* 2001). This could be caused by the relatively large amount of time that calves and juveniles spend at the surface or in shallow coastal areas where they are vulnerable to being hit (Laist *et al.* 2001). Considering that at least one cow/calf pair has been sighted in the action area, we can assume that this life stage may be present and susceptible to ship strike.

Ship strikes may affect the continued existence of North Pacific right whales. Little is known of the nature or extent of this problem in the North Pacific (Allen and Angliss 2013). However, their slow swim speed and skim feeding behavior (Allen and Angliss 2013) may put right whales at a high risk of collision if they were to overlap in time and space with a vessel.

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

Vessels would have a transitory and short-term 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 8 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.

The extent of impact would be local, given the infrequency of occurrence and the non-random distribution of both baleen whales and survey, maintenance and recovery activities in the action area.

Based on the small number of vessels associated with the proposed activities in the Beaufort, the limited number of sightings of fin, humpback, and North Pacific right whales in the action area, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike in the Beaufort, Chukchi or Bering Seas, we conclude that the probability of a SAE vessel striking an endangered bowhead whale, fin, humpback, or right whale in the Bering, Chukchi, or Beaufort Seas is sufficiently small as to be discountable.

Pinniped Exposure (ringed and bearded seals, and Steller sea lions)

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

Ringed seals are year round residents in the Beaufort Sea, and are anticipated to be in the action area during any time seismic activities may occur. 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.

Vessels transiting to and from Dutch Harbor in association with SAE’s authorized activities will pass through designated critical habitat for the western DPS of SSLs. Dutch Harbor sits within the Bogoslof designated foraging area and is within the 20 nm aquatic zone associated with rookery and haulout locations (see Figure 6). In addition, depending on the routes vessels take to transit through the Bering Strait, they may also overlap with critical habitat designated on the Pribilof Islands, St. Matthew Island, or St. Lawrence Island (see Figure 5). Steller sea lions are anticipated to be within the Bering Sea section of the action area, and may overlap with SAE’s authorized vessels.

Vessels associated with oil and gas exploration activities represent a suite of stressors that pose several potential hazards to ice seals in the Beaufort and Chukchi Seas. First, the size and speed of transiting vessels pose some probability of collisions between ice seals. Second, vessel traffic represents a source of noise disturbance for ice seals (however, this issue was covered under the previous noise exposure section).

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

Ringed seals are often reported to be widely distributed in low densities (averaging 1-2 seal/km^2 in “good” habitats (Kovacs 2007). The dispersed distribution may help mitigate the risks of localized shipping disturbance since the impacts from such events would be less likely to affect a large number of seals (Kelly *et al.* 2010b). However, pinnipeds may be at the greatest risk from shipping threats in areas of the Arctic where geographic constriction concentrates seals and vessel activity into confined areas, such as the Bering Strait, Hudson Strait, Lancaster Sound, Pechora Sea, and Kara Point (Arctic Council 2009). The Bering Strait area is where routes associated with the Northwest Passage (NWP) and Northern Sea Route converge in an area used by bearded seals in the early spring for whelping, nursing, and mating (from April to May) and in the late spring for molting and migrating (from May to June). At this choke point there is currently close spatial overlap between ships and seals, but less so temporally (Cameron *et al.* 2010). However, this may change as diminishing ice in the spring transforms existing and potential shipping corridors, making those less prone to sporadic blockages during seals’ whelping and nursing periods (Cameron *et al.* 2010).

Since bearded seals are benthic feeders, they generally associate with seasonal sea ice over shallow water of less than 200m (656 ft) (NMFS 2013b). Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack-ice edge frequently beyond the continental shelf, over water too deep for benthic feeding (BOEM 2011a). For this reason, NMFS would anticipate that there is a higher likelihood of SAE vessels encountering bearded seals in the Chukchi Sea than in the Beaufort Sea.

As previously discussed, vessels transiting to the Beaufort Sea from Dutch Harbor at the start of the open water season, or returning to the Bering Strait at the end of the season, transiting between sites, or for resupply in and out of Okliktok or Nome in the may pose the most risk to ringed seals because that’s when the vessels are traveling at high speeds and covering areas where ringed seals are known to aggregate (NMFS 2013b).

The fact that nearly all shipping activity in the Arctic (with the exception of icebreaking) purposefully avoids areas of ice and primarily occurs during the ice-free or low-ice seasons also helps to mitigate the risks of shipping to ringed seals since this species is closely associated with ice at nearly all times of the year and especially during the whelping, breeding, and molting periods when the seals (especially young pups) may be most vulnerable to shipping impacts (Smith 1987).

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.

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. However, 3-mile no-transit zones are established and enforced around rookeries (NMFS 2008c). These measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c). In addition, timing restrictions would likely avoid adverse effects to newborn ringed and bearded seal pups, particularly when nursing and molting (NMFS 2013b).

Despite all of this traffic in and around rookery and haulout locations near Dutch Harbor, there have been no incidents of ship strike with Steller sea lions in Alaska. In addition, the Steller sea lion population in and around Dutch Harbor has been increasing at about 3% per year, indicating that vessel traffic hasn't been an impact (Lowell Fritz personal comm. April 6, 2012).

Bearded seals aggregate during breeding and molting in areas with ice favorable for hauling out (Cameron *et al.* 2010). Recent research suggests that bearded seals may exhibit fidelity to distinct areas and habitats during the breeding season (Van Parijs and Clark 2006). If vessels happened to overlap in space and time with bearded seal breeding and molting periods, there is the potential that a larger number of seals may be impacted.

Huntington (2009) considered vessels to be a low level threat with modest impacts that should be amenable to effective regulation. Indeed, vessel impacts alone may comprise a low risk to entire populations, but when combined with the effects related to diminishing ice cover, such as increasingly denser aggregations, the impacts may be magnified and may play an important role in affecting the future health of populations (Kelly *et al.* 2010b).

Vessels would have a transitory and short-term presence in any specific location. NMFS is not able to quantify existing traffic conditions across the entire Bering, Chukchi, and Beaufort Seas to provide context for the addition of 8 vessels. However, the absence of collisions involving vessels and ice seals in the Arctic and seals and sea lions in the subarctic despite decades of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated with the proposed activities in the Beaufort Sea, the small number of vessels used for the proposed action, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike in the Beaufort Sea, Chukchi Sea or Bering Sea for ice seals or Steller sea lions, the mitigation measures in place to minimize exposure of pinnipeds to vessel activities, we conclude that the probability of a SAE vessel striking an endangered Steller sea lion, or threatened ringed or bearded seal in the Bering, Chukchi, and Beaufort Seas sufficiently small as to be discountable.

2.4.3 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.

The stressors that would be associated with the proposed action PR1 anticipates permitting in the Chukchi Sea consist of two classes: *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 (Anisman and Merali 1999, de Kloet *et al.* 2003, Herman and Cullinan 1997). Disturbance from surface vessels would be an example of processive stressors while ship strikes would be an example of a systemic stressor. As a result, exposures resulting from the SAE's proposed activities are likely to 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 7: 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 7: Physical Response).

In the narratives that follow, we summarize the best scientific and commercial data on the responses of marine mammals to stressors associated with the proposed action. Then we use that information to make inferences about the probable responses of the endangered and proposed threatened species we are considering in this opinion.

Based on the evidence available, the North Pacific right whale, fin whale, and Steller sea lion are not likely to be exposed to active seismic noise sources because these species only occur in the Chukchi Sea, and Bering Sea section of the action area, far from the exposure zones of the other stressors in the Beaufort Sea. For this reason we will only consider the potential responses to vessel traffic in the Chukchi Sea and Bering Sea for these species.

2.4.3.1 Potential Responses to Noise from Airguns

For the purposes of consultations on activities that involve the use of airguns, our assessments try to detect the probability of physical damage (resonance, noise induced loss of hearing sensitivity ((threshold shift)); behavioral responses (avoidance, vigilance, acoustic masking, no reaction); physiological responses (particular stress responses); and social responses that are likely to directly or indirectly reduce the fitness of listed individuals.

Our response analyses consider and weigh all of the evidence available on the response of listed species upon being exposed to seismic airgun noise and probable fitness consequences for the animals that exhibit particular responses or sequence of responses. It is important to acknowledge, however, that the empirical evidence on how endangered or threatened marine animals respond upon being exposed to sounds produced by equipment employed during seismic surveys in natural settings is very limited. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to sounds produced by equipment employed during seismic surveys, or responses of other species to other acoustic stimuli.

Figure 7 illustrates the conceptual model we use to assess the potential responses of marine animals when they are exposed to seismic operations (or other acoustic stimuli). The narratives that follow are generally organized around the potential responses; physical damage, acoustic resonance, noise-induced loss of hearing sensitivity, behavioral responses (broken down further into behavioral avoidance of initial exposures or continued exposure, vigilance, continued pre-disturbance behavior, habituation, or no response), impaired communication, fitness consequences of vocal adjustments, allostasis, stranding events (broken down further into global stranding patterns and taxonomic patterns).

Based on those data, we identify the probable responses of endangered and threatened marine animals to seismic transmissions.

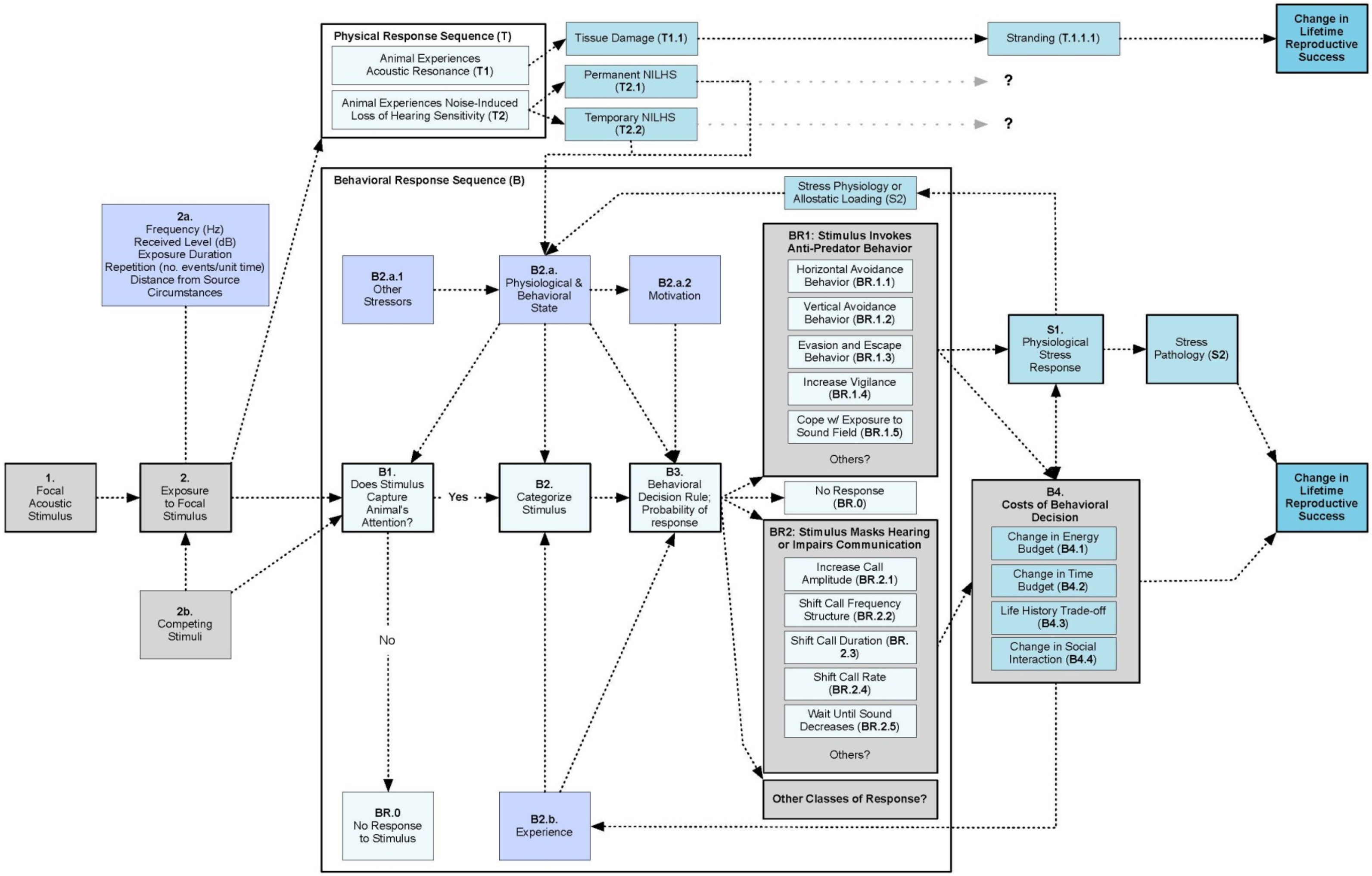

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Figure 8. Conceptual model of the potential responses of listed species upon being exposed to seismic airgun noise and the pathways by which those responses might affect the fitness of individual animals that have been exposed. See text in the *Approach to the Assessment* and *Response Analyses* for an explanation of the model and supporting literature.

Physical Damage

For the purposes of this assessment, "injuries" represents physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of those injuries to an animal (we distinguish between injuries that result from an acoustic exposure and injuries that result from an animal's behavioral reaction to an acoustic exposure, which is discussed later in this section of the opinion). Based on the literature available, pulsed noise sources might injure marine animals through two mechanisms (see "Box T" in Figure 7): acoustic resonance and noise induced loss of hearing sensitivity (more commonly-called "threshold shift"). However, as discussed below, there is no specific evidence of acoustic resonance occurring upon exposure to airgun pulses (NSF 2010). There is also no indication that the species being analyzed in this opinion have exhibited or would exhibit similar dive pattern responses to seismic operations as those shown by beaked whales to sonar operations.

ACOUSTIC RESONANCE

Acoustic resonance results from hydraulic damage in tissues that are filled with gas or air that resonates when exposed to acoustic signals (Box T1 of Figure 7 illustrates the potential consequences of acoustic resonance; see Rommel *et al.* 2007). Based on studies of lesions in beaked whales that stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, investigators have identified two physiological mechanisms that might explain some of those stranding events: tissue damage resulting from resonance effects (Cudahy and Ellison 2001, Ketten 2004) and tissue damage resulting from "gas and fat embolic syndrome" (Jepson *et al.* 2003, 2005, Fernandez *et al.* 2005). Fat and gas embolisms are believed to occur when tissues are supersaturated with dissolved nitrogen gas and diffusion facilitated by bubble-growth is stimulated within those tissues (the bubble growth results in embolisms analogous to the "bends" in human divers). While this example involves sonar, concerns have been raised that sounds from seismic surveys might have similar effects (Taylor *et al.* 2004).

Airgun pulses are less energetic and have slower rise times than sonar, and there is no specific evidence that they can cause serious injury, death, or stranding events. However, there has been at least one case where strandings of beaked whales occurred simultaneously with a seismic survey (Malakoff 2002; Taylor *et al.* 2004; Cox *et al.* 2006). Whether or not this survey caused the beaked whales to strand has been a matter of debate because of the small number of animals involved and a lack of knowledge regarding the temporal and spatial correlation between the animals and the sound source (Cox *et al.* 2006).

Seismic pulses and mid frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid frequency sonars emit non-impulse sounds at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time (though the frequency may change over time). Thus, it is not appropriate to assume that the effects of seismic surveys on beaked whales or other species would be the same as the apparent effects of military sonar. For example, resonance effects and acoustically-mediated bubble-growth (Crum et al. 2005) are implausible in the case of exposure to broad-band airgun pulses. Nonetheless, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge 2001; NOAA and U.S. Navy 2001; Jepson et al. 2003; Fernández et al. 2004, 2005; Hildebrand 2005; Cox et al. 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity ‘pulsed’ sound. One of the hypothesized mechanisms by which naval sonars lead to strandings might, in theory, also apply to seismic surveys. If the strong sounds sometimes cause deep-diving species to alter their surfacing–dive cycles in a way that causes bubble formation in tissue, that hypothesized mechanism might apply to seismic surveys as well as mid frequency naval sonars. However, there is no specific evidence of this upon exposure to airgun pulses (NSF 2010). There is also no indication that the species being analyzed in this opinion have exhibited or would exhibit similar dive pattern responses to seismic operations as those shown by beaked whales to sonar operations.

Cudahy and Ellison (2001) analyzed the potential for resonance from low frequency sonar signals to cause injury and concluded that the expected threshold for *in vivo* (in the living body) tissue damage for underwater sound is on the order of 180 to 190 dB. There is limited direct empirical evidence (beyond Schlundt *et al.* 2000) to support a conclusion that 180 dB is “safe” for marine mammals; however, evidence from marine mammal vocalizations suggests that 180 dB is not likely to physically injure marine mammals. For example, Frankel (1994) estimated the source level for singing humpback whales to be between 170 and 175 dB; McDonald *et al.* (2001) calculated the average source level for blue whale calls as 186 dB; Watkins *et al.* (1987) found source levels for fin whales up to 186 dB; Cummings and Holliday (1987) calculated source level measurements for bowhead whale songs in the spring off of Barrow to be between 158 and 189 dB; and Møhl *et al.* (2000) recorded source levels for sperm whale clicks up to 223 dB (rms). Because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that these source levels are not likely to damage the tissues of the endangered and threatened species being considered in this consultation.

Crum and Mao (1994) hypothesized that received levels would have to exceed 190 dB in order for there to be the possibility of significant bubble growth due to super-saturation of gases in the blood. Jepson *et al.* (2003, 2005) and Fernández *et al.* (2004, 2005) concluded that *in vivo* bubble formation, which may be exacerbated by deep, long-duration, repetitive dives may explain why beaked whales appear to be particularly vulnerable to sonar exposures.

Based on the information available, the listed marine mammals that we are considering in this opinion are not likely to experience acoustic resonance. All of the evidence available suggests that this phenomenon poses potential risks to species like beaked whales rather than the cetaceans and pinnipeds being considered in this opinion due to beaked whale’s deep diving characteristics and sensitivity to impulsive noise sources.

NOISE-INDUCED LOSS OF HEARING SENSITIVITY

Noise-induced loss of hearing sensitivity[11] or “threshold shift” refers to an ear’s reduced

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[11] Animals experience losses in hearing sensitivity through other mechanisms. The processes of aging and several

sensitivity to sound following exposure to loud noises; when an ear's sensitivity to sound has been reduced, sounds must be louder for an animal to detect and recognize it. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected. These losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting, instead, they affect the frequency ranges that are roughly equivalent to or slightly higher than the frequency range of the noise itself. Nevertheless, most investigators who study temporary threshold shift in marine mammals report the frequency range of the "noise," which would change as the spectral qualities of a waveform change as it moves through water, rather than the frequency range of the animals they study. Without information on the frequencies of the sounds we consider in this opinion at the point at which it is received by endangered and threatened marine mammals, we assume that the frequencies are roughly equivalent to the frequencies of the source.

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift (PTS), temporary threshold shift (TTS), and compound threshold shift (CTS) (Ward *et al*. 1998; Yost 2007). When permanent loss of hearing sensitivity, or PTS, occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness, or an animal's hearing can be permanently impaired in specific frequency ranges, which can cause the animal to be less sensitive to sounds in that frequency range. Traditionally, investigations of temporary loss of hearing sensitivity, or TTS, have focused on sound receptors (hair cell damage) and have concluded that this form of threshold shift is temporary because hair cell damage does not accompany TTS and losses in hearing sensitivity are short-term and are followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks. More recently, however, Kujawa and Liberman (2009) reported on noise-induced degeneration of the cochlear nerve that is a delayed result of acoustic exposures that produce TTS, that occurs in the absence of hair cell damage, and that is irreversible. They concluded that the reversibility of noise induced threshold shifts, or TTS, can disguise progressive neuropathology that would have long-term consequences on an animal's ability to process acoustic information. If this phenomenon occurs in a wide range of species, TTS may have more permanent effects on an animal's hearing sensitivity than earlier studies would lead us to recognize.

Compound threshold shift or CTS, occurs when some loss in hearing sensitivity is permanent and some is temporary (for example, there might be a permanent loss of hearing sensitivity at some frequencies and a temporary loss at other frequencies or a loss of hearing sensitivity followed by partial recovery).

Although the published body of science literature contains numerous theoretical studies and discussion papers on hearing impairments that can occur with exposure to a strong sound, only a few studies provide empirical information on noise-induced loss in hearing sensitivity in marine mammals. The following subsections summarize the available data on noise-induced hearing impairment in marine mammals.

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diseases cause some humans to experience permanent losses in their hearing sensitivity. Body burdens of toxic chemicals can also cause animals, including humans, to experience permanent and temporary losses in their hearing sensitivity (for example see: Mills and Going 1982).

Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments conducted by researchers at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (SPAWAR) the University of California Santa Cruz, and the Hawaii Institute of Marine Biology (Schlundt *et al.* 2000; Finneran *et al.* 2001; Finneran 2003). Schlundt *et al.* (2000) reported on "behavioral alterations" (deviations from the behaviors the animals had been trained to exhibit) that occurred during their experiments.

Finneran *et al.* (2001) and Finneran 2003 conducted TTS experiments using 1-second duration tones and a test method that was similar to that of Schlundt *et al.* (2000) except these tests were conducted in a pool with very low ambient noise levels (below 50 dB re 1 μPa/Hz); as a result of the latter, they used no masking noise. The signal in these experiments was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and sound pressure level of about 100 dB re 1 μPa rms. They conducted two separate experiments. In the first experiment, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa rms were randomly presented.

Finneran *et al*. (2005) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt *et al.* (2000), Finneran *et al.* (2001) and Finneran 2003 experiments. These included observations from 193 exposure sessions (fatiguing stimulus level > 141 dB re 1 μPa) conducted by Schlundt *et al.* (2000) and 21 exposure sessions conducted by Finneran *et al.* (2001, 2003). For their analyses, Finneran *et al.* (2005) placed each exposure into one of the following nine decibel ranges: 160 ± 3, 170 ± 3, 175 ± 2, 180 ± 2, 186 ± 3, 192 ± 2, 196 ± 1, 199 ± 1, and 201 ± 1 dB re μPa rms. The exposure groups and ± ranges were based on the distribution of the actual exposure sound pressure levels. During their experimental trials, these investigators collected incidental information on the behavioral responses of the cetaceans involved in an experiment. The behavioral responses they recorded included attempts to avoid sites of previous noise exposures (e.g., Schlundt *et al.* 2000), attempts to avoid an exposure in progress, aggressive behavior or refusal to further participate in tests (Schlundt *et al.* 2000).

Richardson *et al*. (1995) hypothesized those marine mammals within less than 100 meters of a sonar source might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 Pa which might cause TTS. However, there is no empirical evidence that exposure to active sonar transmissions with this kind of intensity can cause PTS in any marine mammals; instead the probability of PTS has been inferred from studies of TTS (see Richardson *et al*. 1995). On the other hand, Kujawa and Liberman (2009) argued that traditional testing of threshold shifts, which have focused on recovery of threshold sensitivities after exposure to noise, would miss acute loss of afferent nerve terminals and chronic degeneration of the cochlear nerve, which would have the effect of permanently reducing an animal's ability to perceive and process acoustic signals. Based on their studies of small mammals, Kujawa and Liberman (2009) reported that two hours of acoustic exposures produced moderate temporary threshold shifts but caused delayed losses of afferent nerve terminals and chronic degeneration of the cochlear nerve in test animals.

Recent data measuring noise-induced threshold shifts in phocid pinnipeds (i.e., harbor seals) indicates that temporary threshold shift onset can be lower than onset thresholds measured in cetaceans from continuous noise sources (Kastak *et al.* 2005, Kastelein *et al.* 2012). We have limited data on a limited number of individuals, but the same trend may also be true for TTS onset from impulsive noise sources.

Results from other studies [harbor porpoise (Lucke *et al*. 2009; Kastelein *et al.* unpublished data), and bottlenose dolphin (Mooney *et al*. 2009)] suggest that SEL criteria obtained from only short duration/high level exposures might lead to underestimation of the amount of TTS induced as a function of the exposure duration, particularly for longer exposures (e.g., hours) and low levels.

Despite the extensive amount of attention given to threshold shifts by researchers, environmental assessments conducted by BOEM and seismic survey operators, and its use in permits issued by PR1, it is not certain that threshold shifts are common. Several variables affect the amount of loss in hearing sensitivity: the level, duration, spectral content, and temporal pattern of exposure to an acoustic stimulus as well as differences in the sensitivity of individuals and species. All of these factors combine to determine whether an individual organism is likely to experience a loss in hearing sensitivity as a result of acoustic exposure (Ward 1998; Yost 2007). In free-ranging marine mammals, an animal's behavioral responses to a single acoustic exposure or a series of acoustic exposure events would also determine whether the animal is likely to experience losses in hearing sensitivity as a result of acoustic exposure. Unlike humans whose occupations or living conditions expose them to sources of potentially-harmful noise, in most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an animal out of a sound field entirely or reduce the intensity of an exposure would reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity. It is unlikely that a marine mammal would remain close enough to a large airgun array long enough to incur a threshold shift in hearing. The levels of successive pulses received by a marine mammal will increase and then decrease gradually as the seismic vessel approaches, passes and moves away, with periodic decreases also caused when the animal goes to the surface to breath, reducing the probability of the animal being exposed to sound levels large enough to elicit a threshold shift.

More importantly, the data on captive animals and the limited information from free-ranging animals suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the longevity or reproductive success of animals that experience permanent, temporary, or compound threshold shifts (Box T2 of Figure 12 illustrates the potential consequences of noise-induced loss in hearing sensitivity). Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues about their environment while their ears recover from the temporary loss of hearing sensitivity. Although we could not locate information how animals that experience noise-induced hearing loss alter their behavior or the consequences of any altered behavior on the lifetime reproductive success of those individuals, the limited information available would not lead us to expect temporary losses in hearing sensitivity to incrementally reduce the lifetime reproductive success of animals.

In addition, mitigation measures will be used, including visual monitoring, and specific power down, shut down, and ramp-up procedures for marine mammals spotted within the identified exclusion zone or that have the potential to enter the exclusion zone (the cetacean exclusion zone at 180 dB rms isopleth is estimated to be 160 m from the seismic source, and the pinniped exclusion zone at 190 dB rms isopleth is estimated to be 50 m from the seismic source) would help reduce the received level of any exposures that may occur and further minimize the risk of a threshold shift response as a result of the proposed survey.

Behavioral Responses

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, environmental conditions, and many other factors (Richardson *et al.* 1995). Responses also depend on whether an animal is less likely (habituated) or more likely (sensitized) to respond to sound exposure (Southall *et al.* 2007). Responses to anthropogenic sounds are highly variable. Meaningful interpretation of behavioral responses should not only consider the relative magnitude and severity of reactions but also the relevant acoustic, contextual variables (e.g. proximity, subject experience and motivation, duration, or recurrence of exposure), and ecological variables (Southall *et al.* 2007).

