UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

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

Office of Naval Research (ONR) Arctic Research Activities 2018-2021 and Associated Proposed Issuance of an Incidental Harassment Authorization in the Beaufort Sea, Alaska

NMFS Consultation Number: *AKR-2018-9725*

Action Agencies: U.S. Navy ONR
and
National Marine Fisheries Service (NOAA), Office of Protected Resources, Permits and Conservation Division

Affected Species and Effects 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 (*Balaena mysticetus*)	Endangered	No	No	N/A
Blue whale (*Balaenoptera musculus*)	Endangered	No	No	N/A
Fin Whale (*Balaenoptera physalus*)	Endangered	No	No	N/A
Humpback Whale, Western North Pacific DPS (*Megaptera novaeangliae*)	Endangered	No	No	N/A
Humpback Whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	No	No	N/A
North Pacific Right Whale (*Eubalaena japonica*)	Endangered	No	No	No
Sperm Whale (*Physeter macrocephalus*)	Endangered	No	No	N/A
Ringed Seal, Arctic Subspecies (*Phoca hispida hispida*)	Threatened	Yes	No	N/A
Bearded Seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	Yes	No	N/A
Steller Sea Lion, Western DPS (*Eumatopias jubatus*)	Endangered	No	No	No

Consultation Conducted by: Alaska Region, National Marine Fisheries Service, NOAA

Issued by:

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

Date: September, 7 2018

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TERMS AND ABBREVIATIONS

ADCP	Acoustic Doppler Current Profiler
AMOS	Arctic Mobile Observing System
ARA	Arctic Research Activities
ASAMM	Aerial Surveys of Arctic Marine Mammals
AFTT	Atlantic Fleet Training and Testing
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CANAPE	Canada Basin Acoustic Propagation Experiment
CWA	Clean Water Act
CGC	Coast Guard Cutter
CTD	Conductivity temperature depth
COST	continental offshore stratigraphic test
DQA	Data Quality Act
dB	decibel
DPS	distinct population segment
EIS	Environmental impact statement
ESA	Endangered Species Act
EPA	Environmental Protection Agency
EMATT	Expendable Mobile Anti-Submarine Warfare Training Target
IHA	Incidental Harassment Authorization
IWC	International Whaling Commission
ITS	Incidental Take Statement
kHz	kilohertz
km	kilometer
kts	knots
MMPA	Marine Mammal Protection Act
mi	mile
m/s	meters per second
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRL	Naval Research Laboratory
NAEMO	Navy Acoustic Effects Model
ONR	Office of Naval Research
OCS	offshore continental shelf
Opinion	this biological opinion
p-p	peak-to-peak

PAM	passive acoustic monitoring
PCB	polychlorinated byphenyls
PIES	Pressure Inverted Echosounders
Permits Division	NMFS Office of Protected Resources, Permits and Conservation
PSO	protected species observer
PTS	permanent threshold shift
RES	relative environmental suitability
rms	root mean square
RPM	Reasonable and Prudent Measures
R/V	Research Vessel
SSV	sound source verification
SODA	Stratified Ocean Dynamics of the Arctic
SOP	Standard Operating Procedures
SWIFT	Surface Wave Instrument Float with Tracking
TTS	temporary threshold shift
UAS	Unmanned Aerial System
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
μPa	micropascal
0-p	peak

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1536(a)(2)), requires Federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat. When a Federal agency's action "may affect" a protected species, that agency is required to consult with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR 402.14(a)). Federal agencies may fulfill this general requirement informally if they conclude that an action may affect, but "is not likely to adversely affect" endangered species, threatened species, or designated critical habitat, and NMFS or the USFWS concurs with that conclusion (50 CFR 402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS and/or USFWS provide an opinion stating how the Federal agencies' actions is likely to affect ESA-listed species and their critical habitat. If incidental take is reasonably certain to occur, section 7(b)(4) requires the consulting agency to provide an Incidental Take Statement (ITS) that specifies the impact of any incidental taking, includes reasonable and prudent measures necessary to minimize such impact, and sets forth terms and conditions to implement those measures.

For the actions described in this document, the action agencies are the U.S. Navy's Office of Naval Research (ONR) which proposes to conduct Arctic Research Activities (ARA), and the NMFS Office of Protected Resources, Permits and Conservation Division (hereafter referred to as "the Permits Division"). The Permits Division plans to issue an incidental harassment authorization (IHA) pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA) (16 U.S.C. 1361 et seq.), to ONR for harassment of marine mammals incidental to the proposed research (83 FR 40234). When issued, the IHA will be valid from September 15, 2018 through September 14, 2019, and will authorize the incidental harassment of two ESA-listed pinniped species, the threatened Beringia DPS bearded seal and threatened Arctic ringed seal. This biological opinion will cover the entirety of ONR's proposed activity from 2018-2021.

ONR may continue to conduct Arctic research after 2021, however, the nature of the platforms and the locations of future deployments are unknown, and such future activities would be covered under future environmental planning documentations in collaboration with other Navy entities.

The NMFS Alaska Region (hereafter referred to as "we") consulted with ONR and the Permits Division on the proposed actions. This document represents our biological opinion (opinion) on the proposed actions and their effects on endangered and threatened species and designated critical habitat for those species.

This opinion and ITS were prepared by NMFS Alaska Region in accordance with section 7(b) of the ESA of 1973, as amended (16 U.S.C. 1531 *et seq.*), and implementing regulations at 50 CFR 402. The opinion and ITS are in compliance with the Data Quality Act (44 U.S.C. 3504(d)(1) *et seq.*) and underwent pre-dissemination review.

1.1 Background

This opinion considers the effects of activities associated with ONR's proposed ARA, from August 2018 to December 2021 and the associated proposed issuance of an IHA for the first year of these activities. The ARA includes two vessels that will deploy various towed and moored active acoustic sources and sensors, manned and unmanned aircraft, deployment of on-ice measurement systems, bottom interaction systems (e.g., coring), and deployment of weather balloons. Depending on sea-ice conditions, one vessel may also perform icebreaking. These actions have the potential to affect the endangered bowhead whale (*Balaena mysticetus*), endangered blue whale (*Balaenoptera musculus*), endangered fin whale (*Balaenoptera physalus*), endangered Western North Pacific distinct population segment (DPS) humpback whale (*Megaptera novaeangliae*), threatened Mexico DPS humpback whale (*Megaptera novaeangliae*), endangered North Pacific right whale (*Eubalaena japonica*), endangered Western North Pacific DPS gray whale (*Eschrichtius robustus*), endangered sperm whale (*Physeter macrocephalus*), endangered Western DPS Steller sea lion (*Eumatopias jubatus*), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), and threatened Beringia DPS bearded seal (*Erignathus barbatus nauticus*), and designated critical habitats for North Pacific right whales and Steller sea lions.

This opinion is based on information provided to us in the Biological Evaluation (BE) received April 5, 2018 (ONR 2018a), the IHA application received by the Permits Division on May 3, 2018 (ONR 2018b), the proposed IHA (83 FR 40234), updated project proposals, emails and telephone conversations between NMFS Alaska Region, NMFS Permits Division staff and ONR, and other sources of information. A complete record of this consultation is on file at NMFS's field office in Anchorage, Alaska.

Table 1 shows the amount of proposed take for the two ESA-listed species in the proposed IHA[1] (which covers one year of activities) and the amount of proposed ESA take (which covers the full four years of activities). Section 6.2 of this Opinion contains more information about the methods used to calculate these take numbers (see also ONR 2018a, b).

Table 1. Amount of proposed incidental harassment (Level B takes) of ESA-listed species in the proposed IHA for 2018-2019 activities, and total takes associated with the proposed action (3 years of full activities, plus one extra year of icebreaking).

Stock/DPS	Scientific Name	Proposed MMPA-authorized Takes (2018-2019)	Proposed Total ESA Takes (2018-2021)
Arctic ringed seal	*Phoca hispida hispida*	3,071	8,499
Beringia DPS bearded seal	*Erignathus barbatus nauticus*	5	15

[1] Please see proposed IHA (83 FR 40234) for MMPA-authorized takes of marine mammal species not listed under the ESA.

1.2 Consultation History

Our communication with ONR and the Permits Division regarding this consultation is summarized as follows:

- **December 15, 2017:** Received a section 7 consultation initiation request and biological assessment via email from ONR.
- **December 19, 2017:** Requested, and received, from ONR the IHA application package sent to Permits Division December 15, 2017.
- **January 26-February 12, 2018:** In several emails the NMFS Alaska Region and the Permits Division requested further information and clarification from ONR on both their IHA and ESA packages.
- **March 5, 2018:** ONR indicated by email they were considering changes to the activities and timeline and that updated information would follow.
- **April 6, 2018:** ONR provided the NMFS Alaska Region and the Permits Division an updated BE and IHA application with major revisions to the proposed action. These changes included: proposed activities to begin the first week of August rather than June; proposed activities are now further from the coast; impulsive sources have been removed; and weather balloons have been added.
- **April 24, 2018**: The Permits Division asks ONR for further clarity on the action via email.
- **May 3, 2018**: ONR provided the Permits Division an updated IHA application with changes in chapters 13 and 14.
- **May 24, 2018**: The Permits Division and the NMFS Alaska Region met to discuss additional questions for ONR.
- **May 25, 2018**: The Permits Division sent additional questions to ONR on both their IHA and ESA packages.
- **June 7, 2018**: Telephone call between the Permits Division and ONR, addressing questions sent on May 25. This included information on the input data that ONR is using for the effects modeling, and that there will be no takes requested for bowhead whales, and confirmed that there will be only one take of bearded seals, as stated in the BE and IHA application. The take numbers of ringed seals also remained the same.
- **June 8, 2018**: ESA section 7 formal consultation initiated.
- **June 18, 2018**: ONR informed the Permits Division and AKR that they may be adding an additional passive acoustic receiver during the 2018 SODA cruise. This would not affect the takes, since it is a passive receiver only.
- **July 31, 2018**: Telephone call between the Permits Division, AKR and ONR to discuss the modeling used for the icebreaking noise.
- **August 2, 2018**: ONR provides the Permits Division updated exposure/take calculations for icebreaking.
- **August 7, 2018:** Permits Division sent AKR a revised IHA with the updated take calculations from icebreaking.
- **August 13, 2018:** AKR received an updated BE from ONR.
- **August 14, 2018:** Publication in the Federal Register of the proposed IHA.
- **September 5, 2018**: ONR informed AKR of the Standard Operating Procedures and mitigation measures that will be implemented during vessel transit.

2 DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

2.1 Proposed Action and Proposed Activities

"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 (50 CFR 402.02). NMFS Alaska Region has not identified any interrelated or interdependent actions associated with this action.

The proposed action for this consultation consists of ONR's ARA in the Beaufort Sea, 2018-2021 (Office of Naval Research 2018a), and the Permits Division's proposed issuance of an IHA for harassment of marine mammals incidental to ONR's 2018-2019 activities (Office of Naval Research 2018b) and 83 FR 40234.

The purpose of ONR's ARA will be to conduct scientific experiments in the Beaufort Sea from August 2018 to December 2021. The proposed action includes several scientific objectives which support the Arctic and Global Prediction Program as well as the Ocean Acoustics Program and the Naval Research Laboratory (NRL), for which ONR is the parent command. Specifically, the proposed action will include the Stratified Ocean Dynamics of the Arctic (SODA) project, Arctic Mobile Observing System (AMOS) project, Ocean Acoustics field work, and NRL experiments. Details about specific project components are provided in the following sections.

SODA, AMOS, Ocean Acoustics, and Naval Research Components of the ARA

The ONR's Arctic Research Activities include the Arctic and Global Prediction Program, which supports two major projects (SODA and AMOS). Additionally, the ONR Ocean Acoustics Program also supports Arctic field work. NRL would also conduct Arctic research in the same timeframe with the same general scientific purpose as the SODA, AMOS, and Ocean Acoustics Programs. Descriptions of each of these programs are below, and descriptions of the equipment and platforms are in Section 2.1.1.

SODA

The SODA project would begin field work in August 2018 and continue until the summer/fall of 2020, consisting of research cruises and the deployment of autonomous measurement devices (gliders, unmanned undersea vehicles, moored sources) for year-round observation of water properties (temperature and salinity) and the associated stratification and circulation (see Section 2.1.1). These physical processes are related to the ice cover and as the properties of the ice cover change, the water properties will change as well. Warm water feeding into the Arctic Ocean also plays an important role changing the environment. Observations of these phenomena require sampling in multiple areas of varying ice cover and temperature profile, and year-round temporal sampling to understand what happens during different parts of the year. Autonomous systems are needed for this type of year-round observation of a representative sample of active waters. Geolocation of autonomous platforms requires the use of acoustic navigation signals, and therefore, year-long use of active acoustic signals. The deployment of the navigational sources would occur in the "deep water area" of the study area depicted in Figure 2.

AMOS

The AMOS project involves field work (moored navigation sources) from the summer/fall of 2019 to the summer/fall of 2021. The purpose of AMOS is to advance the technology required to field and operate an autonomous network of mobile sensing platforms of sea ice dynamics and thermodynamics to improve the understanding of the circulation and evolution of water masses in the Arctic, providing the Navy with the potential for persistent, year-round maritime domain awareness capability[2] in the Arctic for both ice-covered and ice-free conditions. AMOS would develop and test a mobile array of unmanned platforms in the surface, air, and undersea domains (see Section 2.1.1). The first generation of acoustic navigation beacons, deployed as part of SODA, would be usable (due to battery lifetime) through the summer of 2021.

ONR Ocean Acoustics Program

The ONR Ocean Acoustics Program also supports Arctic field work. The emphasis of the Ocean Acoustics Program's field efforts is to understand how the changing environment affects acoustic propagation and the noise environment. These experiments are also spatially and temporally dependent, so observations in different locations on a year-round basis would be required. The potential for understanding the large-scale (range and depth) temperature structure of the ocean requires the use of long-range acoustic transmissions. The use of specialized waveforms and acoustic arrays allows signals to be received over a hundred kilometers from a source, while only requiring moderate source levels. The Ocean Acoustics program may perform these experiments in conjunction with the Arctic and Global Prediction Program by operating in the same location and with the same research vessels.

Naval Research Laboratory

NRL would also conduct Arctic research in the same time frame with the same general scientific purpose as the Arctic and Global Prediction and Ocean Acoustics programs. Up to ten ice-tethered acoustic buoys are expected to be deployed for real-time environmental sensing and mid-frequency sonar performance predictions in the deep water area. Real-time assimilation of acoustic data into an ocean model is also planned. The ice-tethered acoustic buoys are designed to be operational for up to two years. In addition, the NRL Acoustics Division has sources designed for long-range transmissions in the Arctic, and can perform acoustic experiments in conjunction with other ongoing experiments. NRL also will perform ice-characterization experiments with autonomous unmanned vehicles and aircraft.

2.1.1 Research Equipment and Platforms

Below are the descriptions of the equipment and platforms that would be deployed at different times during the proposed action.

2.1.1.1 Glider surveys

Glider surveys will begin in August 2018 as part of the SODA and AMOS projects, with the deployment of gliders from a small vessel in the Beaufort Sea, outside U.S. territorial waters. The gliders will transit to the study area (Figure 2). Glider deployments and surveys are also proposed for 2019, 2020 and 2021. All gliders will be recovered during the cruises of the U.S. Coast Guard Cutter (CGC) *Healy* and/or Research/Vessel (R/V) *Sikuliaq*.

[2] Maritime Domain Awareness (MDA) is the effective understanding of anything associated with the global maritime domain that could impact the security, safety, economy or environment of the United States (USCG 2007).

Gliders (Figure 1) are buoyancy-driven, equipped with satellite modems providing two-way communication, and are capable of transiting to depths of up to 3,280 feet (ft; 1,000 meters [m]). Gliders will collect data in the shallow water area near the continental shelf, moving at a speed of about 0.25 meters per second (m/s; 23 kilometers per day [km/day]).

When operating in ice-covered waters, gliders navigate by trilateration (the process of determining location by measurement of distances, using the geometry of circles, spheres or triangles) from moored acoustic sound sources (or dead reckoning should navigation signals be unavailable). Hibernating gliders would continue to track their position, waking to reposition should they drift too far from their target region.

Figure 1. Example of seagliders (Office of Naval Research 2018a)

2.1.1.2 **Research Vessels: CGC *Healy* and R/V *Sikuliaq***

CGC *Healy* and/or the R/V *Sikuliaq* will be the two vessels to perform research cruises as part of the proposed action (including SODA, AMOS, Ocean Acoustics Program, and NRL's Arctic research). Research cruises are proposed for the fall in 2018, 2019, 2020 and 2021. Therefore, there will be a maximum of eight cruises; one cruise per vessel that could occur each year in each of the four calendar years (2018-2021) of the proposed action. For the purposes of this opinion, NMFS assumes ONR will conduct all eight cruises. The research cruises will last up to 30 days and the research activities will occur within the study area (Figure 2). The vessels will depart from Dutch Harbor, transit to the study area, and then return to Dutch Harbor (Figure 3).

The R/V *Sikuliaq* has a maximum speed of approximately 12 knots with a cruising speed of 11 knots (UAF 2014). The R/V *Sikuliaq* is not an ice breaking ship, but an ice strengthened ship. It will not be ice breaking and therefore acoustic signatures of ice breaking for the R/V *Sikuliaq* are not relevant. The R/V *Sikuliaq* has a one-third octave signature band range of 10 Hertz (Hz) to

200 kilohertz (kHz) and a source level of 130 to 172 decibels (dB) referenced to 1 microPascal at 1 m (re 1 µPa at 1 m) when traveling the maximum transit speed of 11 knots, and an one-third octave signature band range of 10 Hz to 200 kHz with a source level of 127 to 154 dB r re 1 µPa at 1 m when traveling at a nominal tow speed of 4 knots n (Naval Sea Systems Command 2015).

CGC *Healy* travels at a maximum speed of 17 knots with a cruising speed of 12 knots (United States Coast Guard 2013), and a maximum speed of 3 knots when traveling through 3.5 ft. (1.07 m) of sea ice (Murphy 2010). CGC *Healy* may be required to perform icebreaking to deploy the moored and ice tethered acoustic sources in deep water. Based on the observed ice conditions in August 2018, ONR estimated only one day would be needed for icebreaking during their first cruise. However, as ice conditions may change from year to year, ONR estimated a total of three days of icebreaking per year during the 2019-2021 cruises. CGC *Healy* has proven capable of breaking ice up to 8 ft. (2.4 m) thick while backing and ramming (Roth et al. 2013). While conducting icebreaking, the CGC *Healy* icebreaker events generated signals with center frequencies near 10, 50, and 100 Hz with maximum source levels of 190 to 200 dB re 1 µPa at 1 m (Roth et al. 2013). Icebreaking will only occur in the deep water area, off the continental shelf (Figure 2), while deploying moored and ice-tethered sources.

The R/V *Sikuliaq* and CGC *Healy* will perform the following activities during their research cruises:

- Towing of active acoustic sources in open water or marginal ice
- Deployment of moored and/or ice-tethered passive sensors (oceanographic measurement devices, acoustic receivers)
- Deployment of moored and/or ice-tethered active acoustic sources to transmit acoustic signals for up to three years after deployment. Transmissions could be terminated during ice-free periods (August-October) each year if needed.
- Deployment of unmanned surface, underwater and air vehicles
- Recovery of equipment

Additional oceanographic measurements will be made using ship-based systems, including the following:

- Modular Microstructure Profiler, a tethered profiler that will measure oceanographic parameters within the top 984 ft. (300 m) of the water column.
- Shallow Water Integrated Mapping System, a winched towed body with a Conductivity Temperature Depth sensor, upward and downward looking Acoustic Doppler Current Profilers (ADCPs), and a temperature sensor within the top 328 ft. (100 m) of the water column.
- Three dimensional Sonic Anemometer, which will measure wind stress from the foremast of the ship.
- Surface Wave Instrument Float with Tracking (SWIFTs) are freely drifting buoys measuring winds, waves, and other parameters with deployments spanning from hours to days.
- A single mooring (designated as *de minimis* mooring on Figure 2) will be deployed to perform measurements of currents with an ADCP.

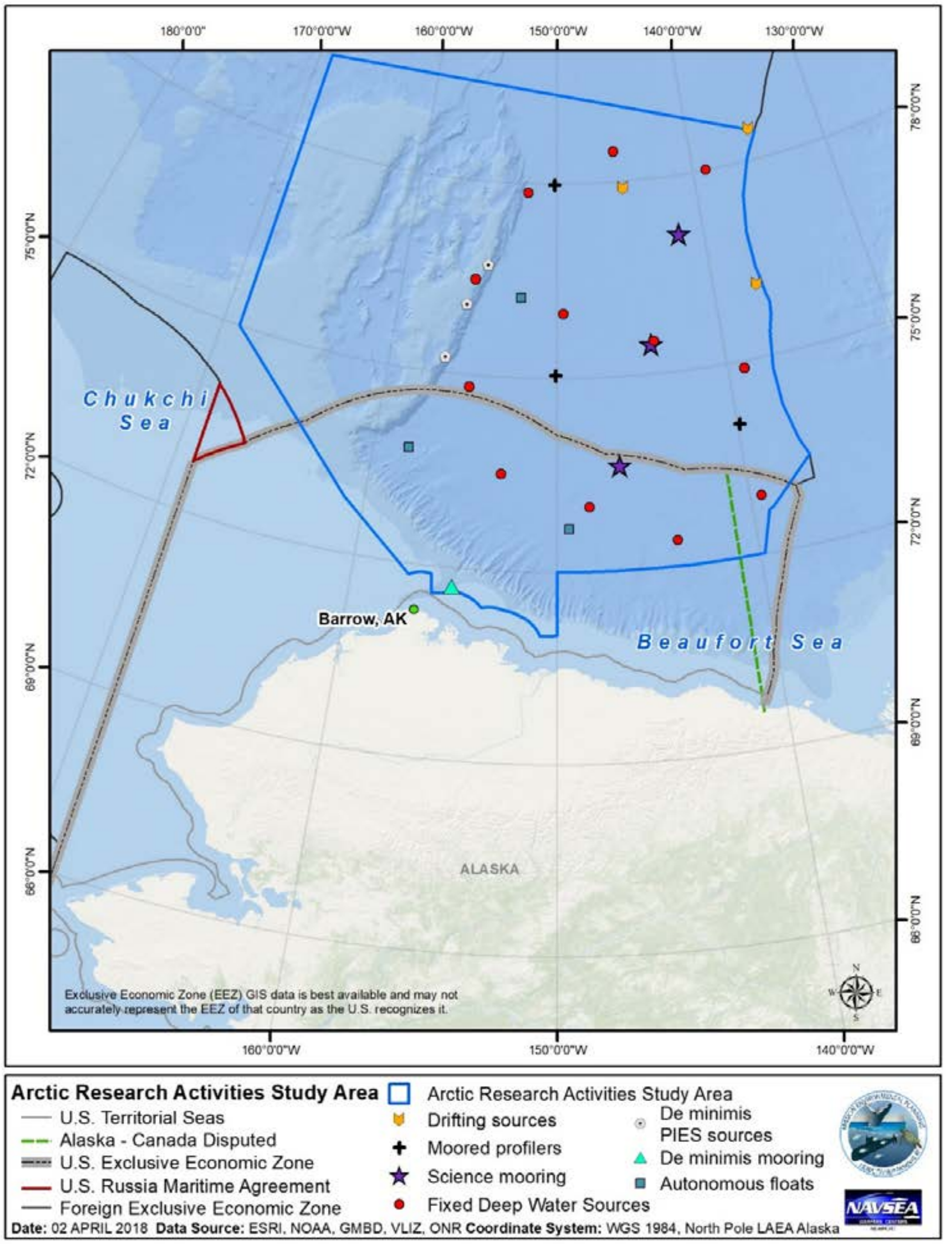

Figure 2. Area proposed for ONR's 2018-2021 Arctic Research Activities (Office of Naval Research 2018a)

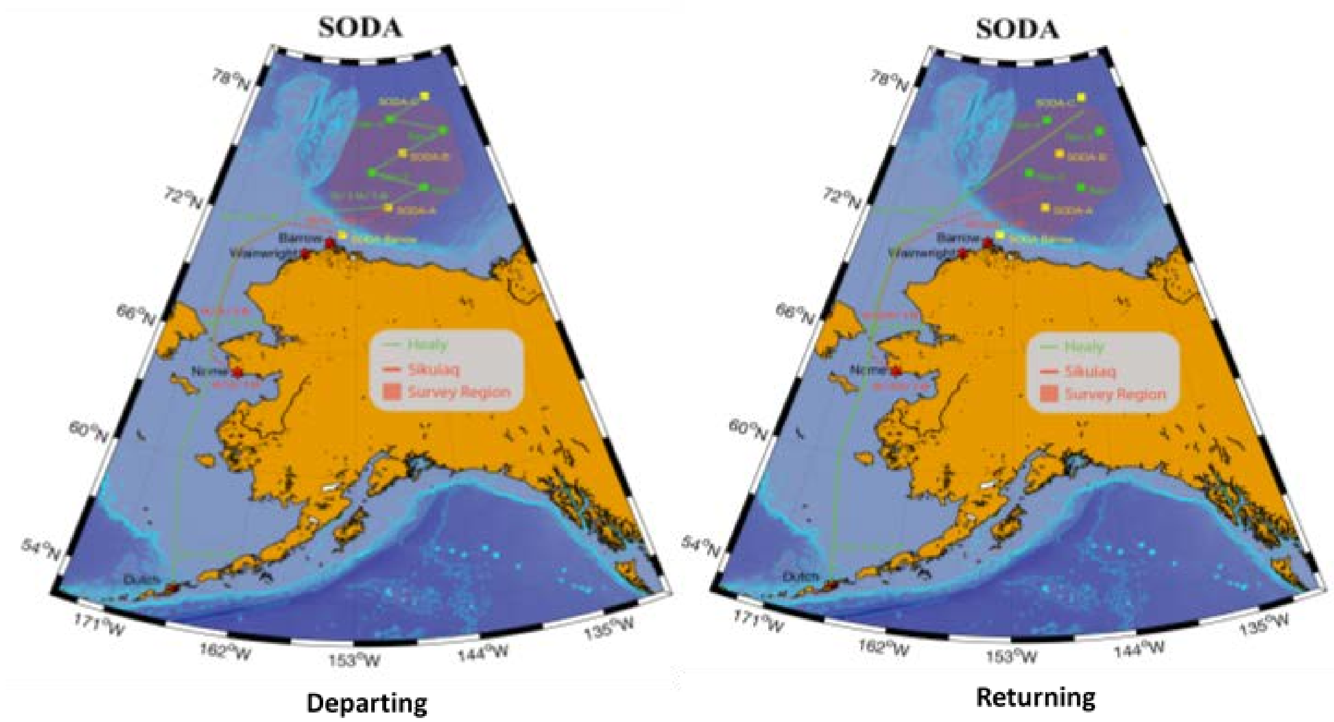

Figure 3. Planned transit routes/dates for 2018 (left is departing, right is returning). A similar route and schedule are anticipated in 2019-21

2.1.1.3 Towed Active Acoustic Sources

CGC *Healy* and/or R/V *Sikuliaq* will tow active acoustic sources as part of the SODA, AMOS, and Ocean Acoustics Program in transit to deploying moored or ice-tethered acoustic sources. Each vessel will tow sources for up to 15 days in the deep area during three of the four cruises only in open water or marginal ice. Towing cannot be conducted while icebreaking. Navy acoustic sources are categorized into "bins" based on frequency (L= low frequency, M=medium frequency), source level, and mode of usage, as previously established between the Navy and NMFS (Department of the Navy 2013a). The towed sources associated with the proposed action are non-impulsive noise sources and fall within bins LF4, LF5, and MF9 (parameters listed in the first three rows of Table 2).

Table 2. Source Characteristics of Modeled Non-Impulsive Acoustic Sources for the proposed action (Office of Naval Research 2018a).

Source Name	Frequency Range (Hz)	Sound Pressure Level (dB re 1 µPa at 1 m)	Pulse Length (milli-seconds)	Duty Cycle (Percent time active)	Level B Take radii used to calculate take[5]	Source Type	Usage
LF4 towed source	100 to 1,000	200	10,000	50% [1]	10 km	Towed	4 hours per day for 15 days
LF5 towed source	100 to 1,000	180	10,000	50% [1]	10 km	Towed	4 hours per day for 15 days
MF9 towed source	1,000 to 10,000	200	10,000	50% [1]	10 km	Towed	8 hours per day for 15 days
Spiral Wave Beacon	2,500	183	50	< 1% [2]	10 km	Moored	24 hours per day for 7 days
Navigation and real-time sensing sources	700	185	60,000	< 1% [3]	10 km	Moored or Drifting	1 minute every 4 hours, up to 3 years
Tomography Sources	250	185	135,000	< 1% [4]	10 km	Moored	2.25 minutes every 4 hours, up to 3 years

[1] On for 10 sec, off for 10 sec
[2] On for 0.05 sec, off for at least 59.95 sec
[3] On for 1 min, off for at least 59 min
[4] On for 135 sec, off for at least 57 min
[5] Based on NAEMO modeling

2.1.1.4 Moored/Drifting Acoustic Sources

Moored and drifting acoustic sources will be deployed from either CGC *Healy* or the R/V *Sikuliaq* in deep water areas as described below, as part of the SODA, AMOS, and Ocean Acoustics Program. The sound source frequencies and pressure levels for each of the moored and towed acoustic sources are presented in Table 2. All of these sources are within the hearing range of seals (Southall et al. 2007, Office of Naval Research 2018a).

Each vessel will deploy up to three moored spiral wave beacon sources in the deep water area and these sources will operate for up to seven days per year. The acoustic characteristics of the spiral-wave beacon source are given in Table 2. The spiral wave beacon sources will be separated by distances similar to the separation of the deep water source locations shown in Figure 2. They will operate at 183 dB re 1 µPa at 1 m at 2500 Hz, which is within the hearing range of all marine mammals.

The two vessels (combined) will deploy a maximum of 15 acoustic navigation sources between 2018 and 2021 during the period September 2018 to October 2020 at the deep water source locations shown in Figure 2. Navigation sources transmit intermittently from multiple locations. Autonomous vehicles will be able to navigate using signals from these sources. Acoustic transmissions from these non-impulsive acoustic sources could transmit until October 2021 at the latest, and the total transmission time for each individual source will be no more than three years. The acoustic parameters of these sources are given in Table 2. Source transmissions will be offset by 15 minutes from each other (i.e. sources will not be transmitting at the same time). The navigation sources will also be used for rapid environmental characterization.

CGC *Healy* and R/V *Sikuliaq* (combined) will deploy a maximum of six moored tomography sources in the deep water area during the period September 2018 to September 2020 at the mooring locations closest to the coast shown in Figure 2. Acoustic transmissions from these non-impulsive acoustic sources will occur at 185 dB re 1 µPa at 1 m at 250 Hz until October 2021 at the latest, and the total transmission time for each individual source will be less than three years. The acoustic parameters of these sources are given in Table 2. Source transmissions will be offset by six minutes from each other (i.e. sources will not be transmitting at the same time). When the acoustic navigation sources and tomography sources are both transmitting they will be offset from each other by at least three minutes.

All moorings will be anchored on the seabed and held in the water column with subsurface buoys. All sources will be deployed by shipboard winches which will lower sources and receivers in a controlled manner. Anchors will be steel "wagon wheels" typically used for this type of deployment. All moored and drifting sources will be recovered.

2.1.1.5 Other In-water Acoustic Sources

The proposed action (including SODA, AMOS, Ocean Acoustics Program, and NRL's Arctic research) will include in-water acoustic sources that ONR and the Permits Division determined are likely to have minimal or undetectable effects on marine mammals, which ONR refers to as "*de minimis*" sources (Table 3). These sources have some combination of the following parameters: low source levels, narrow beams, downward directed transmission, short pulse lengths, low duty cycles (fraction of time that the sound is active), or frequencies above (outside) known marine mammal hearing ranges (see Table 3; Department of the Navy 2013b). All of these sources will be deployed either on moorings or unmanned undersea vehicles.

The following are the other planned in-water acoustic sources (Table 3) which will be used during the proposed action: Pressure Inverted Echosounders (PIES) sources, ADCPs, ice profilers (upward looking chirp sonar), Expendable Mobile Anti-Submarine Warfare Training Targets (EMATTs), and additional sources below 160 dB re 1 µPa used during towing operations. The PIES sources will be deployed on moorings (i.e., the sounds will be produced year-round) and will have a sound source level of 160 dB within 32-320 ft (10-100 m) of the ocean bottom. Observations of oceanographic phenomena (i.e., temperature, salinity, velocity, turbulence) flowing into the Beaufort Sea will be made using PIES, which will be deployed on the ocean bottom at the white circles with the center dot locations shown in Figure 2. PIES transmit acoustic signals upwards rather than downwards. The PIES have an extremely low pulse length and very low duty cycle, as shown in Table 3. ADCPs may be used on moorings or deployed on unmanned undersea vehicles. The shallow water ADCP mooring location is depicted on Figure 2 by the bright green triangle. Ice-profilers using upward looking chirp sonar measure ice properties and roughness. An upward looking chirp-sonar will also be deployed for measuring ice and oceanographic properties.

Up to ten EMATTs will be deployed each year. Each EMATT will transmit two simultaneous Continuous Wave signals at frequencies selected from two different frequency bands (700-1100 Hz and 1100-4000 Hz; see Table 3). The EMATTs, swimming at 164 to 459 ft. (50 to 140 m) below the surface, will scuttle after completing missions that will last up to 8 hours.

The bottom loss measurement system (echosounder) will be used for bottom characterization. The bottom loss measurement system (parameters listed in Table 3) could be attached to a Conductivity Temperature Depth Sensor, which is typically found on research vessels. The source will move up and down in the water column, transmitting very short pulses (4 milliseconds) with a low duty cycle (2 percent).

Table 3. Parameters for Other In-Water (ONR determined "*de minimis*") Acoustic Sources

Source Name	Frequency Range (kHz)	Sound Pressure Level (dB re 1 μPa at 1 m)	Maximum Distance to 120 dB isopleth	Pulse Length (milli-seconds)	Duty Cycle (Percent time active)	Beamwidth (degrees)	ONR's De minimis justification
PIES[1]	12	170-180	1000 m	6	<0.01	45	Extremely low duty cycle, low source level, very short pulse length
ADCP[2]	>200, 150, or 75	190	3162 m	<1	<0.1	2.2	Very low pulse length, narrow beam, moderate source level
Chirp sonar	2-16	200	10 km	20	<1	narrow	Very short pulse length, low duty cycle, narrow beam width
EMATT[3]	700-1100 Hz and 1100-4000 Hz	<150	32 m	N/A	25-100	Omni	Very low source level
Coring system[4]	25-200	158-162	126 m	< 1	16	Omni	Very low source level[2]
CTD[5] attached Echosounder	5-20	160	100 m	4	2	Omni	Very low source level
Ice profilers	500	n/a	n/a	n/a	n/a	Multi	Above frequency range of marine mammal hearing

[1] PIES= Pressure Inverted Echosounders
[2] Acoustic Doppler Current Profilers
[3] Expendable Mobile Anti-Submarine Warfare Training Targets
[4] within sediment, not within the water column
[5] CTD = Conductivity Temperature Depth

2.1.1.6 Drifting Oceanographic Sensors

Observations of ocean-ice interactions require the use of sensors which are moored and embedded in the ice as part of the SODA, AMOS, and NRL's Arctic research. Sensors are deployed within a few dozen meters of each other on the same ice floe. Their initial locations are depicted as the yellow arrow symbols in Figure 2. Three types of sensors will be used: autonomous ocean flux buoys, Integrated Autonomous Drifters, and Ice Tethered Profilers. The autonomous ocean flux buoys measure oceanographic properties just below the ocean-ice interface. These devices will have ADCPs and temperature chains attached, to measure temperature, salinity, and other ocean parameters in the top 20 ft. (6 m) of the water column. Integrated Autonomous Drifters will have a long temperate string extending down to 656 ft. (200 m) depth and will incorporate meteorological sensors, and a temperature spring to estimate ice thickness. The Ice Tethered Profilers will collect information on ocean temperature, salinity and velocity down to 820 ft. (250 m) depth.

Fifteen autonomous floats (Air-Launched Autonomous Micro Observer) will be deployed during the proposed action (as part of the NRL's Arctic research) to measure seasonal evolution of the ocean temperature and salinity, as well as currents. They will be deployed on the eastern edge of the Chukchi Sea in water less than 3,280 ft (1,000 m) deep. Three autonomous floats will act as virtual moorings by originating on the seafloor, then moving up the water column to the surface and returning to the seafloor. The other 12 autonomous floats will sit on the seafloor and at intervals begin to move towards the surface. At programmed intervals, a subset of the floats will release anchors and begin their profiling mission. Up to 15 additional floats may be deployed by ships of opportunity in the Beaufort Gyre. The general locations for the autonomous floats are depicted by the blue squares in Figure 2.

2.1.1.7 Moored Oceanographic Sensors

Moored sensors will capture a range of ice, ocean, and atmospheric conditions on a year-round basis as part of the NRL's Arctic research. The location of the bottom-anchored sub-surface moorings sensors are depicted by the purple stars in Figure 2. These will be bottom anchored, sub-surface moorings measuring velocity, temperature, and salinity in the upper 1,640 ft. (500 m) of the water column. The moorings also collect high-resolution acoustic measurements of the ice using the ice profilers discussed above. Ice velocity and surface waves will be measured by 500 kHz multibeam Acoustic Wave and Current Profilers from Nortek Signatures, which are well above the hearing range of marine mammals (Table 3).

Additionally, Beaufort Gyre Exploration Project moorings BGOS-A and BGOS-B (depicted by the black plus signs in Figure 2) will be augmented with McLane Moored Profilers. BGOS-A and BGOS-B will be placed on existing Woods Hole Oceanographic Institute moorings. The two BGOS moorings will provide measurements near the Northwind Ridge, with considerable latitudinal distribution. Nortek Acoustic Wave and Current Profilers deployed on BGOS-A and BGOS-B as part of previous projects will also be continued as part of the Proposed Action.

2.1.1.8 Fixed and Towed Receiving Arrays

Horizontal and vertical arrays will be used to receive acoustic signals as part of the SODA, AMOS, and Ocean Acoustics Programs. The Distributed Vertical Line Array is a long line acoustic receiver that was used in a recent ONR action (i.e., the Canada Basin Acoustic Propagation Experiment (CANAPE) project) and will be deployed within the SODA sensor locations. The Distributed Vertical Line Array will be moored to the seafloor by a 1,940 pound (lb; 880 kilogram [kg]) anchor. An array (horizontal and vertical) will also be placed on the seabed in the shallow water area. Other receiving arrays are the Single Hydrophone Recording Units and Autonomous Multichannel Acoustic Recorder. All these arrays will be moored to the seafloor and remain in place throughout the activity. CGC *Healy* and R/V *Sikuliaq* will also tow arrays of acoustic receivers.

2.1.1.9 Activities involving Aircraft and Unmanned Air Vehicles

The NRL will be conducting flights to characterize the ice structure and character, ice edge and wave heights across the open water and marginal ice zone to the ice. Up to four flights, lasting approximately three hours in duration will be conducted each year over a 10 day period during February or March for ice structure and character measurements and during late summer/early fall for ice edge and wave height studies. Flights will be conducted with a Twin Otter aircraft over the seafloor mounted acoustic sources and receivers. Most flights will transit at 1,500 ft. or 10,000 ft. (457 or 3,048 m) above sea level. Twin Otters have flight speeds of 80 to 160 knots, with a typical survey speed of 90 to 110 knots (U.S. DOC and NOAA, 2015). Received pressure levels for Twin Otters have been measured at a distance of 2,152 ft. (656 m) away and range from 80 to 98.5 A-weighted decibels (dBA; expression of the relative loudness in the air as perceived by the human ear). At the lower flight altitude of 1,500 ft., the received levels are estimated to be 83 to 101.5 dBA, and at the higher flight altitude of 10,000 ft., the estimated received levels are 56 to 75.5 dBA. The frequency levels range from 20 Hz to 10 kHz, though they are more typically in the 500 Hz range (Metzger 1995a).

Rotary wing aircraft will also be used during the activity (Figure 3). Helicopter transit will be no longer than two hours to and from the ice location, and will avoid pressure ridges and other sensitive areas where seals are likely to occur. An infrared-capable twin engine helicopter may be used to transit scientists from land to an offshore, floating ice location. Once on the floating ice, the team will drill holes with up to a 10 inch (in; 25.4 centimeter [cm]) diameter to deploy scientific equipment (e.g. source, hydrophone array, EMATT) into the water column. The science team will depart the area and return to land after three hours of data collection and leave the equipment behind for a later recovery.

Figure 4. Helicopter assisted on-ice experiments (Office of Naval Research 2018a)

The proposed action (including AMOS and NRL) includes the use of an Unmanned Aerial System (UAS). The UAS will be utilized for aid of navigation and to confirm and study ice cover. The UAS will be deployed ahead of the ship to ensure a clear passage for the vessel and will have a maximum flight time of 20 minutes. The UAS will not be used for marine mammal observations or hover close to the ice near marine mammals. The UAS that will be used during the proposed action is a small commercially available system that generates low sound levels and is smaller than military grade systems. The dimensions of the proposed UAS are: 11.4 in (29 cm) by 11.4 in (29 cm) by 7.1 in (18 cm) and weighs only 2.5 lbs (1.13 kg). The UAS can operate up to 984 ft. (300 m) away, which will keep the device in close proximity to the ship. The planned operation of the UAS is to fly it vertically above the ship to examine the ice conditions in the path of the ship and around the area (i.e. not flown at low altitudes around the vessel). No acoustic parameters are currently available for the proposed models of UASs to be utilized in the proposed action. However, based on sound profiles of similar UAS, it is unlikely marine mammals will hear the device since the noise generated will likely not be audible above ambient noise levels, and will be masked by the vessel noise (Christiansen et al. 2016).

2.1.1.10 On-Ice Measurement Systems

On-ice measurement systems will be used to collect weather data. These will include an Autonomous Weather Station (Figure 4) and an Ice Mass Balance Buoy (Figure 5). The Autonomous Weather Station will be deployed on a tripod; the tripod has insulated foot platforms that are frozen into the ice. The system will consist of an anemometer, humidity sensor, and pressure sensor. The Autonomous Weather Station also includes an altimeter that is *de minimis* due to its very high frequency (200 kHz). The Ice Mass Balance Buoy is a 20 ft. (6 m) sensor string, which is deployed through a two-inch (5 cm) hole drilled into the ice. The string is weighted by a 2.2 lb (1 kg) lead weight, and is supported by a tripod. The buoy contains a *de minimis* 200 kHz (above the hearing range of marine mammals) altimeter and snow depth sensor. Autonomous Weather Stations and Ice Mass Balance Buoys will be deployed in fall 2018, and will drift with the ice, making measurements, until their host ice floes melt, thus destroying the instruments (likely in summer, roughly one year after deployment). After the on-ice instruments are deployed they cannot be recovered, and will sink to the seafloor as their host ice floes melted. ONR anticipates deploying Autonomous Weather Stations and Ice Mass Balance Buoys again in 2019 and 2020, for similar one-year missions.

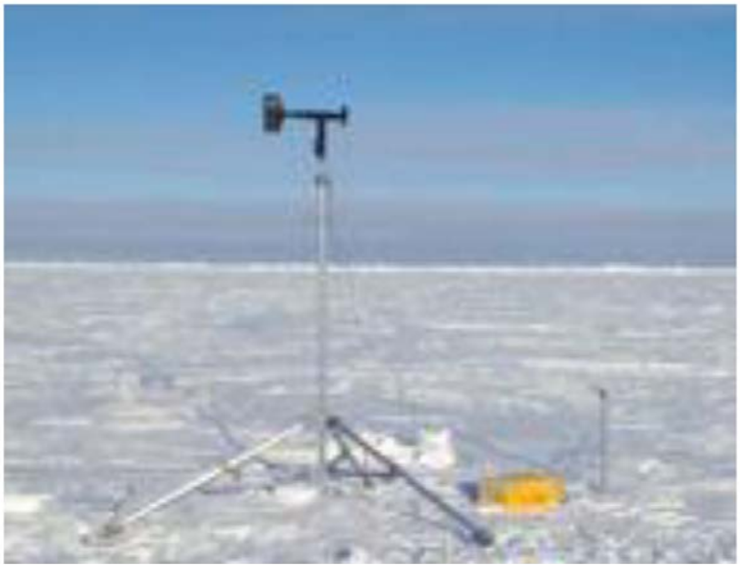

Figure 5. Autonomous measurement system (Office of Naval Research 2018a)

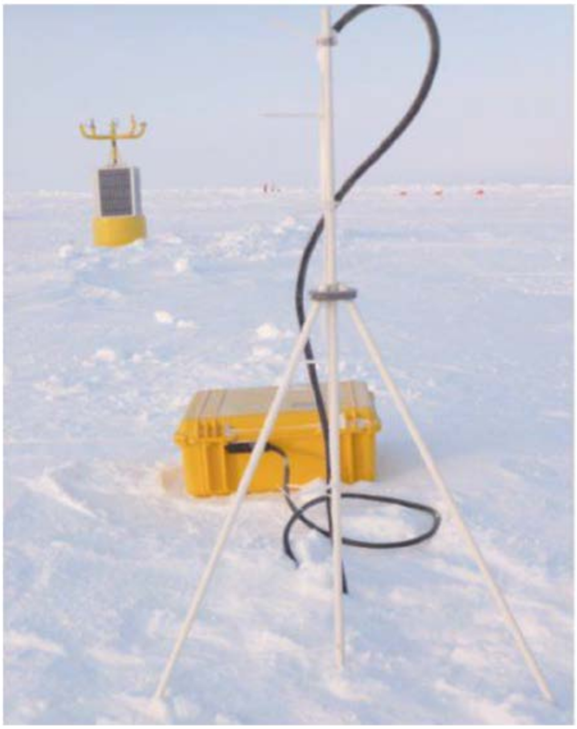

Figure 6. Ice mass balance buoy (foreground) (Office of Naval Research 2018a)

2.1.1.11 Bottom Interaction Systems

Coring of bottom sediment will occur at various locations within the study area to obtain a more complete understanding of the Arctic environment. Coring equipment will take up to 50 samples of the ocean bottom in the study area annually. The samples will be roughly cylindrical, with a 3.1 in (8 cm) diameter cross-sectional area; the corings will be between 10 and 20 ft. (3 and 6 m) long. Coring will only occur while the R/V *Sikuliaq* or CGC *Healy* are deployed, during the summer or early fall. The coring equipment moves very slowly through the muddy bottom, at a speed of approximately 1 m per hour, and will not create any detectable acoustic signal within the water column, though very low levels of acoustic transmissions may be created in the mud (parameters listed in Table 3).

2.1.1.12 Weather Balloons

To support weather observations, up to forty Kevlar or latex balloons will be launched per year for the duration of the proposed action. These balloons and associated radiosondes (a sensor package that is suspended below the balloon) are similar to those that have been deployed by the National Weather Service since the late 1930s. When released, the balloon is approximately 5-6 ft (1.5-1.8 m) in diameter and gradually expands as it rises owing to the decrease in air pressure. When the balloon reaches a diameter of 13-22 ft (4-7 m), it bursts and a parachute is deployed to slow the descent of the associated radiosonde. Weather balloons will not be recovered.

2.2 Standard Operating Procedures and Mitigation Measures

While in transit (Figure 3), CGC *Healy* and RV *Sikuliaq* will follow the U.S. Coast Guard’s Standard Operating Procedures (SOPs) for operating in Alaska (see pgs. 5-6, USCG (2011)). These SOPs include maintaining 500 yds of separation from North Pacific right whales (50 CFR 224.103), 100 yd from any other whale, and avoiding the 3 nm no-transit zones around Steller sea lion rookeries (50 CFR 224.103, d(1)(ii)(A).

Once at the study area (Figure 2), ONR will follow both standard operating procedures and mitigation measures as outlined in their Biological Evaluation (ONR 2018a) and IHA application (ONR 2018b). Standard operating procedures serve the primary purpose of providing safety and mission success, and are implemented regardless of their secondary benefits (e.g., to a resource), while mitigation measures are used to avoid or reduce potential impacts to protected resources.

Standard Operating Procedures

Ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when moving through the water (underway). Watch personnel undertake extensive training in accordance with the U.S. Navy Lookout Training Handbook or civilian equivalent, including on-the-job instruction and a formal Personal Qualification Standard program (or equivalent program for supporting contractors or civilians), to certify that they have demonstrated all necessary skills (such as detection and reporting of floating or partially submerged objects). Their duties may be performed in conjunction with other job responsibilities, such as navigating the ship or supervising other personnel. While on watch, personnel employ visual search techniques, including the use of binoculars, using a scanning method in accordance with the U.S. Navy Lookout Training Handbook or civilian equivalent. A primary duty of watch personnel is to detect and report all objects and disturbances sighted in the water that may be indicative of a threat to the ship and its crew, such as debris, or surface disturbance. Per safety requirements, watch personnel also report any marine mammals sighted that have the potential to be in the direct path of the ship as a standard collision avoidance procedure.

While underway, the ships (including non-Navy ships operating on behalf of the Navy) utilizing active acoustics and towed in-water devices will have at least one watch person during activities. While underway, watch personnel are alert at all times and have access to binoculars.

Mitigation Measures

The proposed IHA includes the following mitigation, monitoring, and reporting requirements which will be incorporated by ONR to minimize potential impacts from project activities:

- (a) All ships operated by or for the Navy shall have personnel assigned to stand watch at all times while underway.
- (b) For all towed active acoustic sources, ONR shall implement a minimum shutdown zone of 200 yards (183 meters (m)) radius from the source. If a marine mammal comes within or approaches the shutdown zone, such operations shall cease.
  - (i) Active transmission may recommence if any one of the following conditions are met:
    - i. The animal is observed exiting the shutdown zone;
    - ii. The animal is thought to have exited the shutdown zone based on its course and speed and relative motion between the animal and the source;
    - iii. The shutdown zone has been clear from any additional sightings for a period of 30 minutes; or
    - iv. The ship has transited more than 400 yards (366 m) beyond the location of the last sighting.
- (c) During mooring deployment, ONR shall implement a shutdown zone of 60 yards (55 m) around the deployed mooring. Deployment shall cease if a marine mammal comes within or approaches the shutdown zone.
  - (i) Deployment may recommence if any one of the following conditions are met:
    - i. The animal is observed exiting the shutdown zone;
    - ii. The animal is thought to have exited the shutdown zone based on its course and speed; or
    - iii. The shutdown zone has been clear from any additional sightings for a period of 15 minutes.
- (d) Ships will avoid approaching marine mammals head on and will maneuver to maintain an exclusion zone of 500 yd (457 m) around observed whales, and 200 yd (183 m) around all other marine mammals, provided it is safe to do so in ice free waters.
- (e) These requirements do not apply if a vessel's safety is at risk, such as when a change of course would create an imminent and serious threat to safety, person,

vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. No further action is necessary if a marine mammal other than a whale continues to approach a vessel after there has already been one maneuver and/or speed change to avoid the animal. Avoidance measures shall continue for any observed whale in order to maintain an exclusion zone of 500 yd (457 m).

Monitoring

ONR will conduct marine mammal monitoring during Arctic Research Activities. Monitoring and reporting shall be conducted in accordance with the Integrated Comprehensive Monitoring Program (ICMP).[3]

(a) While underway, all ships utilizing active acoustics and towed in-water devices shall have at least one person on watch during all activities.

(b) During deployment of moored sources, visual observation shall begin 15 minutes prior to deployment and continue throughout the source deployment.

Reporting

ONR will:

(a) Submit a draft report to the Permits Division on all monitoring conducted under the IHA within 90 calendar days of the completion of marine mammal monitoring. The report shall include data regarding acoustic source use and any marine mammal sightings. If no comments are received from NMFS within 30 days of submission of the draft final report, the draft final report will constitute the final report. If comments are received, a final report must be submitted within 30 days after receipt of comments.

(b) Reporting injured or dead marine mammals:

  (i) In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA, such as an injury (Level A harassment), serious injury, or mortality, ONR shall immediately cease the specified activities and report the incident to the Office of Protected Resources, NMFS, and the Alaska Regional Stranding Coordinator (877-925-7773), NMFS. The Navy shall adhere to protocols outlined in the Stranding Response Plan for Atlantic Fleet Training and Testing (AFTT) study area (November 2013).

2.3 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.

ONR proposes to conduct scientific experiments in the Beaufort Sea from August 2018 to December 2021. The study area (Figure 2) consists of a "deep water area" (where the twelve red dots are located, Figure 2) and a "shallow water area" (where ONR determined "*de minimis*"

[3] https://www.navymarinespeciesmonitoring.us/about/integrated-comprehensive-monitoring-program/

sources will be used near the continental shelf). Additionally, the R/V *Sikuliaq* and CGC *Healy* will transit from Dutch Harbor to the Beaufort Sea (Figure 6), and for purposes of this consultation the transit route is part of the action area. All activities, except for the transit of ships or aircraft, will take place outside the U.S. territorial sea in either the U.S. Exclusive Economic Zone (EEZ) or international waters.

3 APPROACH TO THE ASSESSMENT

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

Under NMFS’s regulations, the destruction or adverse modification of critical habitat “means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features” (50 CFR 402.02).

The designation(s) of critical habitat for North Pacific right whales and Steller sea lions use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a “destruction or adverse modification” analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We used the following approach to determine whether the proposed action described in Section 2 of this Opinion is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on listed species or critical habitat. As part of this step, we identify the action area – the spatial and temporal extent of these direct and indirect effects.
- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We

determine the rangewide status of critical habitat by examining the condition of its PBFs - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 4 of this opinion.

- Describe the environmental baseline including: past and present impacts of Federal, state, or private actions and other human activities *in the action area*; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 5 of this opinion.
- Analyze the effects of the proposed actions. Identify the listed species that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to stressors and the populations or subpopulations those individuals represent. NMFS also evaluates the proposed action's effects on critical habitat features. The effects of the action are described in Section 6 of this opinion with the exposure analysis described in Section 6.2 of this opinion.
- Once we identify which listed species are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed species are likely to respond given their exposure (these represent our *response analyses*). Response analysis is considered in Section 6.3 of this opinion.
- Describe any cumulative effects. Cumulative effects, as defined in NMFS's implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 7 of this opinion.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 4). Integration and synthesis with risk analyses occurs in Section 8 of this opinion.
- Reach jeopardy and adverse modification conclusions. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 9. These conclusions flow from the logic and rationale presented in the Integration and Synthesis Section 8.
- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, NMFS determines that the action under

consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the action.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative to the action. The reasonable and prudent alternative 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.

For all analyses, we use the best available scientific and commercial data. For this consultation, we relied on:

- Information submitted by the applicant and Permits Division
- Government reports
- Past reports for similar activities
- General scientific literature

4 RANGEWIDE STATUS OF THE SPECIES

Ten species of marine mammals listed under the ESA under NMFS's jurisdiction may occur in the action area. The action area also includes designated critical habitat for two species. This opinion considers the effects of the proposed action on these species and designated critical habitats (Table 4).

Table 4. Listing status and critical habitat designation for marine mammals considered in this opinion.

Species	Status	Listing	Critical Habitat
Bowhead Whale (*Balanea mysticetus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Blue whale (*Balaenoptera musculus*)	Endangered	NMFS 1970 35 FR 18319	Not designated
Fin Whale (*Balaneoptera physalus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Humpback Whale, Western North Pacific DPS (*Megaptera novaeangliae*)	Endangered	NMFS 1970, 35 FR 18319 NMFS 2016 81 FR 62260	Not designated
Humpback Whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	NMFS 1970, 35 FR 18319 NMFS 2016 81 FR 62260	Not designated

Species	Status	Listing	Critical Habitat
North Pacific Right Whale (*Eubalaena japonica*)	Endangered	NMFS 2008, 73 FR 12024	NMFS 2008, 73 FR 19000
Sperm Whale (*Physeter macrocephalus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Ringed Seal, Arctic Subspecies (*Phoca hispida hispida*)	Threatened	NMFS 2012, 77 FR 76706	Not designated
Bearded Seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	NMFS 2012, 77 FR 76740	Not designated
Steller Sea Lion, Western DPS (*Eumatopias jubatus*)	Endangered	NMFS 1997, 62 FR 24345	NMFS 1993, 58 FR 45269

4.1 Species and Critical Habitat Not Likely to be Adversely Affected by the Action

If an action's effects on ESA-listed species will be insignificant, discountable, or completely beneficial, we conclude that the action is not likely to adversely affect those species and further analysis is not required. Insignificant effects relate to the size of impact and are those that one would not be able to meaningfully measure, detect, or evaluate, and should never reach the scale where take occurs. Discountable effects are those that are extremely unlikely to occur. Similarly, if proposed activities are not likely to destroy or adversely modify critical habitat, further analysis is not required.

Section 4.1.1. discusses effects to the blue whale, North Pacific right whale, sperm whale, fin whale, humpback whale (Western North Pacific DPS and Mexico DPS), bowhead whale, and western DPS Steller sea lion. Section 4.1.2 discusses effects to critical habitat for North Pacific right whales and Steller sea lions.

4.1.1 Blue Whale, North Pacific Right Whale, Sperm Whale, Fin Whale, Humpback Whale, Bowhead whale, and Steller Sea Lion Western DPS

The transit route proposed for the R/V *Sikuliaq* and CGC *Healy* (Figure 3) between Dutch Harbor and the Beaufort Sea overlaps with the ranges of the blue whale, North Pacific right whale, sperm whale, fin whale, humpback whale (Western North Pacific DPS and Mexico DPS), bowhead whale, and western DPS Steller sea lion. Potential effects from project vessel traffic on these ESA listed species includes auditory and visual disturbance and vessel collision. ONR will follow the USCG SOPs for operating in Alaska (see Section 2.2) to minimize or avoid auditory and visual disturbance and potential vessel collision during vessel transit. Additionally, ONR has discussed these transit routes with both the Arctic Waterways Safety Committee (AWSC) and the Alaska Eskimo Whaling Commission (AEWC) relative to potential conflicts with subsistence hunting.