Marine mammals have not had the time and have not experienced the selective pressure necessary for them to have evolved a behavioral repertoire containing a set of potential responses to sounds produced by equipment employed during seismic surveys or human disturbance generally. Instead, marine animals invoke behaviors that are already in their repertoire in response to airgun pulses, other potential stressors associated with seismic surveys, or human disturbance generally. An extensive number of studies have established that these animals will invoke the same behavioral responses they would invoke when faced with predation and will make the same ecological considerations when they experience human disturbance that they make when they perceive they have some risk of predation (Lima and Dill 1990; Harrington and Veitch 1992; Lima 1998; Gill *et al.* 2001; Gill and Sutherland 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004a; Romero 2004; Bejder *et al.* 2009). Specifically, when animals are faced with a predator or predatory stimulus, they appear to consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Houston *et al.* 1993; Ydenberg and Dill 1986; Lima 1998; Lima and Bednekoff 1999; Gill *et al.* 2001; Bejder *et al.* 2009). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999; Rodriguez-Prieto *et al.* 2009).

The level of risk an animal perceives results from a combination of factors that include the perceived distance between an animal and a potential predator, whether the potential predator is approaching the animal or moving tangential to the animal, the number of times the potential predator changes its vector (or evidence that the potential predator might begin an approach), the speed of any approach, the availability of refugia, and the health or somatic condition of the animal, for example, along with factors related to natural predation risk (Papouchis *et al.* 2001; Frid and Dill 2002; Frid 2003). In response to a perceived threat, animals can experience physiological changes that prepare them for flight or fight responses or they can experience physiological changes with chronic exposure to stressors that have more serious consequences such as interruptions of essential behavioral or physiological events, alteration of an animal‘s time budget, or some combinations of these responses (Sapolsky *et al.* 2000; Frid and Dill 2002; Romero 2004; Walker *et al.* 2005).

The behavioral responses of animals to human disturbance have been documented to cause animals to abandon nesting and foraging sites (Bejder *et al*. 2009, Gill *et al*. 2001, Sutherland and Crockford 1993), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan *et al*. 1996; Giese 1996; Mullner *et al*. 2004), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002).

Based on the evidence available from empirical studies of animal responses to human disturbance, marine animals are likely to exhibit one of several behavioral responses upon being exposed to seismic surveys: (1) they may engage in horizontal or vertical avoidance behavior to avoid exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening; (2) they may engage in 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; (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, during the time they are vigilant, they are not engaged in other behavior; and (4) they may continue their pre-disturbance behavior and cope with the physiological consequences of continued.

If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a short distance, the impacts of the change are unlikely to be substantial to the individual. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals could be noteworthy. Data on short-term reactions (or lack of reactions) do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect marine mammal reproductive rate or distribution and habitat use in subsequent days or years.

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

BEHAVIORAL AVOIDANCE OF INITIAL EXPOSURE OR CONTINUED EXPOSURE (HORIZONTAL AND VERTICAL AVOIDANCE)

As used in this opinion, *behavioral avoidance* refers to when an animal attends to cues from a particular stimulus or stimuli that lead it to anticipate an adverse event, adverse experience, or adverse outcome. The animal then adjusts its spatial position relative to the source of the stimulus to avoid the adverse event, experience, or outcome. This response is rarely acute and usually would not result in fitness consequences.

Evasion occurs when an animal is already experiencing the adverse event, experience, or outcome. The animal then adjusts its spatial position relative to the source of the stimulus to avoid continued exposure. This response can be acute and can result in fitness consequences.

Since the early 1980s, scientists have conducted studies to determine the displacement distances and to document the behavioral disruption of bowhead whales caused by seismic surveys (see the summary in Richardson *et al.* 1995), but there is still no consensus on whether, how, or to what extent marine seismic survey activities negatively affect the whales (Moore *et al.* 2012).

Richardson *et al.* (1995) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good visibility, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997, 1998, 2000, 2001). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at times of airgun operation (Stone 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003). Baleen whales also altered course more often during periods of shooting and more were headed away from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003).

Richardson *et al.* (1995) and Richardson (1997, 1998) used controlled playback experiments to study the response of bowhead whales in Arctic Alaska. In their studies, bowhead whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB and seismic sources at estimated received levels of 110 to 132 dB. Richardson *et al.* (1995) concluded that some marine mammals would tolerate continuous sound at received levels above 120 dB re 1 μPa for a few hours. These authors concluded that most marine mammals would avoid exposures to received levels of continuous underwater noise greater than 140 dB when source frequencies were in the animal’s most sensitive hearing range.

Brownell (2004) reported the behavioral responses of western gray whales off the northeast coast of Sakhalin Island to sounds produced by seismic activities in that region. In 1997, the gray whales responded to seismic activities by changing their swimming speed and orientation, respiration rates, and distribution in waters around the seismic surveys. In 2001, seismic activities were conducted in a known feeding area of these whales and the whales left the feeding area and moved to areas farther south in the Sea of Okhotsk. They only returned to the feeding area several days after the seismic activities stopped. The potential fitness consequences of displacing these whales, especially mother-calf pairs and “skinny whales,” outside of their the normal feeding area is not known; however, gray whales, like other large whales, must gain enough energy during the summer foraging season to last them the entire year. Sounds or other stimuli that cause whales to abandon a foraging area for several days seems almost certain to disrupt their energetics and force them to make trade-offs like delaying their migration south, delaying reproduction, reducing growth, or migrating with reduced energy reserves (NMFS 2010b).

In 16 approach trials carried out in Exmouth Gulf, off Australia, McCauley *et al.* (2000a, b) reported that pods of humpback whales with resting females consistently avoided a single (20 in^3) operating airgun at an average range of 1.3 km. Standoff ranges were 1.22-4.4 km. McCauley *et al.* (2000a, b) also reported a single a startle response. As this information pertains to whales in general, however, these distances are similar to those observed by Richardson and Malme (1993) during vessel-disturbance experiments in the Canadian Beaufort Sea. McCauley *et al.* (2000a, b) used an algorithm to scale the noise from the single airgun to a larger array and calculated the mean airgun level at which they predicted whale avoidance could occur was 140 dB re 1 µPa (rms), the mean standoff range could be 143 dB re 1 µPa (rms), and the startle response could be at 112 dB re 1 µPa (rms) for groups of female humpback whales in these protected areas. The estimated noise levels at which a response were calculated to occur were considerably less than those published for gray and for bowhead whales. They were also less than those observed by McCauley *et al.* (2000a, b) in observations made from the seismic vessel operating outside of the resting habitats, where whales were migrating and not resting.

As Bejder *et al.* (2006 and 2009) argued, 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 (citing Beale and Monaghan 2004a, 2004b; Gill *et al.* 2001, Frid and Dill 2002, Lima and Dill 1990). Specifically, animals delay their decision to flee from predators and predatory stimuli that they detect, or until they decide that the benefits of fleeing 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 Dill 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 even greater distance, animals will almost always choose not to flee.

Based on a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, that had the most energy at frequencies below or above their hearing capacities appeared not to be noticed, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds.

From these observations, we would have to conclude that the distance between marine mammals and a source of sound, as well as the received level of the sound itself, will help determine whether individual animals are likely to respond to the sound and engage in avoidance behavior. At the limits of the range of audibility, endangered and threatened marine mammals are likely to ignore cues that they might otherwise detect. At some distance that is closer to the source, endangered or threatened marine mammals may be able to detect a sound produced by seismic source vessels, but they would not devote attentional resources to the sound (that is, they would filter it out as background noise or ignore it). For example, we would not expect endangered or threatened marine mammals exposed to seismic airgun pulses at received levels as high as 140 dB to devote attentional resources to that stimulus because those individuals are more likely to be focusing their attention on stimuli and environmental cues that are considerably closer, even if they were aware of the signal.[12]

Those animals that are closer to the source and not engaged in activities that would compete for their attentional resources (for example, migrating or foraging) might engage in low-level avoidance behavior (changing the direction or their movement to take them away from or tangential to the source of the disturbance) possibly accompanied by short-term vigilance behavior, but they are not likely to change their behavioral state (that is, animals that are foraging or migrating would continue to do so). For example, we would expect endangered or threatened marine mammals that find themselves between received levels of 140 and 150 dB to engage in low-level avoidance behavior or short-term vigilance behavior, but they are not likely to change their behavioral state as a result of that exposure.

At some distance that is closer still, these species are likely to engage in more active avoidance behavior followed by subsequent low-level avoidance behavior that does not bring them closer to the seismic activity. At the closest distances, we assume that endangered and threatened marine mammals would engage in vertical and horizontal avoidance behavior unless they have a compelling reason to remain in a location (for example, to feed). In some circumstances, this would involve abrupt vertical or horizontal movement accompanied by physiological stress responses. In the Chukchi and Beaufort Planning Areas, we would expect these kind of responses when received levels from seismic would be greater than 180 dB.[13] However, at these distances endangered or threatened marine mammals would be aware of a wide array of visual and acoustic cues associated with BOEM authorized vessels (including sound associated with a ship’s engines, the bow wake, etc.) and an animal’s decision to change its behavior might be a response to airgun operation, one of these other cues, or the entire suite of cues.

At least six circumstances might prevent an animal from escaping further exposure to low-frequency seismic and could produce any of one the following outcomes:

1. when swimming away (an attempted “escape”) brings marine mammals into a shallow coastal feature that causes them to strand;

2. they cannot swim away because the exposure occurred in a coastal feature that leaves marine mammals no “escape” route (for example, a coastal embayment or fjord that surrounds them with land on three sides, with the sound field preventing an “escape”);

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[12] When NMFS calculated the mean distances to different received levels for various airgun sources that were used in the past seismic operations in the Chukchi and Beaufort Seas from 90-day reports the mean distance to received level of 140dB varied between the Chukchi and Beaufort Sea locations. The mean distance for the Chukchi Sea to received level 140 dB was ~45 kilometers while the mean distance for the Beaufort Sea was ~30 kilometers.

[13] The distance at which received levels ≥180dB would occur will be dependent on the sound source and location characteristics. However, based on past seismic operations in the Beaufort Sea, we would anticipate this would occur between 0 and 1.7 kilometers from the source vessel.

3. they cannot swim away because the marine mammals are exposed to multiple sound fields in a coastal or oceanographic feature that act in concert to prevent their escape;

4. they cannot dive "below" the sound field while swimming away because of shallow depths;

5. to remain "below" the sound field, they must engage in a series of very deep dives with interrupted attempts to swim to the surface (which might lead to pathologies similar to those of decompression sickness);

6. any combination of these phenomena.

VIGILANCE

Once a stimulus has captured an animal's attention, the animal can respond by ignoring the stimulus, assuming a "watch and wait" posture, or treat the stimulus as a disturbance and respond accordingly, which includes scanning for the source of the stimulus or "vigilance" (Cowlishaw *et al.* 2004).

Vigilance is normally an adaptive behavior that helps animals determine the presence or absence of predators, assess their distance from conspecifics, or to attend cues from prey (Bednekoff and Lima 1998). Despite those benefits, vigilance has a cost of time: when animals focus their attention on specific environmental cues, it is not attending to other activities such a foraging. These costs have been documented best in foraging animals, where vigilance has been shown to substantially reduce feeding rates (Saino 1994, Beauchamp and Livoreil 1997, Fritz *et al.* 2002).

Animals will spend more time being vigilant, which translates to less time foraging or resting, when disturbance stimuli approach them more directly, remain at closer distances, have a greater group size (for example, multiple surface vessels), or when they co-occur with times that an animal perceives increased risk (for example, when they are giving birth or accompanied by a calf).

Several authors have established that long-term and intense disturbance stimuli can cause population declines by reducing the body condition of individuals that have been disturbed, followed by reduced reproductive success, reduced survival, or both (Madsen 1985; Daan *et al.* 1996). For example, Madsen (1985) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46% reproductive success compared with geese in disturbed habitat (being consistently scared off the fields on which they were foraging) which did not gain mass and has a 17% reproductive success.

The primary mechanism by which increased vigilance and disturbance appear to affect the fitness of individual animals is by disrupting an animal's time budget and, as a result, reducing the time they might spend foraging and resting (which increases an animal's activity rate and energy demand).

CONTINUED PRE-DISTURBANCE BEHAVIOR, HABITUATION, OR NO RESPONSE

Under some circumstances, some individual animals exposed to seismic transmissions and other acoustic stimuli associated with the oil and gas exploration will continue the behavioral activities they were engaged in prior to being exposed (Richardson *et al.* 1995). Pulsed sounds from airguns are often detectable in the water at distances of several kilometers, without necessarily eliciting behavioral responses. Numerous studies have shown that marine mammals at distances over a few kilometers from operating seismic vessels may show no apparent response (Richardson *et al.* 1995). That is often true even when pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to temporarily react behaviorally to airgun pulses under some conditions, at other times they have shown no overt reactions (Richardson *et al.* 1995).

Watkins (1986) reviewed data on the behavioral reactions of fin, humpback, right and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay. He concluded that underwater sound was the primary cause of behavioral reactions in these species of whales and that the whales responded behaviorally to acoustic stimuli within their respective hearing ranges. Watkins also noted that whales showed the strongest behavioral reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds.

Nevertheless, Watkins concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale’s range of hearing. Further, he noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of his period of study, Watkins (1986) concluded that fin and humpback whales had generally habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

Aicken *et al.* (2005) monitored the behavioral responses of marine mammals to a new low-frequency active sonar system that was being developed for use by the British Navy. During those trials, fin whales, sperm whales, Sowerby’s beaked whales, long-finned pilot whales (*Globicephala melas*), Atlantic white-sided dolphins, and common bottlenose dolphins were observed and their vocalizations were recorded. These monitoring studies detected no evidence of behavioral responses that the investigators could attribute to exposure to the low-frequency active sonar during these trials (some of the responses the investigators observed may have been to the vessels used for the monitoring).

There are several reasons why such animals might continue their pre-exposure activity:

1. RISK ALLOCATION. When animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Ydenberg and Dill 1986; Lima 1998; Lima and Bednekoff 1999; Gill *et al.* 2001; Bejder *et al.* 2009). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999, Rodriguez-Prieto *et al.* 2009). As a result, for animals that decide that the ecological cost of changing their behavior exceeds the benefits of continuing their behavior, we would expect them to continue their pre-existing behavior. For example, baleen whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, are more likely to continue foraging in the face of disturbance.

   This does not mean, however, that there are no costs involved with continuing pre-disturbance behavior in the face of predation or disturbance. We assume that individual animals that are exposed to sounds associated with seismic airgun operations will apply the economic model we discussed earlier (Ydenberg and Dill 1986). By extension, animals that continue their pre-disturbance behavior would have to cope with the costs of doing so, which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill 2002).

2. HABITUATION. When free-ranging animals do not appear to respond when presented with a stimulus, they are commonly said to have become habituated to the stimulus (Bejder *et al.* 2009, Rodriguez-Prieto *et al.* 2009, and the example cited earlier from Watkins 1986). Habituation has been given several definitions, but we apply the definition developed by Thompson and Spencer (1966) and Groves and Thompson (1970), which are considered classic treatments of the subject, as modified by Rankin *et al.* (2009): *an incremental reduction in an animal's behavioral response to a stimulus that results from repeated stimulation to that stimulus and that does not involve sensory adaptation, sensory fatigue, or motor fatigue*. The value of this definition, when compared with other definitions (for example, Bejder *et al.* 2009 citing Thorpe 1963), is that it would lead us to establish that an animal did not experience reduced sensory sensitivity to a stimulus (which would be accompanied by threshold shifts, for example) before we would conclude that the animal had become habituated to the stimulus. Habituation has been traditionally distinguished from sensory adaptation or motor fatigue using dishabituation (presentation of a different stimulus that results in an increase of the decremented response to the original stimulus), by demonstrating stimulus specificity (the response still occurs to other stimuli), or by demonstrating frequency dependent spontaneous recovery (more rapid recovery following stimulation delivered at a high-frequency than following stimulation delivered at a low frequency).

   Animals are more likely to habituate (and habituate more rapidly) to a stimulus, the less intense the stimulus (Rankin *et al.* 2009). Conversely, numerous studies suggest that animals are less likely to habituate (that is, exhibit no significant decline in their responses) as the intensity of the stimulus increases (Rankin *et al.* 2009). Further, after animals have become habituated to a stimulus, their responses to that stimulus recover (a process that is called "spontaneous recovery") over time, although habituation becomes more rapid and pronounced after a series of habituation-recovery events (a process that is called "potentiation of habituation").

3. DECREASED SENSITIVITY. The individuals that might be exposed may have lowered sensitivity to the stimulus. This might occur because the animals are naïve to the potential risks (which would be more common among juveniles than adults) or they have limited sensory sensitivity by physiological constitution or constitutional endowment.

The results reported by Watkins (1986) and Aicken *et al.* (2005) could be explained either by concluding that the marine mammals had habituated to the sounds by concluding that the animals had made a decision to continue their pre-disturbance behavior despite the potential risks represented by the sounds (that is, the animals tolerated the disturbance). The results reported by Watkins (1986) are better explained using risk allocation than habituation because he associated the strongest, negative reactions (avoidance, interruptions in vocalizations, etc.) with sounds that were either unexpected, too loud, suddenly louder or different, were perceived as being associated with a potential threat (such as an approaching ship on a collision course), or were from distant human activities despite having considerable energy at frequencies well within the whale's range of hearing (whales would be less likely to respond to cues they would associate with a predator if their distance from the predator preserved their ability to escape a potential attack).

Because it would be difficult to distinguish between animals that continue their pre-disturbance behavior when exposed to seismic because of a risk-decision and animals that habituate to disturbance, we do not assume that endangered or threatened marine mammals that do not appear to respond to seismic or other have become habituated to those sounds.

Impaired Communication

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; Krakauer *et al.* 2009), assess other members of their species (Parker 1974; Owings *et al.* 2002), evade predators (Greig-Smith 1980), and defend resources (Zuberbuehler *et al.* 1997). Human activities that impair an animal's ability to communicate effectively might have significant effects on the animal.

Communication usually involves individual animals that are producing a vocalization or visual or chemical display for other individuals. Masking, which we discuss separately (below), affects animals that are trying to receive acoustic cues in their environment, including cues from other members of the animals' species or social group. However, anthropogenic noise presents separate challenges for animals that are vocalizing. This subsection addresses the probable responses of individual animals whose attempts to communicate are affected by impulsive noise sources. When they vocalize, animals are aware of environmental conditions that affect the active space of their vocalizations, which is the maximum area within which their vocalizations can be detected before it drops to the level of ambient noise (Lohr *et al.* 2003; Brumm 2004). Animals are also aware of environmental conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brumm 2004; Patricelli and Blickley 2006).

Most animals that vocalize have evolved with an ability to make vocal 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 (Brumm 2004; Patricelli and Blickley 2006). Vocalizing animals will make one or more of the following adjustments to preserve the active space and recognizability of their vocalizations:

1. Adjust the amplitude of vocalizations. Animals responding in this way increase the amplitude or pitch of their calls and songs by placing more energy into the entire vocalization or, more commonly, shifting the energy into specific portions of the call or song.

This response is called the Lombard reflex or Lombard effect and represents a short-term adaptation to vocalizations in which a signaler increases the amplitude of its vocalizations in response to an increase in the amplitude of background noise (Lombard 1911). This phenomenon has been studied extensively in humans, who raise the amplitude of their voices while talking or singing in the face of high, background levels of sound (Lombard 1911).

Although this type of response also has not been studied extensively in marine animals, Holt *et al*. (2007) reported that endangered southern resident killer whales (*Orcinus orca*) in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise.

2. Adjust the frequency structure of vocalizations. Animals responding in this way adjust the frequency structure of their calls and songs by increasing the minimum frequency of their vocalizations while maximum frequencies remain the same. This reduces the frequency range of their vocalizations and reduces the amount of overlap between their vocalizations and background noise.

3. Adjust temporal structure of vocalizations. Animals responding this way adjust the temporal structure of their vocalizations by changing the timing of modulations, notes, and syllables within vocalizations or increasing the duration of their calls or songs.

Miller et al. (2000) recorded the vocal behavior of singing humpback whales continuously for several hours using a towed, calibrated hydrophone array. They recorded at least two songs in which the whales were exposed to low-frequency active sonar transmissions (42 second signals at 6 minute intervals; sonar was broadcast so that none of the singing whales were exposed at received levels greater than 150 dB re 1μPa). They followed sixteen singing humpback whales during 18 playbacks. In nine follows, whales sang continuously throughout the playback; in four follows, the whale stopped singing when he joined other whales (a normal social interaction); and in five follows, the singer stopped singing, presumably in response to the playback. Of the six whales whose songs they analyzed in detail, songs were 29 percent longer, on average, during the playbacks. Song duration returned to normal after exposure, suggesting that the whale’s response to the playback was temporary.

Foote et al. (2004) compared recordings of endangered southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). They suggested that the amount of boat noise may have reached a threshold above which the killer whales needed to increase the duration of their vocalization to avoid masking by the boat noise.

4. Adjust the temporal delivery of vocalizations. Animals responding in this way change when they vocalize or change the rate at which they repeat calls or songs.

Many animals will combine several of these strategies to compensate for high levels of background noise. For example, Brumm et al. (2004) reported that common marmosets (*Callithrix jacchus*) increased the median amplitude of the twitter calls as well as the duration of the calls in response to increased background noise.

Although this form of vocal adjustment has not been studied extensively in marine animals, Dahlheim (1987) studied the effects of man-made noise, including ship, outboard engine and oil drilling sounds, on gray whale calling and surface behaviors in the San Ignacio Lagoon, Baja, California. She reported statistically significant increases in the calling rates of gray whales and changes in calling structure (as well as swimming direction and surface behaviors) after exposure to increased noise levels during playback experiments. Although whale responses varied with the type and presentation of the noise source, she reported that gray whales generally increased their calling rates, the level of calls received, the number of frequency-modulated calls, the number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

Parks *et al.* (2007b) reported that surface active groups of North Atlantic right whales would adopt this strategy as the level of ambient noise increased. As ambient noise levels increased from low to high, the minimum frequency of right whale scream calls increased from 381.4 Hz (± 16.50), at low levels of ambient noise, to 390.3 Hz (± 15.14) at medium noise levels, to 422.4 Hz (± 15.55) at high noise levels. Surface active groups of North Atlantic right whales would also increase the duration and the inter-call interval of their vocalizations as the level of ambient noise increased.

5. Termination of vocalization sequences.

Two studies reported that some Mysticete whales stopped vocalizing when exposed to active sonar. Miller *et al*. (2000) reported that during 5 of 18 playbacks of low-frequency active sonar transmissions, male humpback whales stopped singing, presumably in response to the sonar playbacks. The proportion of humpback whales that stopped vocalizing in their study was 0.2778 (95% CI: 0.1250 to 0.5087). Melcón *et al*. (2012) reported that during 110 of the 395 d-calls 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. The proportion of blue whales that stopped vocalizing during their study was 0.2785 (95%CI: 0.2366 to 0.3247). Combining the results of these two studies would lead us to expect 0.2784 (95%CI: 0.1800 to 0.4040) of Mysticete vocalizations to stop when vocalizations coincide with active sonar transmissions.

During the period when Ocean Acoustic Waveguide Remote Sensing (OAWRS) transmission was recorded, there was a marked decrease in the occurrence of humpback whale song that was not evident in the control years (Risch *et al.* 2012). The received levels of OAWRS pulses approximately 200 km from the source array were 5–22 dB above ambient noise levels. In response to OAWRS FM pulses, with relatively low signal excess, male humpback whales either moved out of the study area or sang less. Several known, sexually mature males (ages 6–28 years) were photographically identified in Stellwagen Bank National Marine Sanctuary during the OAWRS experiment. While only two known males were identified prior to the experiment, four individuals were present in the area in the ''during'' period (J. Robbins, pers. comm.). This suggests that individuals did not leave the area but instead ceased singing (Risch *et al.* 2012). Risch *et al.* (2012) data provide clear evidence for the reduction of humpback whale song in response to the reception of OAWRS pulses. They interpreted this decrease as a change in singing behavior by individual whales.

FITNESS CONSEQUENCES OF VOCAL ADJUSTMENTS

Although the fitness consequences of these vocal adjustments remain unknown, like most other trade-offs animals must make, some of these strategies probably come at a cost (Patricelli and Blickley 2006).

Patricelli and Blickley (2006) argued that females of many species use the songs and calls of males to determine whether a male is an appropriate potential mate (that is, they must recognize the singer as a member of their species); if males must adjust the frequency or temporal features of their vocalizations to avoid masking by noise, they may no longer be recognized by conspecific females (Slabbekoorn and Peet 2003b; Brumm 2004; Wood and Yezerinac 2006). Although this line of reasoning was developed for bird species, the same line of reasoning should apply to marine mammals.

If an animal fails to make vocal adjustments in presence of masking noise, that failure might cause the animal to experience reduced reproductive success or longevity because it fails to communicate effectively with other members of its species or social group, including potential mates.

MASKING

Masking occurs when biologically meaningful sounds (e.g. communication, prey) are obscured by ambient or anthropogenic noise (Richardson *et al.* 1995; Clark *et al.* 2009; Jensen *et al.* 2009). It degrades marine-mammal acoustic habitat much like fog or smoke obscures important visual signals for terrestrial animals (Slabbekoorn *et al.* 2010). Introduced underwater sound will, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used by the marine mammal, and if the anthropogenic sound is present for a significant period of time (Richardson *et al.* 1995). Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations (Box BR2 of Figure 7) illustrates the potential responses of animals to acoustic masking).

Masking can occur (1) when competing sounds reduce or eliminate the salience of the acoustic signal or cue on which the animal is trying to focus or (2) when the spectral characteristics of competing sounds reduce or eliminate the coherence of acoustic signals on which the animal is trying to focus. In the former, the masking noise might prevent a focal signal from being salient to an animal; in the latter, the masking noise might prevent a focal signal from being coherent to an animal. Masking, therefore, is a phenomenon that affects animals that are trying to receive acoustic information about their environment, including sounds from other members of their species, predators, prey, and sounds that allow them to orient in their environment. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations.

Marine mammals are highly dependent on sound, and their ability to recognize sound signals amid other noise is important in communication, predator and prey detection, and, in the case of toothed whales, echolocation. Even in the absence of manmade sounds, the sea is usually noisy. Background ambient noise often interferes with or masks the ability of an animal to detect a sound signal even when that signal is above its absolute hearing threshold. Natural ambient noise includes contributions from wind, waves, precipitation, other animals, and (at frequencies above 30 kHz) thermal noise resulting from molecular agitation (Richardson *et al.* 1995). Background noise also can include sounds from human activities. Masking of natural sounds can result when human activities produce high levels of background noise. Conversely, if the background level of underwater noise is high (e.g. on a day with strong wind and high waves), an anthropogenic noise source will not be detectable as far away as would be possible under quieter conditions and will itself be masked.

Although some degree of masking is inevitable when high levels of manmade broadband sounds are introduced into the sea, marine mammals have evolved systems and behavior that function to reduce the impacts of masking. Structured signals, such as the echolocation click sequences of small toothed whales, may be readily detected even in the presence of strong background noise because their frequency content and temporal features usually differ strongly from those of the background noise (Au and Moore 1988, 1990). The components of background noise that are similar in frequency to the sound signal in question primarily determine the degree of masking of that signal.