The R/V *Sikuliaq* and CGC *Healy* would have a short-term presence in the Bering and Chukchi Seas as they transit between Dutch Harbor and the Beaufort Sea. Automatic Identification System (AIS) data were recorded from 532 vessels in the Bering Strait and northern Bering Sea region from 2013 through 2015 (Nuka Research and Planning Group 2016), and from 250 vessels in U.S. waters north of the Pribilof Islands in 2012 (ICCT 2015). Only one trip per year is planned for both the R/V *Sikuliaq* and CGC *Healy* along the marine transit route.

Vessel Noise

Although some marine mammals could receive sound levels in exceedance of the acoustic threshold of 120 dB from the vessels or be disturbed by their visual presence, take is unlikely to occur. NMFS has interpreted the term “harass” in the Interim Guidance on the ESA Term "Harass" (Wieting 2016) as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.” While listed marine mammals will likely be exposed to acoustic stressors from vessel transit, the nature of the exposure will be low-frequency, with much of the acoustic energy emitted by the vessels at frequencies below the best hearing ranges of the marine mammals expected to occur within the action area. In addition, because vessels will be in transit, the duration of the exposure will be very brief.

NMFS anticipates that at the cruising speed of the R/V *Sikuliaq* (11 knots) and CGC *Healy* (12 knots), vessels will ensonify a given point in space to levels above 120 dB (the acoustic threshold for behavioral disturbance from continuous sound; Section 6.2.1.1) for less than 6 minutes. The project vessels will emit continuous sound while in transit, which will alert marine mammals before the received sound level exceeds 120 dB. Therefore, a startle response is not expected. Rather, slight deflection and avoidance are expected to be common responses in those instances where there is any response at all. The adherence to USCG SOPs, as specified in Section 2.2, is expected to further reduce the potential for marine mammals to react discernibly to transiting vessels.

The USCG SOPs discussed in Section 2.2 make it extremely unlikely that transiting vessels would elicit behavioral responses by blue whales, North Pacific right whales, sperm whales, fin whales, Western North Pacific DPS humpback whales, Mexico DPS humpback whales, bowhead whales, or Western DPS Steller sea lions that would rise to the level of harassment as interpreted in NMFS guidance (Wieting 2016). In other words, we expect any effects to these species to be too small to detect or measure. Therefore, we conclude that adverse effects to these species from vessel noise would be insignificant.

In addition, based on the extremely small number of North Pacific right and sperm whales in the Bering Sea, and limited number of transits associated with the project, we do not anticipate spatial overlap between these species and vessel operations. Thus, the probability of exposure to vessel noise at the level of harassment by transiting vessels is very small, and thus adverse effects to North Pacific right and sperm whales are extremely unlikely to occur. Therefore, we conclude that adverse effects from the vessel noise to North Pacific right and sperm whales are discountable.

Vessel Strike

Vessels transiting the marine environment have the potential to collide with, or strike, marine mammals (Laist et al. 2001, Jensen and Silber 2003). From 1978 to 2012, there were at least 108 recorded whale-vessel collisions in Alaska, with the majority occurring in Southeast Alaska (Figure 7; Neilson et al. 2012). Among larger whales, humpback whales were the most frequently documented victims of ship strikes, accounting for 86 percent of all reported collisions. Fin whales accounted for 2.8 percent of reported collisions, gray whales 0.9 percent, and sperm whales 0.9 percent. The probability of strike events depends on the frequency, speed, and route of the marine vessels, and the distribution and density of marine mammals in the area, as well as other factors. Vanderlaan and Taggart (2007) used records of large whale-vessel strikes to develop a model of the probability of lethal injury based upon vessel speed. The model projected that the chance of lethal injury to a large whale struck by a vessel travelling at speeds over 15 knots (28 km/hour) is approximately 80 percent, and that this probability drops to about 20 percent for vessels travelling between 8.6 knots (16 km/hour) and 15 knot (28 km/hour).

Although risk of ship strike has not been identified as a significant concern for Steller sea lions (Loughlin and York 2000), the recovery plan for this species states that Steller sea lions may be more susceptible to ship strike mortality or injury in harbors or in areas where animals are concentrated (e.g., near rookeries or haulouts; NMFS 2008). Despite all of the traffic in and around rookery and haulout locations near Dutch Harbor, there have been no reported ship strikes of Steller sea lions in Alaska. Moreover, the Steller sea lion population in and around Dutch Harbor has been increasing at about 2 to 3 percent per year, despite ongoing vessel traffic (Fritz 2012, Muto et al. 2017).

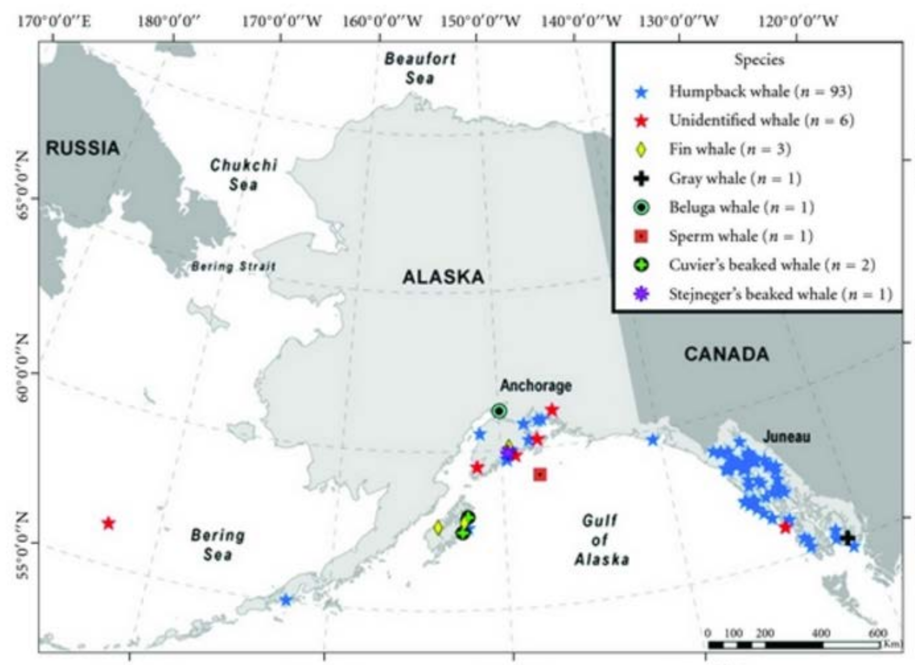

Figure 7. Location of whale-vessel collision reports in Alaska (*n* = 108) by species 1978–2011, from Nielson et al. (2012)

Based on: 1) the limited annual number of vessel trips between Dutch Harbor and the Beaufort Sea; 2) the transitory nature of this vessel traffic; 3) decades of vessels transiting in the Bering and Chukchi Seas with only a single report of a ship striking a cetacean; 4) the extremely low density of North Pacific right and sperm whales in the Bering Sea, 5) the agility of pinnipeds and their ability to avoid strikes by slow-moving vessels; and 6) USCG SOPs in place to minimize or avoid effects of transiting vessels on cetaceans and pinnipeds, NMFS concludes that the probability of a project vessel striking a blue whale, North Pacific right whale, sperm whale, fin whale, Western North Pacific DPS humpback whale, Mexico DPS humpback whale, or Western DPS Steller sea lion is very small, and thus adverse effects to these species are extremely unlikely to occur. Therefore, we conclude that adverse effects from vessel strike on these species are discountable.

Occurrence in the Study Area (Beaufort Sea)

Although bowhead whales occur in the Beaufort Sea from about June to August, sightings during the Aerial Surveys of Arctic Marine Mammals (ASAMM, Figure 8) and tracks from satellite tagged bowhead whales (Quakenbush et al. 2013, Quakenbush 2018) indicate that they primarily remain close to shore, i.e., less than 50 km (Clarke et al. 2017), although some tagged individuals have travelled substantially further offshore in the Beaufort Sea during summer. During the ONR's ARA action, there will be one mooring location that occurs close to shore (about 55 km), however this mooring contains only *de minimis* acoustic sources (Figure 2). The remaining activities occur in the deep water (>2,000 m; see Figure 2) further offshore (more than 200 km) where bowhead whales occur at very low densities.

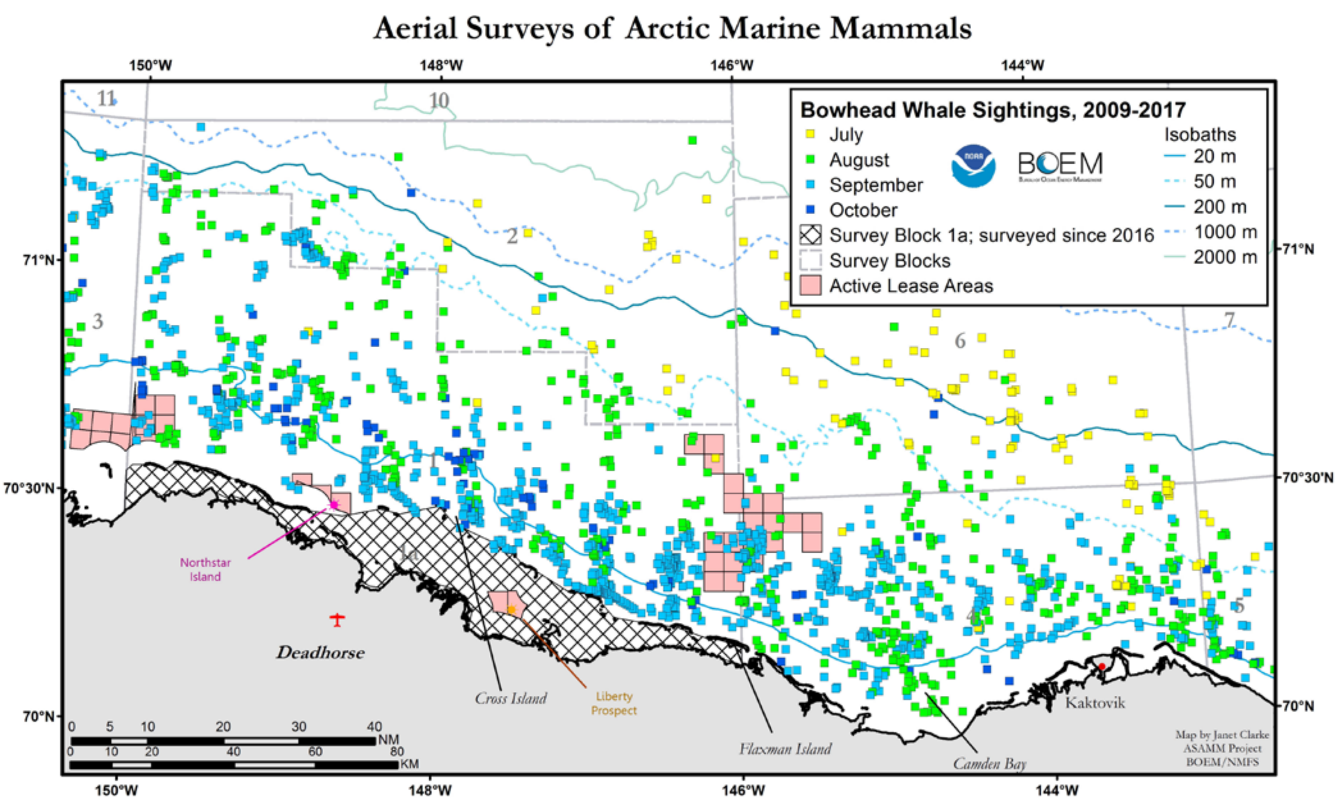

Figure 8. Bowhead whale sightings during the Aerial Surveys of Arctic Marine Mammals (ASAMM, Clarke et al. 2017)

Bowhead whales are present at extremely low densities in the deep water (>2,000 m; see Figure 2) areas of the Beaufort Sea during the time window of project activities. Their risk of exposure to noise and disturbance from project activities is therefore very small, and adverse effects to bowhead whales are extremely unlikely to occur. Therefore we conclude that adverse effects from the project activities in the Beaufort Sea on bowhead whales are discountable.

Small numbers of fin and humpback whales (of unknown DPS) have been seen in the Chukchi Sea during the ASAMM surveys (Figure 9), and humpback whales have also been seen in the Beaufort Sea east of Barrow (Hashagen et al. 2009). However, it is unlikely that either of these species would be present in the deep water (>2,000 m; see Figure 2) areas of the Beaufort Sea. The risk of humpback and fin whale exposure to noise and disturbance from project activities is extremely small, and adverse effects are extremely unlikely to occur. Therefore we conclude that adverse effects from the project activities in the Beaufort Sea on fin and humpback whales are discountable.

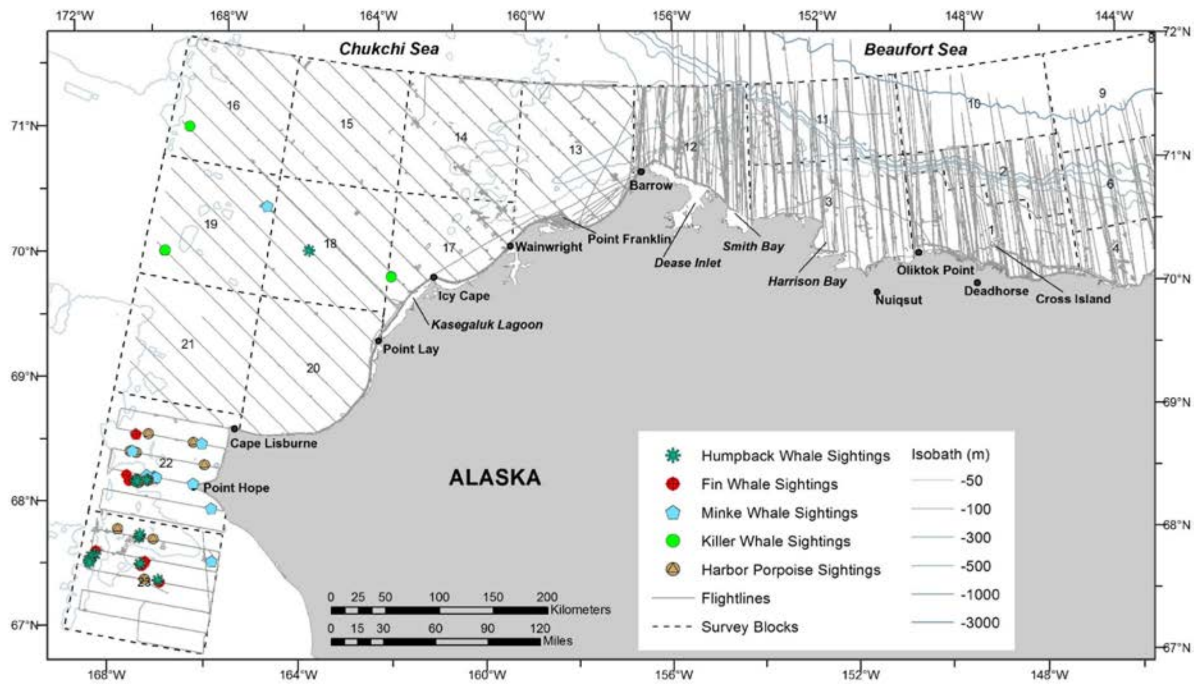

Figure 9. Sightings of humpback and fin whales (ESA-listed) during the Aerial Surveys of Arctic Marine Mammals. Non-ESA listed species (minke and killer whales, and harbor porpoises) are also shown (Clarke et al. 2017)

In summary, NMFS concludes that the proposed action is not likely to adversely affect the blue whale, North Pacific right whale, sperm whale, fin whale, Western North Pacific DPS and Mexico DPS humpback whale, bowhead whale, or Western DPS Steller sea lion. These species are not discussed further in this opinion.

4.1.2 North Pacific Right Whale and Steller Sea Lion Critical Habitat

North Pacific Right Whale Critical Habitat

North Pacific right whale critical habitat (Figure 10) was designated in areas where this species is known or believed to feed in the eastern Bering Sea and Gulf of Alaska (73 FR 19000; April 8, 2008). The physical and biological features (PBFs) 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 are primary prey items for the species.

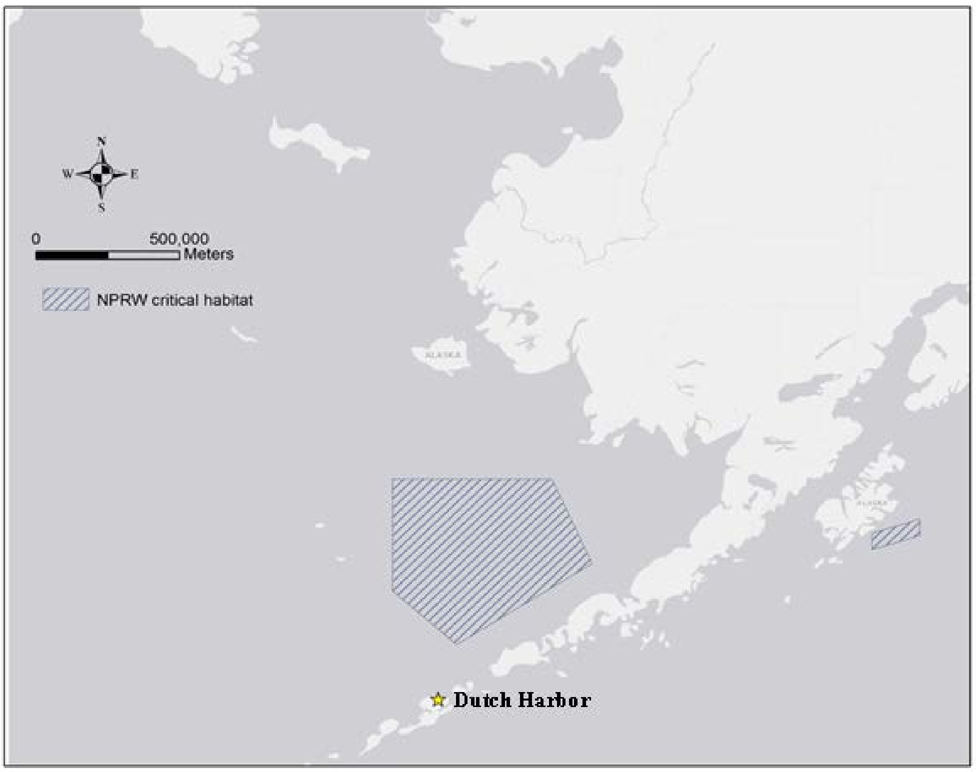

Figure 10. North Pacific right whale critical habitat.

The potential effects of the action that may overlap with North Pacific right whale critical habitat include exposure to spilled or otherwise-discharged fuel or other chemicals, and acoustic disturbance resulting from vessels transiting between Dutch Harbor and the Beaufort Sea. While vessels associated with the action may enter designated critical habitat, vessel traffic is not anticipated to affect aggregations of copepods or euphausiids, and therefore we do not expect effects to the PBFs associated with North Pacific right whale critical habitat. In addition, given the small number of trips by project vessels per year (one per year between 2018 and 2021) and the low likelihood of a spill occurring, we find it extremely unlikely that a fuel spill, other chemical spill, or discharge will occur as a result of this vessel traffic that would have more than a *de minimis* effect on the PBF for the critical habitat. The Bering Sea in the area of North Pacific right whale critical habitat is a very dynamic body of water, with high tidal currents, frequent high wind conditions, and significant wave-induced mixing. Even if a small spill were to occur in this critical habitat, it would be expected to evaporate, dissipate, or become entrained within 24 hours, such that any effects to this PBF would be insignificant. We also do not expect that noise from transiting project vessels would result in effects on the PBF of the critical habitat that could be meaningfully measured or detected. The impacts of the vessels transiting through the Bering Sea on North Pacific right whale critical habitat, including the planktonic prey that comprise the PBF of this critical habitat, will be immeasurably small. Therefore, we conclude that the adverse effects from vessel transit on the planktonic prey PBF of North Pacific right whale critical habitat are insignificant.

Steller Sea Lion Critical Habitat

NMFS identified PBFs essential for conservation of Steller sea lions in the final rule to designate critical habitat (58 FR 45269; August 27, 1993) including terrestrial, air, and aquatic habitats (as described at 50 CFR 226.202) that support reproduction, foraging, rest, and refuge. The potential effects of project vessels transiting between Dutch Harbor and the Beaufort Sea on Steller sea lion critical habitat include exposure to spilled or otherwise-discharged fuels or other chemicals, and acoustic or visual disturbance. We evaluate these effects on each of the PBFs of the critical habitat below.

1. *Terrestrial zones that extend 3,000 feet (0.9 km) landward from each major haulout and major rookery in Alaska.*

   Project vessels and activities will not be located in a terrestrial zone that is 3,000 ft (0.9 km) landward from a major haulout or rookery, and any effects are extremely unlikely to occur in those areas. Therefore, we conclude that adverse effects from the project to the terrestrial zones are discountable.

2. *Air zones that extend 3,000 feet (0.9 km) above the terrestrial zone of each major haulout and major rookery in Alaska.*

   Project activities are not located in an air zone that is 3,000 ft (0.9 km) above a major haulout or rookery and any effects are extremely unlikely to occur in those areas. Therefore, we conclude that adverse effects from the project to the air zones are discountable.

3. *Aquatic zones that extend 20 nm (37 km) seaward of each major haulout and major rookery in Alaska that is west of 144^{o} W longitude.*

   A small portion of the proposed marine transit route overlaps with or is adjacent to parts of the 20-nm aquatic zones in the Bering Sea, including near Dutch Harbor (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.

   Waters near Unalaska and Unimak Pass are frequently used by many ocean-going and commercial fishing vessels. Despite all of the traffic in and around rookery and haulout locations near Dutch Harbor, the Steller sea lion population in and around Dutch Harbor has been increasing at about 3% per year (Fritz 2012).

The incremental increase in vessel traffic due to this action will be extremely small. Transiting project vessels will be present within or adjacent to the aquatic zones for a very short period of time (about 3 hours), and they will most likely travel only along the outermost edges of these zones. Additionally, project vessels will not travel within 3 nm (5.5 km) of any Steller sea lion rookery or major haulout as part of the USCG SOPs (USCG 2011). Given the minimum distance to be maintained from these sites, as well as the limited overlap of the marine transit route with the aquatic zones, the probability that the proposed vessel traffic will cause visual or acoustic disturbance to Steller sea lion rookeries or major haulouts is very small, and thus adverse effects to the major haulouts and rookeries are extremely unlikely to occur. Therefore, we conclude that the adverse effects from visual or acoustic disturbance from vessels on Steller sea lion rookeries or major haulouts are discountable.

We also consider the probability of a spill or other discharge occurring that would have more than a *de minimis* effect on these aquatic zones very small. Moreover, if a small fuel spill occurred in these waters, it would be expected to evaporate, dissipate or become entrained within 24 hours. Therefore, we conclude that the adverse effects from a potential spill or other discharge on the major haulouts and rookeries west of 144° W longitude are discountable.

4. *Three special aquatic foraging areas: the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area, as specified at 50 CFR §226.202(c).*

Dutch Harbor is located within the Bogoslof special aquatic foraging area; consequently, transiting project vessels will travel through this designated area (Figure 11). Waters within the Bogoslof foraging area are frequently used by many ocean-going and commercial fishing vessels. As discussed above, the incremental increase in vessel traffic due to this action will be extremely small (as there will only be a maximum of two vessels per year for certain years of the project). Project vessels will be present within the Bogoslof foraging area for about 20 hours per traverse. Project vessels will are not expected to transit through the Shelikof Strait or Seguam Pass special aquatic foraging areas.

The impact of the transiting project vessels is very minor, and thus adverse effects to the waters of these foraging areas will be immeasurably small. Furthermore, adverse effects of the transiting vessels on the waters of these foraging areas are extremely unlikely to occur. Therefore we conclude that the adverse effects from vessels transiting through the foraging areas on the waters of the foraging areas are insignificant and discountable.

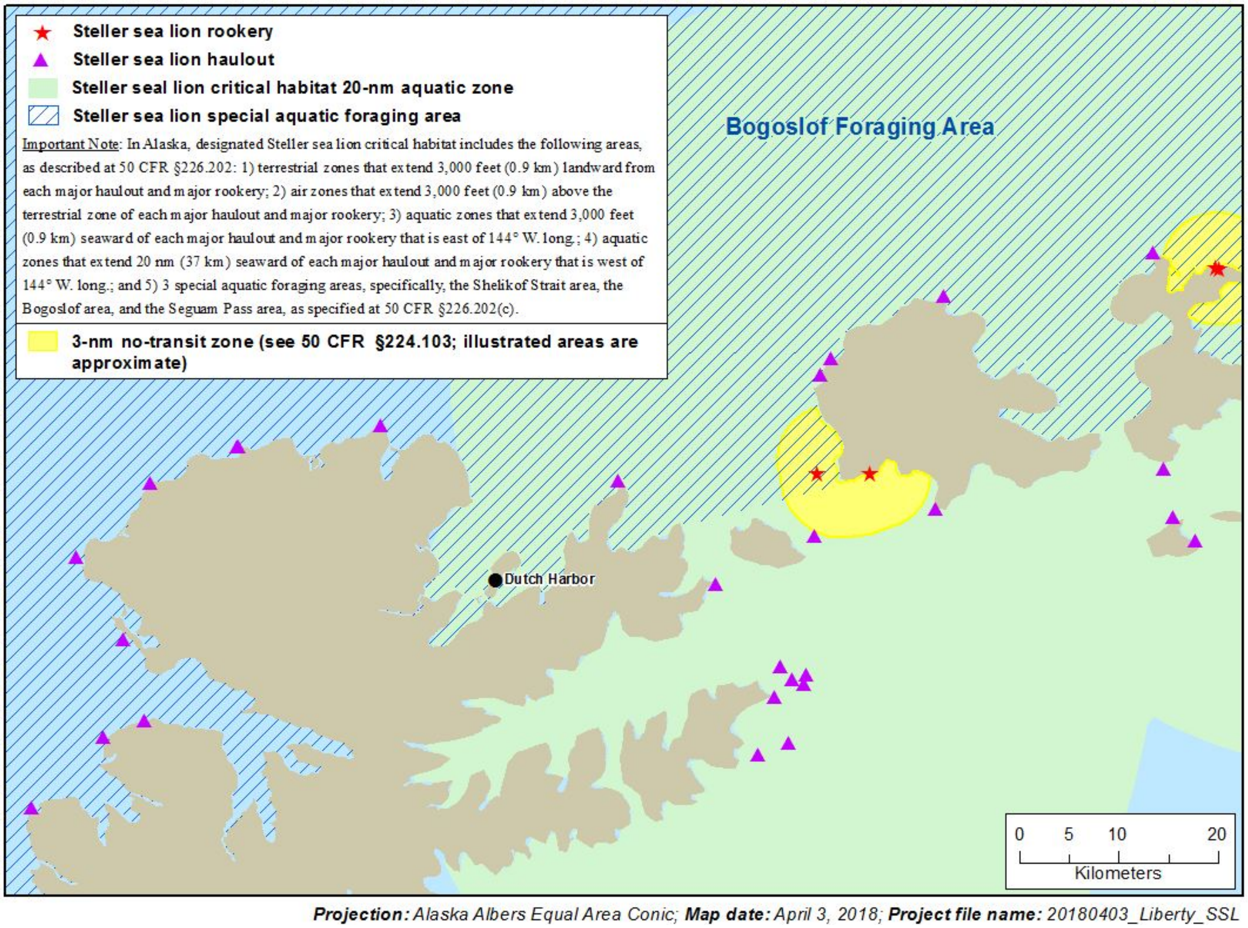

Figure 11. Designated Steller sea lion critical habitat and known Steller sea lion rookeries and haulouts near Dutch Harbor

In summary, the proposed action is not likely to adversely affect designated critical habitat for the North Pacific right whale or the Steller sea lion.

4.2 Climate Change

A threat that is common to all Arctic marine mammals, including Arctic ringed and Beringia DPS bearded seals, is global climate change. Because of this commonality, we present this narrative here rather than in the species-specific narratives that follow.

There is widespread consensus within the scientific community that atmospheric temperatures are increasing and that this will continue for at least the next several decades (Watson and Albritton 2001, Oreskes 2004). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat waves, floods, storms, and wet-dry cycles. Warming of the climate system is unequivocal, as is 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 average global surface temperature rose by 0.85° C from 1880 to 2012, and it continues to rise at an accelerating pace (IPCC 2014); the 15 warmest years on record since 1880 have occurred in the first 17 years of the 21st century, with 2016 being the warmest (NCEI 2017). The warmest year on record for average ocean temperature was 2015 (NCEI 2016). Since 2000, the Arctic (latitudes between 60 and 90° N) has been warming at three times the rate of lower latitudes (Comiso and Hall 2014) due to “Arctic amplification,” a characteristic of the global climate system influenced by changes in sea ice extent, atmospheric and oceanic heat transports, cloud cover, black carbon, and many other factors (Serreze and Barry 2011, Richter-Menge et al. 2017).

Direct effects of climate change include increases in atmospheric temperatures, decreases in sea ice, and changes in sea surface temperatures, oceanic pH, patterns of precipitation, and sea level. Indirect effects of climate change have impacted, are impacting, and will continue to impact marine species in the following ways (IPCC 2014):

- Shifting abundances
- Changes in distribution
- Changes in timing of migration
- Changes in periodic life cycles of species

Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2009), including ESA-listed species. Therefore, we expect the extinction risk of at least some ESA-listed species to increase with global warming. Cetaceans with restricted distributions linked to water temperature may be particularly vulnerable to range restriction (Learmonth et al. 2006, Isaac 2009). MacLeod (2009) estimated that, based on expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, 47 percent will be negatively affected, and 21 percent will be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters, and preferences for shelf habitats (e.g. North Pacific right whales) (MacLeod 2009).

Arctic sea ice extent, in general, has been in decline since 1979 and has a negative trend (Jeffries et al. 2014). In March, 2016, the National Snow and Ice Data Center reported that the maximum extent of Arctic sea ice reached a record low for the second straight year (NSIDC, 2016), and the April 2018 sea ice extent tied 2016 for the lowest year on record (NSIDC, 2018). Arctic sea ice thickness and annual minimum sea ice extent (i.e., September sea ice extent) have accelerated in their rate of decline considerably in the first decade of the 21st century and approximately three-quarters of summer Arctic sea ice volume has been lost since the 1980s (IPCC 2013). Perennial sea ice extent has declined at a rate of approximately 12 percent per decade and multi-year ice extent is declining at rate of approximately 15 percent per decade (Comiso 2012). Wang and Overland (2012) estimated that the Arctic will be nearly ice-free (i.e., sea ice extent will be less than 1 million km^2) during the summer in the 2030s.

The depth and duration of snow cover are projected to decline substantially throughout the range of Arctic ringed seals (Hezel et al. 2012). The persistence of the Arctic ringed seal will likely be challenged as decreases in ice and snow cover lead to increased juvenile mortality from premature weaning, hypothermia, and predation (Kelly et al. 2010b). It is likely, within the foreseeable future, the number of Arctic ringed seals will decline substantially, and no longer persist in substantial portions of their range (Kelly et al. 2010b). The Beringia DPS bearded seal will likely be challenged as decreases in sea ice lead to the spatial separation of sea ice from shallow feeding areas, loss of suitable molting habitat, and decreases in prey density or availability (Cameron et al. 2010). Within the foreseeable future, demographic problems associated with abundance, productivity, spatial structure, or diversity might place the DPS in danger of extinction (Cameron et al. 2010).

There have recently been increases of subarctic species seasonally found in the Arctic. With increasing sea-surface temperatures in the Arctic, instances of northward movement of non-native species, and range-expansion of sub-Arctic species into this ecosystem have already been seen, and more is expected in the coming years (Fernandez 2014). This northward movement can impact Arctic species by altering Arctic marine food webs (Kortsch et al. 2015), introducing novel diseases (Burek et al. 2008, Bossart 2011), increasing abundance of predators (e.g., Ferguson et al. 2010), and competition for resources with non-native species (Kovacs et al. 2011).

4.3 Status of Listed Species

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02.

This section consists of narratives for each of the threatened species that may be adversely affected by the proposed action. 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. More detailed background information on the status of these species can be found in a number of published documents including stock assessment reports for Alaska marine mammals (Muto et al. 2017) and the comprehensive status review reports completed in 2010 for bearded and ringed seals (Cameron et al. 2010, Kelly et al. 2010b).

4.3.1 Arctic ringed seals

Status and Population Structure

Under the MMPA, NMFS recognizes one stock of Arctic ringed seals, the Alaska stock, whose range includes the entire study area (both within U.S. waters and outside the U.S. EEZ). The Arctic ringed seal was listed as threatened under the ESA on December 28, 2012, primarily due to expected impacts on the population from declines in sea ice and snow cover stemming from climate change within the foreseeable future (77 FR 76706). The ESA listing was challenged in court and vacated temporarily, but has since been reinstated.

Ringed seal population surveys in Alaska have used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current, comprehensive, and precise abundance estimates or trends for the Alaska stock are not available. Frost et al. (2004) conducted aerial surveys within 40 km (25 mi) of shore in the Alaska Beaufort Sea during May and June from 1996 through 1999 and observed ringed seal densities ranging from 0.81 seals per square kilometer in 1996 to 1.17 seals per square kilometer in 1999. Moulton (2002) conducted similar, concurrent surveys in the Alaska Beaufort Sea between 1997 and 1999 but reported substantially lower ringed seal densities than Frost et al. (2004). The reason for this disparity was unclear (Frost et al. 2004). Bengtson et al. (2005) conducted aerial surveys in the Alaskan Chukchi Sea during May and June of 1999 and 2000. While the surveys were focused on the coastal zone within 37 km (23 mi) of shore, additional survey lines were flown up to 185 km (115 mi) offshore. Population estimates were derived from observed densities corrected for availability bias using a haul-out model from six tagged seals. Ringed seal abundance estimates for the entire survey area were 252,488 (standard error = 47,204) in 1999 and 208,857 (standard error = 25,502) in 2000. Using the most recent survey estimates from surveys by Bengtson et al. (2005) and Frost et al. (2004) in the late 1990s and 2000, Kelly et al. (2010b) estimated the total population in the Alaska Chukchi and Beaufort seas to be at least 300,000 ringed seals. This estimate is likely an underestimate since the Beaufort Sea surveys were limited to within 40 km from shore.

Though a precise population estimate for the entire Alaska stock is not available, research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted image-based aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these surveys are still being analyzed, but for the U.S. portion of the Bering Sea, Boveng et al. (2017) reported model-averaged abundance estimates of 186,000 and 119,000 ringed seals in 2012 and 2013, respectively. It was noted that these estimates should be viewed with caution because a single point estimate of availability (haul-out correction factor) was used and the estimates did not include ringed seals in the shorefast ice zone, which was surveyed using a different method. The authors suggested that the difference in seal density between years may reflect differences in the numbers of ringed seals using Russian versus U.S. waters between years, and they noted that if this was the case, the eventual development of comprehensive estimates of abundance for ringed seals in the Bering Sea that incorporate data in Russian waters may show less difference between years.

Due to the lack of precise population estimates, the population trends for the Arctic subspecies and Alaska stock are unknown.

Distribution

The Arctic subspecies of ringed seal has a circumpolar distribution and is found in all seasonally ice-covered waters throughout the Arctic basin and adjacent waters (Figure 12). They remain with the ice most of the year and use it as a haul-out platform for resting, pupping and nursing in late winter to early spring, and molting in late spring to early summer. During summer, ringed seals range hundreds to thousands of kilometers to forage along ice edges or in highly productive open-water areas (Harwood and Stirling 1992, Freitas et al. 2008, Kelly et al. 2010b, Harwood et al. 2015). Harwood and Stirling (1992) reported that in late summer and early fall, aggregations of ringed seals in open-water in some parts of their study area in the southeastern Canadian Beaufort Sea where primary productivity was thought to be high. Harwood et al. (2015) also found that in the fall, several satellite-tagged ringed seals showed localized movements offshore east of Point Barrow in an area where bowhead whales are known to concentrate in the fall to feed on zooplankton. With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack, with many seals dispersing throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Frost and Lowry 1984, Crawford et al. 2012, Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010b).

Occurrence in the Action Area

In Alaskan waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort seas (Frost 1985, Kelly 1988a), and therefore are in the study area (Figure 2). Passive acoustic monitoring (PAM) of ringed seals from a high frequency recording package deployed at a depth of 787 ft. (240 m) in the Chukchi Sea (65 nm) 120 km north-northwest of Barrow, Alaska detected ringed seals in the area between mid- December and late May over the four year study (Jones et al. 2014). With the onset of the fall freeze, ringed seal movements become increasingly restricted and seals will either move west and south with the advancing ice pack with many seals dispersing throughout the Chukchi and Bering Seas, or remain in the Beaufort Sea (Frost and Lowry 1984, Crawford et al. 2012, Harwood et al. 2012). Kelly et al. (2010a) tracked home ranges for ringed seals in the subnivean period (using shorefast ice); the size of the home ranges varied from less than 1 up to 27.9 km^2; (median is 0.62 km^2 for adult males and 0.65 km^2 for adult females). Most (94 percent) of the home ranges were less than 3 km^2 during the subnivean period (Kelly et al. 2010a). Near large polynyas, ringed seals maintain ranges, up to 7,000 km^2 during winter and 2,100 km^2 during spring (Born et al. 2004). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010a). The size of winter home ranges can, however, vary by up to a factor of 10 depending on the amount of fast ice; seal movements were more restricted during winters with extensive fast ice, and were much less restricted where fast ice did not form at high levels (Harwood et al. 2015).

A density estimate of 0.3760 ringed seals per km^2 was used (among other information) to estimate take (see Section 10). This density estimate was derived from habitat-based modeling by (Kaschner 2004) and (Kaschner et al. 2006). The study area in the Beaufort Sea has not been surveyed in a manner that supports quantifiable density estimation of marine mammals. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and the likelihood of the presence of specific species have been used to predict densities using model-based approaches. These habitat suitability models include relative environmental suitability (RES) models. Habitat suitability models can be used to understand the possible extent and relative expected concentration of a marine species distribution. These models are derived from an assessment of the species occurrence in association with evaluated environmental explanatory variables that results in defining the RES suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated for each RES value based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed.

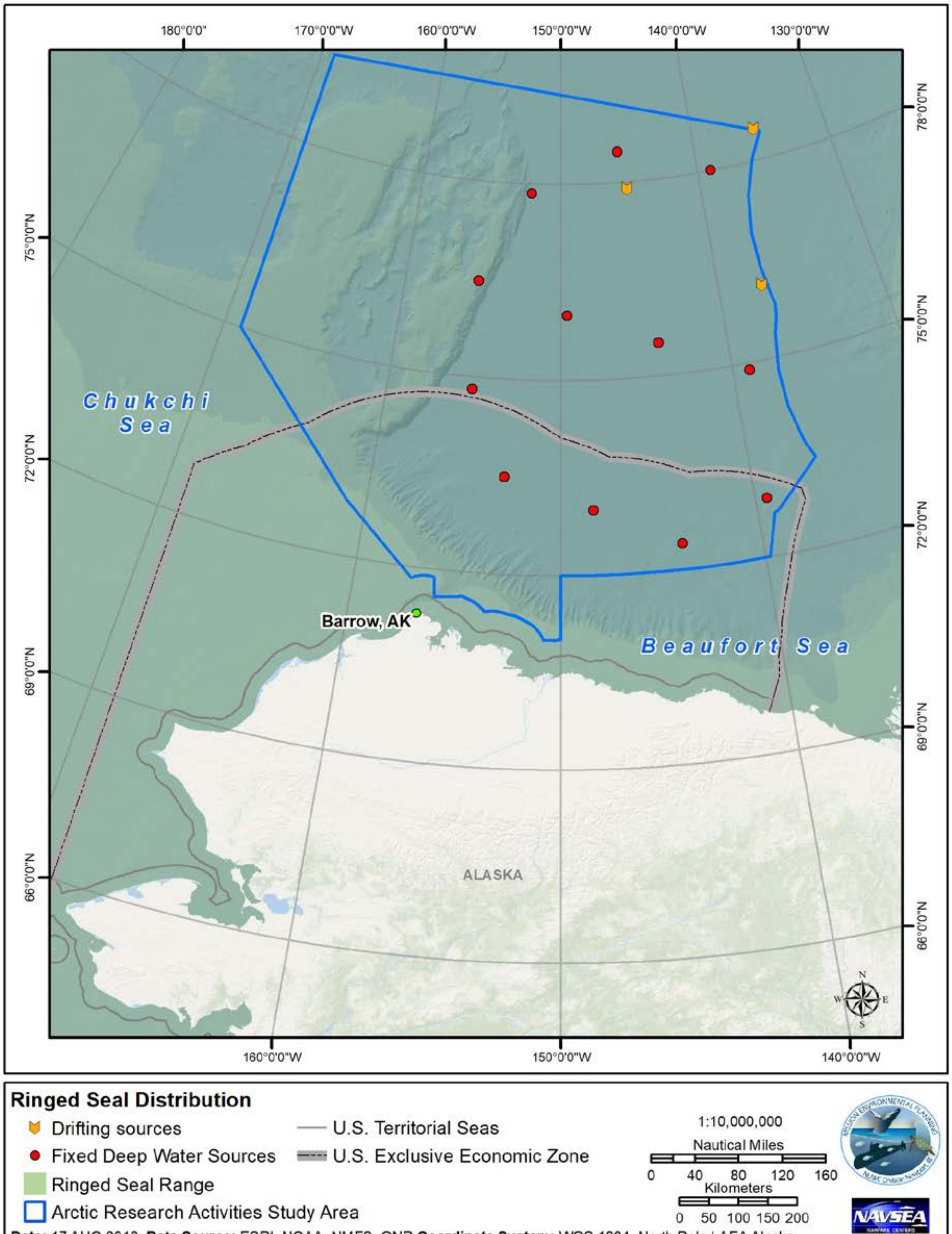

Figure 12. Ringed Seal Distribution in the study area

Reproduction, Growth, and Molt

Ringed seals are the smallest of the Arctic seals, reaching lengths of 1.5 m and weights of 50 to 70 kg. Their coat is dark with silver rings along the back and sides and silver along the underside. They are distinguished by their small head; short, cat-like snout, and plump body. The lifespan of ringed seals is 25 to 30 years. Males reach sexual maturity at 5 to 7 years of age; females mature at 4 to 8 years of age and give birth to a single pup annually. Mating is thought to take place under the ice in the vicinity of birth lairs while mature females are still lactating (Kelly et al. 2010b). Although mating generally occurs in May, implantation of the fertilized egg is delayed for 3 to 3.5 months. Once implanted, the gestation period lasts about 8 months and pups are weaned between 5 to 9 weeks of age (Lydersen and Hammill 1993, Lydersen and Kovacs 1999).

Ringed seal pups are born and nursed in the spring (March through May), normally in subnivean birth lairs, with the peak of pupping occurring in early April (Frost and Lowry 1981). Subnivean lairs provide thermal protection from cold temperatures, including wind chill effects, and some protection from predators (Smith and Stirling 1975, Smith 1976). These lairs are especially important for protecting pups. Arctic ringed seals appear to favor shore-fast ice as whelping habitat. Ringed seal whelping has also been observed on both nearshore and offshore drifting pack ice (e.g., Lentfer 1972). Seal mothers continue to forage throughout lactation, and move young pups between lairs within their network of lairs. The pups spend time learning diving skills, using multiple breathing holes, and nursing and resting in lairs (Smith and Lydersen 1991, Lydersen and Hammill 1993).

Ringed seals undergo an annual molt (shedding and regrowth of hair and skin) that occurs between mid-May to mid-July, during which time they spend many hours hauled out on the edge of the pack ice, or on remnant landfast ice until their old pelt dries out and sheds (Reeves 1998). The relatively long periods of time that ringed seals spend out of the water during the molt have been ascribed to the need to maintain elevated skin temperatures during new hair growth (Feltz and Fay 1966) and make molt a particularly stressful time for this species (Ryg et al. 1990). Figure 13 summarizes the approximate annual timing of Arctic ringed seal reproduction and molting (Kelly et al. 2010b).

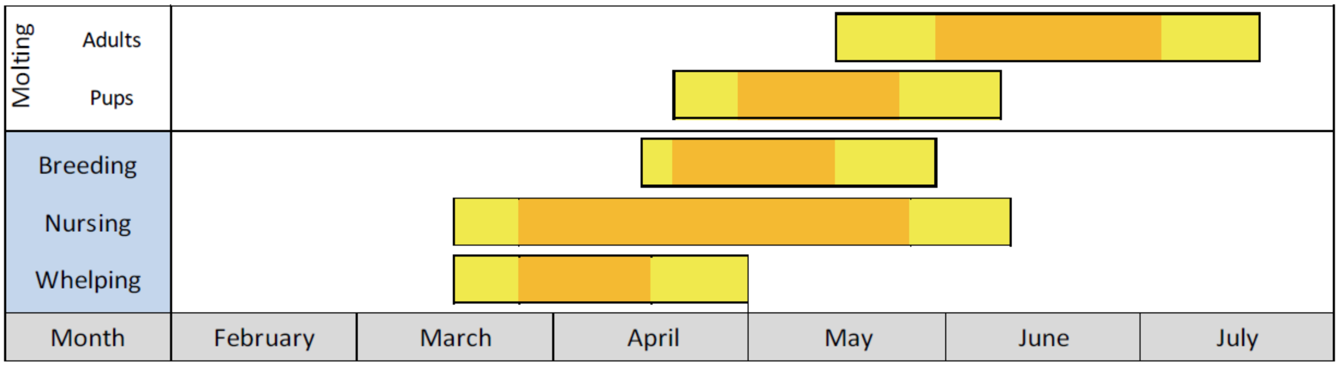

Figure 13. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicate the "peak" timing of each event (from Figure 3 in Kelly et al. 2010b)

Diving and Foraging

Ringed seals tend to haul out of the water during the daytime and dive at night during the spring to early summer breeding and molting periods, while the inverse tends to be true during the late summer, fall, and winter (Kelly and Quakenbush 1990, Lydersen 1991, Teilmann et al. 2000, Carlens et al. 2006, Kelly et al. 2010a).

Ringed seals feed year-round, but forage most intensively during the open-water period and early freeze-up, when they spend 90 percent or more of their time in the water (Kelly et al. 2010a). 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 (in the 5-10 cm (2-4 in) length range for fishes and the 2-6 cm (0.8-2.4 in) length range for crustaceans), and preferred prey tends to be schooling species that form dense aggregations. Quakenbush et al. (2011b) found fish were consumed more frequently in the 2000s than in the 1960s and 1970s, and Arctic cod, saffron cod, sculpin, rainbow smelt, and walleye pollock were identified as the dominant fishes, while mysids, amphipods, and shrimp were the dominant invertebrate species in ringed seal diets.

Fish 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 (DFO 1979, Lowry et al. 1980, Holst et al. 2001, Labansen et al. 2007). Quakenbush et al. (2011b) reported evidence that in general, the diet of Alaska ringed seals sampled consisted of cod, amphipods, and shrimp. Fish are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by seasonal availability and nutritional value of 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).

When not whelping, lactating, breeding or molting, ringed seals travel widely and may occur in waters of nearly any depth, though their distribution remains strongly correlated with the presence of sea ice and with food availability (Simpkins et al. 2003, Freitas et al. 2008).

Hearing, Vocalizations, and Other Sensory Capabilities

Ringed seals produce underwater vocalizations which range from approximately 0.1 to 1.0 kHz (Jones et al. 2014) in association with territorial and mating behaviors. Underwater audiograms for ringed seals indicate that their hearing is most sensitive at 49 dB re 1 µPa (12.8 kHz) in water, and -12 dB re 20 µPa (4.5 kHz) in air (Sills et al. 2015). NMFS defines the functional hearing range for phocids (seals) as 50 Hz to 86 kHz (NMFS 2016c).

Sills et al. (2015) suggested that because ringed seal hearing is sensitive for a greater frequency range than their vocalizations, their hearing is likely not only used for detection of the vocalizations conspecifics (Sills et al. 2015), but may also be important in locating breathing holes and the ice edge, detection of predators, locating prey, and orienteering (Elsner et al. 1989, Wartzok et al. 1992, Miksis-Olds and Madden 2014). Sills et al. (2015) further reported that ringed seal hearing appears to be resistant to masking across a range of frequencies, as indicated by their enhanced ability to detect signals from background noise.

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).

Additional information on ringed seals can be found at:
http://www.nmfs.noaa.gov/pr/species/mammals/seals/ringed-seal.html

4.3.2 Bearded Seal (Beringia DPS)

Population Structure and Status

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. 1976b). Based on evidence for discreteness and ecological uniqueness, NMFS concluded that the *E. b. nauticus* subspecies consists of two DPSs: the Okhotsk DPS in the Sea of Okhotsk, and the Beringia DPS, encompassing the remainder of the range of this subspecies (75 FR 77496; December 10, 2010). Only the Beringia DPS is found in U.S. waters (and the action area), and this portion is recognized by NMFS as a single Alaska stock.

The Beringia DPS was listed as threatened under the ESA on December 28, 2012 (77 FR 76739) due to the projected loss of sea ice and alteration of prey availability from climate change in the foreseeable future. The ESA listing was challenged in court and vacated temporarily, but has since been reinstated.

A precise population estimate for the entire Alaska stock is not available, but research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these image-based surveys are still being analyzed, but for the U.S. portion of the Bering Sea, Boveng et al. (2017) reported model-averaged abundance estimates of 170,000 and 125,000 bearded seals in 2012 and 2013, respectively. These results reflect use of an estimate of availability (haulout correction factor) based on data from previously deployed satellite tags. The authors suggested that the difference in seal density between years may reflect differences in the numbers of bearded seals using Russian versus U.S. waters between years, and they noted that if this was the case, the eventual development of comprehensive estimates of abundance for bearded seals in the Bering Sea that incorporate data in Russian waters may show less difference between years.

Distribution

Bearded seals have a circumpolar distribution that does not extend farther north than 85° N (Folkens et al. 2002, Muto et al. 2017). The Beringia DPS of the bearded seal includes all bearded seals from breeding populations in the Arctic Ocean and adjacent seas in the Pacific Ocean between 145°E longitude (Novosibirskiye Archipelago) in the East Siberian Sea and 130°W longitude in the Canadian Beaufort Sea, except west of 157°W longitude in the Bering Sea and west of the Kamchatka Peninsula (where the Okhotsk DPS is found). The bearded seal's effective range is generally restricted to areas where seasonal sea ice occurs over relatively shallow waters. Cameron et al. (2010) defined the core distribution of bearded seals as those areas of known extent that are in waters less than 500 m (1,640 ft) deep.

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 moving ice that produces natural openings and areas of open-water (Heptner et al. 1976b, Fedoseev 1984, Nelson et al. 1984). They usually avoid areas of continuous, thick, shorefast ice and are rarely seen in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Fedoseev 1965, Burns and Harbo 1972, Frost et al. 1979, Burns 1981, Smith and Hammill 1981, Fedoseev 1984, Nelson et al. 1984). Within the U.S. range of the Beringia DPS, the extent of favorable ice conditions for bearded seals is most restricted in the Beaufort Sea, where there is a relatively narrow shelf with suitable water depths. There is more suitable ice floating over suitable water depths in the Chukchi and Bering Seas (Burns 1981). During winter, the central and northern parts of the Bering Sea shelf where heavier pack ice occurs, have the highest densities of adult bearded seals (Heptner et al. 1976b, Burns and Frost 1979, Burns 1981, Nelson et al. 1984, Cameron et al. 2018), possibly reflecting the favorable ice conditions there. In contrast, Cameron et al. (2018) found that young bearded seals were closely associated with the ice edge farther south in the Bering Sea. Spring surveys conducted in 1999 through 2000 along the Alaska coast of the Chukchi Sea, and in 2001 near St. Lawrence Island, indicated that bearded seals tended to prefer areas of between 70 and 90 percent ice coverage, and were typically more abundant in offshore pack ice 37 to 185 km (20 to 100 nautical miles [nm]) from shore than within 37 km (20 nm) from shore, except for high concentrations nearshore to the south of Kivalina (Simpkins et al. 2003, Bengtson et al. 2005).

It is thought that in the fall and winter most bearded seals move south with the advancing ice edge through Bering Strait into the Bering Sea where they spend the winter, and in the spring and early summer, as the sea ice melts, many of these seals move north through the Bering Strait into the Chukchi and Beaufort Seas (Burns 1967a, Burns and Frost 1979, Burns 1981, Cameron and

Boveng 2007, Cameron and Boveng 2009, Cameron et al. 2018). However, bearded seal vocalizations have been recorded year-round in the Chukchi and Beaufort Seas (MacIntyre et al. 2013, MacIntyre et al. 2015), indicating some unknown proportion of the population occurs there over winter. The overall summer distribution is quite broad, with seals rarely hauled out on land (Heptner et al. 1976b, Burns 1981, Nelson et al. 1984). However some seals, mostly juveniles, have been observed hauled out on land along lagoons and rivers in some areas of Alaska, such as in Norton Bay (Huntington and Sookiayak 2000) and near Wainwright (Nelson 1982) and on sandy islands near Barrow (Cameron et al. 2010).

Occurrence in the Action Area

Beringia DPS bearded seals are widely distributed throughout the northern Bering, Chukchi, and Beaufort Seas and are most abundant north of the ice edge zone (MacIntyre et al. 2013). Figure 14 shows the distribution of bearded seals in relation to the study area. Telemetry data from Boveng and Cameron (2013) showed that large numbers of bearded seals move south in fall/winter as sea ice forms and move north as the seasonal sea ice melts in the spring. The highest densities of bearded seals are found in the central and northern Bering Sea shelf during winter (Fay 1974, Heptner et al. 1976b, Burns and Frost 1979, Braham et al. 1981, Burns 1981, Nelson et al. 1984). In late winter and early spring bearded seals are widely (not uniformly) ranging from the Chukchi Sea south to the ice front in the Bering Sea usually on drifting pack ice (Muto et al. 2016). Bearded seal calls were recorded throughout the year in the Beaufort Sea (MacIntyre et al. 2013) and northeastern Chukchi Sea (Jones et al. 2014) and the timing of the peak calling periods in both of these studies (increasing through spring with peak rates in April) suggest that bearded seals are breeding in these areas. During the open-water period the Beaufort Sea likely supports fewer bearded seals than the Chukchi Sea because of the more extensive foraging habitat (i.e., on the continental shelf) available to bearded seals there.

Bearded seals along the Alaskan coast tend to prefer areas where sea ice covers 70 to 90 percent of the surface, and are most abundant 20 to 100 nm (37 to 185 km) offshore during the spring season (Simpkins et al. 2003, Bengtson et al. 2005). In spring, bearded seals may also concentrate in nearshore pack ice habitats, where females give birth on the most stable areas of ice (Folkens et al. 2002). Bearded seals haul out on spring pack ice (Simpkins et al. 2003) and generally prefer to be near polynyas (areas of open water surrounded by sea ice) and other natural openings in the sea ice for breathing, hauling out, and prey access (Nelson et al. 1984, Stirling 1997). While molting between April and August, bearded seals spend substantially more time hauled out than at other times of the year (Folkens et al. 2002).

Harwood et al. (2005) observed bearded seals in the Canada Basin (Beaufort Sea) in waters of less than 656 ft. (200 m) during the months from August to September. These sightings were east of 140° W. The Bureau of Ocean Energy Management (BOEM) conducted an aerial survey from June through October that covered the shallow Beaufort and Chukchi Sea shelf waters, and observed bearded seals from Point Barrow to the border of Canada (Clarke et al. 2015). The farthest from shore that bearded seals were observed was the waters of the continental slope.

A density estimate of 0.0332 bearded seals per km^2 was used (among other information) to estimate take (see Section 10). This density estimate was derived from habitat-based modeling by (Kaschner 2004) and (Kaschner et al. 2006). The study area in the Beaufort Sea has not been surveyed in a manner that supports quantifiable density estimation of marine mammals. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and the likelihood of the presence of specific species have been used to predict densities using model-based approaches. These habitat suitability models include relative environmental suitability (RES) models. Habitat suitability models can be used to understand the possible extent and relative expected concentration of a marine species distribution. These models are derived from an assessment of the species occurrence in association with evaluated environmental explanatory variables that results in defining the RES suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated for each RES value based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed.