Redundancy and context can also facilitate detection of weak signals. These phenomena may help marine mammals detect weak sounds in the presence of natural or manmade noise. Most masking studies in marine mammals present the test signal and the masking noise from the same direction. 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). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these noises by improving the effective signal-to-noise ratio.

To a degree, marine mammals may be able to compensate for masking, either by increasing the amplitude of their calls or by altering other signal characteristics (see Parks *et al.* 2010 and the references therein). A few marine mammal species are known to increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage *et al.* 1993, 1999; Terhune 1999; Foote *et al.* 2004; Di Lorio 2005; Parks *et al.* 2007a, 2009; Holt *et al.* 2009).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. Directional hearing has been demonstrated at frequencies as low as 0.5 to 2 kHz in several marine mammals, including killer whales (Richardson *et al.* 1995). This ability may be useful in reducing masking at these frequencies. In summary, high levels of noise generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies.

Masking of marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data of relevance (BOEM 2011a). Gordon *et al.* (2003) suggested that phocids may be susceptible to the masking of biologically important signals by low frequency sounds, such as those from seismic surveys, and while brief, small scale masking episodes might have few long term consequences. Some whales are known to continue calling in the presence of seismic pulses; their calls can be heard between seismic pulses (Richardson *et al.* 1986, McDonald *et al.* 1995, Greene *et al.* 1999, Nieukirk *et al.* 2004). The greatest limiting factor in estimating impacts of masking is a lack of understanding of the spatial and temporal scales over which marine mammals actually communicate, although some estimates of distance are possible using signal and receiver characteristics (BOEM 2011a). Estimates of communication masking, however, depend on assumptions for which data are currently inadequate (Clark *et al.* 2009).

Cumulative Effects of Anthropogenic Underwater Sound on Marine Mammals is a project currently underway between BP America, North Slope Bureau (NSB), and the University of California. The project will center on bowhead whales in the Beaufort Sea and will focus on summarizing and synthesizing literature on the effects of anthropogenic sound on marine mammals, developing a method of approach for such effects, and suggesting future research needs. This effort may help better understand masking and the effects of masking on marine mammals (NMFS 2013b).

Allostasis

The allostatis load is the wear and tear on the body which grows over time when the individual is exposed to repeated or chronic stress (McEwen and Wingfield 2003). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune response.

In the case of many stressors, an animal's first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor (Box S1 of Figure 7). An animal's second line of defense to stressors involves the autonomic nervous system and the classical "fight or flight" response. These responses have a relatively short duration and may or may not have significant long-term effect on an animal's welfare (NMFS 2010b).

An animal's third line of defense to stressors involves its neuroendocrine or sympathetic nervous systems. Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones.

The primary distinction between *stress* (which is adaptive and does not normally place an animal at risk) and *distress* is the biotic cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose a risk to the animal's welfare. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions which impair those functions that experience the diversion.

We assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC 2003). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses (Moberg 2000), we also assume that stress responses are likely to persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS.

Stranding Events

Causes of strandings and mortality related to sound could include: 1) swimming into shallow water to avoid sound; 2) a change in dive behavior; 3) a physiological change; and 4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues.   Some of these are unlikely to apply to airgun impulse sounds. There are increasing indications that gas-bubble disease ("the bends") could be a mechanism for the strandings and mortality of some deep-diving whales exposed to naval mid-frequency sonar.   Evidence is still circumstantial and, in the Arctic, there are no data showing strandings or mortalities as a result of exposure to seismic surveys (Cox *et al.* 2006, Southall *et al.* 2007).

Stranding events of baleen whales are very rare. Two minke whales (*Balaenoptera acutirostra*) stranded during the mass stranding event in the Bahamas in 2000 and is noteworthy because it the only mass stranding of baleen whales that has coincided with the Navy's use of mid-frequency active sonar. In addition, there have been suggestions to link seismic surveys and strandings of humpback whales in Brazil (Engel *et al.* 2004), but these were not well founded (IAGC 2004, IWC 2007b).

2.4.3.2 Potential Responses to Vessel Traffic

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

As we discussed previously, based on the suite of studies of cetacean behavior to vessel approaches (Au and Green 1990, Au and Perryman 1982, Bain *et al.* 2006, Bauer 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, David 2002, Erbé 2002b, Félix 2001, Magalhães *et al.* 2002, Goodwin and Cotton 2004, Hewitt 1985, Lusseau 2003, 2006; Lusseau and Bejder 2007, Ng and Leung 2003, Nowacek *et al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *et al.* 1998), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *number of vessels*;
2. *the distance between vessel and marine mammals*;
3. *the vessel's speed and vector*;
4. *the predictability of the vessel's path*;
5. *noise associated with the vessel*;
6. *the type of vessel*; and
7. *the behavioral state of the marine mammals*.

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

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

Because of the number of vessels involved in oil and gas leasing and exploration activities, their speed, their use of course changes for surveys, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat BOEM authorized vessels as potential stressors. Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (*see* Blumstein 2003 and Nonacs and Dill 1990):

a. ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist;

b. alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately;

c. change their behavior proportional to increases in their perceived risk of predation which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity, or

d. take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

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

2.4.3.3 Potential Responses to Other Acoustic Sources

Behavioral reactions of free-ranging marine mammals to echosounders, and other sound sources appear to vary by species and circumstance (NMFS 2012b). Observed reactions have included silencing and dispersal by sperm whales (Watkins *et al.* 1985) and increased vocalizations and no dispersal by pilot whales (Rendell and Gordon 1999). When a 38 kHz echosounder and a 150 kHz acoustic Doppler current profiler were transmitting during studies in the Eastern Tropical Pacific, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis 2005). Very few data are available on the reactions of pinnipeds to echosounder sounds at frequencies similar to those used during seismic operations. Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson *et al.* 1995).

Michel *et al.* (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with shipping. At lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background.

2.4.3.4 Probable Responses to Proposed Action

Thus far, this opinion has identified the endangered and threatened species that might be exposed to active seismic and other noise sources, and vessel traffic associated with the oil and gas exploration activities PR1 proposes to authorize in the Chukchi Sea and the potential responses of those species given that exposure.

Based on the evidence available, the North Pacific right whale, Northeast Pacific fin whale, and Steller sea lion are not likely to be exposed to the proposed 3D seismic activities in the Beaufort Sea because these species only occur in the Chukchi Sea (fin whale) and Bering Sea (fin whale, right whale, and Steller sea lion) portion of the action area, far from the exposure zones of the seismic operations. However, these species were analyzed for vessel traffic exposure, and we concluded (in Sections 2.4.2.2 (vessel noise) 2.4.2.3 (vessel strike)) that North Pacific right whales are not likely to be exposed to vessel traffic associated with the proposed action because of the low density of the species and the short duration of vessel traffic in the area, which reduced their probability of being exposed to vessel traffic associated with PR1 proposed permitted activities to levels that we would consider 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 North Pacific right whales are not likely to be directly or indirectly exposed to vessel traffic that would occur in the Bering Sea portion of the action area, 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. We do not consider this species further in this section of our opinion. Fin whales and Steller sea lions, on the other hand, may be exposed to vessel traffic such as noise disturbance, but are not expected to be struck. We will analyze their probable response to vessel traffic below.

The narratives that follow discuss the probable responses of those species that are anticipated to be exposed to the stressor(s) associated with the exploration activities PR1 proposes to authorize.

2.4.3.4.1 Probable Responses to Exposure to Active Seismic

Of all of the stressors we consider in this opinion, the potential responses of marine mammals upon being exposed to low-frequency seismic 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 is very limited. The narratives that follow summarize the best scientific and commercial data on the responses of species to seismic operations or other acoustic stimuli.

Bowhead Whales

NMFS estimated between 146 and 177 instances where bowhead whales might be exposed to seismic activities in Federal and international waters during the open-water season per year (see Section 2.4.2.1., *Exposure to Active Seismic*, Table 10).

These instances of exposure are likely to be overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures being in place, and they are assume all of the tracklines will be shot during the season (see Section 2.4.2.1 for full list). In addition, SAE will begin seismic surveys in the more offshore areas first with the intention of completing seismic surveys that overlap with the bowhead whale migration corridor (waters >15 meters deep) prior to the arrival of the fall bowhead migration (SAE 2013a). It is anticipated that only 12% of the seismic survey area will overlap with the bowhead migration corridor (SAE 2013a). For these reasons we will use the lower range of the anticipated instances of exposure for our effects analysis.

Given the large size of bowhead whales, and the 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 TTS or PTS. However, despite observer effort to mitigate exposure to sounds ≥180 dB re 1 μPa rms, some cetaceans may enter within the exclusion radii. In the Chukchi Sea in 2006 and 2008, 13 cetaceans were sighted within the ≥180 dB re 1 μPa rms radius and exposed to noise levels above that range before appropriate mitigation measures could be implemented (Haley *et al.* 2010).[14] The majority of cetaceans exhibited no reaction to vessels in 2006-2008 regardless of received sound levels (~96% of sightings). An increase in speed and splash were the next commonly observed reactions (Haley *et al.* 2010).

As discussed in the *Status of the Species* section, we have no data on bowhead whale hearing so we assume that bowhead whale vocalizations are partially representative of their hearing sensitivities. 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). Vocalization bandwidths vary. Tonal FM modulated vocalizations have a bandwidth of 25 to 1200 Hz with the dominant range

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

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, Würsig and Clark 1993; Cummings and Holliday, 1987 in Erbe 2002a). As previously mentioned, Cumming and Holliday (1987) calculated source level measures for bowhead whales songs to be between 158 and 189 dB. 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 this species.

Seismic activity in the Beaufort Sea would likely impact bowhead whales, although the level of disturbance will depend 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.

Observed responses of bowhead whales to seismic noise depend on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a). 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, 1995, Ljungblad *et al.* 1988, 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).

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 (Shell 2013c). 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).

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

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

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 *et al.* 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.

Avoidance is one of many behavioral responses a feeding bowhead 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 continue pre-disturbance behavior and cope 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 (Zuberbuehler *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 vocal 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 *et al*. 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, Melcón *et al.* 2012). Melcón *et al*. (2012) reported that during 110 of the 395 d-calls (associated with foraging behavior) they recorded during mid-frequency active sonar transmissions, blue whales stopped vocalizing at received levels ranging from 85 to 145 dB, presumably in response to the sonar transmissions. These d-calls are believed to attract other individuals to feeding grounds or maintain cohesion within foraging groups (Oleson, Wiggins, and Hildebrand 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; Melcón *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 *et al.* 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).

Based on this information, we would not anticipate migrating bowhead to devote attentional resources 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 attentional resources 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 might be exposed to received levels between 160 and 190 dB during seismic surveys for SAE's open water 2013 season, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid seismic operations, change their respiration rates, increase dive times, or reduce feeding behavior, 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; Melcón *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.

Some bowhead whales may be less likely to engage in these responses because they are feeding. While foraging they are less likely to devote attentional resources to the seismic activities being conducted. The bowhead whales that are likely to be exposed would have had prior experience with similar seismic stressors resulting from their exposure during previous years; that experience will make some bowhead whales more likely to avoid the seismic activities PR1 is proposing to authorize while other whales would be less likely to avoid those activities. Some bowhead 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 (ex: if whales are attempting to avoid seismic operations being conducted by SAE and encounter seismic operations being conducted by Shell).

Most observed disturbance reactions appear to be short-term, yet short-term reactions to airgun noise are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use over periods of days or years.

Humpback Whales

We estimated a total of 2 instances (from Federal and international waters) where humpback whales might be exposed to SAE's seismic activities in the Chukchi Sea during the open-water season, (see Section 2.4.2.1., *Exposure to Active Seismic*, Table 10).

These instances of exposure are likely to be overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures being in place, and they are assume all of the tracklines will be shot during the season (see Section 2.4.2.1 for full list). In addition, very few humpback whales are expected to occur within the SAE survey area. Given the large size of humpback whales, and the pronounced vertical blow, it is likely that PSOs would be able to detect humpback whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of seismic sound, the short duration and intermittent exposure to seismic airgun pulses, and the relatively small size of the airgun array, reduces the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions (reproduction or survival) or cause TTS or PTS. However, despite observer effort to mitigate exposure to sounds ≥180 dB re 1 μPa rms, some cetaceans may enter within the exclusion radii. In the Chukchi Sea in 2006 to 2007,[15] 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).[16] The majority of cetaceans exhibited no reaction to vessels in 2006-2008 regardless of received sound levels (~96% of sightings). An increase in speed and splash were the next commonly observed reactions (Haley *et al.* 2010).

As discussed in the *Status of the Species* section, we have no data on humpback whale hearing so we assume that humpback whale vocalizations are partially representative of their hearing sensitivities. Humpback whales produce a wide variety of sounds. Those vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971, 1995; Clark and Fristrup 1997; Rivers 1997). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten 1997). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction.

During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970, Thompson *et al.* 1986, Winn *et al.* 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson *et al.* 1979). The songs

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[15] There were no cetaceans sighted within the ≥180 dB re 1 μPa rms radius in 2008 (Haley *et al.* 2010).

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

appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Tyack 1981; Tyack and Whitehead 1983; Silber 1986).

Sounds that investigators associate with aggressive behavior in male humpback whales are very different from songs; they extend from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Tyack 1983, Silber 1986). These sounds appear to have an effective range of up to 9 kilometers (Tyack and Whitehead 1983).

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

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

1. Complex songs with components ranging from at least 20 Hz–5 kHz with estimated source levels from 144– 174 dB; these are mostly sung by males on the breeding grounds (Winn *et al.* 1970; Thompson *et al.* 1979; Richardson *et al.* 1995; Frazer and Mercado 2000; Au *et al*. 2000, 2006);
2. Social sounds in the breeding areas that extend from 50Hz to more than 10 kHz with most energy below 3kHz (Tyack 1983; Tyack and Whitehead 1983, Richardson *et al.* 1995); and
3. Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels from 175-192 dB (D'Vincent *et al.* 1985; Thompson *et al.* 1986; Richardson *et al.* 1995; Sharpe and Dill 1997).

Houser *et al.* (2001) produced a mathematical model of a humpback whale's hearing sensitivity based on the anatomy of the whale's ear. Based on that model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7kHz to 10kHz, with a maximum sensitivity between 2 and 6kHz, and good sensitivity between 700 Hz-10kHz (Houser *et al.* 2001). More recently, Au *et al.* (2006) conducted field investigations of humpback whale songs which led these investigators to conclude that humpback whales have an upper frequency limit reaching as high as 24 kHz.

Based on this information, it is reasonable to assume that the low-frequency seismic (10-120 Hz) PR1 proposes to authorize during oil and gas exploration activities in the action area are within the hearing and vocalization ranges of humpback whales.

There is limited information on how humpback whales are likely to respond upon being exposed to low-frequency seismic. Malme *et al.* (1985) concluded that some humpbacks seemed startled when the airgun was first turned on at ranged up to 3.2 km, but these responses did not persist. Sound levels received by these whales were 150-169 dB re 1µ Pa. Malme *et al.* (1985) concluded that subtle effects may have occurred, but that there was no clear evidence of avoidance at exposure levels up to 172 dB 1µ Pa effective pulse pressure level. Weir (2008) showed no localized avoidance of active airguns by humpback whales and higher encounter rates. However, increased encounter rates during active seismic surveying might also have arisen from animals spending more time near the surface to avoid seismic exposure[17] (thereby increasing their detection).

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

In 9 of the 16 trials (McCauley *et al.* 2000b), mostly single, large mature humpbacks approached the operating airgun within 100-400m to investigate before swimming off. These whales would have received maximum air gun signals at 100m of 179 dB re 1 μPa rms (or 195 dB re 1 μPa peak–peak). This level is equivalent to the highest peak-peak source level (level at one meter) of song components measured in the 1994 humpback whale song in Hervey Bay by McCauley *et al.* (1996), or as given by Thompson *et al.* (1986) for humpback whale sounds in Alaska, of 192 dB re 1μPa peak-peak at one meter. The underwater signals produced by humpback whale breaching were audibly similar to air gun signals. McCauley *et al.* (2000b) speculate that given the similarities between airgun and breaching signals, male humpback whales may identify airgun signals as a "competitor." Humpback whales on the breeding grounds did not stop singing in response to underwater explosions (Payne and McVay 1971). Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150dB re 1μ Pa/Hz at 350Hz (Lien *et al.* 1993, Todd *et al.*1996). However, at least two individuals were probably killed by the high-intensity, impulse blasts and had extensive mechanical injuries in their ears (Ketten *et al.* 1993, Todd *et al.* 1996). Frankel and Clark (1998) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60 - 90 Hz sounds with a received level of up to 190 dB. Although these studies demonstrated that humpback whales may exhibit short-term behavioral reactions to playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

Based on this information, we would not anticipate that humpback whales would devote attentional resources to a seismic stimulus beyond the 140 dB isopleth. We would not anticipate startle responses with ramp-up procedures in place. Females and females with calves may avoid sound sources ≥ 140 dB. However, we would not anticipate the majority of individuals to show low-level avoidance until noise levels are ≥ 150 dB.

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[17] The received level of low-frequency underwater sound from an underwater source is generally lower by 1-7 dB near the surface (depth of 3 m) than at deeper (greater than 9 m) depths (Greene and Moore 1995, BOEM 2011a).

Of the humpback whales that might be exposed to received levels between 160 and 169 dB, some are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid seismic operations, change their respiration rates, increase dive times, reduce feeding behavior, alter vocalizations, or alter social interactions (Richardson *et al.* 1995; Gordon *et al*. 2003; Clark and Gagnon 2006; Castellote *et al.* 2012; Nieukirk *et al.* 2012). We assume that these responses are more likely to occur when humpback whales are aware of multiple vessels in their surrounding area.

Most observed disturbance reactions appear to be short-term, yet short-term reactions to airgun noise are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use over periods of days or years.

Ringed Seals

We estimated a total of 3,576 possible instances where ringed seals (during summer and fall season) might be exposed to seismic activities during the SAE's 2013 open water operations (see Section 2.4.2.1., *Exposure to Active Seismic*, Table 10). We assume these instances of exposure are overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures being in place, and assume all of the tracklines will be shot during the season (see Section 2.4.2.1 for full list).

While a single individual may be exposed multiple times over the course of a year, 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 seals traveling across a broad area may encounter more than one exploration activity in a season and may therefore be disturbed repeatedly by the presence of vessels or seismic survey sound or both. If exploration activities are more concentrated near the pack ice edges where seals are more common, the chances are greater that more seals would experience multiple disturbances in a season than if exploration activities were clustered away from the ice. 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 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 auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall *et al.* 2007). The airgun sound sources being proposed for this project are anticipated to be between 10 Hz to 120 Hz, and should be within the auditory bandwidth for the ringed seal.

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 (Stirling 1973, Cummings *et al.* 1984, as cited in 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.* 1984). Ringed seals may produce sounds at higher frequencies, given their most sensitive band of hearing extends up to 45kHz (Terhune and Ronald 1975) and most equipment used in studies is unsuitable for frequencies >15 kHz (Richardson *et al.* 1995). Ringed seals are known to vocalize at sources levels of up to 130 dB (Stirling 1973; Cumming *et al.* 1984; Richardson *et al.* 1995).

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). 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).[18] The results suggested 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).

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 2013b).

During the open water season (July through October) when the proposed activities would occur (for about 35 days), ringed seals are anticipated to be making short and long distance foraging trips (Smith *et al.* 1973, 1976; Smith and Stirling 1978; Teilmann *et al.* 1999; Gjertz *et al.* 2000; Harwood and Smith 2003) across the Chukchi and Beaufort Seas. Therefore, there is potential for exposure to seismic sources during this time period.

While the potential instances of exposure derived from ringed seal density multiplied by the

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[18] 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).

potential ensonified area associated with 3D seismic surveys estimate a high number of exposures at received levels that are likely to cause temporary losses in hearing sensitivity, these outcomes do not seem likely given the tendency of pinnipeds such as ringed seals to raise their heads above water, or haulout to avoid exposure to sounds fields, as well as mitigation measures being in place. 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. Even if we accept these estimates at face value, we still cannot assess the potential consequences of any losses in hearing sensitivity because the estimates provide no information about the magnitude of losses in hearing sensitivity (a 3 dB loss in sensitivity versus a 10 dB loss in sensitivity), the duration of the impairment (for example, whether the "temporary" loss in hearing sensitivity persists for minutes, hours, days, or weeks), or the frequency range affected by the loss (that is, what environmental cues might the animal not detect given the loss in hearing sensitivity). Without this information, it would be difficult to conclude that exposure to seismic had any consequence for ringed seals that might be clinically important.

Based on this information, we would not expect ringed seals that find themselves more than 3 kilometers from the seismic sound source to devote attentional resources to that stimulus, even though received levels might be as high as 160 dB. Similarly, we would not expect ringed seals that find themselves more than 1 kilometer 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 seals that might occur within 0.3 kilometers of sounds produced by equipment employed during seismic surveys are likely to change their behavioral state to avoid slight TTS, although this avoidance is anticipated to be localized.

Bearded Seals

We estimated a total of 179 possible instances of exposure to bearded seals (in Federal and international waters) as a result of seismic activities during SAE's 2013 open water operations (see Section 2.4.2.1., *Exposure to Active Seismic*, Table 10). These instances of exposure are likely to be overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures being in place, and assume all of the tracklines will be shot during the season (see Section 2.4.2.1 for full list).

While a single individual may be exposed multiple times over the course of a year, 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.

Bearded seals traveling across a broad area may encounter more than one exploration activity in a season and may therefore be disturbed repeatedly by the presence of vessels or seismic survey sound or both. If exploration activities are more concentrated near the pack ice edges where seals are more common, the chances are greater that more seals would experience multiple disturbances in a season than if exploration activities were clustered away from the ice. 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.

We assume that bearded seal vocalizations are partially representative of their hearing sensitivities (75 Hz-75 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of seismic airgun noise (10-120 Hz).[19]

All ice-breeding pinniped species are known to produce underwater vocalizations (reviewed by Richardson *et al.* 1995, Van Opzeeland *et al.* 2008). 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, 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 auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall *et al.* 2007). 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-3kHz) 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.*1969, Buldelsky 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.

Bearded seals appear to vocalize as a part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sound in water. This is important because most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003).

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). Most of the information available is on ringed seals, but we would anticipate that bearded seals behave in a similar manner to ringed seals during seismic operations. 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

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[19] A more in-depth description on bearded seal vocalizations is presented in section 2.2.3.6 of this opinion.

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).[20] The results suggested that seals tended to avoid the zone closest to the boat (<150m) (or noise levels greater than 190 dB). 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.

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 2013b).

During the open water season (July through October) when the proposed activities would occur (for up to 28 days), 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). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007; Frost *et al.* 2008; Cameron and Boveng 2009). 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 2011a). 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 bearded seal density multiplied by the potential ensonified area associated with 3D seismic surveys estimate a high number of exposures at received levels that are likely to cause temporary losses in hearing sensitivity, these outcomes do not seem likely given the tendency of pinnipeds such as bearded seals to raise their heads above water, as well as mitigation measures being in place. 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. Even if we accept these estimates at face value, we still cannot assess the potential consequences of any losses in hearing sensitivity because the estimates provide no information about the magnitude of losses in hearing sensitivity (a 3 dB loss in sensitivity versus a 10 dB loss in sensitivity), the duration of the impairment (for example, whether the “temporary” loss in hearing sensitivity persists for minutes, hours, days, or weeks), or the frequency range affected by the loss (that is, what environmental cues might the animal not detect given the loss in hearing sensitivity). Without

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[20] 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).

this information, it would be difficult to conclude that exposure to seismic had any consequence for ringed seals that might be clinically important.

Based on this information, we would not expect bearded seals that find themselves more than 3 kilometers from the seismic sound source devote attentional resources to that stimulus, even though received levels might be as high as 160 dB. Similarly, we would not expect bearded seals that find themselves more than 1 kilometer 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. Bearded seals that occur within 0.3 kilometers of sounds produced by equipment employed during seismic surveys are likely to change their behavioral state to avoid slight TTS, although this avoidance is anticipated to be localized.

Responses of Listed Marine Mammal Species to Seismic (Acoustic) Impacts on Fish

An additional effect of the proposed action on endangered and threatened species may be the impact of seismic noise on the fish prey species of these listed marine mammal species. Seismic noise will radiate throughout the water from the airguns until it dissipates to background levels. NMFS would expect any such effects on Arctic fish species to be localized and not to result in an appreciable decrease in the suitability of feeding habitat for listed species.

Although in general little is known about how noise affects fish (Hastings and Popper 2005; DFO 2004), salmon have been found to respond to low frequency sounds such as those created by the proposed action, but only at very short ranges, within distances of a few feet from the sound source. In general, fish perceive underwater sounds in the frequency range of 50 to 2,000 Hz, with peak sensitivities below 800 Hz (Popper and Carlson 1998; Department of the Navy 2001). However, fish are sensitive to underwater impulsive sounds due to swimbladder resonance as the pressure wave passes through the fish. The swimbladder may repeatedly expand and contract, creating pressure on the internal organs surrounding the swimbladder. Permanent injury to fish from acoustic emissions has been shown for high-intensity sounds of several hours long. In a review on the effects of low-frequency noise to fish, a threshold of 180 dB peak sound level was used to define the potential injury to fish. Sound pressure levels (SPL) greater than an average of 150 dB rms are expected to cause temporary behavioral changes such as a startle response or behaviors associated with stress. Although these SPLs are not expected to cause direct injury to a fish, the functional effect of impaired sensory ability could potentially reduce survival, growth, and reproduction, increase predation, and alter foraging and reproductive behaviors. This may decrease the quantity of fish available as prey to these listed species.

Some research indicates that some noises may evoke flight and avoidance response in juvenile salmon. Other studies have shown that the avoidance response is temporary. Salmon have been found to respond to low frequency sounds, but only at very short ranges (Chamberlin 1991). Carlson (1994), in a review of 40 years of studies concerning the use of underwater sound to deter salmonids from hazardous areas at hydroelectric dams and other facilities, concluded that salmonids were able to respond to low-frequency sound and to react to sound sources within a few feet of the source. He speculated that the reason that underwater sound had no effect on salmonids at distances greater than a few feet is because they react to water particle motion/acceleration, not sound pressures. Detectable particle motion is produced within very short distances of a sound source, although sound pressure waves travel farther (USDOT 2005). It is also likely that fish will avoid sound sources within ranges that may be harmful (McCauley et al. 2003).

Engas et al. (1993) examined changes in fishing catch levels for Atlantic cod and haddock as a result of a seismic study near Finnmark, Norway. The study documents changes in catch rates which it attributes to the seismic experiment; there was a decrease in the rate of cod caught via the trawl fishing method, but an increase in the rate of cod caught via the longline fishing method within the seismic survey area. Gausland (2003) examined information provided by Engas et al. (1993) and concluded there was not a clear trend of reduced catch rates which could be directly attributable to seismic noise. Gausland (2003) postulated that the differences in catch rates of cod in the Engas study may have been more a result of the scaring effect of fishing than the start-up of seismic shooting.