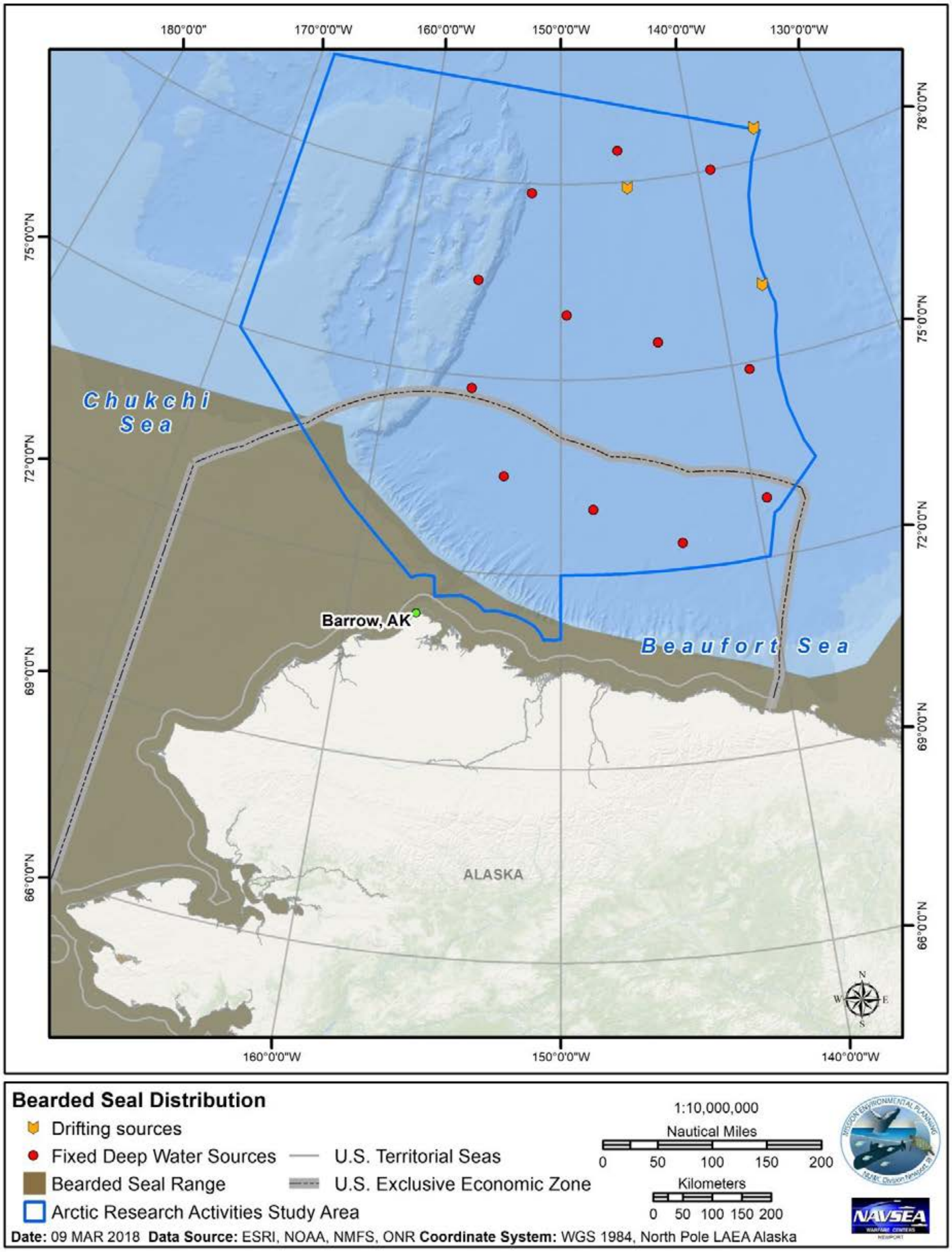

Figure 14. Bearded Seal Distribution in the Study Area

Reproduction, Growth and Molt

Bearded seals are the largest of the Arctic seals, reaching lengths of 2.0 to 2.5 m and weights of 260 to 360 kg. They are distinguished by their small head, small, square foreflippers, and the thick, long, white whiskers that give them their trademark "beard." The lifespan of bearded seals is 20 to 30 years. Males reach sexual maturity at 6 to 7 years of age; females mature at 5 to 6 years of age and give birth to a single pup annually. The total gestation period for bearded seals is from 11 to 11 ½ months long (including the 2.5 month long period of delayed implantation), allowing a pup to be birthed during spring when environmental conditions favor pup survival (Burns and Frost 1979, Burns 1981). Birthing and nursing occur on the sea ice, and pups are weaned at approximately 3 to 4 weeks of age. There are few observations of mating, however, based on dissections of ovaries and presence of spermatozoa, ovulation and mating is believed to occur after lactation (McLaren 1958, Potelov 1975, Atkinson 1997).

Individual male bearded seals use distinct vocalizations during the breeding season (see "Vocalizations and Hearing" below) which are believed to advertise mate quality, signal competing claims on reproductive rights, or to identify territory. Studies in the fjords of the Svalbard Archipelago and shore leads in the Chukchi Sea of Alaska have suggested site fidelity of males within and between years supporting earlier claims that males defend aquatic territories (Cleator et al. 1989, Cleator and Stirling 1990, Van Parijs et al. 2003, 2004, Van Parijs and Clark 2006, Risch et al. 2007). Males exhibiting territoriality maintain a ≤ 12 km^2 core area, unlike wandering males that call across several larger core areas (Van Parijs et al. 2003, 2004, Van Parijs and Clark 2006, Risch et al. 2007), and scars on the males suggest fighting may be involved in defending territories as well.

Pups have been observed throughout bearded seals' range, however there is little information on the timing of whelping, and if there are concentrations in certain geographical areas for whelping, nursing, breeding, and molting (Cameron et al. 2010; also see Figure 15). The availability of sea ice is likely a primary necessity for these life history events (Heptner et al. 1976b, Burns 1981, Reeves et al. 1992, Lydersen and Kovacs 1999, Kovacs 2009) and pupping may occur at the timing of maximum ice extent (Fedoseev 2000), March through April (Heptner et al. 1976b). Bearded seals with pups have been observed in the Beaufort, Chukchi, and Bering Seas in areas of drifting pack ice along the ice edge, but also in the heavy winter pack ice where there are leads (Burns and Frost 1979, Cameron et al. 2010).

Females with pups are solitary (Heptner et al. 1976b, Kovacs et al. 1996), with pups nursing on the ice but also swimming, diving, and likely foraging while they are still with their mothers (Hammill et al. 1994, Lydersen et al. 1994, Lydersen and Kovacs 1999, Gjertz et al. 2000, Watanabe et al. 2009). Van Parijs et al. (2001) found that the locations of mother/pup pairs was highly variable and dependent upon the availability of sea ice in the area.

Bearded seals undergo an annual molt (shedding and regrowth of hair and skin) which occurs after mating (Chapskii 1938, Ling 1970, 1972, King 1983, Yochem and Stewart 2009), and like other phocids, bearded seals spend more time hauled out of the water during the molt, which allows for higher skin temperatures that appear to be required for shedding and regrowth of hair and skin (Héroux 1960, Feltz and Fay 1966, Fay 1982).

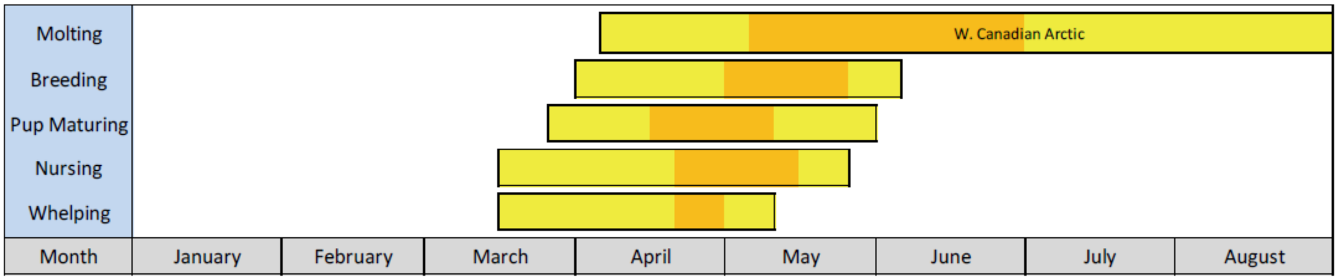

Figure 15. Approximate annual timing of the bearded seal's reproduction and molting in the Bering Strait, central Chukchi, and Western Canadian Arctic. Yellow bars indicate the range over which each event is reported to occur and orange bars indicate the peak timing of each event. For molting, reports for juveniles and adults were combined. "Pup Maturing" refers to the period when weaned pups may remain at least partially dependent on sea ice while they develop proficiency at diving and foraging for themselves. Locations are noted where differences within regions occur (Cameron et al. 2010)

Diving and Foraging

Bearded seals primarily feed on or near the bottom, typically diving is to depths of less than 100 m, although they are capable of going much deeper. Adult dives have been recorded at 300 m and juveniles have been recorded diving down to almost 500 m (Gjertz et al. 2000). Satellite tagging indicates that adults, subadults, and to some extent pups, maintain some level of site fidelity to feeding areas, often remaining in the same general area for weeks or months at a time (Cameron 2005, Cameron and Boveng 2009).

Bearded seal diets vary with age, location, season, and changes in prey availability (Kelly 1988b). They are mostly benthic feeders (Burns 1981), consuming a variety of invertebrates (e.g., crabs, shrimp, clams, worms, and snails; Quakenbush et al. 2011a), fish (including arctic and saffron cod, flounders, and sculpins), and octopuses (Burns 1981, Kelly 1988b, Reeves et al. 1992, Hjelset et al. 1999, Cameron et al. 2010). Unlike walrus that "root" in the soft sediment for benthic organisms, bearded seals "scan" the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall et al. 2006, Marshall et al. 2008). Bearded seals also feed on ice-associated organisms when practicable, allowing them to live in areas with water depths considerably deeper than 200 m if necessary.

Vocalization and Hearing

Male bearded seals produce a variety of underwater vocalizations ranging from approximately 0.2 to 4.3 kHz (Jones et al. 2014) which can travel up to 30 kilometers (Cleator et al. 1989, Van Parijs et al. 2001, Van Parijs et al. 2003, 2004, Van Parijs and Clark 2006) and are used to find mates (Cameron et al. 2010). Mating calls peak during and after pup rearing (Wollebaeck 1927, Freuchen 1935, Dubrovskii 1937, Chapskii 1938), and evidence suggests these calls originate only from males (Burns 1967b, Poulter 1968, Ray et al. 1969, Burns 1981, Stirling 1983, Cleator et al. 1989, Cleator and Stirling 1990, Van Parijs et al. 2001, Van Parijs et al. 2003, 2004, Davies et al. 2006, Van Parijs and Clark 2006, Risch et al. 2007).

Although no audiograms have been published for bearded seals (Halliday et al. 2017), it is likely that their hearing is similar to other phocids (Terhune 1999). NMFS classifies bearded seals in the phocid pinniped ("true" seal) functional hearing group, with an applied frequency range between 0.050 and 86 kHz (NMFS 2016c).

Additional information on Beringia DPS bearded seals can be found at: http://www.fisheries.noaa.gov/pr/species/mammals/seals/bearded-seal.html.

5. ENVIRONMENTAL BASELINE

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

Focusing on the impacts of activities specifically within the action area allows us to assess the prior experience and condition of the animals that will be exposed to effects from the actions under consultation. This focus is important because individuals of ESA-listed species may commonly exhibit, or be more susceptible to, adverse responses to stressors in some life history states, stages, or areas within their distributions than in others. These localized stress responses or baseline stress conditions may increase the severity of the adverse effects expected from proposed actions.

Factors Affecting Species within the Action Area

A number of human activities have contributed to the current status of populations of the ESA-listed species in the action area. The factors that have likely had the greatest impact are discussed in the sections below. For more information on all factors affecting the ESA-listed species considered in this Opinion, please refer to the following documents:

- "Alaska Marine Mammal Stock Assessments, 2017" (Muto et al. 2018)
  - https://www.fisheries.noaa.gov/webdam/download/77013044
- "Status Review of the Ringed Seal (*Phoca hispida*) (Kelly et al. 2010b)
  - Available online at https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-212.pdf
- "Status Review of the Bearded Seal (*Erignathus barbatus*) (Cameron et al. 2010)
  - Available online at https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-211.pdf

5.1 Climate Change

As discussed in Section 4.2, climate change is a major environmental concern for Beringia DPS bearded seals and Arctic ringed seals (Cameron et al. 2010, Kelly et al. 2010b). Changes in sea ice and ocean acidification are expected to result in changes to the biological environment, causing shifts, expansion, or retraction of species' home ranges, changes in behavior, and changes in prey availability and population parameters of species. 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, IPCC 2014). These threats will be most pronounced for ice-obligate species such as the polar bear, walrus, ringed seal and bearded seal (Moore and Huntington 2008).

The main concern for the conservation status of ringed and bearded seals stems from the likelihood that their sea ice habitat has been, and will continue to be, modified by the warming climate. A second concern for bearded seals, 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 77496; December 10, 2010). According to climate model projections, snow cover is projected to be inadequate for the formation and occupation of birth lairs for ringed seals within this century over the Alaska stock's entire range (Kelly et al. 2010b). A decrease in the availability of suitable sea ice conditions may not only lead to high mortality of ringed seal pups but may also produce behavioral changes in seal populations (Loeng et al. 2005). Changes in snowfall over the 21st century were projected to reduce areas with suitable snow depths for ringed seal lairs by 70 percent (Hezel et al. 2012).

The ringed seal's broad distribution, ability to undertake long movements, diverse diet, and association with widely varying ice conditions suggest they may be somewhat resilient in the face of environmental variability. Bearded seals, on the other hand, are restricted to areas where seasonal sea ice occurs over relatively shallow waters where they are able to forage on the bottom (Fedoseev 2000), and although bearded seals usually associate with sea ice, young seals may be found in ice-free areas such as bays and estuaries. Although no scientific studies have directly addressed the impacts of ocean acidification on ringed or bearded seals, the effects would likely be through their ability to find food. The decreased availability or loss of prey species from the ecosystem may have a cascading trophic effects on these species (Kelly et al. 2010b).

5.2 Predation and Disease

Polar bears are the main predator of ringed and bearded seals (Cameron et al. 2010, Kelly et al. 2010b). Other predators of both species include walruses and killer whales (Burns and Eley 1976, Heptner et al. 1976a, Heptner et al. 1976b, Fay et al. 1990, Derocher et al. 2004, Melnikov and Zagrebin 2005). In addition, Arctic foxes prey on ringed seal pups by burrowing into lairs; and gulls, ravens, and possibly snowy owls successfully prey on pups when they are not concealed in lairs (Smith 1976, Kelly et al. 1986, Lydersen et al. 1987, Lydersen and Smith 1989, Lydersen and Ryg 1990, Lydersen 1998). The threat currently posed to ringed and bearded seals by predation is considered moderate, but predation risk is expected to increase as snow and sea ice conditions change with a warming climate (Cameron et al. 2010, Kelly et al. 2010b).

Abiotic and biotic changes to ringed and bearded seal habitat could lead to exposure to new pathogens or new levels of virulence, but the potential threats to these seals is considered low (Cameron et al. 2010, Kelly et al. 2010b). Beginning in mid-July 2011, elevated numbers of sick or dead seals, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions. By December 2011, there were more than 100 cases of affected pinnipeds, including ringed seals, bearded seals, spotted seals, and walruses, in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NMFS and USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on December 20, 2011. Disease surveillance efforts in 2012 through 2014 detected few new cases similar to those observed in 2011. To date, no specific cause for the disease has been identified.

5.3 Harvest

Substantial commercial harvest of both ringed and bearded seals in the late 19th and 20th centuries led to local depletions; however, the commercial harvest of ice seals has been prohibited in U.S. waters since 1972 under the MMPA. Since that time, only subsistence harvests of ringed and bearded seals by Alaska Native subsistence hunters are allowed in U.S. waters. Ringed and bearded seals are important subsistence species for many northern coastal communities. Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ringed and bearded seals for subsistence purposes (Ice Seal Committee 2016). Estimates of subsistence harvest of ringed and bearded seals are available for 17 of these communities based on annual household surveys conducted from 2009 through 2014 (Table 5), but more than 50 other communities that harvest these species for subsistence were not surveyed within this time period or have never been surveyed. Household surveys are designed to estimate harvest for the specific community surveyed; extrapolation of harvest estimates beyond a specific community is not appropriate because of local differences in seal availability, cultural hunting practices, and environmental conditions (Ice Seal Committee 2017). During 2010 through 2014, the total annual ringed and bearded seal harvest estimates across surveyed communities ranged from 695 to 1,286 and 217 to 1,176, respectively (Table 5). However, it should be noted that the geographic distribution of communities surveyed varied among years such that these totals may be geographically or otherwise biased.

Table 5. Alaska ringed and bearded seal harvest estimates based on household surveys, 2010–2014 (Ice Seal Committee 2017)

Community	Estimated Ringed Seal Harvest					Estimated Bearded Seal Harvest				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Nuiqsut	-	-	-	-	58	-	-	-	-	26
Utqiaġvik	-	-	-	-	428	-	-	-	-	1,070
Point Lay	-	-	51	-	-	-	-	55	-	-
Kivalina	-	16	-	-	-	-	123	-	-	-
Noatak	-	3	-	-	-	-	65	-	-	-
Buckland	-	26	-	-	-	-	48	-	-	-
Deering	-	0	-	-	-	-	49	-	-	-
Golovin	-	-	0	-	-	-	-	11	-	-
Emmonak	-	56	-	-	-	-	106	-	-	-
Scammon Bay	-	137	169	-	-	-	82	51	-	-
Hooper Bay	458	674	651	667	158	148	210	212	171	64
Tununak	162	257	219	-	-	40	42	44	-	-
Tuntutuliak	-	-	-	75	-	-	-	-	53	-
Quinhagak	163	117	140	160	51	29	26	44	49	16
Togiak	1	0	-	-	-	0	2	-	-	-
Twin Hills	0	-	-	-	-	0	-	-	-	-
Dillingham	-	-	3	-	-	-	-	7	-	-
Total	784	1,286	1,233	902	695	217	753	424	273	1,176
Source: (Ice Seal Committee 2017)										

5.4 Ambient and Anthropogenic Noise

5.4.1 Ambient Noise

Ambient noise is the typical environmental soundscape or background sound pressure level at a given location. Generally, a new signal or sound would be detectable only if it is stronger than the ambient noise at similar frequencies. There are many sources that influence ambient noise in the ocean, including wind, waves, ice, rain, and hail; sounds produced by living organisms; noise from volcanic and tectonic activity; and thermal noise that results from molecular agitation (which is important at frequencies greater than 30 kHz).

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 function to dampen or heighten ambient sound. Smooth annual ice can enhance sound propagation compared to open water conditions (Richardson et al. 1995). However, with increased cracking, ridging, and other forms of sub-surface deformation, transmission losses in ice-covered waters generally become higher compared to those in open water (Richardson et al. 1995, Blackwell and Greene Jr 2000). Urick (1983) discussed variability of ambient noise in water including under Arctic ice; he stated 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.” 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 re 1 µPa at 1 m within 24 hours due to diurnal variability in air temperatures (BOEMRE 2011b).

Data are limited, but in at least one instance it has been shown that ice-deformation sounds produced frequencies of 4 to 200 Hz (Greene 1981).

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 (Richardson et al. 1995). Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. Along the Chukchi Sea slope region, Roth et al. (2012) found that the highest noise levels were during the open-water season (80–83 dB re: 1 lPa2 /Hz at 20–50 Hz), while months with both ice cover and low wind speeds had the lowest noise levels (65 dB at 50 Hz).

There are many marine mammals in the Arctic marine environment whose vocalizations contribute to ambient sound including, but not limited to, bowhead whales, gray whales, beluga whales, walrus, ringed seals, and spotted seals. Walrus, seals, and seabirds all produce sound that can be heard in air as well. Underwater sound source levels of walrus vocalizations have been measured at 177.6 dB re 1 lPa peak @ 1 m (Mouy et al. 2012). Ringed seal calls have a source level of 95 to 130 dB re 1 μPa at 1 m, with the dominant frequency under 5 kHz (Cummings et al. 1984, Thomson and Richardson 1995). Bowhead whales produce sounds with estimated source levels ranging from 128 to 189 dB re 1 μPa at 1 m in frequency ranges from 20 to 3,500 Hz. Thomson and Richardson (1995) summarized that most bowhead whale calls are “tonal frequency-modulated” sounds at 50 to 400 Hz.

5.4.2 Anthropogenic Noise

Anthropogenic (human-caused) sources of noise in the action area include vessels, shipping, oil and gas activities, geophysical surveys (including seismic activities), drilling, construction, dredging, pile-driving, icebreaking, sonars, and aircraft. The combination of anthropogenic and natural noises contributes to the total noise at any one place and time. Levels of anthropogenic sound can vary dramatically depending on the season, type of activity, and environmental conditions. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994, Richardson et al. 1995, NRC 1996, NRC 2001, NRC 2003, Jasny et al. 2005, NRC 2005).

Because responses to anthropogenic noise vary among species and individuals within species, it is difficult to determine long-term effects. Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Clark et al. (2009) identified increasing levels of anthropogenic noise as a habitat concern for whales because of its potential effect on their ability to communicate and echolocate. Some research (Parks 2003, McDonald et al. 2006, Parks 2009) suggests marine mammals compensate for masking by changing the frequency, source level, redundancy, and timing of their calls. However, the long-term implications of these adjustments, if any, are currently unknown. Additional information on anthropogenic noise sources can also be found in Section 5.5.1 (*Vessel Noise*) and Section 5.7.1 (*Noise related to Oil and Gas Activities*).

5.5 Vessels

The general seasonal pattern of vessel traffic in the Arctic is correlated with seasonal ice conditions, which results in the bulk of the traffic being concentrated within the months of July through October, and unaided navigation being limited to an even narrower time frame.

However, this pattern appears to be rapidly changing, as ice-diminished conditions become more extensive during the summer months.
The number of unique vessels tracked via AIS in U.S. waters north of the Pribilof Islands increased from 120 in 2008 to 250 in 2012, and is expected to continue to increase in the coming years (Azzara et al. 2015).

However, the number of vessels identified in this region in 2012 includes a spike in vessel traffic associated with the offshore exploratory drilling program that was conducted by Shell on the outer continental shelf (OCS) of the Chukchi Sea that year. A comparison of the geographic distribution of vessel track lines between 2011 and 2012 provides some insight into the changes in vessel traffic patterns that may occur as a result of such activities (see Figure 16; from Azzara et al. (2015)). Overall, in 2012 there was a shift toward more offshore traffic and there were also noticeable localized changes in vessel traffic concentration near Prudhoe Bay and in the vicinity of the drilling project in the Chukchi Sea (Azzara et al. 2015).

Vessel traffic can pose a threat to marine mammals primarily because of the potential disturbance from vessel noise and the risk of ship strikes.

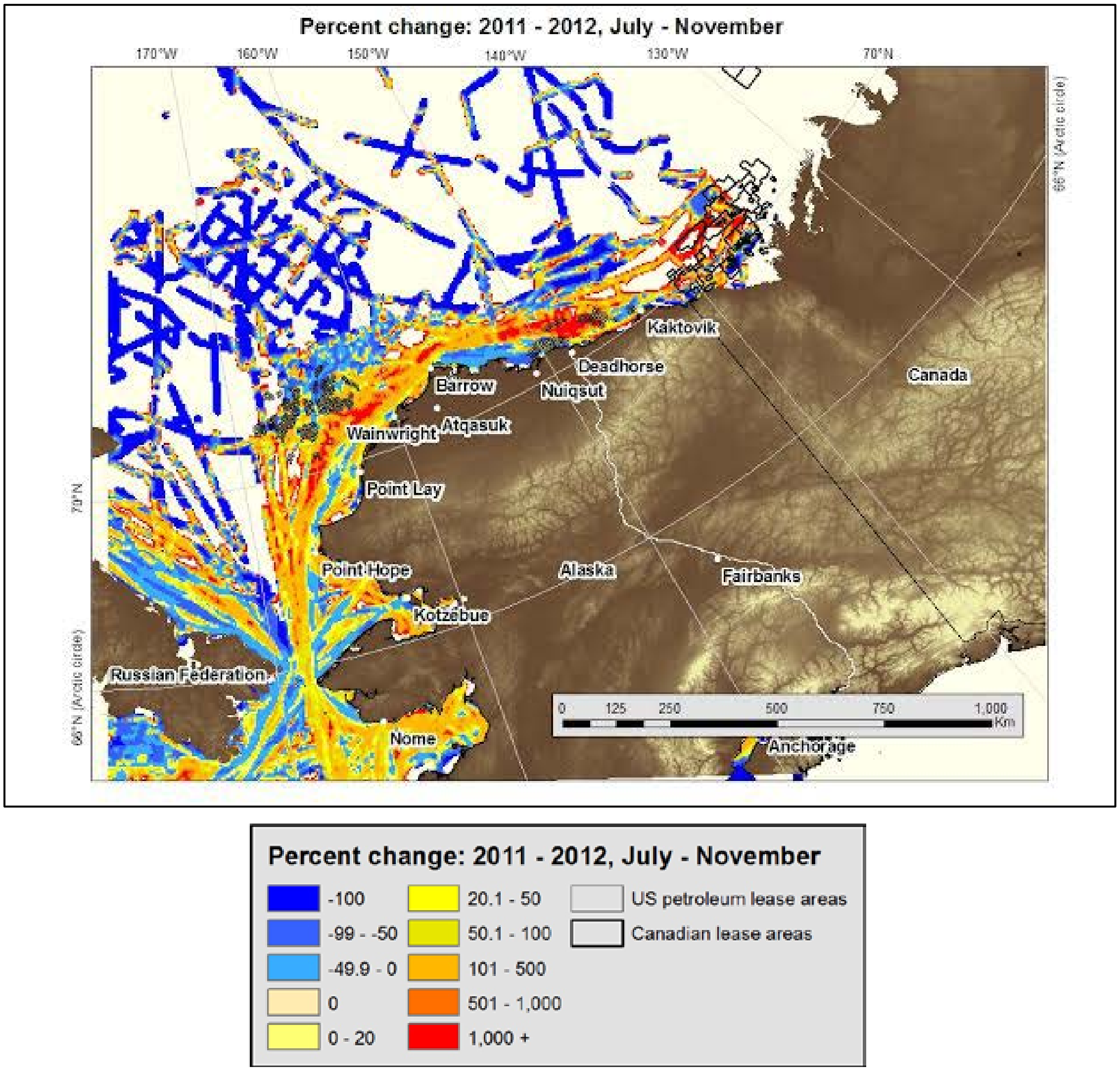

Figure 16. Percent difference in vessel activity between 2011 and 2012 using 5-km grid cells. (Azzara et al. (2015)

5.5.1 Vessel Noise

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the oceans (Simmonds and Hutchinson 1996, NRC 2003). The types of vessels operating in the Beaufort Sea typically include barges, skiffs with outboard motors, icebreakers, scientific research vessels, and vessels associated with oil and gas exploration, development, and production. The primary underwater noise associated with vessel operations is the continuous noise produced from propellers and other on-board equipment. Cavitation noise is expected to dominate vessel acoustic output when tugs are pushing or towing a barges or other vessels. Other noise sources include onboard diesel generators and the main engine, but both are subordinate to propeller harmonics (Gray and Greeley 1980). Shipping sounds are often at source levels of 150 to 190 dB re 1 μPa at 1 m (BOEMRE 2011a) with frequencies of 20 to 300 Hz (Greene and Moore 1995). Sound produced by smaller boats is typically at a higher frequency, around 300 Hz (Greene and Moore 1995). In shallow water, vessels more than 10 km (6.2 mi) away from a receiver generally contribute only to background-sound levels (Greene and Moore 1995). Noise from icebreakers comes from the ice physically breaking, the propeller cavitation of the vessel, and the "bubbler systems" that blow compressed air under the hull which moves ice out of the way of the ship. Broadband source levels for icebreaking operations are typically between 177 and 198 dB re 1 μPa at 1m (Greene and Moore 1995, Austin et al. 2015); however, they can be extremely variable mainly due to the varying thickness of ice that is being broken and the resulting horsepower required to break the ice.

5.5.2 Ship strikes

Current shipping activities in the Arctic pose varying levels of threats to marine mammals, including ringed and bearded seals, depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with their habitats. The presence and movements of ships in the vicinity of seals can affect their normal behavior (Jansen et al. 2010) and may cause them 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, Sternfeld (2004) documented a single spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike.

Icebreakers, ice-breaking cargo ships, and ice-breaking container ships pose additional threats to bearded and ringed seals. These vessels are capable of operating year round and have the potential to crush animals, destroy lairs, and harass animals from noise propagated through air or water. Reeves (1998) noted that some ringed seals have been killed by icebreakers moving through breeding areas in land-fast ice.

5.6 Fisheries

While no commercial fishing is currently authorized in the Beaufort or Chukchi Seas, ringed and bearded seals may be impacted by commercial fishing interactions during times of the year when they are present in the Bering Sea. Commercial fisheries may impact ringed and 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 ringed and bearded seal bycatch could only be found for commercial fisheries that operate in Alaska waters. From 2010 through 2014, incidental mortality and serious injury of ringed seals was reported in 4 of the 22 federally-regulated commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Muto et al. 2017). An additional ringed seal mortality due to U.S. commercial fisheries was reported to the NMFS Alaska Region stranding network in 2011; however, because the seal was discovered during the offloading process, the resulting mean annual mortality and serious injury rate of 0.2 could not be assigned to a specific fishery (Helker et al. 2015). Based on data from 2010 through 2014, the average annual rate of mortality and serious injury incidental to U.S. commercial fishing operations is 3.9 ringed seals (3.7 from observer data + 0.2 from stranding data).

From 2010 through 2014, incidental mortality and serious injury of bearded seals occurred in three fisheries: the Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands flatfish trawl, and Bering Sea/Aleutian Islands Pacific cod trawl fisheries (Muto et al. 2017). The estimated minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries is 1.4 bearded seals, based exclusively on observer data.

Commercial fisheries may also affect seals indirectly by reducing the amount of available prey or affecting prey species composition. In Alaska, commercial fisheries target known prey species of ESA-listed seals such as pollock and Pacific cod. Additionally, bottom-trawl fisheries may affect bottom-dwelling prey of these ESA-listed species.

5.7 Oil and Gas Activities

Offshore petroleum exploration activities have been conducted in State of Alaska waters and the OCS of the Beaufort and Chukchi Sea Planning Areas, in Canada's eastern Beaufort off the Mackenzie River Delta, in Canada's Arctic Islands, and in the Russian Arctic, and around Sakhalin Island in the Sea of Okhotsk (NMFS 2016a). The following sections discuss oil and gas activities in the action area.

5.7.1 Noise Related to Oil and Gas Operations

NMFS has conducted numerous ESA section 7 consultations related to oil and gas activities in the Beaufort Sea. Many of the consultations have authorized the take (by harassment) of bearded and ringed seals from sounds produced during geophysical (including seismic) surveys and drilling operations conducted by leaseholders during open water (i.e., summer) months.

In 2013, NMFS conducted an incremental step consultation with the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) on the effects of the authorization of oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi Seas over a 14-year period, from March 2013 to March 2027 (i.e., the Arctic Regional Biological Opinion) (NMFS 2013). The incidental take statement for the 14-year period in the biological opinion allows takes (by harassment) from sounds associated with high-resolution, deep penetration, and in-ice deep penetration seismic surveys of 91,616 bearded seals and 506,898 ringed seals. Take will be more accurately evaluated for subsequent projects that fall under this overarching consultation (i.e. stepwise consultations), and the cumulative take for all subsequent consultations will be tracked and tiered to these consultations.

In 2014, NMFS Alaska Region conducted three internal consultations with NMFS Permits Division on the issuance of IHAs to take marine mammals incidental to 3D ocean bottom sensor seismic and shallow geohazard surveys in Prudhoe Bay, Foggy Island Bay, and the Colville River Delta, in the Beaufort Sea, Alaska, during the 2014 open-water season (NMFS 2014c, b, a). These project-specific consultations were either directly or indirectly linked to the Arctic Regional Biological Opinion. The incidental take statements issued with the three biological opinions allowed for takes (by harassment) of 744 bearded seals and 427 ringed seals, total, as a result of exposure to impulsive sounds at received levels at or above 160 dB re 1 μPa_{rms}.

In 2015, NMFS Alaska Region conducted two internal consultations with NMFS Permits Division on the issuance of IHAs to take marine mammals incidental to shallow geohazard and 3D ocean bottom node seismic surveys in the Beaufort Sea, Alaska, during the 2015 open-water season. These consultations were also either directly or indirectly linked to the Arctic Regional Biological Opinion. The incidental take statements in the three biological opinions allowed for takes (by harassment) of 202 bearded seals, and 1,472 ringed seals, total as a result of exposure to impulsive sounds at received levels at or above 160 dB re 1 μPa_{rms} and, 10 bearded seals and 20 ringed seals harmed, injured, or killed as a result of exposure to impulsive sounds at received levels at or above 180 dB re 1 μPa_{rms}.

In 2015, NMFS Alaska Region conducted an internal consultation with NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to ice overflight and ice survey activities conducted by Shell Gulf of Mexico and Shell Offshore Inc., from May 2015 to April 2016 (NMFS 2015b). The incidental take statement issued with the biological opinion authorized takes (by harassment) of 793 ringed seals and 11 bearded seals as a result of exposure to visual and acoustic stimuli from aircraft.

The first stepwise (i.e., tiered) consultation under the lease sale 193 incremental step consultation was conducted in 2015. NMFS Alaska Region consulted with the NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to exploration drilling activities in the Chukchi Sea, Alaska, in 2015 (NMFS 2015a). The incidental take statement issued with the biological opinion allowed for takes (by harassment) of 1,722 bearded seals and 25,217 ringed seals as a result of exposure to continuous and impulsive sounds at received levels at or above 120 dB re 1 μPa_{rms} and 160 dB re 1 μPa_{rms}, respectively.

There were no consultations for oil and gas activities completed with the NMFS Permits Division in 2016 and 2017. In 2018, NMFS Alaska Region conducted a consultation with the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE), Environmental Protection Agency (EPA), and the U.S. Army Corps of Engineers (USACE), to authorize Hilcorp Alaska, LLC (Hilcorp) to conduct oil and gas development, production, and decommissioning activities for the Liberty Development and Production Project (Liberty Project) in the Beaufort Sea under the Outer Continental Shelf (OCS) Lands Act over a 25-year period beginning in December 2019 through November 2044. The ITS issued with the biological opinion authorized takes of bearded and ringed seals by Level A harassment (noise) and Level B harassment (noise and physical presence), and mortality for a small number of ringed seals (Table 6).

Table 6. Summary of incidental take of ringed seals and bearded seals associated with the Liberty Project.

Species	**Type of Take**	**Year**								**Total Take**	
		1	**2**	**3**	**4**	**5**	**6-23**	**24**	**25**	**Years 1-5**	**Life of Project**
Bearded Seal	Level B Harassment	1	58	1	1	1	18 *(1 per year)*	1	49	62	130
	Level A Harassment	0	2	0	0	0	0	0	2	2	4
	Mortality	0	0	0	0	0	0	0	0	0	0
Ringed Seal	Level B Harassment Noise	2	336	21	21	14	108 *(6 per year)*	16	296	394	814
	Level A Harassment Noise	0	3	0	0	0	0	0	3	3	6
	Level B Harassment Physical Presence	2	2	2	2	2	36 (*2 per year)*	2	2	10	50
	Mortality	2					8 *(2 per 5 years)*			2	10
Note: To be conservative, take estimates have been rounded up per year.											

5.7.2 Spills

Since 1975, 84 exploration wells, 14 continental offshore stratigraphic test (i.e., COST), and six development wells have been drilled on the Arctic OCS (BOEM 2012). Historical data on offshore oil spills for the Alaska Arctic OCS region consists of all small spills (i.e., less than 1,000 barrels [31,500 gallons]) and cannot be used to create a distribution for statistical analysis (NMFS 2013). Instead, agencies use a fault tree model[4] to represent expected spill frequency and severity of spills in the Arctic. Table 7 shows the assumptions BOEM presented regarding the size and frequency of spills in the Beaufort and Chukchi Seas Planning Area in its final programmatic environmental impact statement (EIS) for the Outer Continental Shelf oil and gas leasing program for 2012 to 2017 (BOEM 2012).

Table 7. Oil spill assumptions for the Beaufort and Chukchi Seas Planning Areas, 2012 to 2017

Spill Type	Assumed Spill Volume (barrels)	Assumed Number of Spill Events	Maximum Volume of Assumed Spill Events (barrels)
Small	≥ 1 to < 50	50 to 90	9,310
	≥ 50 to < 1,000	10 to 35	34,965
Large	≥ 1,000	-	-
Pipeline	1,700	1 to 2	3,400
Platform	5,100	1	5,100
		TOTAL	**52,775**
Table adapted from BOEM (2012)			

Increased 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 2015).

5.7.3 Pollutants and Discharges (Excluding Spills)

Previous development and discharges in portions of the action area are the source of multiple pollutants that may be bioavailable (i.e., may be taken up and absorbed by animals) to ESA-listed species or their prey items (NMFS 2013). Drill cuttings and fluids contain contaminants that have high potential for bioaccumulation, such as dibenzofuran and polycyclic aromatic hydrocarbons. Historically, drill cuttings and fluids have been discharged from oil and gas developments in the Beaufort Sea near the action area, and residues from historical discharges may be present in the affected environment (Brown et al. 2010).

The Clean Water Act of 1972 (CWA) has several sections or programs applicable to activities in offshore waters. Section 402 of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges into waters of the United States. Section 403 of the

[4] Fault tree analysis is a method for estimating spill rates resulting from the interactions of other events. Fault trees are logical structures that describe the causal relationship between the basic system components and events resulting in system failure. Fault tree models are graphical techniques that provide a systematic estimate of the combinations of possible occurrences in a system, which can result in an undesirable outcome.

CWA requires that EPA conduct an ocean discharge criteria evaluation for discharges of pollutants from point sources into the territorial seas, contiguous zones, and the oceans. The Ocean Discharge Criteria (40 CFR part 125, subpart M) sets forth specific determinations of unreasonable degradation that must be made before permits may be issued.

On November 28, 2012, EPA issued a NPDES general permit for discharges from oil and gas exploration facilities on the outer continental shelf and in contiguous state waters of the Beaufort Sea (Beaufort Sea Exploration GP). The general permit authorizes 13 types of discharges from exploration drilling operations and establishes effluent limitations and monitoring requirements for each waste stream.

On January 21, 2015, EPA issued a NPDES general permit for wastewater discharges associated with oil and gas geotechnical surveys and related activities in Federal waters of the Beaufort and Chukchi Seas (Geotechnical GP). This general permit authorizes twelve types of discharges from facilities engaged in oil and gas geotechnical surveys to evaluate the subsurface characteristics of the seafloor and related activities in federal waters of the Beaufort and Chukchi Seas.

Both the Beaufort Sea Exploration GP and the Geotechnical GP establish effluent limitations and monitoring requirements specific to each type of discharge and include seasonal prohibitions and area restrictions for specific waste streams. For example, both general permits prohibit the discharge of drilling fluids and drill cuttings to the Beaufort Sea from August 25 until fall bowhead whale hunting activities by the communities of Nuiqsut and Kaktovik have been completed. Additionally, both general permits require environmental monitoring programs to be conducted at each drill site or geotechnical site location, corresponding to before, during, and after drilling activities, to evaluate the impacts of discharges from exploration and geotechnical activities on the marine environment.

The principal regulatory mechanism 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 also the CWA. The EPA issued a NPDES vessel general permit effective from December 19, 2013, to December 18, 2018, that applies to pollutant discharges from non-recreational vessels that are at least 24 m (79 ft) in length, as well as ballast water discharged from commercial vessels less than 24 m. This general permit restricts the seasons and areas of operation, as well as discharge depths, and includes monitoring requirements and other conditions.

In addition, the U.S. Coast Guard has issued regulations that address pollution prevention with respect to discharges from vessels carrying oil, noxious liquid substances, garbage, municipal or commercial waste, and ballast water (33 CFR part 151). The State of Alaska regulates water quality standards within three miles of the shore.

5.8 Contaminants in Ringed and Bearded Seals

Metals and hydrocarbons introduced into the marine environment from offshore exploratory drilling activities are not likely to enter the Beaufort Sea food webs in ecologically significant amounts. However, there is a growing body of scientific literature on concentrations of metals and organochlorine chemicals (e.g., pesticides and polychlorinated biphenyls [PCBs]) in tissues of higher trophic level marine species, such as marine mammals, in cold-water environments.

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

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 compounds and heavy metals have been found in all of the subspecies of ringed seal (with the exception of the Okhotsk ringed seal). The variety, sources, and transport mechanisms of contaminants vary across ringed seal ecosystems (Kelly et al. 2010b).

Heavy metals such as mercury, cadmium, lead, selenium, arsenic, and nickel accumulate in ringed seal vital organs, including liver and kidneys, as well as in the central nervous system (Kelly et al. 2010b). Gaden et al. (2009) suggested that during ice-free periods the seals eat more Arctic cod, and therefore ingest more mercury. Because it is sequestered in tissues, mercury levels increase with ringed seal age for both sexes (Dehn et al. 2005, Gaden et al. 2009). Becker et al. (1995) reported ringed seals had higher levels of arsenic in Norton Sound than ringed seals taken by residents of Point Hope, Point Lay, and Barrow. Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals, which might reflect localized natural arsenic sources.

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

5.9 Other Arctic Projects

In the winters of 2014, 2017, and 2018, the U.S. Navy conducted submarine training, testing, and other research activities in the northern Beaufort Sea and Arctic Ocean from a temporary camp constructed on an ice flow toward the northern extent of the U.S. EEZ, about 185 to 370 km (115 to 230 mi) north of Prudhoe Bay. Equipment, materials, and personnel were transported to and from the ice camp via daily flights based out of the Deadhorse Airport (located in Prudhoe Bay). No takes were expected, nor authorized, for this activity.

In 2016, NMFS Alaska Region conducted internal consultations with NMFS Permits Division on the issuance of three IHAs to take marine mammals incidental to dock construction and anchor retrieval in the Bering, Chukchi, and Beaufort Seas during the 2016 open water season. The incidental take statements issued with the three biological opinions allowed for takes (by harassment) of 706 bearded seals and 7,887 ringed seals as a result of exposure to continuous or impulsive sounds at received levels at or above 120 dB or 160 dB re 1 μPa rms, respectively.

In 2016 and 2017, NMFS Alaska Region conducted internal consultations with NMFS Permits Division on the issuance of an IHA associated with the continuation of fiber optic cable laying. Quintillion was permitted to install 1,904 km (1,183 mi) of subsea fiber optic cable during the open-water season, including a main trunk line and six branch lines to onshore facilities in Nome, Kotzebue, Point Hope, Wainwright, Barrow, and Oliktok Point. The incidental take statements issued with the two biological opinions allowed for takes (by harassment) of 62 bearded seals and 855 ringed seals as a result of exposure to sounds of received levels at or above 120 dB re 1 μPa_{rms} from sea plows, anchor handling, and operation and maintenance activities (NMFS 2016b).

5.10 Scientific Research

In the following section, we describe the types of scientific research currently permitted for ESA-listed bearded and ringed seals in the action area. NMFS issues scientific research permits that are valid for five years for ESA-listed species. When permits expire, researchers often apply for a new permit to continue their research. Additionally, applications for new permits are issued on an on-going basis; therefore, the number of active research permits is subject to change in the period during which this Opinion is valid.

Species considered in this Opinion also occur in Canadian waters. Although we do not have specific information about any permitted research activities in Canadian waters, we assume they will be similar to those described below.

Of the nine active scientific research permits authorizing takes of bearded and ringed seals in Alaska, five (Permit Nos. 18537, 20465, 16239, 14856, and 18890) include bearded and ringed seals as non-target species, and authorized takes for these species are for incidental take (e.g., disturbance) during the course of research on other marine mammals in Alaska. A single permit (No. 18786) covers stranding response activities which includes bearded and ringed seals in the event of a stranding.

Three of the current permits (Permit Nos. 18902, 19309, and 20466) include bearded and ringed seals as target species. Activities include behavioral observations, counting/surveying, photo-identification, and capture and restraint (by hand, net, cage, or board), for the purposes of performing the following procedures:

- Collection of:
  - Blood
  - Clipped hair
  - Urine and feces
  - Nasal and oral swabs
  - Vibrissae (pulled)
  - Skin, blubber, or muscle biopsies
  - Weight and body measurements
- Injection of sedative
- Administration of drugs (intramuscular, subcutaneous, or topical)
- Attachment of instruments to hair or flippers, including flipper tagging
- Ultrasound

These activities may cause stress to individual seals, but, in most cases, are not expected to rise to the level where injury or mortality is expected to occur; however, Permit No. 19309 allows the unintentional mortality of up to 15 ringed and 15 bearded seals over the course of the permit (not to exceed five in any 12 month period), and Permit No. 18902 allows the unintentional mortality of no more than two animals for any species over the life of the permit (five years). Permit No. 18902 involves animals that are already in captivity, and therefore there is no effect of this permit to the wild populations of bearded and ringed seals.

6. EFFECTS OF THE ACTION

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

This biological opinion relies on the best scientific and commercial information available. We try to note 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). In analyzing the effects of the proposed action, we assume the maximum amount of possible proposed activities will occur.

We organize our effects analysis using a stressor identification – exposure – response – risk assessment framework for the proposed activities.

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.

6.1. Project Stressors

Stressors are any physical, chemical, or biological entity that can induce and adverse response. The proposed activities will expose ringed and bearded seals to the sounds and physical presence of autonomous seagliders, research vessels transiting and icebreaking, towed and moored acoustic sources, drifting and moored oceanographic sensors, fixed and towed receiving arrays, manned aircraft and unmanned air vehicles, on-ice measurement systems, bottom interaction systems (e.g., coring), and weather balloons.

Based on our review of the data available, the proposed activities may cause these primary stressors:

- Sound fields produced by continuous noise sources (e.g., vessels (in transit and icebreaking), towed and moored acoustic sources, and manned and unmanned aircraft) which may result in auditory impacts and disruption of behavior;
- Non-acoustic disturbances (e.g., including vessel transit/icebreaking) which may cause behavioral disruption
- Vessel and in-water device strikes;
- Physical destruction of ice habitat
- Risk of entanglement and/or ingestion by introduction of lines (towed and moored arrays) and debris (weather balloons); and
- Pollution from unauthorized spills from vessel activities

Below we discuss each stressor's potential to affect ESA-listed species.

6.2. Exposure and Response 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.

For our exposure analyses, NMFS generally relies on an action agency's estimates of the number of marine mammals that might be "taken." A quantitative exposure analysis was provided in the Biological Evaluation (ONR 2018a) and IHA application (ONR 2018b). Based on these initial qualitative and quantitative analyses, NMFS AKR calculated the exposure and "take" estimates for the full 4 years of the project.

Briefly, the ONR's quantitative exposure analysis is based on the Navy Acoustic Effects Model (NAEMO) and estimates the number of marine mammals that could be harassed by the underwater non-impulsive acoustic sources during the proposed action (ONR 2018a). Inputs to the quantitative analysis included marine mammal density estimates obtained from the Navy Marine Species Density Database, marine mammal depth occurrence distributions, oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential animal exposures. The model calculates sound energy propagation from the proposed non-impulsive acoustic sources, the sound received by animat (virtual animal) dosimeters representing marine mammals distributed in the area around the modeled activity, and whether the sound received by a marine mammal exceeds the thresholds for effects.

Section 3(18) of the MMPA defines Level A harassment (for non-military activities) as "any act of pursuit, torment, or annoyance which has the potential to *injure* a marine mammal or marine mammal stock in the wild." Level B harassment means any such act that "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."

While the ESA does not define "harass," NMFS recently issued guidance interpreting the term "harass" under the ESA as a means to: "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016). For the purposes of this consultation, any action that amounts to incidental harassment under the MMPA—whether Level A or Level B—constitutes an incidental "take" under the ESA.

Following the exposure analysis is the response analysis. The 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.

As discussed in Section 2.2, the ONR proposed mitigation measures that should avoid or minimize exposure of ESA-listed species to stressors.

Possible responses by ESA-listed species to project activities in this analysis are:

- Threshold shifts
- Auditory interference (masking)
- Behavioral responses
- Non-auditory physical or physiological effects

6.2.1. Sound Measurements Used in this Document

"Sound pressure" is the sound force per unit micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. "Sound pressure level" is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure in underwater acoustics is 1 μPa, and the units for sound pressure levels are dB re 1 μPa. Sound pressure level (in dB) = 20 log (pressure/reference pressure).

Sound pressure level is an instantaneous measurement and can be expressed as "peak" (0-p), "peak-to-peak" (p-p), or "root mean square" (rms). Root mean square, which is the square root of the arithmetic average of the squared instantaneous pressure values, is typically used in discussions of the effects of sounds on vertebrates. All references to sound pressure level in this document are expressed as rms, unless otherwise indicated. In instances where sound pressure levels for airguns were originally expressed as 0-p or p-p, the following rough conversions were used in order to express those values in rms (Harris et al. 2001):

- rms is approximately 10 dB lower than 0-p
- rms is approximately 16 dB lower than p-p

The original 0-p or p-p measurements appear in footnotes. Note that sound pressure level does not take the duration of a sound into account.

6.2.2. Threshold Shifts

Exposure of marine mammals to very loud noise can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Temporary threshold shift (TTS) is a temporary hearing change, and its severity is dependent upon the duration, frequency, sound pressure, and rise time of a sound (Finneran and Schlundt 2013). TTSs can last minutes to days. Full recovery is expected, and this condition is not considered a physical injury. At higher received levels, or in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur. When PTS occurs, auditory sensitivity is unrecoverable (i.e., permanent hearing loss). The effect of noise exposure generally depends on a number of factors relating to the physical and spectral characteristics of the sound (e.g., the intensity, peak pressure, frequency, duration, duty cycle), and relating to the animal under consideration (e.g., hearing sensitivity, age, gender, behavioral status, prior exposures). Both TTS and PTS can result from a single pulse or from accumulated effects of multiple pulses from an impulsive sound source (e.g., impact pile or pipe driving) or from accumulated effects of non-pulsed sound from a continuous sound source (i.e., vessel noise). In the case of exposure to multiple pulses, each pulse need not be as loud as a single pulse to have the same accumulated effect.

As it is a permanent auditory injury, the onset of PTS may be considered an example of "Level A harassment" as defined in the MMPA. TTS is by definition recoverable rather than permanent, and has historically has been treated as "Level B harassment" under the MMPA. Behavioral effects may also constitute Level B harassment, and are expected to occur at even lower noise levels than would generate TTS.

Both duration and pressure level of a sound are factors in inducement of threshold shift. Exposure to non-pulsed sound (i.e., thruster noise from dynamic positioning) may induce more threshold shift than exposure to a pulsed sound with the same energy; however, this is dependent on the duty cycle of the pulsed source because some recovery may occur between exposures (Kryter et al. 1966, Ward 2007). For example, exposure to one pulse of a sound with a higher sound pressure level than a continuous sound may induce the same impairment as that continuous sound; however, exposure to the continuous sound may cause more impairment than exposure to a series of several intermittent softer sounds with the same total energy (Ward 2007). Temporary threshold shift was reported in toothed whales after exposure to relatively short, continuous sounds (ranging from 1 to 64 sec) at relatively high sound pressure levels (ranging from 185 to 201 dB re 1 μPa_{rms}) (Ridgway et al. 1997, Schlundt et al. 2000, Finneran et al. 2005, Finneran et al. 2007); however, toothed whales experienced TTS at lower sound pressure levels (160 to 179 dB re 1 μPa_{rms}) when exposed to continuous sounds of relatively long duration (ranging from 30 to 54 min) (Nachtigall et al. 2003, Nachtigall et al. 2004).

For a single pulse at a given frequency, sound levels of approximately 196 to 201 dB re 1 μPa_{rms} are required to induce low-level TTS (Southall et al. 2007). PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis (Southall et al. 2007).

To experience TTS from a continuous source, a marine mammal will have to remain in the ensonified area for an extended period of time and will need to remain in the area even longer to experience PTS.

Data are lacking on the energy levels required to induce TTS or PTS in pinnipeds. Finneran et al. (2003) exposed two California sea lions to single underwater pulses up to 183 dB re 1 $\mu Pa_{p\text{-}p}$ and found no measurable TTS following exposure. Southall et al. (2007) estimated TTS will occur in pinnipeds exposed to a single pulse of sound at 212 dB re 1 $\mu Pa_{0\text{-}p}$ and PTS will occur at 218 dB re 1 $\mu Pa_{0\text{-}p}$. Kastak et al. (2005) indicated pinnipeds exposed to continuous sounds in water experienced the onset of TTS from 152 to 174 dB re 1 μPa_{rms}.[5] Southall et al. (2007) estimated PTS will occur in pinnipeds exposed to continuous sound pressure levels of 218 dB re: 1 $\mu Pa_{0\text{-}p}$.

6.2.2.1 NMFS Acoustic Threshold Guidance

Since 1997, NMFS has used generic sound exposure thresholds to determine whether an activity produces underwater and in-air sounds that might result in impacts to marine mammals (70 FR

[5] Values originally reported as sound exposure level of 183 to 206 dB re 1 μPa^2-s.

1871). NMFS recently developed comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary thresholds shifts (PTS and TTS; Level A harassment) (81 FR 51693). NMFS is in the process of developing guidance for behavioral disruption (Level B harassment). However, until such guidance is available, NMFS uses the following conservative thresholds of underwater sound pressure levels[6], expressed in root mean square[7] (rms), from broadband sounds that cause behavioral disturbance, and referred to as Level B harassment under section 3(18)(A)(ii) of the Marine Mammal Protection Act (MMPA):

- impulsive sound: 160 dB re 1 μPa_{rms}
- continuous sound: 120 dB re 1μPa_{rms}

Under the PTS/TTS Technical Guidance, NMFS uses the following thresholds (Table 8) for underwater sounds that cause injury, referred to as Level A harassment under section 3(18)(A)(i) of the MMPA (NMFS 2016d). These acoustic thresholds are presented using dual metrics of cumulative sound exposure level (L_E) and peak sound level (PK) for impulsive sounds and L_E for non-impulsive sounds:

Table 8. PTS Onset Acoustic Thresholds for Level A Harassment (NMFS 2016c)

Hearing Group	PTS Onset Acoustic Thresholds* (Received Level)	
	Impulsive	**Non-impulsive**
Low-Frequency (LF) Cetaceans	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	$L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	$L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	$L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	$L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	$L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	$L_{E,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	$L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	$L_{E,OW,24h}$: 219 dB

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (L_{pk}) has a reference value of 1 µPa, and cumulative sound exposure level (L_E) has a reference value of 1$\mu Pa^2 s$. The subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

[6] Sound pressure is the sound force per unit micropascals (µPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. Sound pressure level is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in acoustics is 1 µPa, and the units for underwater sound pressure levels are decibels (dB) re 1 µPa.

[7] Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.

In addition, NMFS uses the following thresholds for in-air sound pressure levels from broadband sounds that cause Level B behavioral disturbance under section 3(18)(A)(ii) of the MMPA:

- 100 dB re 20μPa_{rms} for non-harbor seal pinnipeds

6.2.3. Auditory Interference (masking)

Auditory interference, or masking, occurs when an interfering noise is similar in frequency and loudness to (or louder than) the auditory signal received by an animal while it is processing echolocation signals or listening for acoustic information from other animals (Francis and Barber 2013). Masking can interfere with an animal's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Francis and Barber 2013).

Although studies of the responses of phocids to the effects of masking are limited (Terhune 1999), other marine mammals exhibit changes to vocal behavior and call structure when the animals are compensating for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (Holt et al. 2009). Vocalizations may also change in response to variation in the natural acoustic environment (e.g., from variation in sea surface motion) (Dunlop et al. 2014), including vocalizations of conspecifics (Terhune 1999). Both ringed and bearded seals exhibit a wide variety of vocalizations that are likely used as communication with conspecifics, and this communication could be masked by anthropogenic noise in the Beaufort Sea.

In addition to hearing being important to communication with conspecifics, evidence suggests that at least some marine mammals, including phocids, have the ability to acoustically identify predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. Auditory masking may prevent marine mammals from responding to the acoustic cues produced by their predators. The effects of auditory masking on the predator-prey relationship depends on the duration of the masking and the likelihood of encountering a predator during the time that predator cues are impeded.

Phocids (ringed and bearded seals) 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 vessel noise or pile driving (Gordon et al. 2003). There are overlaps in frequencies between vessel transit and icebreaking noise, noise from towed and acoustic arrays, and the assumed hearing ranges of the ESA-listed pinnipeds considered in this Opinion. The proposed activities could mask vocalizations or other important acoustic information, which could affect communication among individuals or affect their ability to receive information from their environment.

6.2.4 Behavior Response

NMFS expects the majority of responses of bearded and ringed seals to the proposed activities will occur in the form of behavioral response. Marine mammals may exhibit a variety of behavioral changes in response to underwater sound which can be generally summarized as:

- Modifying or stopping vocalizations
- Changing from one behavioral state to another
- Movement out of feeding, breeding, or migratory areas

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995). More recent reviews (Nowacek et al. 2007, Southall et al. 2007, Southall et al. 2009, Ellison et al. 2012) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see following section). Responses can overlap; for example, an increased respiration rate is likely to be coupled with a flight response. Differential responses are expected among and within species since hearing ranges vary across species and individuals, the behavioral ecology of individual species is unlikely to completely overlap, and individuals of the same species may react differently to the same, or similar, stressor.

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995) and Southall et al. (2007). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to drilling noise with mean underwater levels of 157 dB re 1 µPa rms and in air levels of 112 dB re 20 µPa, suggesting the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an impulsive source at levels of 165 to 170 dB re 1 µPa (Finneran et al. 2003).

For non-impulsive sounds (*i.e.*, similar to the sources used during the proposed action), data suggest that exposures of pinnipeds to sources between 90 and 140 dB re 1 µPa do not elicit strong behavioral responses. Seals experimentally exposed to non-impulsive sources with a received sound pressure level similar to the levels in the proposed action have been shown to change their behavior by modifying diving activity and avoidance of the sound source (Götz and Janik 2010, Kvadsheim et al. 2010). In general, we expect exposure to the sounds from the proposed action to be brief, and that any behavioral response will be minor and within the normal range of behaviors for the animal (e.g., the use of a breathing hole further from the acoustic source, rather than one closer to the acoustic source) (Kelly 1988a).

Experimentally, Götz and Janik (2011) tested underwater responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's threshold at that frequency]) and a non-startling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the non-startling treatment either did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal’s habituation.

Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012). In cases where marine mammal response is brief (i.e., changing from one behavior to another, relocating a short distance, or ceasing vocalization), the effect(s) are not likely to be measurable at the population level, but could rise to the level of take of individuals.

6.2.5 Physical or Physiological Effects

Individuals exposed to noise can experience stress and distress, where stress is an adaptive response that does not normally place an animal at risk, and distress is a stress response resulting in a biological consequence to the individual. Both stress and distress can affect survival and productivity (Curry and Edwards 1998, Cowan and Curry 2002, Herráez et al. 2007, Cowan and Curry 2008). Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. In a review of research on stress physiology in marine mammals, Atkinson et al. (2015) highlighted the need to investigate the link between stress and the possible population-level consequences of marine mammal responses to stress in order to make informed conservation and management decisions.