In 2004, the Department of Fisheries and Oceans (DFO) Canada published the results from teams of scientists who conducted major literature reviews of the "primary and secondary literature that reports on experimental studies and field monitoring of effects of sound, particularly seismic sound, on marine organisms." The literature reviews were then further reviewed at a National Advisory Process meeting on Seismic Impact Evaluation Framework in May 2004. The literature reviews and the scientific deliberations resulted in the conclusions presented in the DFO 2004 report. Some of the conclusions derived through that intensive review process specific to impacts from seismic to fish include:

- "There have been no documented cases of fish mortality upon exposure to seismic sound under field operating conditions;
- Overall, exposure to seismic sound is considered unlikely to result in direct fish mortality;
- Of several scientific studies examining behavioral effects to fish during seismic surveys, only some have found a change in horizontal distribution of fish not closely associated with habitat structures such as reefs or pinnacles;
- Changes in catchability of fish are possibly related to changes in behavior. However, differences in experimental regimes and lack of adequate controls in some of the experiments means that the published results are an insufficient basis to predict the nature of any change that may occur, or even if a change will occur; and
- The potential for seismic sound to disrupt communication, detection of predators/prey, navigation and other functional uses of sound by fish has not been studied. There is speculation that the discontinuous nature of seismic signals may allow these functions to occur between pulses."

The listed marine mammal species that prey on fish that potentially could be affected by exposure to active seismic include: fin whale, humpback whale, Arctic ringed seal, and Beringia DPS of bearded seal.

Fish are not a preferred prey type for the fin whale or the Beringia DPS of bearded seals, thus it is unlikely that seismic effects on fish would impair the feeding opportunities for fin whales or bearded seals. Although humpback whales have been observed in the western Beaufoprt Sea, they are typically not sighted before September, thus it is not likely that seismic impacts from this project during the summer would occur at a time that would meaningfully affect the availability of fish that are preyed upon by humpback whales. Whereas the preferred prey of Arctic ringed seals tend to be schooling species that form dense aggregations, invertebrate prey seem to become more important in the diet of Arctic ringed seals in the open water season, thus it is unlikely that seismic impacts to fish prey species will significantly affect Arctic ringed seals. It is possible that there may be localized effects to fish prey species (such as Arctic cod) but these are unlikely to reduce the overall suitability of the foraging habitat for listed marine mammals.

2.4.3.4.2 Probable Responses to Other Acoustic Sources

The empirical evidence available did not allow us to estimate the number of threatened or endangered marine mammals that are likely to be exposed to the continuous noise associated with vessel traffic PR1 plans to permit. Nevertheless, we assume that any individuals that overlap in time and space with these noise sources may be exposed.

Baleen Whales (bowhead, fin, and humpback whales)

Baleen whales under this analysis include bowhead, fin, and humpback whales. While cetaceans are a diverse group with varied life histories and migratory patterns (see Section 2.2.3), they share many important traits and exhibit similar physiological and behavioral responses. Each group is analyzed collectively where appropriate, as the individual species within each group share many similar characteristics which are correlated with potential impacts from offshore oil and gas exploration activities. Where sufficient information exists for species-specific analysis, or unique effects or susceptibilities exist, individual species have been discussed separately. The majority of the information provided below focuses on bowhead whales as they are the most commonly occurring listed baleen whale in the action area, and a large amount of research has been done on this species. We anticipate responses from fin and humpback whales to be similar to the bowhead whale.

Continuous Noise Sources

As described in the *Exposure to Other Acoustic Sources* Section 2.4.2.2, the empirical information available does not allow us to estimate the number of baleen whales that might be exposed to the continuous noise source associated with vessel operations during the activities PR1 plans to permit. However, bowhead and humpback whales are anticipated to occur in the Beaufort Sea, Chukchi Sea, and Bering Sea portions of the action area, whereas fin whales are only anticipated to occur in the Chukchi and Bering Sea portions of the action area during the open water season when these activities are occurring. It is anticipated that whenever noise is produced from vessel operations, it may overlap with these baleen whale species. We assume that some individuals are likely to be exposed to these continuous noise sources.

Vessel Noise

Reactions of marine mammals to vessels often include changes in general activity (e.g. from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement (NMFS 2013b). Past experiences of the animals with vessels are important in determining the degree and type of response elicited from an animal-vessel encounter. Whale reactions to slow-moving vessels are less dramatic than their reactions to faster and/or erratic vessel movements. Some species have been noted to tolerate slow-moving vessels within several hundred meters, especially when the vessel is not directed toward the animal and when there are no sudden changes in direction or engine speed (Wartzok *et al.* 1989, Richardson *et al.* 1995a, Heide-Jorgensen *et al.* 2003).

Bowhead whales react to approaching vessels at greater distances than they react to most other activities. Vessel-disturbance experiments in the Canadian Beaufort Sea by Richardson and Malme (1993) showed that most bowheads begin to swim rapidly away when fast moving vessels approach directly. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.62 to 2.5 mi) away. Whales move away more quickly when approached closer than 2 km (1.2 mi) (Richardson and Malme 1993). A few whales reacted at distances of 5 to 7 km (3.1 to 4.3 mi), while others did not react until the vessel was <1 km (<0.62 mi) away. Received noise levels as low as 84 dB re 1 µPa, or 6 dB above ambient, elicited strong avoidance reactions from bowhead from an approaching vessel 4 km (2.5 mi) away. During the experiments, vessel disturbance temporarily disrupted activities, and socializing whales moved apart from one another. Fleeing from a vessel usually stopped soon after the vessel passed, but scattering lasted for a longer time period. Some bowheads returned to their original locations after the vessel disturbance (Richardson and Malme 1993). However, it is not known whether they would return after repeated disturbance (Richardson 1995). Boat disturbance also tended to cause unusually brief surfacing with few respirations per surfacing (Richardson *et al.* 1985a, Koski and Johnson 1987). Bowheads showed clear reactions to approaching vessels as much as 4 km away, based on measurements of whale headings, speeds, surface times, and number of respirations per surfacing (Richardson and Malme 1993). Bowheads react less dramatically to and appear more tolerant of slow-moving vessels, especially if they do not approach directly.

Confirming assertions made by native bowhead hunters, low levels of underwater noise can elicit flight reactions in bowhead whales (Richardson and Malme 1993; NMFS 2013b). In one test, received noise levels from an approaching fishing boat were only ~6-13 dB above the background noise and cause flight reactions in bowhead (Miles *et al.* 1987, Richardson and Malme 1993). Mothers traveling with calves can be particularly sensitive to vessel traffic, and showed strong evasive behaviors when vessels were over 15 km away (Richardson and Malme 1993). In contrast, animals that are actively feeding may be less responsive to boats (Wartzok *et al.* 1989).

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

Fin whales also responded to vessels at distances of about 1 km (Edds and Macfarlane 1987). Watkins (1981) found that fin and humpback whales appeared startled and increased their swimming speed to avoid approaching vessels. Jahoda *et al.* (2003) studied responses of fin whales in feeding areas when they were closely approached by inflatable vessels. The study concluded that close vessel approaches caused the fin whales to swim away from the approaching vessel and to stop feeding. These animals also had increases in blow rates and spent less time at the surface (Jahoda *et al.* 2003). This suggests increases in metabolic rates, which may indicate a stress response. All these responses can manifest as a stress response in which the mammal undergoes physiological changes with chronic exposure to stressors, it can interrupt essential behavioral and physiological events, alter time budget, or a combination of all these stressors (Frid and Dill 2002, Sapolsky 2000). All of these responses to stressors can cause an abandonment of an area, reduction in reproductive success, and even death (Mullner *et al.* 2004, and Daan *et al.* 1996).

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

However, with mitigation measures in place which specify procedures for changing vessel speed and/or direction to avoid groups of whales, and potential for collision, and PSOs on board to spot nearby whales, the impact of vessel traffic on bowhead whales is anticipated to be minor.

Based on this information, we would not anticipate baleen whales that find themselves more than 176 meters from the seismic source vessel to devote attentional resources to the vessel noise, even though received levels might be has high as 120 dB. In addition to the noise associated with the vessel itself, baleen whales are anticipated to react to the other noises associated with project operations which will reach much farther than vessel noise (such as pinger and seismic operations). 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. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Non-Airgun Impulsive Noise Sources

We estimated a total 3 possible instances where bowhead whales (1 from a pinger source and 2 from a transponder source) might be exposed to pinger and transponder noise during SAE's operations in 2013 (see Section 2.4.2.2., *Exposure to Other Acoustic Sources*). No other cetacean is anticipated to be exposed to these noise sources. All of these potential exposures are anticipated to occur at received levels between 120 and 130dB.

Given the directionality, short pulse duration, and small beam widths for pingers and transponders; it is not anticipated that baleen whales would be exposed to these sources. If exposed, whales are not anticipated to be in the direct sound field for more than one to two pulses (NMFS 2013b). Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of baleen whales 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 acoustic sources including airguns. Many whales 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. However, if a whale did not move away from the other noise sources and was exposed to pinger and transponder noise, we would anticipate the potential responses discussed below.

Based on this information, we would not anticipate bowhead whales to devote attentional resources to pinger and transponder stimuli even though received levels might be as high as 130 dB and reach more than 1.4 kilometers from the source. Since all of the potential instances of exposure to bowhead whales are anticipated to occur at levels ≤ 130dB, we would not anticipate exposures to bowhead whales to rise to the level of take.

Masking

Marine mammal communications are not anticipated to be masked appreciably by pinger or transponder signals given their relatively low duty cycle, directionality, and the brief period when an individual mammal is likely to be within its beam. Some level of masking could result for whales in close proximity to the survey vessel during brief periods of exposure to the sound if signals were within the hearing range of the species. However masking is unlikely to be an issue because whales are likely to avoid survey vessels. In the case of marine mammals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of the higher-power airgun sources would further reduce or eliminate any minor effects of the non-airgun noise sources.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. Marine mammal behavioral reactions to pulsed sound sources from an active airgun array are discussed above, and responses to the pulsed noise associated with pinger and transponder signals are likely to be similar to those for other pulsed sources if received at the same levels. During exposure to a 21–25 kHz whale-finding sonar with a source level of 215 dB re 1 μPa · m, gray whales showed slight avoidance

(~200 m) behavior (Frankel 2005). However, these sources are anticipated to operate in brief pulses which are concentrated in a downward beam, with noise sources that are typically outside the hearing range of our species. For these a disturbance reaction is highly unlikely to occur from non-airgun impulsive noise sources associated with this consultation.

Pinnipeds (ringed and bearded seals, and steller sea lions)

Continuous Noise Sources

As described in the *Exposure to Other Acoustic Sources* Section 2.4.2.2, the empirical information available does not allow us to estimate the number of pinnipeds that might be exposed to continuous noise sources (vessels) during the activities PR1 plans to permit. However, pinnipeds are by far the most commonly observed marine mammals in the Beaufort and Chukchi Seas and they are anticipated to be present during these operations. Steller sea lions are only anticipated to be present in the Bering Sea portion of the action area. It is anticipated that whenever noise is produced from vessel operations, it may overlap with these pinniped species. We assume that some individuals are likely to be exposed to these continuous noise sources.

Vessel Noise

Few authors have specifically described the responses of pinnipeds to boats, and most of the available information on reactions to boats concerns pinnipeds hauled out on land or ice. However, the mere presence and movements of ships in the vicinity of seals and sea lions can cause disturbance to their normal behaviors (Calkins and Pitcher 1982, Kucey 2005, Jansen *et al.* 2010), and could potentially cause Steller sea lions, ringed seals and bearded seals to abandon their preferred breeding habitats in areas with high traffic (Kenyon 1962; Smiley and Milne 1979; Mansfield 1983; Reeves 1998). Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals and sea lions to leave haulout locations and enter the water (Richardson 1995, Kucey 2005). The possible impact of vessel disturbance on Steller sea lions has not been well studied, yet the response by sea lions to disturbance will likely depend on the season and life stage in the reproductive cycle (NMFS 2008c). Due to the relationship between ice seals and sea ice, the reactions of seals to vessels activity are likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during open water conditions in the Chukchi and Beaufort Seas.

Vessels that approach rookeries and haulouts at slow speed, in a manner that allows sea lions to observe the approach, should have less effect than vessels that appear suddenly and approach quickly (NMFS 2008c). Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response. Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned. Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles (NMFS 2008c). Pups are the age-class most vulnerable to disturbance from vessel traffic (NMFS 2008c).

Ringed seals hauled out on ice pans often showed short-term escape reactions when a ship came within 0.25-0.5 km (0.15-0.3 mi; Brueggeman *et al.* 1992). Jansen *et al.* (2006) reported that harbor seals approached by vessels to 0.1 km (0.06 mi) were 25 times more likely to enter the water than were seals approached at 0.5km (0.3 mi). However, during the open water season in the Chukchi and Beaufort Seas, bearded and ringed seals are commonly observed close to vessels where received sound levels were low (e.g., Harris *et al.* 2001, Moulton and Lawson 2002, Blees *et al.* 2010, Funk *et al.* 2010). In places where boat traffic is heavy, there have been cases where seals have habituated to vessel disturbance (e.g. Bonner 1982, Jansen *et al.* 2006). Such variations in seal responses may be explained as the result of the risk assessment, and conclusions made by individual seals on a case by case basis (BOEM 2011a).

Pups have a greater potential for heat loss than adults and so would be more prone to incur energetic costs of increased time in the water if vessel disturbance became a more frequent event (Cameron *et al.* 2010). If a vessel disturbs young ice seals, some might become energetically and behaviorally stressed, leading to lower overall fitness of those individuals (BOEM 2011a). The potential for ship traffic to cause a mother to abandon her pup may be lower in bearded seals than in ringed seals (Smiley and Milne 1979), as bearded seal mothers appear to exhibit a high degree of tolerance when approached by small boats.

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

Studies show that animals adapt acoustic signals to compensate for environmental modifications to sound (Wilczynski and Ryan 1999). Indeed, background noise has been suggested to account for geographical differences in the range and quality of bearded seal calls (Rogers 2003, Risch *et al.* 2007). However, compensating for sound degradation – such as by delaying calling, shifting frequencies, moving to a quieter area, or calling louder, longer, and more frequently – incurs a cost (Tyack 2008). The cost of these adaptations, or that of missing signals, is inherently difficult to study in free-ranging seals and to date has not been measured in any phocid seal. Because bearded seals broadcast over distances of at least 30-45 km (Cleator *et al.* 1989), perhaps over

100s of kilometers (Stirling *et al.* 1983, Rossong and Terhune 2009), their calls are increasingly susceptible to background interference. Though in some areas male bearded seals may "practice" calling throughout the year, the period of peak vocalization is during the breeding season (April to mid-June) (S. Van Parijs, NMFS Northeast Fisheries Science Center, Protected Species Division, September 1, 2010, pers. comm.). The extent to which vessel traffic is localized near areas where bearded seals are mating, and the acoustic characteristics of the area, will determine the level that communication is disrupted. If vessels largely avoid areas of pack ice, where communication and mating occurs, or transit these areas outside the breeding season, effects are not expected to be as significant.

Most ships in the Arctic purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice, though these may be difficult to predict. This necessarily mitigates many of the risks of shipping to populations of ice seals that are closely associated with ice throughout the year.

Vessels produce sound that may elicit behavioral changes in sea lions, and ice seals, mask their underwater communications, mask received noises, and cause them to avoid noisy areas. Richardson (1995) found vessel noise does not seem to strongly affect pinnipeds that are already in the water, explaining that hauled out seals often respond more strongly to the presence of vessels.

Non-Airgun Impulsive Noise Sources

We estimated a total 17 possible instances where bearded seals (5 from a pinger source and 12 from a transponder source) might be exposed to pinger and transponder noise during SAE's operations in 2013 (see Section 2.4.2.2., *Exposure to Other Acoustic Sources*). No other pinniped is anticipated to be exposed to these noise sources. All of these potential exposures are anticipated to occur at received levels between 120 and 130dB.

We are not aware of any data on the reactions of pinnipeds to pingers and transponders. However, based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to single-beam echosounder sonar sources, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Jacobs and Terhune (2000) observed the behavioral responses of harbor seals exposed to acoustic harassment devices with source levels of 172 dB re 1 μPa m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

Costa *et al.* (2003) placed acoustic data loggers on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the

ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. However, because of the brevity of exposure of pinnipeds to such sound sources, pinniped reactions are anticipated to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Based on this information, we would not anticipate ringed seals to devote attentional resources to pinger and transponder stimuli even though received levels might be as high as 130 dB and reach more than 1.4 kilometers from the source. Since all of the potential instances of exposure to ringed seals are anticipated to occur at levels ≤ 130dB, we would not anticipate exposures to ringed seals from pinger and transponder sources to rise to the level of take.

2.4.3.4.3 Probable Responses to Vessel Strike

As we indicated in *Section 2.4.2.3 Exposure to Vessel Strike*, the likelihood of a vessel strike occurring to a listed baleen whale or pinniped in the Bering, Chukchi, or 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 Chukchi or Bering Seas, 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.

2.4.4 Effects of the Action on Steller Sea Lion Critical Habitat

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

Based on the preceding description of critical habitat status within the action area, the overall functioning of the essential features (rest, refuge, reproduction, and foraging) in the action area is high. Despite all of this traffic in and around rookery and haulout locations near Dutch Harbor, there have been no reported incidents of ship strike with Steller sea lions in Alaska. The 3-mile no transit zones are established and enforced around rookeries in the area for further protection, and NMFS' guidelines for approaching marine mammals discourage vessels approaching within 100 yards of haulout locations. The Bogoslof Foraging Area is the only foraging area designated as critical habitat which occurs within the action area. This site historically supported large aggregations of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for SSLs (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas.

The potential effects to critical habitat essential features associated with exploration and leasing activities are described below.

1. Terrestrial Areas
    a. Rest - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.
    b. Refuge - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.
    c. Reproduction – No effect. Vessels are excluded from transiting within 3nm of rookeries.

2. Aquatic Areas
    a. Foraging – No effect. Vessels are not targeting Steller sea lions or their prey species and would only occur in the foraging areas for a short period of time while transiting.

3. Air zone – No effect

Dutch Harbor is a very active port with hundreds of vessels transiting in and around it. Despite this high amount of vessel traffic, Steller sea lions have maintained an active rookery at Cape Morgan which is within 20 nm of Dutch Harbor. In addition to this rookery, there are many haulout locations near Dutch Harbor (see Figure 5). Considering that the Steller sea lion population is increasing at about 3% per year in the Dutch Harbor area, vessel traffic doesn't appear to impact the breeding, feeding, or resting locations nearby (Lowell Fritz personal comm). The number of vessels associated with Shell's activities is anticipated to be few and insignificant in comparison to the current vessel traffic in and around Dutch Harbor.

2.5 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 of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

NMFS reviewed recent environmental reports, NEPA compliance documents, BOEM's biological evaluation, 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 2013). Most of the action area includes federal waters, which would preclude the possibility of future state, tribal, or local action that would not require some form of federal funding or authorization. However, reasonably foreseeable future State, tribal, local or private actions include: oil and gas exploration, development, and production activities; mining exploration, development, and production; military facilities and training exercises; air and marine transportation; major community development projects; recreation and tourism.

Oil and Gas Projects

State of Alaska: There are currently no State of Alaska leases in the Chukchi Sea, and no onshore oil and gas production along the Chukchi Sea coast. In its most recent five-year plan, the State of Alaska does not intend to hold lease sales in the nearshore waters of the Chukchi Sea (ADNR 2013).

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. Whether there will be a federal nexus for ESA consultation is not known at this time, so we will consider these activities under cumulative effects. While the projects described below would not occur in the Chukchi Sea portion of the action area, they would potentially increase vessel traffic within the Chukchi Sea.

***Point Thomson Project*:** ExxonMobil is proposing to produce gas and hydrocarbon liquids (condensate and oil) from the Thomson Sand reservoir and delineate other hydrocarbon resources in the Point Thomson area on the North Slope of Alaska. This project is located to the east of the existing Badami field, and west of ANWR. Produced fluids will be processed on site, with condensate and oil being transported by pipeline to existing common carrier pipelines at Badami that supply the Trans Alaska Pipeline System (TAPS). The primary activities that would contribute to cumulative effects include marine and air traffic associated with construction and operation, and an increased level of construction activity on the shoreline over a three-year period.

Sealift by ocean-going barges direct to the Point Thomson location was selected as the option for moving heavy loads, such as process modules, to the site. Module transportation to the project site is scheduled for the summer of 2013 and would take place over three open water seasons (2013 through 2015). It is anticipated that the large ocean barges will be in place at the Point Thomson site for approximately 14 days, providing adequate time to dock and offload cargo. Once offloaded, the barges will leave the site. The method of barge access will be utilized for up to three construction seasons (2013 through 2015), with barges passing through the Chukchi Sea to and from offloading.

Alpine Unit CD-5 and CF-6 Projects: Permits applications for construction of Alpine CD-5 were submitted several years ago, but were delayed due to regulatory challenges resulting in denial of permits. These challenges were resolved in late 2011, with production now anticipated to begin in 2016. Construction of CD 5 and 6 would involve constructing a bridge across the Colville River to access the production pad; road connections to the Prudhoe Bay Kuparuk road system would be limited to seasonal ice roads. Barge support for construction would be based out of Prudhoe Bay, with modules and other construction material transported by gravel/ice roads. Air traffic would be associated with construction and operations. The primary areas of nexus with offshore exploratory activity would involve barge sealifts through the Chukchi and Beaufort seas, and offloading activity at West Dock.

Liberty Project: The Liberty Project is located on the eastern end of the Prudhoe Bay area in nearshore waters. It was initially conceived as an offshore production island, but has been redesigned as directional drilling from a location at the Endicott Satellite drilling island. Exploratory drilling was suspended in 2010. Development within the next five years is possible. Road access would be provided through the existing Prudhoe Bay road system; barge support for construction would be based out of Prudhoe Bay, with modules and other construction material transported by gravel roads. Air traffic would use the existing Prudhoe Bay air facilities. The primary areas of nexus with offshore exploratory activity would involve barge sealifts through the Chukchi and Beaufort seas, and offloading activity at West Dock.

Continuation of Badami Production: The Badami project is located approximately 20 miles east of Prudhoe Bay on the Beaufort Sea coast. It is connected by pipeline to Endicott, but there are no all-season road connections; Badami has a gravel causeway barge dock. The facility went into production around 2001, but was suspended in 2007 after production results were less than expected. In 2010, production was temporarily restarted. Additional winter exploratory drilling is currently being conducted; depending on results, production could be resumed on a continuing basis within a couple of years. Some improvements to the dock and other facilities may be needed. The primary areas of nexus with offshore exploratory activity would involve barge sealifts through the Chukchi and Beaufort seas, and offloading activity at Badami (Bradner 2011; Petroleum News 2011b; NMFS 2013b).

Mining

Mining takes place in onshore areas of the Chukchi Sea portion of the project area. While the majority of mining activities take place onshore, marine and air transportation could contribute to potential cumulative effects through the disturbance of marine mammals. The world’s largest known zinc resources are located in the western Brooks Range. As much as 25 million tons of high-grade zinc is estimated to be present near Red Dog Mine, approximately 40 mi from the southwest corner of the NPR-A (Schoen and Senner 2002). The Red Dog Mine port site may also become the port facility for a very large proposed coal mining operation adjacent to the Chukchi Sea. In addition, coal mining prospecting proposals for the Brooks Range have been submitted to Alaska Department of Natural Resources, Division of Mining, Land and Water for approval.

Military

Military activity in the Arctic is thought to have increased in recent years, and it may be reasonable to expect that military activity will continue to increase in the foreseeable future. Military activities in the proposed action area include the transit of military vessels through area waters, as well as submarine activity, aircraft overflights, and related maneuvers. However, very little public information is available about future military activity in the region. Military vessel, submarine, and aircraft traffic could contribute to cumulative effects through the disturbance of marine mammals, and the potential for marine fuel spills.

Transportation

It is reasonable to assume that trends associated with transportation to facilitate the maintenance and development of coastal communities, Red Dog Mine, 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: Vessel traffic through the Bering Strait has risen steadily over recent years according to United States Coast Guard (USCG) estimates, and Russian efforts to promote a Northern Seas Route for shipping may lead to continued increases in vessel traffic adjacent to the western portion of the project area.

An analysis done by Shell Oil as part of a Revised Outer Continental Shelf Lease Exploration Plan for the Chukchi Sea (Shell 2011b) indicated that barge traffic passing through the Chukchi Sea during the month of July through October has increased from roughly 2000 miles of non-seismic vessel traffic in 2006 to roughly 11,500 miles of non-seismic vessel traffic in 2010. In comparison, the same analysis estimated that vessel miles associated with seismic surveys in

2006 were roughly 70,000 miles, compared to roughly 30,000 miles in 2010.

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. For example, villages along the Beaufort and Chukchi sea coasts are serviced by vessels from Crowley Alaska and or Northern Transportation Company. Additional vessel traffic supports the Arctic oil and gas industry, and some activity is the result of emergency-response drills in marine areas.

In addition, research vessels, including NSF and USCG icebreakers, also operate in the 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.

Community Development

Community development projects in Arctic communities involve major infrastructure projects, such as construction of airports and response centers, as well as smaller projects. These projects could result in construction noise in coastal areas, and could generate additional amounts of marine and aircraft traffic to support construction activities. Marine and air transportation could contribute to potential cumulative effects through the disturbance of marine mammals.

Major community development projects that are foreseeable at the present time include the construction of a new airport at the village of Kaktovik, and potentially a new emergency response facility at Wainwright.

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).

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS's assessment of the risk posed to the species as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) 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; (2) or result in appreciable reductions in the likelihood of recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (3) result in the adverse modification or destruction of critical habitat as measured through potential reductions in the value of designated critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species (Section 2.2).

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 listed species exposed to an action's effects to experience reductions in the current or expected future survivability or reproductive success (that is, their fitness), we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Stearns 1977; Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). Therefore, if we conclude that listed species are not likely to experience reductions in their fitness, we would conclude our assessment because we would not expect the effects of the action to affect the performance of the populations those individuals represent or the species those population comprise. If, however, we conclude that listed species are likely to experience reductions in their fitness as a result of their exposure to an action, we then determine whether those reductions would reduce the viability of the population or populations the individuals represent and the "species" those populations comprise (in section 7 consultations, the "species" represent the listed entities, which might represent 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 actions, individually and cumulatively, given that the individuals in the action areas for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range. These stressors or the response of individual animals to those stressors can produce consequences — or "cumulative impacts"— that would not occur if animals were only exposed to a single stressor. In addition, we consider whether there is a reasonable likelihood that future incremental steps (production and development) will violate section 7(a)(2) of the ESA.

As we discuss in the narratives that follow, our analyses led us to conclude that endangered or threatened individuals that are likely to be exposed to the planned 2013 SAE activities are likely to experience disruptions in their normal behavioral patterns, but are not likely to be killed, injured, or experience measurable reductions in their current or expected future reproductive success as a result of that exposure.