Mammalian stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996, Gardiner and Hall 1997, Hunt et al. 2006, Romero et al. 2008). The stress response can be behavioral (e.g., startle, sudden change in behavior) and/or physiological (e.g., release of stress hormones, increase in heart rate, etc.). Different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al. 2004).

Marine mammals use hearing as a primary way to gather information about their environment and for communication; therefore, we assume that limiting these abilities is stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NRC 2003, NMFS 2006).

We expect individuals may experience Level B acoustic harassment and acoustic masking, and may exhibit behavioral responses from project activities. Therefore, we expect ESA-listed seals may experience stress responses. If seals are not displaced and remain in a stressful environment, we expect the stress response will dissipate shortly after the individual leaves the area or after the cessation of the acoustic stressor.

6.3 Acoustic Stressors

The proposed action involves a wide variety of activities that produce underwater sounds that will result in impacts to marine mammals in the action area. The proposed action involves the use of low-(less than 1 kHz), mid-(1-10 kHz), and high-(10-100 kHz) frequency sources in the deep area; most of the high-frequency sources are above the hearing range of marine organisms. As discussed in section 10, acoustic stressors (including icebreaking) are responsible for all of the instances of marine mammal take expected to result from this project.

As discussed in Section 6.2, the Navy performed a quantitative analysis to estimate the number of marine mammals that could be harassed by the underwater acoustic transmissions during the proposed action, called the Navy Acoustic Effects Model (NAEMO). Inputs to the quantitative analysis included marine mammal density estimates (see Table 10) (Kaschner 2004, Kaschner et al. 2006), marine mammal depth occurrence distributions (Navy 2017a), oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential animal exposures. The NAEMO model calculates sound energy propagation from the proposed non-impulsive acoustic sources, the sound received by an animat (virtual animal) representing marine mammals distributed in the area around the modeled activity, and whether the sound received by a marine mammal exceeds the thresholds for effects. More information on the details of the NAEMO modelling can be found in Office of Naval Research (2018b, 2018a) and 83 FR 40234.

Table 9 provides range to effects for non-impulsive sources (other than *de minimis* sources) and icebreaking noise proposed for the Arctic research activities to pinniped specific criteria (83 FR 40234). Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting non-impulsive acoustic impacts, but also in verifying the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher level effects, especially physiological effects, in marine mammals. Therefore, the ranges in Table 9 provide realistic maximum distances over which the specific effects from the use of non-impulsive sources during the proposed action would be possible.

Table 9. Range to PTS, TTS, and Behavioral Effects for Phocids in the Study Area

Source	Level B		Level A
	Range to Behavioral Effects (m)	Range to TTS Effects (m)	Range to PTS Effects (m)
LF4 towed source	10,000	1	0
LF5 towed source	10,000	1	0
MF9 towed source	10,000	50	4
Navigation and real-time sensing sources	10,000	6	0
Tomography sources	10,000	2	0
Spherical Wave source	10,000	0	0
Icebreaking noise	4,525	12	0

6.3.1 Vessel Noise

The primary underwater noise associated with vessel operations is the continuous cavitation noise produced by the propeller. The R/V *Sikuliaq* has a source level of 130 to 172 dB re 1 μPa at 1 m when travelling at maximum speed of 11 knots. Source levels for the CGC *Healy* were estimated to be 180 to 190 dB during transit (i.e., 10 dB less than during icebreaking operations; Roth et al. 2013).

Underwater noise from vessels may also temporarily disturb or mask communication of marine mammals. However, Sills et al. (2015) reported that ringed seals may be resilient to masking, as shown by an enhanced ability to detect signals from background noise. Additionally, we expect pinnipeds will transit through or around the area where vessels are in transit, rather than remaining in the area, and that any masking during this time will be brief. It is possible, however, that individuals may remain in the area if they are highly motived to stay due to the presence of a food source. In this instance, masking may affect an individual's ability to locate prey or interfere with communication among individuals.

Auditory disturbance to listed species could occur during all vessel activities. If animals are exposed to vessel noise they may exhibit deflection from the noise source, engage in low level avoidance behavior, and/or exhibit short-term vigilance behavior, but these behaviors are not likely to result in significant disruption of normal behavioral patterns.

6.3.2 Towed and moored acoustic sources

The towed and moored acoustic sources associated with the proposed action can cause behavioral harassment resulting in Level B take (see Table 10 for Level B take estimates). The towed acoustic sources will have duty cycles of about 50 percent (they will be transmitting acoustic signals for about half of the time that they are in use), but will be deployed for only 4-8 hours per day for 15 days. Source levels for this equipment will be 180-200 dB re 1 μPa at 1 m at frequencies ranging from 100-10,000 Hz (Table 2). ONR NAEMO modelling resulted in a range to behavioral effects of 10 km for both towed and moored acoustic sources (Table 10) and the takes were calculated based on these ranges. ONR also modelled the radius within which TTS may occur as 1 m for the LF4 and LF5 towed source, and 50 m for the MF9 towed source (Table 10).

Moored acoustic sources will have a very low duty cycle (they will be transmitting an acoustic signal for less than one percent of the time), transmitting signals of 183-185 dB re 1 μPa at 1 m at frequencies ranging from 250-2,500 Hz (Table 2). ONR modelling indicated that the range to behavioral effects is 10 km, and the radius within which TTS may occur is 0-12 m.

We expect it is extremely unlikely that seals will experience TTS or PTS (and ONR modeling did not indicate any TTS or PTS level exposures) as a result of exposure to noise from any of these acoustic sources because they will either hear the towed sources as they approach and have time to evade it, or they will be aware of the location of the moored sources as they approach them, and likewise be able to navigate around them.

For both towed and moored devices, acoustic masking may occur. However, for towed sources, such masking will occur for only a few hours per day for no more than 15 days, and for moored sources, masking will occur for only a very small proportion of time (less than one percent) throughout the maximum deployment time of three years. As such, acoustic masking from these devices is not expected to have more than a minor effect upon the seals' ability to communicate.

Seals may respond behaviorally to the sounds produced by the towed and acoustic sources with a range of reactions including a brief startle response (Götz and Janik 2011), change in vocalizations, avoiding the noise, modifying diving activity and avoidance of the sound source (Götz and Janik 2010, Kvadsheim et al. 2010). The reactions may differ depending on a variety of factors including the animal's age class, sex, and behavioral state (e.g., foraging, resting, diving) at the time of the noise exposure (Ellison et al. 2012). We expect ringed and bearded seals to be exposed to acoustic sources that will result in takes due to Level B harassment during the course of this project (see Table 10 and Table 11).

6.3.3 Icebreaking Noise

Sound source levels of 190 to 200 dB were reported during icebreaking by the CGC *Healy* (Roth et al. 2013). Based on the observed ice conditions in August 2018, ONR estimated only one day would be needed for icebreaking during their first cruise, with 357 ringed seals exposed to noise levels that would result in Level B behavioral harassment (Table 10). As ice conditions may change from year to year, to be conservative, ONR estimated a total of three days of icebreaking would be required per year during the 2019-2021 cruises, resulting in 888 ringed seals exposed to noise levels that would result in Level B behavioral harassment (Table 10). No modeled takes are projected for bearded seals, as very low densities of bearded seals are expected to be in the study area during icebreaking (August-October) (Office of Naval Research 2018a). Although ringed seals will be present in the study area, they do not begin construction of lairs until January (Kelly et al. 2010a), well after the time when icebreaking would occur. Therefore ringed seals will not be in lairs during icebreaking, and any young seals responding to the icebreaking noise will be sufficiently developed to be able to survive the response (i.e., there will be no seal pups with lanugo that are unable to thermoregulate in water).

The expected range for behavioral effects from icebreaking noise is 4,525 m (Table 9), and therefore it is almost certain that multiple ringed seals will be exposed to icebreaking noise, and these exposures will result in takes due to Level B behavioral harassment. Seals that are underwater during icebreaking activities may alter their behavior (e.g., use a different breathing hole, alter vocalizations, cease foraging, move away from the icebreaking), but this is likely to be temporary, and not cause significant disruption. Icebreaking noise may also temporarily disturb or mask hearing and communication of seals. However we expect most pinnipeds will transit through or around the area where vessels are in transit and/or icebreaking is occurring, rather than remaining in the area and possibly experiencing TTS, and that any masking during this time will be brief. It is possible, however, that individuals may remain in the area if they are highly motivated to stay due to the presence of a food source. In this instance, masking may affect an individual's ability to locate prey or interfere with communication among individuals.

If noise from icebreaking is perceived as a threat, ringed seals could react to the sound in a similar fashion to their reaction to other threats, such as polar bears (their primary predators), by fleeing into the water or leaving the area. Responses of ringed seals to a variety of human-induced sounds (*e.g.*, helicopter noise, snowmobiles, dogs, people, and seismic activity) have been variable; some seals entered the water and some seals remained stationary. In the extremely unlikely case that bearded seals would be in the area at the time of icebreaking, it is likely that hauled-out bearded seals will exhibit similar behavior to hauled-out ringed seals, with some seals entering the water and some seals remaining hauled out. We expect that only ringed seals will be subjected to acoustic harassment from project-associated icebreaking sound.

6.3.4 Other In-water Acoustic Sources (ONR determined "*de minimis*")

The proposed action will include devices that are acoustic sources which ONR refers to as "*de minimis*" sources, and have one or more of the following parameters: low source levels, narrow beams, downward directed transmission, short pulse lengths, low duty cycles (fraction of time that the sound is active), or frequencies above (outside) known marine mammal hearing ranges factors (see Table 3; Department of the Navy 2013b). For example, any sources 200 kHz or above in frequency are considered by ONR to be *de minimis* because they are outside the range of marine mammal hearing. Although ONR did not include these sources in their NAEMO modeling, we calculated the distance to the 120 dB isopleth for these sources. We consider these calculations of the area of affected marine waters to be conservative for the following reasons: 1) narrow beam and downwardly-directed sources will propagate outside of the source signal's cone at much reduced intensity; 2) pulses of very short durations are less audible than longer pulses at the same sound source levels (Plomp and Bouman 1959, Terhune 1988, Kastelein et al. 2010); 3) sounds with a very low duty cycle are less likely to elicit responses from marine mammals than the equivalent sounds with high duty cycles; and 4) sounds outside of a species' hearing ranges are not likely to be perceived by individuals of that species at all (Southall et al. 2007).

The PIES will be deployed on moorings. They produce sounds at 12 kHz, which is within the hearing range of seals, and have a distance to the 120 dB isopleth of 1,000 m, as calculated by NMFS. However, the PIES have a very short pulse length (0.006 sec) and the fraction of time that they are active (duty cycle) is very small (<0.01 percent). Responses of seals to these sounds are expected to be brief, with animals near the devices expected to quickly habituate to the sounds, therefore these devices are unlikely to cause significant disruptions to normal behavioral patterns.

The Acoustic Doppler Current Profilers (ADCPs) will be moored or deployed on unmanned underwater vehicles. One of the three types of ADCPs used in this project produces signals above 200 kHz; sound that is out of the hearing range of listed marine mammals in Alaska. The other two types of ADCP produce signals from 75-150 kHz; sound that is within the hearing range of listed marine mammals in Alaska. NMFS calculated that sound from these devices will produce received levels above 120 dB within 3,000 m of the source. However, the pulse length is extremely short (<1 ms), and the ADCPs have a very narrow beam (2.2 radians), so that only a very small proportion of waters within 3,000 m of these devices will actually contain sounds in excess of 120 dB. Responses of seals to these sounds are expected to be brief, with animals near the devices expected to quickly habituate to the sounds, therefore these devices are unlikely to cause significant disruptions to normal behavioral patterns.

Ice velocity and surface waves will be measured by 500 kHz multibeam sonars from Nortek Signatures, deployed on oceanographic moorings. These devices produces sounds which are well above the hearing range of marine mammals, and therefore we expect no response from seals to these devices.

The chirp sonar produces sounds between 2-16 kHz, which is within the hearing range of seals, and has a distance to the 120 dB isopleth of 10 km, as calculated by NMFS. However, the pulse length is short (0.02 sec) and duty cycle is very low (<1 percent). The narrow beam width will expose only a very small proportion of waters within 10 km to sounds above 120 dB. Responses of seals to these sounds are expected to be brief, with animals near the devices expected to quickly habituate to the sounds, therefore these devices are unlikely to cause significant disruptions to normal behavioral patterns. While the EMATT is within hearing range of phocids (700-1100 Hz and 1100-4000 Hz) and is mostly continuous (duty cycle of 25-100 percent), the sound pressure level is low (<150 dB re 1 µPa at 1 m) and the resulting distance to the 120 dB isopleth (as calculated by NMFS) is short (32 m). While some seals may approach these devices closely enough to experience MMPA Level B take, it is highly unlikely that they would willingly do so because doing so would require a very close approach to the towing vessel and to this ongoing source of sound. Seals are sufficiently mobile and agile that they can easily avoid a 32 m radius area if they choose to do so. Some seals may approach this source out of curiosity, but such behavior is not considered a significant disruption of important behavioral patterns such as breeding, feeding, sheltering, or resting. The source level for EMATTs is insufficient to cause TTS even if seals closely approach these devices.

The coring system and CTD-attached Echosounder both have low source levels (158-162 and 160 dB, respectively), and seals would have to come within 126 and 100 m, respectively, of these devices to be acoustically harassed. While some seals may approach these devices closely enough to experience MMPA Level B take, it is highly unlikely that they would willingly do so because doing so would require a very close approach (within about 126 or 100 m) to the towing/coring vessel and to this ongoing source of sound. Seals are sufficiently mobile and agile that they can easily avoid a 126 m radius area if they choose to do so. Some seals may approach this source out of curiosity, but such behavior is not considered a significant disruption of important behavioral patterns such as breeding, feeding, sheltering, or resting. Based on NMFS acoustic guidance, the source level for CTDs and coring devices is not capable of causing TTS in seals.

6.3.5 Noise from Aircraft Activity

It is uncertain if an animal reacts to the sound of the aircraft or to its physical presence flying overhead, or both. During February – March, when the fixed-wing and helicopter flights of the proposed action will occur, bearded and ringed seals may be on the ice or in the water, and ringed seals may be within their subnivean lairs. Bearded and ringed seals that are hauled out may react to the noise or visual stimulus by looking up at the aircraft, moving on the ice, entering a breathing hole or crack in the ice, or entering the water (Blackwell et al. 2004, Born et al. 2004). Reactions depend on several factors including the animal's behavioral state, activity, group size, habitat, and the flight pattern of the aircraft (Richardson et al. 1995). Additionally, a study conducted by Born et al. (1999) found that wind chill was also a factor in level of response of ringed seals hauled out on ice (higher wind chill increases probability of leaving the ice), as well as time of day and wind direction. Ringed and bearded seal reactions to helicopter disturbance are difficult to predict, though helicopters have been recorded to elicit a stronger behavioral response from bearded and ringed seals than a fixed-wing aircraft (Burns and Frost 1979, Born et al. 1999). When bearded seals are hauled out on ice they often dive when approached by low-flying aircraft. Furthermore, Perry et al. (2002) found sex and age compositions of haul-out groups (for gray and harbor seals) are important factors in determining the severity of the reaction to aircraft, with mothers and pups more likely to react.

The responses of ringed seals in subnivean lairs are typically stronger than that of a basking ringed seal (Burns et al. 1982). Ringed seals were shown to leave their subnivean lairs and enter the water when a helicopter was at an altitude of less than 1,000 ft. (305 m) and within 1 nm (2 km) lateral distance (Richardson et al. 1995). However, ringed seal vocalizations in water were similar between areas subject to low-flying aircraft and areas that were less disturbed (Calvert and Stirling 1985). These data suggest that although a ringed seal may leave a subnivean lair, aircraft disturbance does not cause the animals to leave the general area. Additionally, ringed seals construct multiple breathing holes and lairs within their home ranges (Smith and Stirling 1975); these additional lairs and breathing holes are used as escape lairs from predators, and therefore would be a suitable alternative in the event they leave a lair directly below the flightpath of an aircraft.

The lowest observed adverse effects levels are rather variable for pinnipeds on land, ranging from just over 492 ft. (150 m) to about 6,562 ft. (2,000 m) (Efroymson and Suter 2001). A conservative (90^{th} percentile) distance effects level for pinnipeds was found to be 3,773 ft. (1,150 m). Most thresholds represent movement away from the overflight. Generally, pinnipeds exposed to intense (approximately 110 to 120 dB re 20 µPa) non-pulse sounds often leave haul-out areas and seek refuge temporarily (minutes to a few hours) in the water (Southall et al. 2007).

Project noise will be generated by fixed-wing aircraft, helicopters, and unmanned aerial systems (UAS). Though some of these aircraft (i.e., UASs) are small and very quiet, some may create enough noise to potentially affect bearded and ringed seals. At frequencies less than 500 Hz (the acoustic energy range of most aircraft), noise travelling through the sea ice would only be slightly lower than that same noise travelling directly from the air to the water (ONR 2018a).

Flights of fixed-wing aircraft will be of short duration (3 hrs) and will fly at altitudes of either 1,500 ft or 10,000 ft (457 m or 3,048 m) above sea level. At this altitude, the footprint of airborne noise at the ice surface would be approximately 0.77 mi^2 (2 km^2) along the flight path of the aircraft. Due to the relatively small area over which aircraft noise would radiate outward, the noise would be transient (about 15 sec, assuming a flight speed of 120 kts). As received sound levels would be reduced by the time the sound reaches the ice from an overhead flight (attenuating in the air column) and would still have to attenuate through the ice, underwater noise would be brief in duration, of reduced intensity, and would transfer to water along a narrow swath of ice (2,588 ft-wide swath). At a distance of 2,152 ft (656 m) away, the received pressure levels of a Twin Otter is 80 to 98.5 dBA (which is less than the Level B threshold for both in-air sound (Metzger 1995b).

Helicopter flights will be short (less than 2 hrs) and will not hover for extended periods. Helicopters produce low-frequency sound and vibration (Richardson et al. 1995, Pepper et al. 2003) and contain dominant tones from the rotors that are generally below 500 Hz. Noise generated from helicopters is transient in nature and variable in intensity. The underwater noise produced is generally brief when compared with the duration of audibility in the air.

Based on the intermittent use of fixed-wing aircraft and helicopters, the helicopter avoidance of pressure ridges and other sensitive areas where seals would occur (ONR 2018a), and the short-term impacts of any behavioral reactions from aircraft activities, we conclude that the impact of aircraft sound is very minor, and thus adverse effects to ringed and bearded seals will be brief and of very low intensity, with any reactions by the seals expected to be imperceptible or very brief. Therefore, we conclude that adverse effects from aircraft traffic will be minimal or undetectable.

Unmanned aerial systems (UAS) that will be used are small, and will not hover over marine mammals. It is likely that marine mammals will not hear the device at all, since the noise generated will likely be masked by the vessel noise (Christiansen et al. 2016), The impact of UAS noise will be very minor, and adverse effects to ringed and bearded seals will be immeasurably small, if they occur at all. Therefore, we conclude that adverse effects from UAS on these seals will be minimal or undetectable.

6.4 Physical Stressors

In addition to the effects of noise-producing activities, bearded and ringed seals may be affected by the physical presence, and physical disturbance to their habitat, by vessels and devices in the action area.

6.4.1 Vessel and seaglider device presence and risk of strike

Behavioral reactions from vessels can vary depending on the type and speed of the vessel, the spatial relationship between the animal and the vessel, the species, and the behavior of the animal prior to the disturbance from the vessel. Response also varies between individuals of the same species. Individual animals' past experiences with vessels appear to be important in determining an individual's response. Vessels moving at slow speeds and avoiding rapid changes in direction or engine power may be tolerated by some species, and seals may even investigate vessels. Other individuals may deflect around vessels and continue on their migratory path.

Various efforts have investigated the impact of vessels on seals (both whale-watching and general vessel traffic noise). Jansen et al. (2015) found disturbance rates (i.e., numbers of harbor seals flushed into the water) from cruise ships as high as 14 percent in Disenchantment Bay, Alaska. In another study on harbor seals in Tracy and Endicott Arms, Alaska, Karpovich et al. (2015) found increases in heart rate in seals disturbed by vessels. This effect persisted through the subsequent haul out period, and could have energetic impacts on individual animals.

The project's seagliders are small and slow moving (0.25 meters per second), and seals will likely be able to visually detect and easily avoid the devices. While they may investigate the gliders, we have no information that would cause us to expect they would display a significant disruption of normal behavior patterns.

Seals will likely be able to hear the R/V *Sikuliaq* and CGC *Healy* from many kilometers away, and if disturbed, would likely move away from the vessel noise before coming into close proximity. Other animals may not be visibly affected by close proximity to slow moving vessels that are not headed directly towards them. Although 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 or ringed seals documented in Alaska (BOEM 2015a) despite the fact that protected species observers (PSOs) routinely observe bearded and ringed seals during oil and gas exploration activities. Finally, personnel will be watching for marine mammals during marine operations, further reducing the possibility of ship strike.

Therefore, we conclude that the probability of project vessels and equipment striking ringed or bearded seals is very small, and adverse effects to these seals are extremely unlikely to occur.

6.4.2 Icebreaking (non-acoustic effects)

Ringed seals and bearded seals on pack ice showed various behaviors when approached by an icebreaking vessel. A majority of seals dove underwater when the ship was within 0.5 nautical miles (0.93 km) while others remained on the ice. However, as icebreaking vessels came closer to the seals, most dove underwater. Ringed seals have also been observed foraging in the wake of an icebreaking vessel (Richardson et al. 1995). In studies by Alliston (1980, 1981), there was no observed change in the density of ringed seals in areas that had been subject to icebreaking. Alternatively, ringed seals may have preferentially established breathing holes in the ship tracks after the icebreaker moved through the area. However, icebreaking can disrupt the habitat of ice associated seals, especially during the breeding period when lairs and breathing holes may be compromised (Huntington 2009). In a study on the impacts of icebreaking on breeding Caspian seals (*Pusa caspica*), Wilson et al. (2017) found that icebreakers caused displacement and separation of mothers and pups, destruction of birth or nursery sites and vessel-seal collisions.

The icebreaking that will occur during the ONR's activities will take place in the deep water area off the continental shelf in the Beaufort Sea during August – October. While the earliest icebreaking could overlap temporally with the end of bearded seal molting season (April – August; Cameron et al. 2010), bearded seal density in the area of the Beaufort Sea where icebreaking would occur will be extremely low (Cameron et al. 2010), and will largely depend upon the distribution of late summer and early fall sea ice, which has become highly variable in recent years. A small number of ringed seals may begin construction of breathing holes and lairs during the fall when icebreaking may be occurring, however ringed seals generally prefer shorefast and pack ice closer to shore (Bengtson et al. 2005). Therefore the densities of ringed seals in the offshore icebreaking area are likely to be extremely low. Additionally, the fall icebreaking would not impact ringed seal mothers and pups in birthing lairs (March – June; Kelly et al. 2010b).

Due to the short duration of the icebreaking (about 7 days), its offshore location (away from favored ringed seal habitat), and its timing (occurring outside of the main molting and breeding periods when bearded and ringed seals are most likely to be hauled out on the ice and/or inside subnivean lairs), adverse effects from icebreaking to seals hauled out on ice habitat are very unlikely to occur.

6.4.3 Entanglement

We expect entanglement of bearded or ringed seals in the lines and wires from towed and moored arrays will be highly unlikely as the lines will be kept taut from their anchor attachments, reducing the risk of entanglement. During deployment, the likelihood of entanglement will be further reduced because personnel will be monitoring for the presence of marine mammals and should be aware of their presence in the area

The weather balloons being released could introduce the potential for entanglement following their descent; these balloons would consist of shredded debris from bursting balloons, a parachute used to slow the descent of the radiosonde, and all of the ropes and twine used to keep all of the components together (the radiosonde would be suspended 82-115 ft [25-35 m] below the balloon). The components from the weather balloons present the highest risk of entanglement. Balloon fragments would temporarily be deposited on the ice, until the ice melts and the materials would sink to the seafloor; some balloon fragments may remain suspended in the water column where ingestion would be a very low-probability risk for these mostly piscivorous foragers.

Although there is a potential for entanglement from an expended material, the amount of materials expended will be low. Additionally, pinnipeds are very mobile within the water column and are capable of avoiding debris. Although it is unknown whether seals will avoid this debris, a recent stranding report found that out of the 21 reported seal strandings that occurred from human interaction in the Arctic regions, none were documented to be from entanglement (Savage 2017). Therefore, based on the lack of evidence of previous pinniped entanglements in this region and the very low amount of project materials capable of resulting in entanglement, the probability of ringed or bearded seals becoming entangled in project-related materials is extremely small, and thus adverse effects to the seals are extremely unlikely to occur.

6.5 Pollution

Increased vessel activity in the action area will temporarily increase the risk of accidental fuel and lubricant spills from vessels. Accidental spills may occur from a spilled container, vessel leak, or hull breach. Spilled oil tends to concentrate in ice leads and in breathing holes, and will be held closer to the surface against ice edges where seals tend to travel (Engelhardt 1987). Floating sea ice also reduces wave action and surface exchange, thus delaying the weathering and dispersion of oil (or other contaminants) and increasing the level and duration of exposure to seals. Low temperatures make oil more viscous and thus increase the hazards associated with fouling of animals. They also reduce evaporation of volatile hydrocarbons, lessening the acute levels of toxins in the air but lengthening the period of exposure (Engelhardt 1987). To date there have been no major oil spills in the Arctic, so real-world data from which to develop a specific response or predict environmental impacts are lacking.

The greatest threat to Arctic marine mammals from small spills is likely from the inhalation of the volatile toxic hydrocarbon fractions of fresh oil, which can damage the respiratory system (Hansen 1985, Neff 2010) and cause neurological disorders or liver damage (Geraci 2012). Freshly spilled oil contains high levels of toxic aromatic compounds that, if inhaled, could cause serious health effects or death in ringed seals, as occurred with an estimated 300 harbor seals following the Exxon Valdez oil spill in Prince William Sound, Alaska (Frost et al. 1994a, Frost et al. 1994b, Lowry et al. 1994, Spraker et al. 1994). Oil that disperses from a spill site may still have high levels of toxic aromatic compounds, depending on the temperature and whether the oil becomes frozen into ice (St Aubin 1990). Pinnipeds stressed by parasitism or other metabolic disorders may be susceptible to injury or death from even brief exposure to low concentrations of hydrocarbon vapors (St Aubin 1990). For example, parasitized lungs—common in pinnipeds—can exacerbate the effects of even mild irritation of respiratory tissues (St. Aubin 1990). Toxicity of oil is generally greater in younger animals so exposure to oil contamination during the breeding season would likely cause higher mortality among pups (Jenssen 1996, Jenssen et al. 1996) .

Direct ingestion of oil, ingestion of contaminated prey, or inhalation of volatile hydrocarbons transfers toxins to body fluids, muscle, liver, and blubber, causing effects that may lead to death, as suspected in dead gray and harbor seals found with oil in their stomachs (Engelhardt et al.

1977, Engelhardt 1987, St Aubin 1990, Frost et al. 1994a, Lowry et al. 1994, Spraker et al. 1994, Jenssen 1996). Furthermore, ingestion of hydrocarbons irritates and destroys epithelial cells in the stomach and intestine, affecting motility, digestion, and absorption, which can result in death or reproductive failure (St Aubin 1990).

Other acute effects of oil exposure, which have been shown to reduce both ringed and bearded seal health and possibly survival include skin irritation, disorientation, lethargy, conjunctivitis, corneal ulcers, and liver legions (Geraci and Smith 1976, St. Aubin 1988).

Project vessels will not be in the region during pupping season, but will be in the region after pups have developed their pelage and insulating blubber layer. Energetic costs associated with exposure to contaminants such as oil would occur if mothers and pups spend more time in the water by swimming out of the affected area. Adults, juveniles, and weaned young of the year rely on blubber for insulation, so effects on their thermoregulation are expected to be minimal (Jenssen 1996).

While the potential effects of pollution, particularly oil pollution, can be severe, the vessels associated with this action will be carrying relatively small volumes of refined fuel and other petroleum products such as lubricating oils and solvents. Refined fuel will contain a higher proportion of toxic aromatic compounds, which pose a greater risk for lung damage if vapors are inhaled, but which also evaporate more rapidly. Given the small volumes of petroleum products carried by these project vessels, their ability to operate in icy waters safely, their ability to clean up spilled petroleum products before it reaches marine waters, their ability to coordinate rapid oil spill response should spilled petroleum products reach marine waters, and their brief time spent in the project area, the probability of project related pollution occurring is very small. Adverse impacts to the seals are therefore extremely unlikely to occur.

7. CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation, per section 7 of the ESA.

We searched for information on non-Federal actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline (Section 5 of this Opinion). We expect subsistence harvest of ringed and bearded seals and commercial shipping will continue into the future. We expect bans on commercial sealing will remain in place. We also expect that with commercial and private vessels operating in the Bering, Chukchi, and Beaufort Seas, the risk of non-permitted oil and pollutant discharges will continue.

The effects of harvest of ringed and bearded seals by Native Alaskans is discussed in Section 5.3, and is currently believed to be sustainable (Ice Seal Committee 2017). The effects of commercial shipping include noise and ship strikes, which are discussed in Section 5.4.2, 5.5.1, and 5.5.2, and are expected to increase in intensity (see Section 5.5).