2.6.1 Bowhead Whale Risk Analysis

Based on the results of the exposure analyses, during the planned 2013 SAE activities, we would expect bowhead whales to be exposed to low-frequency active seismic, vessel noise from transit, and noise from echosounders.

2.6.1.1 Probable Risk of Active Seismic to Bowhead Whales

During SAE's low-frequency seismic activities PR1 proposes to permit in the Beaufort Sea, NMFS estimated up to 177 instances of exposure during the open-water season (in the Federal and international waters) (see Section 2.4.2.1, *Exposure to Active Seismic*). Out of these total exposures during the open water season, a small fraction may be exposed to sounds produced by seismic airguns at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 2.4.3.4.1, *Probable Responses to Exposure to Active Seismic*).[21] No bowhead whales are anticipated to be exposed to sound levels that could result in PTS.

Our consideration of probable exposures and responses of bowhead whales to seismic airgun noise associated with SAE's survey activities PR1 propose to permit are designed to help us answer the question of the whether those activities are likely to increase the extinction risks or jeopardize the continued existence of bowhead whales. Although the seismic activities are likely to cause some individual bowhead whales 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 bowhead whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the seismic operations or migrating through the seismic operations.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like bowhead whales. As a result, the bowhead whales' probable responses to close approaches by seismic vessels and their probable exposure to active seismic are not likely to reduce the current or expected future reproductive success of bowhead 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

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

individuals represent.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise. As a result, the SAE seismic activities in 2013 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 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.* 2004, Schweder *et al.* 2009), despite exposure to oil and gas exploration activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2011a). This increase in the number of bowhead whales suggests that the stress regime these whales are exposed to in the Arctic have not prevented these whales from increasing their numbers in the action area. As discussed in the *Environmental Baseline* section of this opinion, bowhead whales have been exposed to active seismic activities in the Arctic, including vessel traffic, aircraft traffic, and active seismic, for more than a generation. Although we do not know if more bowhead whales might have used the action area or the reproductive success of bowhead whales in the Arctic would be higher absent their exposure to these activities, the rate at which bowhead whales occur in the Arctic suggests that bowhead whale numbers have increased substantially in these important migration and feeding areas despite exposure to earlier seismic operations. The SAE activities are less in number and magnitude as compared to previous activities in the area, and we do not believe these permitted activities are likely to affect the rate at which bowhead whale counts in the Arctic are increasing.

2.6.1.2 Probable Risk of Other Noise Sources to Bowhead Whales

Continuous Noise Sources

Our exposure analyses concluded that we would expect some instances in which bowhead whales might be exposed to continuous noise sources (transiting vessels) associated with PR1's permitted activities.

We assume that bowhead whale vocalizations are partially representative of their hearing sensitivities (7 Hz-22 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[22]

Bowhead whales react to approaching vessels at greater distances than they react to most other activities. Vessel-disturbance experiments in the Canadian Beaufort Sea by Richardson and Malme (1993) showed that most bowheads begin to swim rapidly away when fast moving

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[22] A more in-depth description on bowhead whale vocalizations is presented in sections 2.2.3.1 and 2.6.1.1 of this opinion.

vessels approach directly. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.62 to 2.5 mi) away. Fleeing from a vessel usually stopped soon after the vessel passed, but scattering lasted for a longer time period. Some bowheads returned to their original locations after the vessel disturbance (Richardson and Malme 1993). Bowheads react less dramatically to and appear more tolerant of slow-moving vessels, especially if they do not approach directly.

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

Bowhead reactions to noise sources may also be dependent on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a). The open water season (July through October) during which the proposed activities would occur, overlaps with summer feeding and late-summer/fall westward migration of bowhead across the Alaskan Chukchi and Beaufort Seas. Therefore, the potential for exposure to continuous noise sources is high during this time period.

Mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to bowhead whales.[23]

In most circumstances, bowhead whales are likely to avoid these exposures or are likely to avoid certain ensonified areas. If bowhead whales were present, and responded to noise levels as low as 120 dB, NMFS would anticipate that the maximum avoidance radius would be 3.4 km (2 mi) from a continuous noise source. Noise associated with the scouting vessel is anticipated to be less than the seismic vessel, so this is considered a conservative avoidance radius.

Considering the likely avoidance of bowhead whales from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which bowhead whales would be exposed to continuous noise sources, and would not expect those whales to devote attentional resources to that stimulus, even though received levels might be higher than 120 dB. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those bowhead whales that do not avoid the sound field created by the low-frequency vessel or aircraft noise might experience interruptions in their vocalizations. In either case, bowhead whales that exhibit low-level avoidance should be relatively localized (3.4 km) within these sound fields and any short-term interruptions in their vocalizing are not likely to represent significant disruptions of their normal behavior patterns because the ensonified area where vessel noise will occur would be a small portion of their feeding range and noise is not anticipated to be at levels that would cause harm to the animal(s). 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

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[23] See Section 1.3.4 for additional information on standard mitigation measures.

physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with the activities PR1 plans to permit in the Beaufort Sea during the open water season in 2013 would not be expected to appreciably reduce the Western Arctic bowhead stock's likelihood of surviving or recovering in the wild.

Non-Airgun Impulsive Noise Sources

During the operation of pingers and transponders PR1 proposes to permit in the Beaufort Sea, NMFS estimated 3 instance of exposure during the open-water season (1 from a pinger source, and 2 from transponder source) (see Section 2.4.2.2, *Exposure to Other Acoustic Sources*). Out of these total exposures during the open water season, NMFS would classify 0 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 2.4.3.4.2, *Probable Responses to Other Acoustic Sources*).[24]

Although the operation of pingers and transponders in the Beaufort Sea during the 2013 open water season is likely to expose some bowhead whales, 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, 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 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 on and around the seismic operations or migrating through the seismic operations.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities PR1 plans to permit in the Beaufort Sea during the 2013 open water season, which use non-airgun acoustic sources, would not appreciably reduce the bowhead whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that continuous noise sources and non-airgun impulsive noise sources 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

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

whales has been increasing at approximately 3.2-3.4 percent per year (George *et al.* 2004, Schweder *et al.* 2009), despite exposure to exploration activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2011a). In addition to these activities, Alaska Native subsistence hunters kill between 14 and 72 bowhead per year (Stoker and Krupnik 1993). Furthermore, the Alaska Region stranding reports documented three bowhead whale entanglements between 2001 and 2005. However, the average annual entanglement rate in the U.S. commercial fisheries is currently unknown (Allen and Angliss 2013). Despite all of these activities, this increase in the number of bowhead whales suggests that the stress regime these whales are exposed to throughout their range have not prevented these whales from increasing their numbers. 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 feeding areas despite exposure to earlier sources of continuous and impulsive noise. The activities PR1 proposes to permit during the open water season in 2013 in the Beaufort Sea are less in number and magnitude as compared to previous activities in the area, and we do not believe these permitted activities are likely to affect the rate at which bowhead whale counts in the Arctic are increasing.

2.6.1.3 Bowhead Whale Summary

Based on the evidence available, we conclude that the 3D seismic surveys being proposed by SAE, and permitted by PR1 in the Beaufort Sea during the 2013 open water season, are likely to cause disruptions in the behavioral ecology and social dynamics of individual Western Arctic bowhead whales as a result of their exposure. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like bowhead whales. As a result, the bowhead whales' probable responses to close approaches by seismic and scouting vessels and their probable exposure to active seismic sound and noise from vessels are not likely to reduce the current or expected future reproductive success of bowhead whales or reduce the rates at which they grow, mature, or become reproductively active. As a result, we do not expect the 3D seismic activities being permitted by PR1 to affect the performance of the populations those bowhead whales represent or the species those populations comprise. Accordingly, we do not expect those 3D seismic activities to appreciably reduce the Western Arctic bowhead's likelihood of surviving or recovering in the wild.

2.6.2 Fin Whale Risk Analysis

The only stressor that had the potential for overlap in time and space with the fin whales we noise associated with vessel traffic. However, our exposure analysis concluded that few fin whales were likely to be exposed to vessel traffic associated with PR1's permitted activities in the Beaufort Sea because fin whales occur only in the Chukchi Sea and Bering Sea portions of the action area, and because of the small number and transitory nature of SAE's vessels, the low density and recorded sighting of the species in the action area, and the absence of collisions involving vessels and fin whales.

In our *Response Analysis* we discussed that the fin whale hearing range is anticipated to overlap with the low-frequency range of vessel noise, and the early visual and acoustic warnings vessels provide. We also discussed that fin whale reactions to noise sources may be dependent on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a), and it is anticipated that fin whales would react similarly. The open water season (July through October) during which the proposed activities would occur, overlaps with summer feeding and late-summer/fall westward/southern migration. Therefore, the potential for exposure to continuous noise sources is relatively high during this time period, but the density of fin whales is still anticipated to be low.

In addition, mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to fin whales. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would enter into an area where they would suffer from acoustic harassment.

Considering the low density of this species in the action area, the likely avoidance of fin whales from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which fin whales would be exposed continuous noise sources, and would not expect those whales to devote resources to that stimulus, even though received levels might be higher than 120 dB. Similarly, we would not expect exposure to those sources to cause fin whales to change their behavioral state. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those fin whales that do not avoid the sound field created by the low-frequency vessel noise might not respond, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Erbe 2002a, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). Some fin whales may be less likely to engage in these responses in the Chukchi Sea because they occur in the area to feed; while they forage, they are less likely to devote attentional resources to the periodic activities PR1 intends to authorize. Some fin whales might experience physiological stress (but not distress) responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the fin whales that occur in the Chukchi Sea.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with PR1's permitted activities in the Bering, Chukchi, and Beaufort Seas would not be expected to appreciably reduce the North Pacific fin whales' likelihood of surviving or recovering in the wild.

2.6.3 Humpback Whale Risk Analysis

Based on the results of the exposure analyses, we would expect humpback whales to be exposed to low-frequency active seismic, vessel noise from transit, or other noise sources.

2.6.3.1 Probable Risk of Active Seismic to Humpback Whales

During low-frequency seismic activities PR1 proposes to permit in the Beaufort Sea, NMFS estimated 2 instance of exposure to humpback whales during the open-water season (in Federal and international waters) (see Section 2.4.2.1, *Exposure to Active Seismic*).

As discussed in the narrative for bowhead whales, our consideration of probable exposures and responses of humpback whales to seismic stressors associated with these exploration activities are designed to help us answer the question of whether those activities are likely to increase the extinction risks facing humpback whales. Although the seismic activities could to cause some individual humpback whales 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 humpback whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the seismic operations or migrating through the seismic operations.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like humpback whales. As a result, the humpback whales' probable responses to close approaches by seismic vessels and their probable exposure to active seismic are not likely to reduce the current or expected future reproductive success of humpback 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.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the humpback whale. As a result, the seismic activities are not likely to appreciably reduce the humpback whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that seismic operations will likely have minimal impact on humpback whales is the estimated growth rate of the humpback whale population in the North Pacific. Although there is no estimate of maximum net productivity rate for the western or central stocks, NMFS has estimated that the net productivity rate for both stocks is at least 7% (Wade and Angliss 1997, Allen and Angliss 2013). Despite small numbers humpback whales that are entangled in fishing gear in the Bering Sea section of the action area, the single subsistence take of a humpback in 2006, and past oil and gas activities, this increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, humpback whales have been exposed to active seismic and sonar activities in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, including vessel traffic, aircraft traffic, and active sonar and seismic, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which humpback whales occur in the North Pacific, and the increasing number of sightings of humpback in the Arctic and sub-Arctic suggests that humpback whale numbers have increased substantially in these important feeding areas despite exposure to earlier seismic operations. The activities PR1 proposes to authorize during the open water season in 2013 is less in number and magnitude as compared to previous activities in the area, and we do not believe these permitted activities are likely to affect the rate at which humpback whale counts in the Arctic are increasing.

2.6.3.2 Probable Risk of Increased Non-Airgun Noise to Humpback Whales

Continuous Noise Sources

Our exposure analyses concluded that we would expect some instances in which humpback whales might be exposed to continuous noise sources (transiting vessels) associated with the activities PR1 plans to permit during the 2013 open water season.

We assume that humpback whale vocalizations are partially representative of their hearing sensitivities (7 Hz-22 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[25]

Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme *et al.* 1985), and to calls of other humpback whales at received levels as low as 102 dB (Frankel *et al.* 1995). Malme *et al.* (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 Pa. Studies of reactions to airgun noises were inconclusive (Malme *et al.*1985). However, other studies have shown that humpbacks whales respond behaviorally to anthropogenic noises, including vessels, aircraft, and active sonar (Richardson *et al.* 1995a, Frankel and Clark 2000). Responses include alterations of swimming speed and decreased surface blow rates. Although these studies demonstrated that humpback whales may exhibit short-term behavioral reactions to industrial noise, the long-term effects of these disturbances on the individuals exposed to them are unknown.

Humpback whale reactions to noise sources may also be dependent on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a), and it is anticipated that humpback whales may react similarly. The open water season (July through October) during which the proposed activities would occur, overlaps with summer feeding and late-summer/fall westward/southern migration

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[25] A more in-depth description on humpback whale vocalizations is presented in sections 2.2.3.3 and 2.6.3.1 of this opinion.

across the Chukchi Sea down into the Bering Strait.[26] Therefore, the potential for exposure to continuous noise sources is relatively high during this time period, although humpback whales are in low densities in the northeastern Chukchi Sea or Beaufort Sea. Humpback whales have been seen and heard with some regularity in recent years (2009-2011) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Hashagen *et al.* 2009; Anonymous 2010; Goetz *et al.* 2010; Clarke *et al.* 2011a; Crance *et al.* 2011; NMML 2011). A single humpback was observed between Icy Cape and Wainwright feeding near a group of gray whales during aerial surveys of the northeastern Chukchi Sea in July 2009 as part of COMIDA (Clarke *et al.* 2011a). In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen *et al.* 2009).

Mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to humpback whales. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would enter into an area where they would suffer from acoustic harassment.[27]

In most circumstances, humpback whales are likely to avoid exposure to continuous noise sources or are likely to avoid certain ensonified areas. Noise associated with the scouting vessel is anticipated to be less than the seismic vessel, so this is considered a conservative avoidance radius.

Considering the low density of this species in the Arctic, the likely avoidance of humpback whales from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which humpback whales would be exposed continuous noise sources, and would not expect those whales to devote resources to that stimulus, even though received levels might be higher than 120 dB. Similarly, we would not expect exposure to those sources to cause humpback whales to change their behavioral state. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those humpback whales that do not avoid the sound field created by the low-frequency vessel noise might experience interruptions in their vocalizations. In either case, humpback whales that avoid these sound fields or stop vocalizing are not likely to experience significant disruptions of their normal behavior patterns because the ensonified area represents only a small portion of their feeding range. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with PR1's permitted activities

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[26] This is primarily based on migration timing of bowhead whales since the timing of humpback whale migration in the Arctic is unknown. However, if we assume that humpback whale feeding and migration timing is similar to other baleen whales in the area then we would anticipate overlap with project activities from July-October.

[27] See Section 1.3.3 for additional information on mitigation measures.

would not be expected to appreciably reduce the North Pacific humpback whales' likelihood of surviving or recovering in the wild.

Non-Airgun Impulsive Noise Sources

Our exposure analyses concluded that humpback whales were not likely to be exposed to non-airgun impulsive noise sources because of the relatively low density of these species in Arctic waters; and the directionality, short pulse duration, and small beam widths for single-beam echosounders reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider 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 humpback whales are not likely to be directly or indirectly exposed to the non-airgun acoustic stimuli, 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. Even if a few animals were exposed, they would not be anticipated to be in the direct sound field for more than one to two pulses, and most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, generally (Southall *et al.* 2007). 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. Many whales would move away in response to the approaching 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 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 Section 2.4.2.1) would further reduce or eliminate any potential effect on baleen whales from non-airgun acoustic sources.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities PR1 plans to permit this work during the 2013 open water season, which use non-airgun acoustic sources, would not appreciably reduce the humpback whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that continuous noise sources and non-airgun impulsive noise will likely have minimal impact on humpback whales is the estimated growth rate of the humpback whale population in the North Pacific. Although there is no estimate of maximum net productivity rate for the western or central stocks, NMFS estimated that the net productivity rate for both stocks is at least 7% (Wade and Angliss 1997, Allen and Angliss 2013). Despite small numbers humpback whales that are entangled in fishing gear in the Bering Sea section of the action area, and the single subsistence take of a humpback in 2006, this increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, humpback whales have been exposed to vessel traffic and drilling noise in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, as well as aircraft traffic, active sonar and seismic, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which humpback whales occur in the North Pacific, and the increasing number of sightings of humpback in the Arctic and sub-Arctic suggests that humpback whale numbers have increased substantially in these important feeding areas despite exposure to earlier sources of continuous noise. The activities PR1 proposes to permit are less in number and magnitude as compared to previous activities in the area, and we do not believe these permitted activities are likely to affect the rate at which humpback whale counts in the Arctic are increasing.

2.6.3.3 Humpback Whale Summary

Based on the results of the exposure analysis, for the 2013 open water season, NMFS expects about 2 instances of exposure involving humpback whales due to SAE's seismic activities. We also estimate that 2 humpback whales might be exposed to sound sources that constitute takes by harassment as a result of SAE's seismic activities.

Based on the evidence available, we conclude that the 3D seismic surveys being proposed by SAE and permitted by PR1 may expose some individuals of North Pacific humpback whales, and are likely to cause disruptions in the behavioral ecology and social dynamics as a result of their exposure. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like humpback whales. As a result, the humpback whales' probable responses to close approaches by seismic vessels and scouting vessels and their probable exposure to active seismic sound are not likely to reduce the current or expected future reproductive success of humpback whales or reduce the rates at which they grow, mature, or become reproductively active. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the 3D seismic surveys PR1 plans to permit in the Beaufort Sea during the 2013 open water season, would not appreciably reduce the North Pacific humpback whales' likelihood of surviving or recovering in the wild.

2.6.4 North Pacific Right Whale Risk Analysis

The only stressor that was analyzed as part of our exposure analysis for North Pacific right whale was vessel traffic due to the potential for overlap in time and space with the species. However, our exposure analysis concluded that North Pacific right whales were not likely to be exposed to vessel traffic associated PR1's permitted activities because of the overall low density of the species; the limited sightings of the species in the Bering Sea portion of the action area; the small number of vessels associated the proposed activities; the short-term, transient, nature of authorized vessels in the Bering Sea; the application of mitigation measures; and the decades of authorized activities that have not resulted in a single vessel strike with a North Pacific right whale.

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 North Pacific right whales are not likely to be directly or indirectly exposed to the vessel traffic that would occur within the Bering Sea portion of the action area, 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. As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

As a result, the vessel traffic associated with PR1's permitted activities of the SAE seismic program during the 2013 open water season would not be expected to appreciably reduce the North Pacific right whales' likelihood of surviving or recovering in the wild.

2.6.5 Ringed Seal Risk Analysis

Based on the results of the exposure analyses, we expect ringed seals to be exposed to low-frequency active seismic, vessel noise from transit, and other noise sources.

2.6.5.1 Probable Risk of Active Seismic to Ringed Seals

During the SAE low-frequency seismic activities PR1 proposes to permit, NMFS estimates as many as 3,576 exposures during the open-water season (Federal and international waters) (see Section 2.4.2.1, *Exposure to Active Seismic*). Out of these total exposures during the open water season, NMFS would classify 3,476 instances where ringed seals might be exposed to sounds produced by seismic airguns at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 2.4.3.4.1, *Probable Responses to Exposure to Active Seismic*).[28] No ringed seals are anticipated to be exposed to sound levels that could result in PTS.

These estimates represent the total number of exposures that could potentially occur at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment, not necessarily the number of individuals taken, as a single individual may be "taken" multiple times over the course of the season. We assume these take estimates are overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures being in place, and they assume all of the tracklines will be shot during the season. In addition, large concentrations of ringed seals are not expected to be encountered near SAE's proposed seismic survey areas in the Beaufort Sea during the summer

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[28] For the open-water season, behavioral harassment is not anticipated to occur until received levels are ≥170 dB.

and fall time period. These seals are generally found in association with the ice front that would be avoided during this project.

As we discussed in the narratives for cetaceans listed above, our consideration of probable exposures and responses of ringed seals to seismic stressors associated with these seismic exploration activities are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing ringed seals. Although the 2013 SAE seismic program PR1 plans to permit is 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 on and 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 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.

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). The early fall time period overlaps with fall seismic activities PR1 plans to permit. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like ringed seals. As a result, the ringed seal’s probable responses to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce the current or expected future reproductive success of ringed seals 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.

We do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the

2013 SAE seismic program is not likely to appreciably reduce the Arctic ringed seal's likelihood of surviving or recovering in the wild.

2.6.5.2 Probable Risk of Increased Non-Airgun Noise to Ringed Seals

Continuous Noise Sources

Our exposure analyses concluded that we would expect some instances in which ringed seals might be exposed to continuous noise sources (transiting vessels) associated PR1's permitted activities in the Beaufort Sea. Ringed seals occur year round, and are the most commonly observed marine mammal in both the Beaufort and Chukchi Seas (Haley *et al.* 2010, Savarese *et al.* 2010). We assume that ringed seal vocalizations are partially representative of their hearing sensitivities (75 Hz-75 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[29]

Ringed seals appear to vocalize as a part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sound in water. This is important because most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003).

All ice-breeding pinniped species are known to produce underwater vocalizations (reviewed by Richardson *et al.* 1995a, Van Opzeeland *et al.* 2008). Effects of vessel noise on ringed seal vocalizations have not been studied, though the frequency range of barks, clicks, and yelps (0.4-16 kHz), do not appear to overlap the range (20-300 Hz) (Stirling 1973, Cummings *et al.* 1984) over which ship noise dominates ambient noise in the oceans (Urick 1984). Noise at frequencies outside this masking band has little influence on detection of the signal unless the noise level is very high (Spieth 1956, Kryter 1985).

Ringed seals hauled out on ice often showed short-term escape reactions when a ship came with ¼ to ½ km (Brueggeman *et al.* 1992). Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals to leave haulout locations and enter the water (Richardson *et al.* 1995a). Due to the relationship between ice seals and sea ice, the reactions of seals to vessel activity are likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during open water conditions (BOEM 2011a). During open water surveys in the Beaufort and Chukchi Seas (Harris, Miller, and Richardson, 2001; Blees *et al.* 2010; and Funk *et al.* 2010) ringed and bearded seals showed slight aversions to vessel activity. However, ringed seals did not appear to be affected by vessel traffic with background noises below 120 dB in the 2006-2008 (Funk *et al.* 2010) or the 2010 (Blees *et al.* 2010) surveys when they were in open water conditions and not hauled out on ice. The presence and movement 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 Mine 1979, Mansfield 1983). In addition, if a vessel disturbs young ringed seals and causes them to enter the water, some might

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[29] A more in-depth description on ringed seal vocalizations is presented in sections 2.2.3.5 and 2.6.5.1 of this opinion.

subsequently become energetically and behaviorally stressed, leading to lower overall fitness of those individuals (BOEM 2011a). The isolated and inaccessible habitat of ringed seals in interior and shorefast ice has provided some protection from the effects of vessel traffic (BOEM 2011a).

Frost and Lowry (1988) concluded that local seal populations were less dense within a 2 nmi buffer of man-made islands and offshore wells that were being constructed in 1985-1987, and acoustic exposure was at least a contributing factor in that reduced density. Moulton *et al.* (2003) found seal densities on the same locations to be higher in years 2000 and 2001 after a habituation period. Thus, ringed seals were disturbed by drilling activities, until the drilling and post-construction activity was concluded, then they adjusted to the environmental changes for the remainder of the activity. Seals may be disturbed by drilling activities temporarily, until the drilling and post-construction activity has been completed.

Studies of the effects of low frequency sounds on elephant seals (*Mirounga* spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (LeBoeuf and Peterson 1969; Kastak and Schusterman1996; Croll *et al.* 1999), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

During the open water season (July through October) when the proposed activities would occur, ringed seals are anticipated to be making short and long distance foraging trips (Smith *et al.* 1973, 1976; Smith and Stirling 1978; Teilmann *et al.* 1999; Gjertz *et al.* 2000; Harwood and Smith 2003). Therefore, the potential for exposure to continuous noise sources is high during this time period.

Born *et al.* (2004) confirmed observations by Teilmann *et al.* (1999) that tagged ringed seals in the North Water polynya were concentrated in shallow waters, spending 90% of their time in water less than 100 m deep and that ringed seals preferentially exploited areas of lighter ice within the polynya. They recorded home ranges of 10,300-18,500 km^2 in the open water season. Freitas *et al.* (2008) used satellite tracking to quantify at-sea habitat selection for ringed seals tagged in Svalbard. They documented two main foraging strategies in which seals either moved away from their winter areas to the sea-ice edge or remained close to winter areas at glacier fronts. Those that associated with sea ice showed a preference for ice concentrations of 40-80% indicative of the ice edge. The authors suggested that both strategies – frequenting the sea-ice edge or glacier fronts – provided access to food rich waters as well as to on-ice resting sites. They speculated that the value of resting on ice outside of the breeding or molting periods may relate to reducing thermal stress and minimizing predation, perhaps from Greenland sharks (*Somniosus microcephalus*) (Freitas *et al.* 2008). Kelly *et al.* (2010b) attached satellite-linked transmitters to 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 (July through December), and 6 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). By the subsequent January, 8 of the 9 seals returned to within 55 km of the sites at which they had been captured during the previous breeding season. The ninth seal, an adult male tagged on shorefast ice in May, moved to a pack-ice site 1,000 km to the west in August, returned to his tagging site in October, traveled 800 km east in November, and was back at his shorefast ice tagging site the following June (Kelly *et al.* 2010b).

Overall, the record from satellite tracking indicates that ringed seals breeding in shorefast ice practice one of two strategies during the open-water foraging period (Freitas *et al.* 2008). Some forage within 100 km of their shorefast ice breeding habitat while others make extensive movements of 100s or 1,000s of kilometers to forage in highly productive areas (e.g., Viscount Melville Sound) and along the pack-ice edge. Movements during the foraging period by ringed seals that breed in the pack ice are unknown. 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, Krafft *et al.* 2007, Kelly *et al.* 2010b).

Mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to ringed seals. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would enter into an area where they would suffer from acoustic harassment.

As indicated above, ringed seals generally do not show disturbance reactions unless vessels are relatively close (0.93 km for icebreaking vessels) (Kanik *et al.* 1980, Richardson *et al.* 1995a). However, interpreting reactions of seals from vessels can be misleading. Any animals that react at a long distance may avoid the ship without being observed. Also, animals that show no avoidance may be undisturbed, but alternatively may be disturbed but have no avenue of escape in the ice (Richardson *et al.* 1995a).

Pinnipeds hauled out on ice often become more alert in the presence of noise from an approaching vessel. This alert response may be the only visible manifestation of disturbance, or it may be followed by avoidance (movement into the water) (Richardson *et al.* 1995a). Considering the likely avoidance of pinnipeds from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which ringed seals would be exposed to continuous noise sources, and if a vessel were to come near hauled out ringed seals, we would anticipate that ringed seals might engage in low-level avoidance behavior and short-term vigilance behavior.

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 we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with the 2013 SAE activities PR1 plans to permit would not be expected to appreciably reduce Arctic ringed seal’s likelihood of surviving or recovering in the wild.

Non-Airgun Impulsive Noise Sources

During the operation of pingers and transponders PR1 proposes to permit in the Beaufort Sea, NMFS estimated 17 instance of exposure during the open-water season (5 from a pinger source, and 12 from a transponder source) (see Section 2.4.2.2, *Exposure to Other Acoustic Sources*). Out of these total exposures during the open water season, NMFS would classify 0 instances where ringed seals 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 2.4.3.4.2, *Probable Responses to Other Acoustic Sources*).[30]

While the operation of pingers and transponders in the Beaufort Sea during the 2013 open water season is likely to expose some ringed 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 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 ringed seals 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 ringed seals in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the seismic operations or migrating through the seismic operations.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities PR1 plans to permit in the Beaufort Sea during the 2013 open water season, which use non-airgun acoustic sources, would not appreciably reduce the ringed seal's likelihood of surviving or recovering in the wild.

2.6.5.3 Ringed Seal Summary

Based on the evidence available, we conclude that the 3D seismic surveys being proposed by SAE, and permitted by PR1 in the Beaufort Sea during the 2013 open water season, are likely to cause disruptions in the behavioral ecology and social dynamics of individual Arctic ringed seals as a result of their exposure, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. As a result, the ringed seal's probable responses to close approaches by seismic and scout vessels and their probable exposure to active seismic sound are not likely to reduce the current or expected future reproductive success of ringed seals or reduce the rates at which they grow, mature, or become reproductively active. As a result, we do not expect the 3D seismic surveys being permitted by PR1 to affect the performance of the populations those ringed seals represent or the species those populations comprise. Accordingly, we do not expect those 3D seismic activities to appreciably reduce the Arctic ringed seal's

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[30] For the open-water season, behavioral harassment is not anticipated to occur until received levels are ≥170 dB.

likelihood of surviving or recovering in the wild.

2.6.6 Bearded Seal Risk Analysis

Based on the results of the exposure analyses, during the 2013 open waters season in the Beaufort, we would expect bearded seals to be exposed to low-frequency active seismic, vessel noise from transit, and other noise sources.

2.6.6.1 Probable Risk of Active Seismic to Bearded Seals

Bearded seals are anticipated to occur in the Chukchi Seas from summer to early fall (Heptner *et al.* 1976), but can occur year round particularly in the Chukchi Sea (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). They are anticipated to be present during seismic operations.

In our *Exposure Analysis* we estimated as many as 179 exposures could occur during the open-water season as a result of the low-frequency seismic activities PR1 proposes to permit (see Section 2.4.2.1, *Exposure to Active* Seismic). Out of these total exposures, NMFS would classify 1,725 instances during the open-water season where bearded seals might be exposed to sounds produced by seismic airguns at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 2.4.3.4.1, *Probable Responses to Exposure to Active Seismic*).[31]

These estimates represent the total number of exposures that could potentially occur at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment, not necessarily the number of individuals taken, as a single individual may be “taken” multiple times over the course of the season. We assume these take estimates are overestimates because they assume a uniform distribution of animals, do not account for avoidance or mitigation measures being in place, and they assume all of the tracklines will be shot during the season. In addition, large concentrations of ringed seals are not expected to be encountered near SAE’s proposed seismic survey areas in the northern Chukchi Sea during the summer and fall time period. These seals are generally found in association with the ice front that would be avoided during this project .

As we discussed in the narratives for cetaceans listed above, our consideration of probable exposures and responses of bearded seals to seismic stressors associated with the SAE exploration activities are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing bearded seals. Although the SAE seismic activities PR1 plans to permit during the 2013 open water season are likely to cause some individual bearded 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 bearded seals in ways or to a degree that would reduce their fitness because the seals are actively foraging in waters on and around the seismic operations, have their heads above water, or hauled out.

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[31] For the open-water season, behavioral harassment is not anticipated occur until received levels are ≥170 dB.

During the open water season (July through October) when the proposed activities would occur, 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). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007; Frost *et al.* 2008; Cameron and Boveng, 2009). 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 2011a). However, bearded seals are often spotted by PSOs during surveys so there is still the potential for exposure.

In addition, juveniles may be more susceptible to seismic activities because they have a tendency of remaining near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge (Burns 1981, Cameron *et al.* 2010).

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 2013b).

In most circumstances, bearded seals are likely to avoid certain ensonified areas that may cause TTS. 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.

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). The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like bearded seals. As a result, the bearded seal’s probable responses to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce the current or expected future reproductive success of bearded seals 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.

As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the SAE seismic activities PR1 plans to authorize during the open water season in 2013 are not likely to appreciably reduce the bearded seal's likelihood of surviving or recovering in the wild.

2.6.6.2 Probable Risk of Increased Non-Airgun Noise to Bearded Seals

Continuous Noise Sources

Our exposure analyses concluded that we would expect some instances in which bearded seals might be exposed to continuous noise sources (transiting vessels) associated with PR1's permitted activities in the Chukchi Sea. Bearded seals are anticipated to occur in the Beaufort and Chukchi Seas from summer to early fall (Heptner *et al.* 1976), but can occur year round,particularly in the Chukchi Sea (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). They are anticipated to be present during seismic operations.

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 (BOEM 2011a). Bearded seals in their spring migration north may encounter vessels transiting to the Chukchi Sea. In addition bearded seals are anticipated to be in the action area during the open water season. They 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). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007; Frost *et al.* 2008; Cameron and Boveng 2009). Again, these movements could overlap with vessels transiting out of the action area into overwintering locations.

Where choke points concentrate vessel traffic inside these areas threats to bearded seals will be greater, but the number of vessels, their proximity, and overall impact to seals will probably differ across spatial and temporal scales (Cameron *et al.* 2010). The Bering Strait area is where routes associated with the Northwest Passage (NWP) and Northern Sea Route (NSR) converge in an area used by bearded seals in the early spring for whelping, nursing, and mating (from April to May) and in the late spring for molting and migrating (from May to June). While the whelping, nursing, and mating period is anticipated to be outside the time period when the proposed action would occur, there is still overlap with the late spring molting and migrating periods. At this choke point there is currently close spatial overlap between ships and seals, but less so temporally (Cameron *et al.* 2010). However, this may change as diminishing ice in the spring transforms existing and potential shipping corridors, making those less prone to sporadic blockages during seals' whelping and nursing periods (Cameron *et al.* 2010).

Since bearded seals are benthic feeders, they generally associate with seasonal sea ice over shallow water of less than 200m (656 ft) (NMFS 2011). This overlaps with the depths the majority of SAE's seismic operations will occur at.

We assume that bearded seal vocalizations are partially representative of their hearing sensitivities (75 Hz-75 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[32]

Bearded seals appear to vocalize as a part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sound in water. This is important because most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003).

All ice-breeding pinniped species are known to produce underwater vocalizations (Richardson *et al.* 1995a; Van Opzeeland *et al.* 2008). Male bearded seals rely on underwater vocalizations to find mates. As background noise increases, underwater sounds are increasingly masked and uni-directional, deteriorate faster, and are detectable only at shorter ranges. Effects of vessel noise on bearded seal vocalizations have not been studied, though the frequency range of the predominant "trill" and "moan" calls (130 Hz-10.6 kHz and 130 Hz-1.3 kHz, respectively) that are broadcast during the mating season, partially overlap the range (20-300 Hz) over which ship noise dominates ambient noise in the oceans (Urick 1983, Cleator *et al.* 1989, Ross 1993, Risch *et al.* 2007, Tyack 2008). Vocalizations of the sympatric harp seal were shown to be completely masked by stationary ship noise at a distance of 2 km (Terhune *et al.* 1979), a finding supported by communication-range models for this species which predicted call masking and a significant loss of communication distances in noisy environments (Rossong and Terhune 2009).

Studies show that animals adapt to acoustic signals to compensate for environmental modifications to sound (Wilczynski and Ryan 1999). However, compensating for sound degradation – such as by delaying calling, shifting frequencies, moving to quitter areas, or calling louder, longer, and more frequently – incurs a cost (Tyack 2008). The cost of these adaptations, or that of missing signals, is inherently difficult to study in free-ranging seals and to date has not been measured in any phocid seal. Because bearded seals broadcast over distances of at least 30-45 km (Cleator *et al.* 1989), perhaps over 100s of kilometers (Stirling *et al.* 1983, Rossong and Terhune 2009), their calls are increasingly susceptible to background interference. The period of peak vocalization is during the breeding season (April to mid-June) (Cameron *et al.* 2010). The extent to which vessel traffic is localized near areas where bearded seals are mating, and the acoustic characteristics of the area, will determine the level that communication is disrupted. If vessels largely avoid areas of pack ice, where communication and mating occurs, or transit these areas outside the breeding season, effects are not expected to be as significant (Cameron *et al.* 2010). Based on the anticipated timing of operations for oil and gas projects in the Arctic, NMFS does not anticipate overlap with PR1's permitted activities and peak bearded seal vocalizations.

Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals to leave haulout locations and

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[32] A more in-depth description on bearded seal vocalizations is presented in sections 2.2.3.6 and 2.6.6.1 of this opinion.

enter the water (Richardson *et al.* 1995a), and could cause bearded seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne 1979; Mansfield 1983; Cameron *et al.* 2010). Due to the relationship between ice seals and sea ice, the reactions of seals to vessels activity are likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during open water conditions in the Beaufort and Chukchi Seas (BOEM 2011a). Only icebreakers and certain polar-class vessels are able to transit the typical pack-ice habitat of bearded seals (Cameron *et al.* 2010), which may reduce the risk of bearded seals encountering vessels when the seals are hauled out. However, juveniles may be more susceptible to vessel disturbance because they have a tendency of remaining near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge (Burns 1981, Cameron *et al.* 2010). During open water surveys in the Beaufort and Chukchi Seas (Harris, Miller, and Richardson 2001; Blees *et al.* 2010; and Funk *et al.* 2010) ringed and bearded seals showed slight aversions to vessels activity. The presence and movement of ships in the vicinity of some seals can affect their normal behavior (Jansen *et al.* 2010). Pups have a greater potential for heat loss than adults and so would be more prone to incur energetic costs of increased time in the water if vessel disturbance became a more frequent event. However, the potential for ship traffic to cause a mother to abandon her pup may be lower in bearded seals than in other phocids (Smiley and Milne 1979), as bearded seal mothers appear to exhibit a high degree of tolerance when approached by small boats.

Bearded seals are typically solitary animals and occur at low densities (Cameron *et al.* 2010), suggesting that if encounters with vessels were to occur, it would most likely only impact a small number of seals, reducing overall threats to whole populations. However, bearded seals aggregate during breeding and molting (April and August) in areas with ice favorable for hauling out (Cameron *et al.* 2010). Recent research suggests that bearded seals may exhibit fidelity to distinct areas and habitats during the breeding season (Van Parijs and Clark 2006). If vessels happened to overlap in space and time with bearded seal breeding and molting periods, there is the potential that a larger number of seals may be impacted.

For those individuals in the water, Funk *et al.* (2010) noted among operating vessels in the Chukchi Sea where received levels were <120 dB, 40% of observed seals showed no response to a vessel’s presence, slightly more than 40% swam away from the vessel, 5% swam toward the vessel, and 13% of seals were unidentifiable. This may indicate that even at levels lower than 120 dB, ice seals may respond with slight aversion to operating vessels.

However, ice seals are adapted to moving frequently to accommodate changing ice conditions so displacement due to a passing vessel is likely to be temporary and well within the normal range of ability for ice seals at this time of year.

Studies of the effects of low frequency sounds on elephant seals (*Mirounga* spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (LeBoeuf and Peterson 1969; Kastak and Schusterman 1996; Croll *et al.* 1999), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

Mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to bearded seals. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would enter into an area where they would suffer from acoustic harassment.

Bearded seals have been encountered during past oil and gas exploration activities in the Arctic and their reactions have been recorded by PSOs on board source vessels and monitoring vessels. These data indicate that seals tend to avoid oncoming vessels and active seismic arrays (NMFS 2011). As discussed in the *Probable Responses to Other Acoustic Sources* section 2.4.3.4.2, noise from the seismic source vessel is anticipated to travel the farthest of the continuous noise sources. While information from Funk *et al.* (2010), indicated that bearded seals may respond to noise levels below 120 dB, NMFS would anticipate that the maximum avoidance radius would be 3.4 km (2 mi) from a continuous noise source. As indicated above, bearded seals generally do not show disturbance reactions unless vessels and drilling noise were relatively close (0.93 km for icebreaking vessels) (Kanik *et al.* 1980, Richardson *et al.* 1995a). However, interpreting reactions of seals from vessels can be misleading. Any animals that react at a long distance may avoid the ship without being observed. Also, animals that show no avoidance may be undisturbed, but alternatively may be disturbed but have no avenue of escape in the ice (Richardson *et al.* 1995a).

Pinnipeds hauled out on ice often become more alert in the presence of noise from an approaching vessel. This alert response may be the only visible manifestation of disturbance, or it may be followed by avoidance (movement into the water) (Richardson *et al.* 1995a). Considering the likely avoidance of pinnipeds from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which bearded seals would be exposed to continuous noise sources, and if a vessel were to come near hauled out bearded seals, we would anticipate that bearded seals might engage in low-level avoidance behavior and short-term vigilance behavior.

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 we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with the SAE seismic activities PR1 plans to permit during the open water season in 2013 would not be expected to appreciably reduce the Beringia DPS of bearded seal’s likelihood of surviving or recovering in the wild.

Non-Airgun Impulsive Noise Sources

Our exposure analysis concluded that bearded seals were not likely to be exposed to non-airgun impulsive noise sources in the Beaufort Sea because of the directionality, short pulse duration, and small beam widths for pingers and transponders reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider discountable. Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of pinnipeds in the water, 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 acoustic sources including vessel noise. Many bearded seals would move away in response to the approaching 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 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 would further reduce or eliminate any potential effect on bearded seals.

As a result, the SAE seismic activities PR1 plans to permit in the Beaufort Sea during the 2013 open water season, which use non-airgun acoustic sources, would not appreciably reduce the bearded seal's likelihood of surviving or recovering in the wild.

2.6.6.3 Bearded Seal Summary

Based on the results of the exposure analysis, NMFS expects up to 179 instances of exposure involving bearded seals due to SAEs seismic activities. We expect this same number may be potentially harassed (taken) by these actions.

Based on the evidence available, we conclude that 3D seismic surveys proposed by SAE, and permitted by PR1 in the Beaufort Sea during the 2013 open water season, are likely to cause disruptions in the behavioral ecology and social dynamics of individual bearded seals as a result of their exposure, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. As a result, the bearded seal's probable responses to close approaches by seismic and scout vessels and their probable exposure to active seismic sound and noise from vessels are not likely to reduce the current or expected future reproductive success of bearded seals or reduce the rates at which they grow, mature, or become reproductively active. As a result, we do not expect the SAE seismic activities being permitted by PR1 to affect the performance of the populations those bearded seals represent or the species those populations comprise.

Accordingly, we do not expect those 3D seismic surveys to appreciably reduce the Beringia DPS of bearded seal's likelihood of surviving or recovering in the wild.

2.6.7 Western Steller Sea Lion Risk Analysis

The only stressor that was analyzed as part of our exposure analysis for western Steller sea lion was vessel traffic due to the potential for overlap in time and space with the species. However, our exposure analysis concluded that few Steller sea lions were likely to be exposed to vessel traffic associated with PR1's permitted activities in the Chukchi Sea because Steller sea lions occur only in the Bering Sea portion of the action area, and because of the small number and transitory nature of SAE's vessels, the protection zones around designated rookeries in the Bering Sea, the absence of collisions involving vessels and Steller sea lions, and the continued growth of the population near Dutch Harbor despite heavy traffic.

In our *Response Analysis* we discussed the early visual and acoustic warnings vessels provide, and the absence of recorded injury or mortality to Steller sea lions by vessel collision in the Bering Sea, which lead us to conclude that vessel strike is not a significant threat to the species. In addition the 3nm buffer zones around all designated Steller sea lion rookeries in the Bering Sea, and the NMFS guidelines for approaching marine mammals which discourages approaching any closer than 100 yards to sea lion haulouts, provides Steller sea lions with additional protections against vessel harassment. Despite the thousands of vessel transits that occur in and around rookery and haulout locations near Dutch Harbor, the Steller sea lion population in the area has been increasing at about 3% per year, indicating that vessel traffic has not been an impact.

Based on the evidence available, we concluded that while some Steller sea lions may be exposed to vessel traffic, this exposure is not likely to result in a response that would constitute take or result in the reduced fitness of those individuals being exposed. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual sea lions would not be likely to reduce the viability of the populations those individual sea lions represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

As a result, the 2013 SAE activities activities PR1 plans to permit would not appreciably reduce the western Steller sea lions' likelihood of surviving or recovering in the wild.

2.6.8 Risk to Critical Habitat for Western Steller Sea Lions

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether the proposed action is likely to reduce the value of designated critical habitat for the western Steller sea lion. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2).

NMFS designated critical habitat for the western DPS of SSL on August 27, 1993 (58 FR 45269). Designated critical habitat for Steller sea lions (both eastern and western DPSs) includes 1) a terrestrial zone that extends 3,000 ft (0.9 km) landward from the baseline or base point of each major rookery and major haulout, 2) an air zone that extends 3,000 ft (0.9 km) above the terrestrial zone, measured vertically from sea level, 3) an aquatic zone that extends 20 nm (37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144° W long, and 5) three special aquatic foraging areas in Alaska; the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area. (Specific coordinates for these protected areas can be found in the regulations at 50 CFR § 226.202). A number of haulouts, at least one rookery, and the Bogoslof foraging area- all fall within the action area (See Figure 4 and Figure 5).

Essential features of Steller sea lion critical habitat include the physical and biological habitat features that support reproduction, foraging, rest, and refuge, and include terrestrial, air and aquatic areas. Specific terrestrial areas include rookeries and haul-outs where breeding, pupping, refuge and resting occurs. The principal, essential aquatic areas are the nearshore waters around rookeries and haulouts, their forage resources and habitats, and traditional rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas.

Factors that influence the suitability of a particular area include substrate, exposure to wind and waves, the extent and type of human activities and disturbance in the region, and proximity to prey resources (Mate 1973).

As described in the *Status of Critical Habitat* section (2.2.4), the region near Dutch Harbor has large commercial ship traffic, local fishing fleets, tugs and barges, ferries, and other small vessels transiting in the area which overlap with SSL critical habitat. Despite a relatively high amount of traffic in the area, the preexisting stress regime for SSL critical habitat in the area seem relatively low, and the overall functioning of essential features in the action area appears to be high. Steller sea lions have maintained an active rookery at Cape Morgan which is within 20 nm of Dutch Harbor. In addition to this rookery, there are many haulout locations near Dutch Harbor (see Figure 5). Considering that the Steller sea lion population is increasing at about 3% per year in the Dutch Harbor area, vessel traffic doesn't appear to impact the breeding, feeding, or resting locations nearby.

This is perhaps in part due to the no transit zones for vessels within 3 nm of listed rookeries that was implemented under the ESA during the initial listing of the species as threatened under the ESA in 1990. These 3 nm buffer zones around all Steller sea lion rookeries west of 150°W were designed to prevent shooting of sea lions at rookeries. Today, these measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

Within the action area, SAE's vessels have the potential to transit through the 20nm aquatic zones around rookery and haulout areas, and the Bogoslof foraging area. However, the combination of the 3nm buffer zones around all rookeries, the guidelines for approaching marine mammals, and the standard mitigation measures which require PSOs on vessels and incorporate specified procedures for changing vessel speed and/or direction to avoid marine mammals should minimize the exposure of Steller sea lions and their critical habitat to vessel activities.

The potential effects to critical habitat essential features associated with exploration and leasing activities are described below.

1. Terrestrial Areas
    a. Rest - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.
    b. Refuge - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.
    c. Reproduction – No effect. Vessels are excluded from transiting within 3nm of rookeries.

2. Aquatic Areas
    a. Foraging – No effect. Vessels are not targeting Steller sea lions or their prey species and would only occur in the foraging areas for a short period of time while transiting.

3. Air zones – No effect

Based on our analyses of the evidence available, the quantity, quality, or availability of the essential features or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to vessel traffic associated with the SAE activities PR1 plans to authorize during the 2013 open water season. Vessel traffic is not likely to exclude western SSL from designated critical habitat, and if disturbance were to occur, it is anticipated to for a temporary period of time due to the transitory nature of vessels. In addition, the action area represents a small portion of the designated critical habitat for western SSL. We conclude that vessel traffic is not likely to destroy or adversely modify the designated critical habitat for western SSL.

2.7 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' biological opinion that the proposed action is not likely to jeopardize the continued existence of endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered humpback whale (*Megaptera novaeangliae*), endangered North Pacific right whale (*Eubalaena japonica*), endangered western Steller sea lion (*Eumatopias jubatus*) DPS, threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), or the threatened Beringia DPS of bearded seal (*Erignathus barbatus barbatus*), or destroy or adversely modify the western DPS of Steller sea lion's designated critical habitat.

2.8 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. As discussed above, the ESA does not define harassment. In this opinion and incidental take statement, we consider potential exposures to certain sound levels to constitute take under the ESA. Not all exposures, however, necessarily rise to the level of take. 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.).

To the extent the meaning of "take" can be construed differently under the MMPA and ESA, we generally rely on the IHA's take numbers as a proxy for the ESA take numbers. In this opinion, we present take estimates that are based on an exposure analysis similar to the draft IHA, but for which some estimates are slightly larger. Any such differences are not significant, and reflect the inherent imprecision in our ability to make such estimates. It is also important to note that this opinion's analysis of effects of the action considers all potential takes and is not confined to takes by harassment. In short, it considers all potential stressors associated with the action that may adversely affect listed marine mammals and their critical habitat, and it evaluates all potential reactions or consequences to those stressors.

We find this approach conservative for evaluating effects relative to the jeopardy standard under the ESA since the exposure estimates are likely over-estimates. 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 Marine Mammal Protection Act of 1972, as amended (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**. Absent such authorization, this statement is inoperative.

The terms and conditions described below are nondiscretionary. PR1 has a continuing duty to regulate the activities covered by this incidental take statement. In order to monitor the impact of incidental take, 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 PR1 (1) fails to require their permittees to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, 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.

2.8.1 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 (51 Fed. Reg. 19926, 19953-54 (June 3, 1986)). This biological opinion analyzes and this incidental take statement covers the take associated with PR1 permitting SAE's 3D seismic surveys associated with oil and gas exploration activities in federal waters of the Beaufort Sea during the 2013 open water season (July through October). The numbers of threatened or endangered species estimated to be taken by these activies are presented below. While PR1 did not include any takes of fin whales in its draft IHA, we included two takes of this species in our jeopardy analysis and ITS as a precaution in light of the acknowledged imprecision in predicting exposure events.

Bowhead whale – 177
Humpback whale – 2
Fin whale – 2
Ringed seal – 3,576
Bearded seal – 179

This project-specific section 7 consultation is consistent with the larger programmatic Arctic Regional Biological Opinion that was issued in April 2013. This 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 3D seismic operations. To estimate the number of animals that might be "taken" in this opinion, we estimate the numbers of whales and pinnipeds that are likely to be exposed and respond to low-frequency seismic airgun pulses,vessel approaches, and other project-related activities that are capable of causing behavioral changes that we would classify as "harassment."

For bowhead, fin, and humpback whales, 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." For this reason, the total instances of harassment for baleen whales only considered exposures at received levels ≥ 160 dB.

For ringed 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 120-169 dB would rise to the level of "take." For this reason, total instances of harassment for ringed and bearded seals only considered exposures at received levels ≥ 170 dB.

For purposes of this opinion, the endangered bowhead, fin, North Pacific right, and humpback whale are 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 annual take limit for any species covered by this opinion is exceeded in any year.

2.8.2 Effect of the Take

In the accompanying biological opinion, NMFS determined that the instances of exposure of endangered and threatened marine mammals to low-frequency seismic surveys associated with the 2013 SAE activities PR1 plans to authorize are not likely to jeopardize the continued existence of bowhead whales, fin whales, humpback whales, ringed seals, or bearded seals, and are not likely to adversely affect right whales or Steller sea lions in the action area. Further, NMFS determined that the Proposed Action is not likely to result in destruction or adverse modification of critical habitat for the western DPS of SSL or the North Pacific right whale.

Studies of marine mammals and responses to seismic transmissions and vessel noise have shown that bowhead whales, fin whales, and humpback whales, as well as ringed and bearded seals are likely to respond behaviorally upon hearing low-frequency seismic transmissions and vessel noise. Although the biological significance of those behavioral responses remains unknown, this consultation on SAE’s proposed 3D seismic surveys has assumed that exposure to seismic transmissions and vessel 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.

2.8.3 Reasonable and Prudent Measures (RPM)

The RPMs included below, along with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS concludes that the following RPMs are necessary and appropriate to minimize or to monitor the incidental take of bowhead whales, fin whales, and humpback whales 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, fin whales, humpback whales, ringed seals and bearded seals shall be by incidental harassment only. The taking by serious injury or death is prohibited and may result in the modification, suspension or revocation of the ITS.

3. PR1 shall implement measures to reduce the probability of exposing bowhead whales, fin whales, humpback whales, ringed seals and bearded seals to low-frequency seismic transmissions that will occur during the proposed activities during the open water season.

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

2.8.4 Terms and Conditions.

In order to be exempt from the prohibitions of section 9 of the ESA, 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 1.3.2 and 1.3.3 of this opinion, and reporting/monitoring requirements described in the MMPA permit.

Partial compliance with these terms and conditions may result in more take than anticipated, and invalidate this take exemption. These terms and conditions constitute no more than a minor change to the proposed action because they are consistent with the basic design of the proposed action.

To carry out RPM #1, PR1 or their permittee must undertake the following:

1. At all times when conducting seismic-related activities, PR1 shall require their permitted operators 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, PR1 or their permittees must undertake the following:

1. The taking of any marine mammal in a manner other than that described in this ITS must be reported immediately to NMFS AKR, Protected Resources Division at 907-586-7235.

To carry out RPM #3, BOEM and BSEE or their permittees must undertake the following:

1. Require sound source verification (SSV) tests for sound sources and vessels at the start of the season. Before conducting PR1 permitted activities, the operator (SAE) shall conduct SSV tests to verify the radii of the exclusion and monitoring zones within real-time conditions in the field, thus providing for more accurate radii to be used. The purpose of this mitigation measure is to establish and monitor more accurate safety zones based on empirical measurements, as compared to the zones based on modeling and extrapolation from different datasets. Using a hydrophone system, the vessel operator will be required to conduct SSV tests for all airgun arrays and vessels and, at a minimum, report the following results to NMFS within 14 days of completing the test:

    a. The empirical distances from the airgun array and other acoustic sources to broadband received levels of 190 dB down to 120 dB in 10 dB increments and the radiated sounds versus distance from the source vessel.

    b. Measurements made at the beginning of the survey for locations not previously modeled in the Chukchi Sea.

2. Require operators to calibrate their airgun array before beginning a survey in order to minimize horizontal propagation of the noise signal.

3. The 180 and 190 dB exclusion radii around operating airguns must be fully observed at all times.

To carry out RPM #4, PR1 or their permittees must undertake the following:

1. All mitigation measures as outlined in Section 1.3.2 and 1.3.3 of this biological opinion, or better or equivalent measures, must be implemented, as appropriate, upon issuance of an IHA under the MMPA.

2. SAE shall produce a weekly GIS application that would be available on the web for regulators to view for every observation and mitigation measure implemented.

To carry out RPM #5, PR1 or their lessees or permittees must undertake the following:

1. PR1 must consult weekly by telephone with Jon Kurland, or his designee, at the Juneau Office, Alaska Region, NMFS, at 907-586-7235, providing a status report on the appropriate reporting items, unless other arrangements for monitoring are agreed upon in writing. Status reports should also be emailed to Jon.Kurland@noaa.gov.

2. In the event that the specified activity causes a take of a marine mammal that results in a serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), or is otherwise not authorized by any MMPA permit issued for the activity, PR1's permittee shall immediately cease the specified activities and immediately report the incident to the Protected Resources Division, NMFS, Juneau office at 907-586-7012 and/or by email to Jon.Kurland@noaa.gov, Brad.Smith@noaa.gov, Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities. The report must include the following information:

   > Time, date, and location (latitude/longitude) of the incident; the name and type of the vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24hrs preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

   Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS AKR will work with NMFS PR1 and the permittee to determine what is necessary to minimize the likelihood of further prohibited take. The permittee may not resume their activities until notified by NMFS via letter, email, or telephone.

In the event that the permittee discovers an injured or dead ESA-listed marine mammal under NMFS' jurisdiction, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), the permittee will immediately report the incident to the Assistance Regional Administrator, Protected Resources Division, NMFS, at 907-586-7638, and/or by email to Jon.Kurland@noaa.gov, Brad.Smith@noaa.gov, Alicia.Bishop@noaa.gov, and the Alaska Regional Stranding Coordinator at 907-586-7248 and/or by email (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities. The report must include the same information identified in Condition 6 above. Activities may continue while NMFS AKR and PR1 review the circumstances of the incident. NMFS will work with the permittee to determine whether modifications in the activities are appropriate.

In the event that a PR1 authorized permittee discovers an injured or dead ESA-listed marine mammal under NMFS' jurisdiction, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 6 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the permittee shall report the incident to the Assistant Regional Administrator, Protected Resources Division, NMFS, at 907-586-7638, and/or by email to Jon.Kurland@noaa.gov, Brad.Smith@noaa.gov, Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 and/or by email (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities within 24 hours of the discovery. The permittee shall provide photographs or video footage (if available) or other documentation of the stranded animal sightings to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

3. Submit a draft project specific report that analyzes and summarizes all of the PR1 authorized activities SAE conducted during the 2013 open water season (July through October) 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 February of the following year. This report must contain the following information:

    a. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort Sea State and wind force), and associated activities during all seismic operations, and dynamic positioning activities and NMFS' ESA-listed marine mammal sightings;

    b. Species, number, location, distance from the vessel, and behavior of any ESA-listed marine mammals, associated with seismic activity (number of power-downs and shut-downs), or associated with dynamic positioning activity observed throughout all monitoring activities;

    c. An estimate of the instances of exposure (by species) of NMFS' ESA-listed marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1μPa (rms), 170 dB re 1 μPa (rms), 180 dB re 1 μPa (rms) and 190 dB re 1 μPa (rms) for cetaceans and pinnipeds with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed to the seismic activity at received levels between 160 dB re 1 μPa (rms) and ≥190 dB μPa (rms) for all listed marine mammals with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed;

d. The report should clearly compare authorized takes (as identified in the ITS of this opinion) to the level of actual estimated takes ("take" being defined as an ESA-listed mysticete receiving seismic pulses at ≥ 160 dB re 1 μPa (rms), or an ESA-listed pinniped receiving seismic pulses at ≥ 170 dB re 1 μPa (rms)).

e. 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.

f. A description of the implementation and effectiveness of the: (A) terms and conditions of the biological opinion's Incidental Take Statement (ITS) For the biological opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe the effectiveness, for minimizing the adverse effects of the action on ESA-listed marine mammals.

2.9. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Request PR1 authorized operators to alter speed or course during transit operations if a marine mammal, based on its position and relative motion, appears likely to intersect with the transect of the vessels;

2. Request PR1 authorized operators to avoid vessel transits within designated eastern North Pacific right whale critical habitat. If transit within critical habitat cannot be avoided, request PR1 authorized operators to exercise extreme caution and use slow safe speeds (10 knots or under), while within critical habitat;

3. Request PR1 authorized operators to conduct vessel transits through eastern North Pacific right whale critical habitat only during daylight hours and periods of good visibility, to

the extent practicable;

4. Request PR1 authorized operators transiting through eastern North Pacific right whale critical habitat to have active PSO observers. PSOs would increase vigilance and allow for reasonable and practicable actions to avoid collision with eastern North Pacific right whales;

5. Request PR1 authorized operators maneuver vessels to keep at least 460 m (1,500 ft) away from any observed eastern North Pacific right whale, and avoid approaching whales head-on, consistent with vessel safety. Vessels should take reasonable steps to alert other vessels in the vicinity of the whale(s);

6. Request operators to use real-time passive acoustic monitoring while in migratory corridors and other sensitive areas to alert ships to the presence of whales, primarily to reduce the ship strike risk.

7. Cumulative Impact Analysis – NMFS PR1 should work with BOEM and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, and other marine mammals. This analysis includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species;

In order to keep NMFS Protected Resources Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, PR1 should notify NMFS AKR of any conservation recommendations they implement in their final action.

2.10 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded in any given year for the duration of this opinion, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

3. 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.

3.1 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.

3.2 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.

3.3 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.

4. REFERENCES

Aerts, L., M. Blees, S. Blackwell, C. Greene, K. Kim, D. Hannay and M. Austin. 2008. Marine mammal monitoring and mitigation during BP Liberty OBC seismic survey in Foggy Island Bay, Beaufort Sea, July-August 2008: 90-day report. LGL Rep. P1011-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., Greeneridge Sciences Inc. and JASCO Research Ltd. for BP Exploration Alaska.

Aerts, L.A.M. and W.J. Richardson (eds). 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2007: Annual Summary Report. LGL Rep. P1005b. Rep. from LGL Alaska Research Associates (Anchorage, AK), Greeneridge Sciences Inc. (Santa Barbara, CA) and Applied Sociocultural Research (Anchorage, AK) for BP Exploration (Alaska) Inc., Anchorage, AK.

Allen, B. M., and R. P. Angliss. 2011. Alaska marine mammal stock assessments, 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC- 223, 292 p.

Allen, B. M., and R. P. Angliss. 2012. Alaska marine mammal stock assessments, 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC- 234, 288 p.

Ashjian, C.J., S.R. Braund, R.G. Campbell, J.C. George, J. Kruse, W. Maslowski, S.E. Moore, C.R. Nicolson, S.R. Okkonen, B.F. Sherr, E.B. Sherr and Y.H. Spitz. 2010. Climate Variability, Oceanography, Bowhead Whale Distribution, and Iñupiat Subsistence Whaling near Barrow, Alaska. *Arctic 63*(2). June 2010. pp. 179–194.

Au, W.W.L., and Moore PWB. 1988. Detection of Complex Echoes in Noise by an Echolocating Dolphin. J. Acoust. Soc. Am. 83: 662-668.

Au, W.W.L., and Moore PWB. 1990. Critical Ratio and Critical Bandwidth for the Atlantic Bottlenose Dolphin. J. Acoust. Soc. Am. 88: 1635-1638.

Beland, J. and D. Ireland. 2010. Marine mammal monitoring and mitigation during a marine geophysical survey in the Arctic Ocean, August–September 2010: 90-day Report. LGL Rep. P1123-1. Rep. from LGL Alaska Research Assoc. Inc., Anchorage, AK, for U.S. Geological Survey, Menlo Park, CA, Nat. Mar. Fish. Serv., Silver Spring, MD, and U.S. Fish & Wildl. Serv., Anchorage, AK. 55 p plus Appendices.

Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July–November 2012: Draft 90-Day Report. Editors: D.W. Funk, C.M. Reiser, and W.R. Koski. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc, Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 266 pp, plus appendices.

Blane, J. M. and R. Jaakson (1994). "The impact of ecotourism boats on the St. Lawrence beluga whales." Environmental Conservation **21**(3): 267-269.

BOEM (Bureau of Ocean Energy Management, U.S. Department of Interior). 2011. Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas. Alaska Outer Continental Shelf. September 2011.

BP Exploration (Alaska), Inc. 2011. Incidental Harassment Authorization Request for the Non-Lethal Harassment of Whales and Seals During the Simpson Lagoon OBC Sesimic Survey, Beaufort Sea, Alaska, 2012. Prepared by Lama ecological, and OASIS Environmental. December 5, 2011. 108pp.

Braham, H. W. 1984. The bowhead whale, *Balaena mysticetus*. Mar. Fish. Rev. 46(4):45-53.

Brandon, J., and P. R. Wade. 2004. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG20). 32 pp.

Brandon, J.R, T. Thomas, and M. Bourdon. 2011. Beaufort Sea aerial survey program results. (Chapter 6) In: Reiser, C.M, D.W. Funk, R. Rodrigues, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc. in the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report. LGL Rep. P1171E–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC for Shell Offshore Inc., Houston, TX, Nat. Mar. Fish. Serv., Silver Spring, MD, and U.S. Fish and Wild. Serv., Anchorage, AK. 240 pp, plus appendices.

Bratton, G.R., C.B. Spainhour, W. Flory, M. Reed, K. Jayko. 1993. Presence and Potential Effects of Contaminants. In: *The Bowhead Whale.* J.J. Burns, J.J. Montague & C.J. Cowles, eds. Special Publication Number 2, The Society for Marine Mammalogy, Lawrence, KS. pp. 631-744.

Cameron, M.F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (*Erignathus barbatus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-211, 246 p.

Carlson, T.J. 1994. Use of sound for fish protection at power production facilities: A historical perspective of the state of the art. Phase I Final Report: Evaluation of the use of sound to modify the behavior of fish. DOE/BP-62611-4. Prepared for U.S. Department of Energy; Bonneville Power Administration; Environment, Fish, and Wildlife.

Carroll, G.M., J.C. George, L.F. Lowry, and K.O. Coyle. 1987. Bowhead Whale (Balaena mysticetus) Feeding Near Point Barrow, Alaska during the 1985 Spring Migration. Arctic 40:105-110

Chamberlin, D.W. 1991. Effects of nonexplosive seismic energy releases on fish. Am. Fish. Soc. Symposium 11:22-25, 1991.

Christie, K., C. Lyons, W.R. Koski, D.S. Ireland, and D.W. Funk. 2009. Patterns of bowhead whale occurrence and distribution during marine seismic operations in the Alaskan Beaufort Sea. Page 55 *in* Abstracts of the 18th Biennial Conference on the Biology of Marine Mammals, 12-16 October 2009, Québec City, Canada.

Citta, J.J., L.T. Quakenbush, J.C. George, R.J. Small, M.P. Heide-Jørgensen, H. Brower, B. Adams, and L. Brower. 2012. Winter movements of bowhead whales (*Balaena mysticetus*) in the Bering Sea. Arctic 65(1):13–34.

Clark, C.W. and J.H. Johnson. 1984. The sounds of the Bowhead Whale, *Balaena mysticetus*, during the spring migrations of 1979 and 1980. *Canadian Journal of Zoology 62*:1436-1441.

Clark, C. W., and K. M. Fristrup. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. (Balaenoptera musculus, Balaenoptera physalus). Report of the International Whaling Commission 47:583-600.-Sc/48/Np18).

Clark, C. W., and R. A. Charif. 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997.

Clark, C. W., Borsani, J. F., and Notarbartolo-Di-sciara, G. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Marine Mammal Sci. 18, 286–295.

Clark, C.W., and G. J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics (USN) 52(3):48.

Clark, C. W., and Gagnon, G. C. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales, IWC/SC/58/E9. Submitted to Scientific Committee, International Whaling Commission. 9 pp, available from the Office of the Journal of Cetacean Research and Management.

Clark C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and M. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implications: Marine Ecology Progress Series, v. 395, p. 301-322.

Clarke *et al.* 2011a. Aerial surveys of endangered whales in the Beaufort Sea, Fall 2009. Final Report, OCS Study BOEMRE 2010-040. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke *et al.* 2011b. Aerial surveys of endangered whales in the Beaufort Sea, Fall 2006-

2008. Final Report, OCS Study BOEMRE 2010-042. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke *et al.* 2011c. Aerial surveys of endangered whales in the Beaufort Sea, Fall 2010. Final Report, OCS Study BOEMRE 2011-035. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke *et al.* 2011d. Chukchi Offshore Monitoring in Drilling Area (COMIDA) distribution and elative abundance of marine mammals: aerial surveys. Final Report, OCS Study BOEMRE 2011-06. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2012. Distribution and Relative Abundance of Marine Mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Annual Report, OCS Study BOEM 2012-009. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Cosens, S.E., H. Cleator, and P. Richard. 2006. Numbers of bowhead whales (*Balaena mysticetus*) in the Eastern Canadian Arctic, based on aerial surveys in August 2002, 2003 and 2004. Unpubl. paper submitted to the Scientific Committee of the Int. Whal. Comm. June 2006 (SC/58/BRG7). 19 pp.

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz.

Crowley, T. J. 2000. Causes of climate change over the past 1000 years. Science 289(5477):270-277.

Cudahy, E., and W. T. Ellison. 2002. A review of the potential for *in vivo* tissue damage by exposure to underwater sound. Department of the Navy, Naval Submarine Medical Research Laboratory.

Cummings, W.C., D.V. Holliday and B.J. Lee. 1984 [publ. 1986]. Potential impacts of man-made noise on ringed seals: Vocalizations and reactions. Outer Cont. Shelf Environ. Assess. Program, Final Rep. Princ. Invest., NOAA, Anchorage, AK 37:95-230. 693. OCS Study MMS 86-0021; NTIS PB87-107546.

Cummings, W.C., D.V. Holliday, W.T. Ellison and B.J. Graham. 1983. Technical feasibility of passive acoustic location of bowhead whales in population studies off Point Barrow, Alaska. T-83-06-002. Rep. from Tracor Appl. Sci., San Diego, CA, for North Slope Borough, Barrow, AK. 169p.

Cummings, W.C. and D.V. Holliday. 1987. Sounds and source levels from bowhead whales off Pt. Barrow, Alaska. *J. Acoustical Society of America 78*:1163-1169.

Curran, M. A. J., T. D. v. Ommen, V. I. Morgan, K. L. Phillips, and A. S. Palmer. 2003. Ice core evidence for Antarctic sea ice decline since the 1950s. Science 302(5648):1203-1206.

Davis, R., and W. Koski. 1980. Recent observations of the bowhead whale in the eastern Canadian high Arctic. Rep. Int. Whaling Comm. 30:439-444.

Davis, R.A. and C.I. Malme. 1997. Potential effects on ringed seals of ice-breaking ore carriers associated with the Voisey's Bay nickel project. LGL Report No. TA2147-1. Rep. by LGL Limited for Voisey's Bay Nickel Company Limited.

Delarue, J., Todd, S. K., Van Parijs, S. M., and Di Iorio, L. 2009. Geographic variation in Northwest Atlantic fin whale *Balaenoptera physalus* song: Implications for stock structure assessment. J. Acoust. Soc. Am. 125, 1774–1782.

Delarue, J., D.K. Mellinger, D.M. Stafford, and C.L. Berchok. 2010. Where do the Chukchi Sea fin whales come from? Looking for answers in the structure of songs recorded in the Bering Sea and western north Pacific. *J. Acoust. Soc. Am. 127*(3):1758.

Delarue J, Laurinolli M, Martin B. 2011. Acoustic detections of beluga whales in the northeastern Chukchi Sea, July 2007 to July 2008. Arctic 64:15-24.

Department of Fisheries and Oceans, Canada (DFO). 2004. Review of scientific information on impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. Dept. Fisheries and Oceans Canada. Habitat Status Rep. 2004/002.

Department of the Navy. 2001. Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. January.

Di Lorio, L. 2005. Methods to study communication in whales. Cognition, Brain, Behavior 9(3):583-597.

Di Lorio L, Clark CW. 2009. Exposure to seismic survey alters blue whale acoustic communication. Biol. Lett. doi: 10.1098/rsbl.2009.0651.

Dorst, L. 2010. Side-scan Sonar. *Hydro International 14*(9). http://www.hydro-International.com/productsurvey/id30-Sidescan_Sonar,_NovemberDecember.html.

Ellison, W.T., C.W. Clark, and G.C. Bishop.1987. Potential Use of Surface Reverberation by Bowhead Whales, *Balaena mysticetus*, in Under-ice Navigation: Preliminary Considerations. *Report of the International Whaling Commission 37*: 329-332.

Engås, A., S. Løkkeborg, E. Ona, and A. Vold Soldal. 1993. Effects of seismic shooting on catch and catch-availability of cod and haddock. Havforskningsinsituttet Institute of Marine Research. Fisken Og Havet, 9-1993. 117 p.

Erbe, C. 2002a. Hearing Abilities of Baleen Whales. Report CR 2002-065. Ottawa, Ont., Canada: Defense Research and Development Canada.

Erbe, C. 2002b. Underwater noise of whale-watching boats and potential effects on killer whales (Orcinus orca), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Evans, P. G. H., P. J. Canwell and E. Lewis. (1992). "An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales." European Research on Cetaceans **6**: 43-46. Proceedings of the Sixth Annual Conference of the European Cetacean Society, San Remo, Italy, 20-22 February.

Evans, P. G. H., Q. Carson, P. Fisher, W. Jordan, R. Limer and I. Rees. (1994). "A study of the reactions of harbour porpoises to various boats in the coastal waters of southeast Shetland." European Research on Cetaceans **8**: 60-64.

Evans, W. E. (1992). "Wood,Forrest,Glenn 1919-1992." Marine Mammal Science **8**(3): 324-325.

Frankel, A. S. and C. W. Clark (1998). "Results of low-frequency playback of M-sequence noise to humpback whales, *Megaptera novaeangliae,* in Hawai'i." Canadian Journal of Zoology-Revue Canadienne De Zoologie **76**(3): 521-535.

Finley, K.J. 1990. Isabella Bay, Baffin Island: An Important Historical and Present-day Concentration Area for the Endangered Bowhead Whale (*Balaena mysticetus*) of the Eastern Canadian Arctic. *Arctic 43*(2): 137-152.

Frankel, A. S. 1994. Acoustic and visual tracking reveals distribution, song variability and social roles of humpback whales in Hawaiian waters. (*Megaptera novaeangliae*). University of Hawaii, Manoa, HI. 142p.

Frankel, A.S. 2005. Gray whales hear and respond to a 21–25 kHz high-frequency whale-finding sonar. Page 97 *in* Abstracts of the 16th Biennial Conference on the Biology of Marine Mammals, 12-16 Dec. 2005, San Diego, CA.

Frankel, A. S., and C. W. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, Megaptera novaeangliae, in Hawai'i. Canadian Journal of Zoology-Revue Canadienne De Zoologie 76(3):521-535.

Frankel, A. S., and C. W. Clark. 2000. Behavioral responses of humpback whales (Megaptera novaeangliae) to full-scale ATOC signals. Journal of the Acoustical Society of America 108(4):1930-1937.

Frost, K.J., L.F. Lowry, J.R. Gilbert, and J.J. Burns. 1988. Ringed Seal Monitoring: Relationships of Distribution and Abundance to Habitat Attributes and Industrial Activities. OCS Study MMS 89-0026. Anchorage, AK: USDOI, MMS, Alaska OCS Region, pp. 345-455.

Frost, K.J., L.F. Lowry, G. Pendleton, and H.R. Nute. 2002. Monitoring distribution and abundance of ringed seals in northern Alaska. OCS Study MMS 2002-043. Final Rep. prepared by State of Alaska Department of Fish and Game, Juneau, AK, for U.S. Department of Interior, Minerals Management Service, Anchorage, AK. 66 p. + Appendices.

Gausland, I. 2003. Seismic Surveys Impact on Fish and Fisheries. Report for Norwegian Oil Industry Association (OLF). Stavanger, March 2003. 41 p.

George, J.C., J. Bada, J.E. Zeh, L. Scott, S.E. Brown, T. O'Hara, and R.S. Suydam. 1999. Age and Growth Estimates of Bowhead Whales (*Balaena mysticetus*) via Aspartic Acid Racemization. *Canadian Journal of Zoology 77*(4):571-580.

George, J.C., C. Clark, G.M. Carroll, and W.T. Ellison. 1989. Observations on the Ice-Breaking and Ice Navigation Behavior of Migrating Bowhead Whales (Balaena mysticetus) near Point Barrow, Alaska, Spring 1985. *Arctic 42*(1):24-30.

George, J. C., C. Nicolson, S. Drobot, J. Maslanik, and R. Suydam. 2006. Sea ice density and bowhead whale body condition preliminary findings. Poster presented to the Society for Marine Mammalogy, San Diego, CA.

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R.S. Suydam. 1994. Frequency of Killer Whale (*Orcinus orca*) Attacks and Ship Collisions Based on Scarring on Bowhead Whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas Stock. *Arctic 47*(3):247-255.

George, J. C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of western arctic bowhead whales surveyed near Barrow, Alaska. Mar. Mammal Sci. 20:755-773.

Geraci, J.R., D.M. Anderson, R.J. Timperi, D.J. St. Aubin, G.A. Early, J.H. Prescpott, and C.A. Mayo. 1990. Humpback whales (Megaptera novaeangliae) fatally poisoned by dinoflagellate toxin. *Can J. Fish and Aquat. Sci. 46*(11):1895-1898.

Goodwin, L. and P. A. Cotton (2004). "Effects of boat traffic on the behaviour of bottlenose dolphins (*Tursiops truncatus*)." Aquatic Mammals 30(2): 279-283.

Green, G. 2013a. Response to request for information on the number and location of crew changes and resupply activities. Communication to Alicia Bishop (NMFS) from Gregory Green (SAE), 6/11/2013.

Greene, C.R., Jr. 1995. Chapter 5: Ambient Noise. In Marine Mammals and Noise. W.J.

Richardson, C.R. Greene Jr., C.I. Malme and D.H. Thomson, eds. San Diego, CA: Academic Press. pp. 87-100.

Greene, C.R., Jr. and S.E. Moore. 1995. Chapter 6: Man-made noise. In W.J. Richardson, C.R. Greene Jr., C.I. Malme, and D.H. Thomson (eds.). 1995. Marine Mammals and Noise. San Diego, CA: Academic Press. pp. 101-158.

Greene, C.R. Jr. and W.J. Richardson. 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. *J. Acoust. Soc Am. 83*(6):2246-2254.

Green, G.A., and S. Negri. 2005. Marine Mammal Monitoring Program: FEX Barging Project, 2005. Unpublished report prepared for ASRC Lynx Enterprises, Inc., Anchorage, Alaska, by Tetra Tech EC, Inc., Bothell, Wash.

Green, G.A., K. Hashagen, and D. Lee. 2007. Marine mammal monitoring program, FEX barging project, 2007. Report prepared by Tetra Tech EC, Inc., Bothell, WA, for FEX L.P., Anchorage, AK.

Guan, S. 2013. Response to Request for Additional Information for the ESA Section 7 Consultation. Communication to Alicia Bishop (NMFS) from Shane Guan (NMFS), 5/08/2013.

Harris, R.E., G.W. Miller and W.J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. *Mar. Mamm. Sci.* 17(4):795-812.

Hartin K.G., L.N. Bisson, S.A. Case, D.S. Ireland, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during site clearance and geotechnical surveys by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2011: 90-day report. LGL Rep. P1193. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 202 pp, plus appendices.

Hastings, M.C. and A.N. Popper. 2005. Effects of Sound on Fish. Subconsultants to Jones & Stokes under California Department of Transportation Contract No. 43A0139. August 23.

Hauser, D.D.W., V.D. Moulton, K. Christie, C. Lyons, G. Warner, C. O'Neill, D. Hannay, and S. Inglis. 2008. Marine mammal and acoustic monitoring of the Eni/PGS open-water seismic program near Thetis, Spy and Leavitt islands, Alaskan Beaufort Sea, 2008: 90-day report. LGL Rep. P1065-1. Rep. from LGL Alaska Research Associates Inc. and JASCO Research Ltd., for Eni US Operating Co. Inc., PGS Onshore, Inc., Nat. Mar. Fish. Serv., and U.S. Fish & Wildlife Serv. 180 p.

Hildebrand, J. 2004. *Sources of anthropogenic sound in the marine environment*. Technical Report, Report to the Policy on Sound and Marine Mammals: An International Workshop. U.S. Marine Mammal Commission and Joint Nature Conservation Committee, UK. London, England. http://www.mmc.gov/sound/internationalwrkshp/pdf/hildebrand.pdf .

Horner, G. 2013. Response to request for confirmation on the anticipated source levels and frequency ranges for Shell's equipment for the 2013 open-water season. Communication to Shane Guan (NMFS) from G. Horner (Shell), 4/18/2013.

Houghton, J. 2001. The science of global warming. Interdisciplinary Science Reviews 26(4):247-257.

HydroSurveys. 2008. Side-scan Sonar Systems. Hydro International. http://www.hydro-international.com/files/productsurvey_v_pdfdocument_23.pdf

ION Geophysical. 2012. Request by ION Geophysical for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Seismic Survey in the Arctic Ocean, October-December 2012. LGL Document P1236-1. Application prepared by LGL Alaska Research Associates Inc., LGL Ltd., for NMFS. February. 166pp.

IPCC. 2001. Climate Change 2001: Working Group II: Impacts, Adaptation and Vulnerability. J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, and K. S. White, editors. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland. 104 p.

Ireland, D.S., R. Rodrigues, D. Funk, W. Koski, D. Hannay. (eds.) 2009. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–October 2008: 90-day report. LGL Rep. P1049-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore Inc, Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 277 pp, plus appendices.

IWC. 1992. Chairman's Report of the forty-third annual meeting. Rep. Int. Whal. Comm. 42:11-50.

Kelly, B. P., J. L. Bengtson, P. L. Boveng, M. F. Cameron, S. P. Dahle, J. K. Jansen, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder 2010. Status review of the ringed seal (*Phoca hispida*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-212, 250 p.

Kenney, R.D., M.A.M. Hyman, R.E. Owen, G.P. Scott, and H.E. Winn. 1986. Estimation of prey densities required by western North Atlantic right whales. *Mar. Mammal Sci. 2*(1):1-13.

Kingsley, M.C.S. 1986. Distribution and Abundance of Seals in the Beaufort Sea, Amundsen Gulf, and Prince Albert Sound, 1984. Environmental Studies Revolving Funds Report No. 25. 16 pp.

Koomans, R. 2009. Single-beam Echosounders. Hydro International. 13(5):46-53.

Laban, C., C. Mesdag, and J. Boers. 2009. Single-channel high-resolution seismic systems. *Hydro International. 13*(8):46-50.

Laidre, K.L. M. P. Heide-Jorgensen, and T.G. Nielsen. 2007. Role of the bowhead whale as a predator in West Greenland. *Marine Ecology Progress Series 346*:285-297.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science. 17: 35-75.

LAMA Ecological/OASIS Environmental. 2011. Incidental Harassment Authorization Request for the Non-lethal Harassment of Whales and Seals during the Simpson Lagoon OBC Seismic Survey, Beaufort Sea, Alaska, 2012.

Ljungblad DK, Moore SE, Clarke TJ, Bennett JC. 1986. Aerial surveys of endangered whales in the Northern Bering, Eastern Chukchi and Alaskan Beaufort Seas, 1985: with a seven year review, December 2011 Effects of Oil and Gas Activities in the Arctic Ocean Draft Environmental Impact Statement 7-64 References 1979-85. OCS Study, MMS 86-0002. NOSC Technical Report 1111. Anchorage, AK; USDOI, MMS, Alaska OCS Region. 142 p.

Ljungblad, D.K., S.E. Moore, J.T. Clarke, and J.C. Bennett. 1987. Distribution, Abundance, Behavior, and Bioacoustics of Endangered Whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-86. OCS Study, MMS 87-0039. NOSC Technical Report 1177. NOSC, San Diego, CA for USDOI, MMS, Alaska OCS Region, Anchorage, AK. 187 pp.

Ljungblad DK, Moore SE, Clarke TJ, Bennett JC. 1988. Distribution, Abundance, Behavior and Bioacoustics of Endangered whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-87. Final Report: OSC Study MMS-87-0122. Minerals Management Service, Alaska OCSRegion, Anchorage Alaska.

Lowry, L.F. 1993. Foods and Feeding Ecology. In: The Bowhead Whale Book, J.J. Burns, J. J. Montague and C. J. Cowles, eds. Special Publication of the Society for Marine Mammalogy, 2. Lawrence, KS: The Society for Marine Mammalogy, pp. 201-238.

Lowry, L. F., K. J. Frost, and J. J. Burns. 1980. Variability in the diet of ringed seals, *Phoca hispida*, in Alaska. Canadian Journal of Fisheries and Aquatic Sciences 37:2254-2261.

Lowry, L.F. and K.J. Frost. 1984. Foods and Feeding of Bowhead Whales in Western and Northern Alaska. Scientific Reports of the Whales Research Institute 35 1-16. Tokyo, Japan.

Lowry, L.F., K.J. Frost, and K.W. Pitcher. 1994. Observations of Oiling of Harbor Seals in Prince William Sound. Pages 209-225 in T. R. Loughlin, ed. Marine Mammals and the Exxon Valdez. Academic Press, Inc., San Diego, CA.

Lowry, L.F., G. Sheffield and J.C. George. 2004. Bowhead whale feeding in the Alaskan Beaufort Sea, based on stomach contents analyses. *Journal of Cetacean Research Management 6*:215–223.

Lusseau, D. (2003). "Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts." Conservation Biology **17**(6): 1785-1793.

Melcón M.L., Cummings A.J., Kerosky S.M., Roche L.K., Wiggins S.M., et al. 2012. Blue Whales Respond to Anthropogenic Noise. PLos ONE 7(2): e32681. Doi: 10.1371/journal.pone.0032681.

McCarthy, J.J., O. Canziani, N.A. Leary, D.J. Dokken and K.S. White (editors). 2001. Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom.

McCauley, R.D., J. Fewtrell, and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. J. Acoust. Soc. Am. 113 (1).

Mitchell, E.D., and R.R. Reeves. 1981. Catch history and cumulative catch estimates of initial population size of cetaceans in the eastern Canadian Arctic. Rep. Int. Whaling Comm. 31: 645-682.

MMS (Mineral Management Service). 2002. Liberty Development and Production Plan, Final Environmental Impact Statement. OCS EIS/EA, MMS 2002-019. Anchorage, AK: USDOI, MMS, Alaska OCS Region, 3 Vols.

MMS. 2003. Final Environmental Impact Statement Beaufort Sea Planning Area Sale 186, 195, and 202 Oil and Gas Lease Sale. OCS EIS/EA MMS 2003-001. Anchorage, AK: USDOI, MMS, Alaska OCS Region.

MMS. 2008. Beaufort Sea and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft EIS. OCS EIS/EA MMS 2008-055. Alaska OCS Region, Anchorage, AK.

MMS. 2009a. Environmental Assessment: Shell Offshore, Inc. 2010 Outer Continental Shelf Lease Exploration Plan Camden Bay, Alaska. OCS EIS/EA MMS 2009-052. Anchorage, AK: USDOI, MMS, Alaska OCS Region.Alaska OCS Region, Anchorage, AK.

MMS. 2009b. Environmental Assessment: Shell Gulf of Mexico, Inc. 2010 Exploration Drilling Program, Burger, Crackerjack, and SW Shoebill Prospects, Chukchi Sea Outer Continental Shelf, Alaska. OCS EIS/EA MMS 2009-061. Anchorage, AK: USDOI, MMS, Alaska OCS Region.Alaska OCS Region, Anchorage, AK.

Mocklin, J. A. 2009. Evidence of bowhead whale feeding behavior from aerial photography. AFSC Processed Rep. 2009-06, 118 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., Seattle WA 98115.

Moore P.W.B., Pawloski D.A. 1990. Investigations on the Control of Echolocation Pulses in the Dolphin (*Tursiops truncatus*). p. 305-316. In: J.A. Thomas, and R.A. Kastelein (eds.). Sensory Abilities of Cetaceans/Laboratory and Field Evidence. Plenum Press, New York.

Moore, S.E. 1992. Summer Records of Bowhead Whales in the Northeastern Chukchi Sea. *Arctic 45*(4):398-400.

Moore, S. E., and D. P. DeMaster. 2000. North Pacific right whale and bowhead whale habitat study: R/V *Alpha Helix* and CGC *Laurier* Cruises, July 1999. Annual Report. 3p.

Moore, S.E,. J.C. George, G. Sheffield, J. Bacon, and C. J. Ashijan, 2010. Bowhead Whale Distribution and Feeding near Barrow, Alaska, in the late summer 2005-06. *Arctic 63*(2):195-205.

Moore, S.E. and H.P. Huntington. 2008. Arctic Marine Mammals and Climate Change: Impacts and Resilience. Ecological Applications 18(2), Supplement: Arctic Marine Mammals and Climate Change, pp. S157-S165.

Moore, S.E. and K.R Laidre. 2006. Trends in sea ice cover within habitats used by bowhead whales in the western arctic. *Ecol. Appl. 16*(3):932–944.

Moore, S. E., and R.R. Reeves. 1993. Distribution and movement. Pp. 313-386 *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Moore, S.E., R.R. Reeves, B.L. Southall, T.J. Ragen, R.S. Suydam, and C.W. Clark. 2012. A New Framework for Assessing the Effects of Anthropogenic Sound on Marine Mammals in a Rapidly Changing Arctic. *BioScience* 2012 62(3): 289-295.

Moore, M., Steiner, L., and Jann, B. 2003. Cetacean surveys in the Cape Verde Islands and the use of cookie-cutter shark bite lesions as a population marker for fin whales. *Aquatic Mammals* 29**:** 383–389.

Moore, S. E., J. M. Waite, N. A. Friday and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Progr. Oceanogr. 55(1-2):249-262.

Moore, S. E., J. M. Waite, L. L. Mazzuca, and R. C. Hobbs. 2000. Provisional estimates of mysticete whale abundance on the central Bering Sea shelf. J. Cetacean Res. Manage. 2(3):227-234.

Moshenko, R.W., S.E. Cosens and T.A. Thomas. 2003. Conservation Strategy for Bowhead Whales (*Balaena mysticetus*) in the Eastern Canadian Arctic. National Recovery Plan No. 24. Recovery of Nationally Endangered Wildlife. Ottawa, Ontario. 51 pp.

Moulton, V.D. and J.W. Lawson. 2002. Seals, 2001. p. 3-1 to 3-46 In: W.J. Richardson and J.W. Lawson (eds.), Marine mammal monitoring of WesternGeco's open-water seismic program in the Alaskan Beaufort Sea, 2001. LGL Rep. TA2564-4. Rep. from LGL Ltd., King City, Ont., for WesternGeco LLC, Anchorage, AK; BP Explor. (Alaska) Inc., Anchorage, AK; and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 95 pp.

Napageak, T. 1996. Nuiqsut Whaling Captains' Meeting, Traditional Knowledge for BP's Northstar EIS, Nuiqsut, AK, Aug. 14, 1996. Anchorage, AK: BPXA.

Nerini, M.K., H.W. Braham, W.M. Marquette, and D.J. Rugh. 1984. Life history of the bowhead whale, *Balaena mysticetus* (Mammalia: Cetacea). *J. Zool. (Lond.) 204*:443-468.

NMFS (National Marine Fisheries Service). 1991. Recovery Plan for the Humpback Whale (*Megaptera novaeangliae*). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. 105pp.

NMFS. 1992. Final Recovery Plan for Steller Sea Lion (*Eumetopias jubatus*). NMFS Office of Protected Resources, Silver Spring, MD.

NMFS. 1995. Status Review of the United States Steller Sea Lion, *Eumetopias jubatus*, Population. U.S. Dep. Commer., NOAA, National Marine Mammal Laboratory, AFSC, 7600 Sand Point Way NE, Seattle,Washington 98115. 61 pp.

NMFS. 2001. Biological Opinion on the Minerals Management Service's Oil and Gas Leasing and Exploration Activities in the Beaufort Sea, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK. May 25, 2001.

NMFS. 2005. Recovery plan for the northern right whale, *Eubalaena glacialis*, revision. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. 137 pp.

NMFS. 2006a. Biological Opinion on the Minerals Management Service's Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act. U.S.

Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK. June 16, 2006.

NMFS. 2006b. Review of the Status of the Right Whales in the North Atlantic and North Pacific Ocean. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. December 2006.

NMFS. 2006c. Biological Assessment of the Alaska Groundfish Fisheries and NMFS Managed Endangered Species Act Listed Marine Mammals and Sea Turtles. April 2006. NMFS Alaska Region, Sustainable Fisheries Division, P.O. Box 21688, Juneau, Alaska 99802.

NMFS. 2008a. Biological Opinion on the Issuance of Annual Quotas Authorizing the Harvest of Bowhead Whales to the Alaska Eskimo Whaling Commission for the Period 2008 through 2012. Anchorage, AK: USDOC, NMFS, 31 pp.

NMFS. 2008b. Biological Opinion on the Minerals Management Service’s Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK. July 17, 2008.

NMFS. 2008c. Recovery Plan for the Steller Sea Lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Service, Silver Spring, MD. 325 pages.

NMFS. [Internet]. 2010a. Addendum to the Draft IHA Application for a Marine Seismic Survey of the Arctic NMFS. Addendum to the Draft IHA Application for a Marine Seismic Survey of the Arctic Ocean by the USGS in 2010. National Marine Fisheries Service, NOAA NMFS. 2011. National Marine Mammal Laboratory, Cetacean Assessment & Ecology Program COMIDA Survey Project: 20o8 Preliminary Data. [cited 2013 May 1]. Available from: http://www.afsc.noaa.gov/NMML/cetacean/bwasp/flights_COMIDA_1-3.php

NMFS. 2010b. Endangered Species Act consultation biological opinion on U.S. Navy proposed training activities on the Northwest Training Range from June 2010 to June 2015, promulgation of regulations to authorize the U.S. Navy to "take" marine mammals incidental to training on the Northwest Training Range from June 2010 to June 2015, and the U.S. Navy's proposed research, development, test, and evaluation activities at the Naval Undersea Warfare Center Keyport Range Complex from June 2010 to June 2015. Pages 356 *in*. Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2010c. ESA Section 7 Biological Opinion on the Alaska Groundfish Fisheries. November 2010. NMFS Alaska Region, P.O. Box 21668, Juneau, AK 99802-1668.

NMFS. 2010d. Recovery plan for the fin whale (*Balaenoptera physalus*). National Marine Fisheries Service, Silver Spring, MD. 121 pp.

NMFS. 2011. Draft Environmental Impact Statement for Effects of Oil and Gas Activities in the Arctic Ocean. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. December 2011.

NMFS. 2012a. Final Environmental Assessment for the Issuance of Incidental Harassment Authorizations for the Take of Marine Mammals by Harassment Incidental to Conducting Exploratory Drilling Programs in the U.S. Beaufort and Chukchi Seas. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. May 2012.

NMFS. 2012b. Letter of Concurrence on the Environmental Protection Agency's Issuance of the Chukchi Sea Exploration NPDES General Permit. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, AK. April 11, 2012.

NMFS. 2012c. Letter of Concurrence on the Environmental Protection Agency's Issuance of the Beaufort Sea Exploration NPDES General Permit. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, AK. April 11, 2012.

NMFS. 2013a. Request for Consultation Under Section 7 of the Endangered Species Act (ESA) for the Proposed Issuance of Three Incidental Harassment Authorizations (IHAs) to Take Marine Mammals by Harassment Incidental to Open-Water Seismic and Marine Surveys by Shell Offshore Inc. (Shell), TGS-NOPEC Geophysical Company ASA (TGS), and SAExploration, Inc. (SAE) in the Beaufort and Chukchi Seas. March 11, 2013.

NMFS. 2013b. Effects of Oil and Gas Activities in the Arctic Ocean. Supplemental Draft Environmental Impact Statement. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. March 2013.

NMFS. 2013c. Environmental Assessment for the Issuance of Incidental Harassment Authorization to Take Marine Mammals by Harassment Incidental to Conducting Open-Water Marine and Seismic Surveys in the Beaufort and Chukchi Seas. Prepared by U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resrouces, Silver Spring MD. June 2013. 188pp.

Noongwook G, The Native Village of Savoonga, The Native Village of Gambell, Huntington HP, George JC. 2007. Traditional Knowledge of the Bowhead Whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. Arctic 60 (1): 47-54.

NRC. 2000. Marine Mammals and Low Frequency Sound: Progress since 1994. National Academy Press, Washington, DC.

NRC. 2003. Ocean Noise and Marine Mammals. Ocean Study Board, National Academy Press, Washington, DC.

NRC. 2005. Marine Mammal Populations and Ocean Noise: Determining when noise causes biologically significant effects. National Research Council of the National Academies, Washington, D.C.

NWMB (Nunavut Wildlife Management Board). 2000. Final report of the Inuit Bowhead Knowledge Study, Nunavut, Canada. Iqaluit, Nunavut: Nunavut Wildlife Management Board. 90 pp.

Okkonen SR, Ashjian CJ, Campbell RG, Clarke JT, Moore SE, Taylor KD. 2011. Satellite observations of circulation features associated with a bowhead whale feeding 'hotspot' near Barrow, Alaska. Remote Sensing of Environment 115: 2168-2174.

Parry, M., O. Canziani, J. Palutikof and P.J. van der Linden (editors). 2007. Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom.

Philo, L. M., E. B. Shotts, and J. C. George. 1993. Morbidity and mortality. Pp. 275-312 *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Popper, A.N., and T.J. Carlson. 1998. Application of Sound and Other Stimuli to Control Fish Behavior. Transactions of the American Fisheries Society 127:673-707.

Quakenbush LT, RJ Small, JJ Citta. 2010. Satellite tracking of Western Arctic bowhead whales. Final report. OCS Study BOEM 2010-033. Alaska Department of Fish and Game, Juneau, AK. 118 p.

Quakenbush, L., J. Citta, and J. Crawford. 2011a. Biology of the Ringed Seal (*Phoca hispida*) in Alaska, 1960-2010. Final Report to: National Marine Fisheries Service, 72 p. Alaska Department of Fish and Game, Fairbanks, AK.

Quakenbush, L., J. Citta, and J. Crawford. 2011b. Biology of the Bearded Seal (*Erignathus barbatus*) in Alaska, 1961-2009. Final Report to: National Marine Fisheries Service, 71 p. Alaska Department of Fish and Game, Fairbanks, AK.

Rexford B. [Internet]. 1997. A native whaler's view. [cited 2013 May 1]. Available from: http://www.alaska.boemre.gov/native/rexford/rexford.htm.

Richardson, W. J. 1995. Documented disturbance reactions. Pp. 241-324 *In* W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson (eds.), Marine mammals and noise. Academic Press, San Diego, CA.

Richardson, W.J. 1997. Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaska Beaufort Sea. Rept. From LGL. Ltd, King City, Ont. And Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK and NMFS.

Richardson, W.J. 1998. Marine mammal and acoustical monitoring of BP Exploration (Alaska)'s open-water seismic program in the Alaskan Beaufort Sea, 1997. LGL Rep. TA2150-3. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA) for BP Explor. (Alaska) Inc., Anchorage, AK and Nat. Mar. Fish. Serv.NMFS, Anchorage, AK and Silver Spring, MD + 318 p.

Richardson, W.J. 1999. Marine mammal and acoustical monitoring of Western Geophysical's open water seismic program in the Alaskan Beaufort Sea. 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont. And Greenridge Sciences Inc., Santa Barbara. CA, for Western Geophysical, Houston, TX, and National Marine Fisheries Service, Anchorage AK., and Silver springs, MD. 390pp.

Richardson WJ, Fraker MA, Würsig B, Wells RS. 1985a. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea—Reactions to industrial activities. Biological Conservation. 32(3):195-230.

Richardson, W.J., R.S. Wells, and B. Wursig. 1985b. Disturbance Responses of Bowheads, 1980-1984. In: Behavior, Disturbance Responses, and Distribution of Bowhead Whales, Balaena mysticetus, in the Eastern Beaufort Sea, 1980-84, W.J. Richardson, ed. OCS Study MMS 85-0034. Anchorage, AK: USDOI, MMS, Alaska OCS Region, pp. 255-306.

Richardson W.J., B. Wursig and C.R. Greene. 1986. Reactions of bowhead whales, *Balaena mysticetus,* to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79:1117-1128.

Richardson, W.J., B. Wursig and C.R. Greene, Jr. 1990. Reaction of bowhead whales *Balaena mysticetus,* to drilling and dredging noise in the Canadian Beaufort Sea. *Mar. Environ. Res.* 29(2): 135-160.

Richardson, W. J., J. C. R. Greene, C. I. Malme, and D. H. Thomson. 1991. Effects of noise on marine mammals. Academic Press, San Diego, CA.

Richardson, W. J., and C. I. Malme. 1993. Man-made noise and behavioral responses. Pp. 631-700 *In* J.J. Burns, J.J. Montague, and C. J. Cowles (eds.). The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Richardson W.J., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995a. Marine mammals and noise. Academic Press; San Diego, California.

Richardson, W.J., C.R. Greene Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude and M.A. Smultea. 1995c. Executive Summary. pp. xiii-xxiv. In W.J. Richardson, C.R.

Greene Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude and M.A. Smultea (eds.) 1995b. Acoustic Effects of Oil Production Activities on Bowhead and White Whales Visible During Spring Migration Near Pt. Barrow, Alaska-1991 and 1994 Phases: Sound Propagation and Whale Responses to Playbacks of Icebreaker Noise. OCS Study MMS 95-0051 for U.S. Minerals Management Service, Herndon, VA. Contract 14-12-0001-30412. Herndon, VA: USDOI, BOEMRE.

Richardson, W.J. and D.H. Thomson. 2002. Email dated Apr. 25, 2002, to S. Treacy, USDOI, MMS, Alaska OCS Region; subject: bowhead whale feeding study.

Richardson, W. J., T. L. McDonald, C. R. Greene, and S. B. Blackwell. 2004. Acoustic localization of bowhead whales near Northstar, 2001-2003: Evidence of deflection at high-noise times? Chapter 8 *In* W. J. Richardson and M. T. Williams (eds.). 2004. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea, 1999-2003. Rep. from LGL Ltd (King City, Ont.), Greenridge Science Inc (Santa Barbara, CA), and WEST Inc. (Cheyenne, WY) for BP Explor. (Alaska) Inc., Anchorage, AK.

Richardson, W.J. and M.T. Williams (eds.). 2004. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2003. [Annual and Comprehensive Report, Dec. 2004.] LGL Rep. TA4002. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA), and WEST Inc. (Cheyenne, WY), for BP Explor. (Alaska) Inc., Anchorage, AK. 297 p. + Appendices A–N on CD-ROM.

Ruddy, P. 2013. Response to Request for Additional Information for the ESA Section 7 Consultation. Communication to Shane Guan (NMFS) from P. Ruddy (Shell), 4/05/2013.

Rugh, D., D. DeMaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore. 2003. A review of bowhead whale (*Balaena mysticetus*) stock identity. J. Cetacean Res. Manage. 5(3): 267-279.

SAExploration, Inc. (SAE). 2012. Application for Incidental Harassment Authorization for Taking of Whales and Seals in Conjunction with SAE Proposed 3D Seismic Surveys in the Beaufort Sea, Alaska, Summer 2013. Prepared by Owl Ridge Natural Resource Consultants, Inc. and ICF International. December 11, 2012. 50pp.

SAE. 2013a. Application for Incidental Harassment Authorization for Taking of Whales and Seals in Conjunction with SAE Proposed 3D Seismic Surveys in the Beaufort Sea, Alaska, Summer 2013. Prepared by Owl Ridge Natural Resource Consultants, Inc. and ICF International. Received April 4, 2013. 56pp.

SAE. 2013b. Response to request for information on anticipated sound source levels and frequency ranges for SAE's equipment for the 2013 open-water season. Communication to Alicia Bishop (NMFS) from Gregory Green (SAE), 3/22/2013.

SAE. 2013b. Revisions to response to request for information on anticipated sound source levels and frequency ranges for SAE's equipment for the 2013 open-water season. Communication to Alicia Bishop (NMFS) from Gregory Green (SAE), 6/03/2013.

Schell, D.M. and S.M. Saupe., 1993. Feeding and Growth as Indicated by Stable Isotopes. In: The Bowhead Whale, J.J. Burns, J.J. Montague, and C.J. Cowles, eds. Lawrence, KS: The Society for Marine Mammalogy, pp. 491-509.

Shelden, K.E.W. and D.J. Rugh. 1995. The Bowhead Whale, *Balaena mysticetus*: Its Historic and Current Status. *Marine Fisheries Review 57* 3-4:20 pp.

Shell (Shell Exploration and Production, Inc.). 2013a. Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with a Proposed Open Water Marine Surveys Program in the Chukchi Sea, Alaska, During 2013. Prepared by Shell Exploration and Production, Inc. Revised March 2013. 101pp.

Shell. 2013b. Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with a Proposed Open Water Marine Surveys Program in the Chukchi Sea, Alaska, During 2013. Prepared by Shell Exploration and Production, Inc. Revised April 5, 2013. 102pp.

Shell. 2013c. Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with a Proposed Open Water Marine Surveys Program in the Chukchi Sea, Alaska, During 2013. Prepared by Shell Exploration and Production, Inc. Revised April 10, 2013. 128pp.

Southall BL, Bowles AE, Ellison WT, Finneran JJ, Gentry RL, Greene Jr. CR, Kastak D, Ketten DR, Miller JH, Nachtigall PE, Richardson WJ, Thomas JE, Tyack PL. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals. Special Issue 33(4):11-521. Available from: http://www.sea-inc.net/resources/mmnoise_aquaticmammals.pdf.

Stirling, I., M. Kingsley, and W. Calvert. 1982. The Distribution and Abundance of Seals in the Eastern Beaufort Sea, 1974-79. Can. Wildl. Serv. Occas. Pap. 47. 25 pp.

Suydam, R., J.C. George, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. Unpubl. report submitted to Int. Whal. Commn. (SC/63/BRG2). 7pp.

Thewisson, J.G.M., J. George, C. Rosa, and T. Kishida. 2011. Olfaction and brain size in the bowhead whale (*Balaena mysticetus*). *Marine Mammal Science 27*(2):282-294.

Thomson, D.H., W.R. Koski, and W.J. Richardson. 2002. Integration and Conclusions. In: Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information. Richardson, W.J. and D.H. Thomson, eds. LGL Report TA2196-

7. King City, Ontario: LGL Limited, environmental research associates, pp. 1-35.

Thomas, T., W.R. Koski, and T. Elliot. 2009. Chukchi Sea nearshore aerial surveys. (Chapter 4) In: Ireland, D.S., D.W. Funk. R. Rodrigues, and W.R. Koski (eds.). 2009. Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL Alaska Report P971–2, Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research, Ltd., Victoria, BC, and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage, AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 p. plus Appendices.

Thomas, T., and W.R. Koski. 2011. Chukchi Sea nearshore aerial surveys. (Chapter 4) In: Funk, D.W., C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2011. Joint Monitoring Program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Draft Report P1213-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 p. plus Appendices.

Tyack, P.L. 2000. Functional aspects of cetacean communication. Pages 270-307. In: J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead (eds.) Cetacean societies: field studies of dolphins and whales. The University of Chicago Press; Chicago, Illinois.

[USDOT] U.S. Department of Transportation. 2005. Port intermodal expansion project marine terminal redevelopment Environmental Assessment.

Van Parijs, S.M. 2003. Aquatic mating in pinnipeds: a review. Aquatic Mammals 29:214-226.

Van Parijs, S.M., and C.W. Clark. 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, *Erignathus barbatus*. Animal Behaviour 72:1269-1277.

Van Parijs, S.M., K.M. Kovacs, and C. Lydersen. 2001. Spatial and temporal distribution of vocalizing male bearded seals - implications for male mating strategies. *Behaviour 138*:905-922.

Van Parijs, S.M., C. Lydersen, and K.M. Kovacs. 2003. Vocalizations and movements suggest alternative mating tactics in male bearded seals. *Animal Behaviour 65*:273-283.

Van Parijs, S.M., C. Lydersen, and K.M. Kovacs. 2004. Effects of ice cover on the behavioural patterns of aquatic-mating male bearded seals. *Animal Behaviour 68*:89-96.

Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling, p. 387-407. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Würsig, B. and C. Clark. 1993. Behavior. Pages 157-199 In: J.J. Burns, J.J. Montague and C.J. Cowles, eds. The Bowhead Whale. Spec. Publ. 2. Lawrence, KS: Soc. of Mar. Mammal. Lawrence, KS. 187 pp.

Würsig, BE.M. Dorsey, W.J. Richardson, and R.S. Wells. 1989. Feeding, Aerial and Play Behaviour of the Bowhead Whale, *Balaena mysticetus*, Summering in the Beaufort Sea. *Aquatic Mammals 151*:27-37.

Würsig, B., S. K. Lynn, T. A. Jefferson, and K. D. Mullin. 1998. Behavior of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24:41-50.

Zeh, J. E., and A. E. Punt. 2004. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG1). 10 pp.

Zeh, J. E., C. W. Clark, J. C. George, D. E. Withrow, G. M. Carroll, and W. R. Koski. 1993. Current population size and dynamics. Pp. 409-89 *In* J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.