Some continuing non-Federal activities are reasonably certain to contribute to climate change within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 5.0).

There are currently no other known state or private activities reasonably certain to occur in the action area that may affect listed species and are not subject to section 7 consultation.

8. INTEGRATION AND SYNTHESIS OF EFFECTS

The Integration and Synthesis section is the final step of NMFS's 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 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both the survival or recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) result in the adverse modification or destruction of critical habitat as measured through appreciable reductions in the value of designated critical habitat for the conservation of the listed species. These assessments are made in full consideration of the status of the species (Section 4).

As we discussed in the *Approach to the Assessment* section of this opinion, we begin our risk analyses by asking whether the probable physical, physiological, behavioral, or social responses of endangered or threatened species are likely to reduce the fitness of endangered or threatened individuals or the growth, annual survival, or reproductive success, or lifetime reproductive success of those individuals. If we would not expect individuals of the listed species exposed to an action's effects to experience reductions in the current or expected future survivability or reproductive success (that is, their fitness), we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Stearns 1977, Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). Therefore, if we conclude that individuals of the listed species are not likely to experience reductions in their fitness, we would conclude our assessment because we would not expect the effects of the action to affect the performance of the populations those individuals represent or the species those populations comprise. If, however, we conclude that individuals of the listed species are likely to experience reductions in their fitness as a result of their exposure to an action, we then determine whether those reductions would reduce the viability of the population or populations the individuals represent and the "species" those populations comprise (species, subspecies, or distinct populations segments of vertebrate taxa).

As part of our risk analyses, we consider the consequences of exposing endangered or threatened species to all of the stressors associated with the proposed action, individually and cumulatively, given that the individuals in the action area for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range, including the impacts of climate change.

We assume that existing regulations or similar regulatory requirements will apply over the life of the ONR's Arctic Research Activities from 2018-2021. Regulatory changes may require reinitiation of consultation per 50 CFR 402.16. In addition, we assume that all required mitigation measures and SOPs will be implemented. If required mitigation measures and SOPs are not incorporated into the proposed action, ONR will need to reinitiate consultation per 50 CFR 402.16. Finally, we did not consider optional mitigation measures that may be implemented by ONR.

Ringed and Bearded Seal Risk Analysis

Based on the results of the exposure analysis (see Section 6), we expect ringed and bearded seals may be exposed to underwater noise from vessels in transit and icebreaking, towed and moored acoustic sources, and fixed- and rotary winged aircraft. Exposure to noise from icebreaking, and towed and moored acoustic sources may result in Level B harassment (and therefore takes) due to project sounds (Table 10).

The exposure of ringed and bearded seals to aircraft sound is likely to occur, but such exposure will be very brief and of sufficiently low intensity that we conclude the effects will be insignificant.

Ringed and bearded seals may also be struck by project vessels or project equipment, or entangled in lines, cables, or expended materials associated with this project. However, the probability of a project vessel striking a ringed or bearded seal is very small, as is the probability of a ringed or bearded seal being struck by, striking, or becoming entangled in project-related marine debris, lines, cables or in-water devices. Thus, adverse effects to these species from strikes or entanglement are extremely unlikely to occur.

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 pregnancy, estrus, and lactation (Kelly et al. 2010c). This fall and early winter time period overlaps with the time period when the vessels will be present in the study area. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of ringed and bearded seals. As a result, the ringed and bearded seals' probable responses (tolerance, avoidance, short-term masking, and short-term vigilance behavior) to close approaches by vessels or other in-water devices and their probable exposure to noise or human disturbance are not likely to reduce the fitness or current or expected future reproductive success or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent. During the timeframe when the vessels are present in the action area, and possibly icebreaking, ringed seals will not have begun constructing lairs. While individual ringed seals may be impacted by behavioral responses to vessels and icebreaking, these impacts are not likely to reduce the abundance, reproductive rates, or growth rates of the populations those individuals represent.

We concluded in the Effects of the Action (Section 6 of this Opinion) that ESA-listed pinnipeds may be harassed by the proposed activities. NMFS relied upon ONR's NAEMO modeled exposures to calculate takes. All of the takes are expected to be Level B takes due to acoustic harassment. Table 10 shows the number of takes that are associated with the towed and moored acoustic sources and icebreaking each year. Table 11 shows the yearly total takes for bearded and ringed seals. These exposures constitute very small percentages of the stocks of ringed seals (1.03 percent in 2018-2019, 0.90 percent in 2019-2020 and 2020-2021) and bearded seals (<0.01 percent in each year).

Table 10. Yearly Takes for Towed and Moored Acoustic Sources and Icebreaking. Project Years are from fall in the first year to fall in the next year. Icebreaking is estimated to occur 1 day in 2018, and up to 3 days each year from 2018-2021

Species	Density Estimate within Study Area (animals per square km)[1]	Level B Harassment from Towed and Moored Acoustic Sources (Project Years 2018, 2019, 2020)	Level B Harassment from Icebreaking (Fall 2018 – one day)	Level B Harassment from Icebreaking (Fall 2019-2021 – 3 days / season)
Bearded Seal	0.0332	5	0	0
Ringed Seal	0.3760	1,826	357	888

[1] Kaschner (2004), Kaschner et al. (2006)

Table 11. Take Totals for each Project Year (Acoustic sources and icebreaking) and Grand Total for this opinion

Species	2018-2019*	2019-2020**	2020-2021***	Grand Total ESA Takes
Bearded Seal	5	5	5	**15**
Ringed Seal	3,071	2,714	2,714	**8,499**

* Covered by the IHA. Includes one year of acoustic sources, one day of icebreaking in 2018, and three days of icebreaking in the fall of 2019.
** Includes one year of acoustic sources and three days of icebreaking in fall 2020.
*** Includes one year of acoustic sources and three days of icebreaking in fall 2021.

These estimates represent the total number of take events (instances) that will occur, not necessarily the number of individual seals taken, as an individual seal may be "taken" multiple times over the course of the proposed action. These exposure estimates are likely to be overestimates because they do not account for avoidance of noise fields by seals or the effectiveness of mitigation measures in reducing take.

Exposure to vessel noise, aircraft noise (fixed-wing aircraft, helicopters, and UAS), habitat alteration (sea-ice, from icebreaking) and small oil spill discharge may occur as part of the proposed action, but the effects are considered minor or unlikely and would not rise to the level of take. Entanglement due to the occurrence of vessels or other in-water devices, lines, cables and debris is extremely unlikely to occur.

As 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 listed ringed or bearded seal populations (that is, we would not expect reductions in the reproduction, numbers, fitness, or distribution of such populations). An action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the listed entities. As a result, the activities of the ONR's ARA are not likely to appreciably reduce the ringed or bearded seals' likelihood of surviving or recovering in the wild when considered along with the environmental baseline and cumulative effects.

9. CONCLUSION

After reviewing the current status of Beringia DPS bearded seals and Arctic ringed seals, the environmental baseline for the action area, the anticipated effects of the proposed activities, and the possible cumulative effects, it is NMFS's biological opinion that ONR's proposed Arctic Research Activities in the Beaufort Sea, Alaska and the Permits Division's proposed issuance of an IHA to ONR are **not likely to jeopardize the continued existence of the following species:**

- **Arctic ringed seal**
- **Beringia DPS bearded seal**

No critical habitat has been designated for these species, therefore, none will be affected.

In addition, the proposed action is **not likely to adversely affect the follow species and critical habitats:**

- Bowhead whales
- Blue whales
- North Pacific right whales
- Sperm whales
- Fin whales
- Western North Pacific DPS humpback whales
- Mexico DPS humpback whales
- Western DPS Steller sea lions
- North Pacific right whale critical habitat
- Steller sea lion critical habitat

10. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species unless there is 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 (50 CFR 402.02). Based on recent NMFS guidance, the term "harass" under the ESA means to: "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016). The MMPA defines "harassment" as: "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment]" (16 U.S.C. §1362(18)(A)(i) and (ii)). For this consultation, the Permits Division anticipates that any take will be by harassment only. No Level A takes are contemplated or authorized.

The ESA does not prohibit the taking of threatened species unless special regulations have been promulgated, pursuant to ESA Section 4(d), to promote the conservation of the species. ESA Section 4(d) rules have not been promulgated for Arctic ringed or Beringia DPS bearded seals; therefore, ESA section 9 take prohibitions do not apply. This Incidental Take Statement includes numeric limits on taking of these species because this amount of take was analyzed in our jeopardy analysis. These numeric limits provide guidance to the action agencies on their requirement to reinitiate consultation if the amount of take estimated in the jeopardy analysis of this biological opinion is exceeded. This ITS includes reasonable and prudent measures and terms and conditions designed to minimize and monitor take of these threatened species.

Section 7(b)(4)(C) of the ESA specifies that in order to provide an Incidental Take Statement for an endangered or threatened species of marine mammal, the taking must first be authorized under section 101(a)(5) of the MMPA. Accordingly, **the terms of this Incidental Take Statement become effective only upon the issuance of MMPA authorization to take the marine mammals identified here**. Absent such authorization, this Incidental Take Statement is inoperative.

This biological opinion covers the entirety of ONR's proposed activity from 2018-2021, but we note that ONR has applied for an IHA for only one year, from September 15, 2018 through September 14, 2019. Future MMPA coverage will need to be obtained by ONR for activities spanning 2019-2021, and this Incidental Take Statement will be inoperative for those years without such authorization. Further, the issuance of an IHA constitutes an agency action for the purposes of section 7(a)(2) of the ESA; therefore, NMFS will complete a separate section 7 consultation on the Permits Division's issuance of any subsequent IHAs. If the amount or extent of incidental take proposed to be authorized through the IHA exceeds the levels estimated and analyzed here for any given year, or if the project-specific effects on the listed species or designated critical habitat will occur in a manner or to an extent not considered in this opinion, reinitiation of consultation will be required (50 CFR 402.16).

The Terms and Conditions described below are nondiscretionary. ONR and the Permits Division have a continuing duty to regulate the activities covered by this ITS. In order to monitor the impact of incidental take, ONR and the Permits Division must monitor the progress of the action and its impact on the species as specified in the ITS (50 CFR 402.14(i)(3)). If ONR and the Permits Division (1) fail to require the authorization holder to adhere to the terms and conditions of the ITS through enforceable terms that are added to the authorization, and/or (2) fail to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

10.1 Amount or Extent of Take

The section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or use a surrogate if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (50 CFR § 402.14 (i); see also 80 FR 26832 (May 11, 2015)).

NMFS anticipates the proposed ONR project in the Beaufort Sea, Alaska, between summer 2018 and fall 2021, is likely to result in the incidental take of ESA-listed species by harassment. The Permits Division estimated take by considering: 1) acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; 2) the area or volume of water that will be ensonified above these levels in a day; 3) the density or occurrence of marine mammals within these ensonified areas; and, 4) and the number of days of activities. For the proposed IHA, ONR employed NAEMO for assessing the impacts of underwater sound (see Section 6.2 and (ONR 2018a)).

Table 10 indicates the number of these takes that can be attributed to the towed and moored acoustic sources each year, and the number of takes attributed to icebreaking in each year. The proposed action is expected to take, by Level B harassment, 8,499 Arctic ringed seals and 15 Beringia DPS bearded seals throughout the duration of the project, 2018-2021 (Table 11). Table 11 shows the yearly take totals, including the number of takes covered by the proposed IHA (3,071 ringed seals and 5 bearded seals).

Harassment of these individuals will occur by exposure to sound from towed and moored sound sources with received sound levels of at least 120 dB re 1 μPa_{rms} (i.e., within the ensonified area for the towed and moored acoustic sources), but less than 190 dB re 1 μPa_{rms} (for pinnipeds). NAEMO modelling indicated that bearded and ringed seals would have to be within 10 km from the towed or moored source to elicit any behavioral reaction (e.g., flushing from a lair) (83 FR 40234). If exposure were to occur, bearded seals and ringed seals may exhibit behavioral responses such as avoidance, increased swimming speeds, increased surfacing time, or decreased foraging or on-ice resting time.

Modelling by ONR indicated that ringed seals would have to be within about 4.5 km from icebreaking to elicit any behavioral reactions, and that it is unlikely that bearded seals would be exposed to harassing levels of project-related icebreaking sound. Ringed seal reactions to icebreaking sound may include avoidance, entering the water if hauled out on the ice, or exiting the water if swimming, increased swimming speeds, or decreased foraging or on-ice resting time.

Any incidental take of ESA-listed pinnipeds considered in this consultation is restricted to the permitted action as proposed. If the actual incidental take exceeds the authorized level or type of take, ONR and the Permits Division must reinitiate consultation. Likewise, if the action deviates from what is described in Section 2 of this Opinion, ONR and the Permits Division must reinitiate consultation. All anticipated takes will be by harassment, as described previously, involving temporary changes in behavior.

10.2 Effect of the Take

In this Opinion, NMFS has determined that the level of anticipated incidental take is not likely to jeopardize the continued existence of any ESA-listed species.

The authorized takes from the proposed action are associated with behavioral harassment from acoustic noise. Although the biological significance of behavioral responses remains unknown, this consultation has assumed that exposure to noise sources might disrupt one or more behavioral patterns that are essential to an individual animal's life history. However, any behavioral responses of these pinnipeds to noise sources and any associated disruptions are not expected to affect the fitness of any individuals of these species, the viability of the populations of either species, or either species' survival or recovery.

10.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" (RPM) are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). The RPMs described below, along with their implementing terms and conditions, are necessary and appropriate to minimize or to monitor the amount of incidental take of Arctic ringed seals and Beringia DPA bearded seals resulting from the proposed actions.

The Permits Division must require ONR to implement and monitor the effectiveness of mitigation measures and SOPs incorporated as part of the proposed authorization for the incidental taking of ESA-listed marine mammals pursuant to section 101(a)(5)(D) of the MMPA, as specified below.

1. ONR will document and report relevant aspects of its research and testing activities to verify implementation of the mitigation measures and SOPs, comply with permits, and improve future environmental assessments.
2. The take of listed marine mammals by serious injury or mortality, whether authorized or unauthorized will be immediately reported to NMFS AKR.
3. Observations of dead, injured, contaminated, or entangled marine mammals will be reported to NMFS AKR.

10.4 Terms and Conditions

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

ONR and the Permits Division have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14).

Partial compliance with these terms and conditions may result in more take than anticipated. 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.[8]

To carry out the RPM 1 listed in Section 10.3, the following must occur:

A. ONR must provide NMFS AKR with documentation of ONR's implementation of the mitigation measures and SOPs specified in section 2.2 of the Biological Opinion.

[8] These terms and conditions are in addition to reporting required by the Permits Division.

To carry out RPMs 2 and 3 listed in Section 10.3, the following must occur:

B. ONR must provide NMFS with a draft monitoring report within 90 days of the conclusion of the proposed activity each year. The draft monitoring report will include data regarding acoustic source use and any mammal sightings or detection will be documented. The report will also include information on the number of shutdowns recorded. If no comments are received from NMFS within 30 days of submission of the draft final report, the draft final report will constitute the final report. If comments are received, a final report must be submitted within 30 days after receipt of comments.

1. The report data must include the following for each listed marine mammal observation (or "sighting event" if repeated sightings are made of the same animal[s]):

1.1 Species, date, and time for each sighting event

1.2 Number of animals per sighting event and number of adults/juveniles/calves/pups per sighting event

1.3. Primary, and, if observed, secondary behaviors of the marine mammals in each sighting event

1.4. Geographic coordinates for the observed animals, with the position recorded by using the most precise coordinates practicable (coordinates must be recorded in decimal degrees, or similar standard, and defined coordinate system)

1.5. Time of most recent project activity prior to marine mammal observation

1.6. Environmental conditions as they existed during each sighting event, including, but not limited to:

1.6.1. Beaufort Sea State

1.6.2. Weather conditions

1.6.3. Visibility (km/mi)

1.6.4. Lighting conditions

1.6.5. Percentage of ice cover

2. Observer report data must also include the following for each exposure of a marine mammal that occurs in the manner and extent as described in this Opinion:

2.1 All information listed under Item 1, above

2.2. Cause of the exposure (e.g., ringed seal within the shutdown zone during towing of acoustic sources)

2.2.1. Time the animal(s) entered the zone, and, if known, the time it exited the zone

2.2.2. Mitigation measures implemented prior to and after the animal entered the zone

D. A final technical report must be submitted to NMFS Alaska Region within 90 days after project completion (2021). The report must summarize all project activities and results of marine mammal monitoring conducted during project activities. The final technical report must include all elements from Item 1.1, above, as well as:

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

2. Analyses on the effects from various factors that influences detectability of marine mammals (e.g., sea state, number of observers, fog, glare, etc.)

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

4. Species composition, occurrence, and distribution of marine mammal takes, including date, water depth, numbers, age/size/sex categories (if determinable), group sizes, and ice cover

1.2.5. Analyses of effects of project activities on listed marine mammals

1.2.6. Number of marine mammals observed and taken (by species) during periods with and without project activities (and other variables that could affect detectability), such as:

1.2.6.1. Initial sighting distances versus project activity at time of sighting

1.2.6.2. Observed behaviors and movement types versus project activity at time of sighting

1.2.6.3. Numbers of sightings/individuals seen versus project activity at time of sighting

1.2.6.4. Distribution around the action area versus project activity at time of sighting

E. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury (Level A harassment), serious injury, or mortality, the applicant shall immediately cease operations and immediately report the incident to NMFS AKR, Protected Resources Division at 907-271-3023 and/or by email to Greg Balogh greg.balogh@noaa.gov, the Marine Mammal Stranding Hotline at 877-925-7773, and NMFS Permitting Division (Amy Fowler at 301-427-8461) for any MMPA authorization issues. The report must include the following information:

1. All information listed under Item C.1 and C.2, above

2. Number of listed animals taken

3. Date and time of each take

4. Cause of the take

5. Time the animal(s) entered the zone, and, if known, the time it exited the zone

6. Mitigation measures implemented prior to and after the animal entered the zone

7. NMFS Contacts:

Monthly and final reports and reports of unauthorized take must be submitted to:
NMFS Alaska Region, Protected Resources Division
Greg Balogh
Greg.balogh@noaa.gov
907-271-3023 or 907-271-5006

Activities that may have caused the take must cease upon the occurrence of unauthorized take, and must not resume until NMFS is able to review the circumstances of the prohibited take. ONR must work with NMFS to determine what is necessary to minimize the likelihood of further prohibited take and ensure ESA compliance. ONR must not resume its activities until notified by NMFS via letter, email, or telephone.

F. In the event that an oiled, dead, entangled or stranded listed marine mammal is spotted, ONR must report the incident within 24 hours to NMFS AKR, Protected Resources Division at 907-271-3023 and/or by email to greg.balogh@noaa.gov, the Marine Mammal Stranding Hotline at 877-925-7773, and NMFS Permits Division, Amy Fowler 301-427-8438 for any MMPA authorization issues.

11. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, help implement recovery plans, or develop information (50 CFR 402.02).

1) NMFS recommends that project vessels

   (a) Either avoid transiting within designated North Pacific right whale critical habitat or, in the event that such transit through critical habitat cannot be avoided, exercise extreme caution and observe a 10 knot (19 km/hr) vessel speed restriction.

   (b) Maintain a separation distance of 800 m (874 yards) from North Pacific right whales.

   (c) Slow to 5 kts if North Pacific right whales are observed at less than 800 m from the vessel and for observations of other whales at less than 100 m from the vessel.

Our suggested 800 m avoidance buffer for North Pacific right whales ensures that vessels do not violate the 500 yd separation distance from right whales required by 50 CFR 224.103, while helping to further minimize disturbance of North Pacific right whales. Researchers with the Marine Mammal Laboratory report that North Pacific right whales exhibit extreme vessel avoidance behaviors. The 800m separation distance is common for actions involving transit through North Pacific right whale critical habitat.

We recommend that any North Pacific right whale sightings be transmitted to: National Marine Fisheries Service, Protected Resources Division at greg.balogh@noaa.gov and verena.gill@noaa.gov (individual North Pacific Right Whale sightings may also be called in to (907) 271-3023 or 907-271-1937). In the event that this contact information becomes obsolete, call 907-271-5006 for updated contact information.

2) NMFS encourages ONR's plans to support analysis of marine mammal data in the Canada Basin Acoustic Propagation Experiment (CANAPE 2016/2017) by the Woods Hole Oceanographic Institute. NMFS further encourages ONR to assist with coordination between other interested marine mammal researchers and the appropriate CANAPE researchers to identify and/or collaborate with on data subsets of interest. These efforts will improve our understanding of marine mammal densities and distribution throughout the year in the Arctic. Additionally, the Navy should review information from CANAPE and other recent project activity in the Arctic (e.g., Fairweather 2016) to ensure that the marine mammal density and other data in NAEMO are updated with the most current available information.

3) As information about marine mammals offshore in the Beaufort Sea is limited, NMFS encourages ONR to report sightings of marine mammals in the study area (Figure 2).

In order for the NMFS Alaska Region to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their habitats, ONR and the Permits Division should notify the NMFS Alaska Region of any conservation recommendations those agencies implement.

12. REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed ONR Arctic Research program in the Beaufort Sea, Alaska for 2018-2021 and the associated Permits Division issuance of an IHA for 2018-2019. 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:

- the amount or extent of proposed take is exceeded;
- new information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner, or to an extent, not considered in this opinion;
- the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species, or critical habitat not considered in this opinion; or

- a new species is ESA-listed or critical habitat designated that may be affected by the action.

In instances where the amount or extent of authorized take is exceeded, ONR and the Permits Division must immediately request reinitiation of section 7 consultation.

13. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554; Data Quality Act (DQA)) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

13.1 Utility

This document records the results of an interagency consultation. The information presented in this document is useful to NMFS, BOEM, BSEE, EPA, U.S. Army Corps of Engineers (USACE) 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/pr/biological-opinions/. The format and name adhere to conventional standards for style.

13.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, ‘Security of Automated Information Resources,’ Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

13.3 Objectivity

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.

References

ACIA. 2005. Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, U.K.

Allen, A., and R. P. Angliss. 2015. Alaska marine mammal stock assessments, 2014. U.S. Dep. Commer., NOAA Tech Memo. NMFS-AFSC-301, 304 p. http://dx.doi.org/10.7289/V5NS0RTS.

Alliston, W. G. 1980. The distribution of ringed seals in relation to winter icebreaking activities near McKinley Bay, NWT, January-June 1980. Dome Petroleum.

Alliston, W. G. 1981. The distribution of ringed seals in relation to winter icebreaking activities in Lake Melville, Labrador. LGL limited.

Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs **70**:445-470. file://localhost/Users/craigjohnson/Documents/DA%20ACROBAT%20JOURNALS/JOURNALS%20ECOL%20SOC/ecol%20mono%20anderson%202000.pdf

Atkinson, S. 1997. Reproductive biology of seals. Reviews of Reproduction **2**:175-194.

Atkinson, S., D. Crocker, D. Houser, and K. Mashburn. 2015. Stress physiology in marine mammals: how well do they fit the terrestrial model? Journal of Comparative Physiology B **185**:463-486.

Austin, M., C. O'Neill, G. Warner, J. Wladichuk, M. Wood, and A. Allen. 2015. Chukchi Sea Analysis and Acoustic Propagation Modeling: Task 3 Deliverable. Technical report by JASCO Applied Sciences for NMFS. JASCO Document #01003.

Azzara, A. J., H. Wang, and D. Rutherford. 2015. A 10-year projection of maritime activity in the US Arctic region. Washington, DC: The International Council on Clean Transportation:163-178.

Becker, P. R., E. A. Mackey, M. M. Schantz, R. Demiralp, and R. R. Greenberg. 1995. Concentrations of chlorinated hydrocarbons, heavy metals and other elements in tissues banked by the Alaska Marine Mammal Tissue Archival Project. National Inst. of Standards and Technology (CSTL), Gaithersburg, MD (United States).

Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999–2000. Polar Biology **28**:833-845.

Blackwell, S. B., and C. R. Greene Jr. 2000. Sound measurements, 2000 break-up and open-water seasons. Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar oil development, Alaskan Beaufort Sea:2429-2422.

Blackwell, S. B., J. W. Lawson, and M. T. Williams. 2004. Tolerance by ringed seals (*Phoca hispida*) to impact pipe-driving and construction sounds at an oil production island. The Journal of the Acoustical Society of America **115**:2346-2357.

BOEM. 2012. Outer Continental Shelf Oil & Gas Leasing Program: 2012-2017. Department of the Interior, editor. Final Programmatic Environmental Impact Statement, OCS EIS/EA BOEM.

BOEMRE. 2011a. Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas. OCS EIS/EA BOEMRE.

BOEMRE. 2011b. Chukchi Sea Planning Area Oil and Gas Lease Sale 193 Final Supplemental Environmental Impact Statement. OCS EIS/EA BOEMRE 2011-041. Anchorage, AK: USDOI, BOEM, Alaska OCS Region. USDOI.

Born, E. W., F. F. Riget, R. Dietz, and D. Andriashek. 1999. Escape responses of hauled out ringed seals (Phoca hispida) to aircraft disturbance. Polar Biology **21**:171-178.

Born, E. W., J. Teilmann, M. Acquarone, and F. F. Riget. 2004. Habitat use of ringed seals (*Phoca hispida*) in the North Water area (North Baffin Bay). Arctic:129-142.

Bossart, G. 2011. Marine mammals as sentinel species for oceans and human health. Veterinary Pathology **48**:676-690.

Boveng, P., and M. Cameron. 2013. Pinniped movements and foraging: seasonal movements, habitat selection, foraging and haul-out behavior of adult bearded seals in the Chukchi Sea. Final Report., Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

Boveng, P. L., M. Cameron, P. B. Conn, and E. Moreland. 2017. Abundance Estimates of Ice-Associated Seals: Bering Sea Populations that Inhabit the Chukchi Sea During the Open-Water Period.

Braham, H. W., J. J. Burns, G. A. Fedoseev, and B. D. Krogman. 1981. Distribution and density of ice-associated pinnipeds in the Bering Sea. National Marine Mammal Laboratory.

Brandon, R. 1978. Adaptation and evolutionary theory. Studies in the History and Philosophy of Science **9**:181-206.

Brown, J., P. Boehm, L. Cook, J. Trefry, W. Smith, and G. Durell. 2010. cANIMIDA Task 2: Hydrocarbon and metal characterization of sediments in the cANIMIDA study area. OCS Study MMS 2010-004, Final report. Contract.

Burek, K. A., F. Gulland, and T. M. O'Hara. 2008. Effects of climate change on Arctic marine mammal health. Ecological Applications **18**.

Burns, J. 1967a. The Pacific Bearded Seal. Page 66. Alaska Department of Fish and Game, Juneau, AK.

Burns, J. J. 1967b. The Pacific bearded seal. Pittman-Robertson Project Report, W-6-R and W-14-R. State of Alaska, Department of Fish and Game.

Burns, J. J. 1981. Bearded seal, *Erignathus barbatus* Erxleben, 1777. Handbook of marine mammals **2**:145-170.

Burns, J. J., and T. J. J. Eley. 1976. The natural history and ecology of the bearded seal (*Erignathus barbatus*) and the ringed seal (*Phoca (Pusa) hispida*). Pages 263-294 Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976, U.S. Department of Commerce, NOAA, Boulder, CO.

Burns, J. J., and K. J. Frost. 1979. The natural history and ecology of the bearded seal, *Erignathus barbatus*. Environmental Assessment of the Alaskan Continental Shelf, Final Reports **19**:311-392.

Burns, J. J., and S. J. Harbo. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic:279-290.

Burns, J. J., B. P. Kelly, L. Aumiller, K. J. Frost, and S. Hills. 1982. Studies of ringed seals in the Alaskan Beaufort Sea during winter: impacts of seismic exploration. Unpubl. annual report, OCSEAP Res. Unit **232**.

Calvert, W., and I. Stirling. 1985. Winter distribution of ringed seals (Phoca hispida) in the Barrow Strait area, Northwest Territories, determined by underwater vocalizations. Canadian Journal of Fisheries and Aquatic Sciences **42**:1238-1243.

Cameron, M., and P. Boveng. 2007. Abundance and distribution surveys for ice seals aboard USCG Healy and the Oscar Dyson, April 10-June 18, 2007. Alaska Fisheries Science Center Quarterly Report, April-May-June **2007**:12-14.

Cameron, M., and P. Boveng. 2009. Habitat use and seasonal movements of adult and sub-adult bearded seals. Alaska Fisheries Science Center Quarterly Report October-November-December **2009**:1-4.

Cameron, M. F. 2005. Habitat use and seasonal movements of bearded seals in Kotzebue Sound, Alaska.

Cameron, M. F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, G. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (*Erignathus barbatus*). Technical Memorandum NMFS-AFSC-211, National Oceanic and

Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.
Cameron, M. F., K. J. Frost, J. M. Ver Hoef, G. A. Breed, A. V. Whiting, J. Goodwin, and P. L. Boveng. 2018. Habitat selection and seasonal movements of young bearded seals (*Erignathus barbatus*) in the Bering Sea. PLoS One **13**:e0192743.
Carlens, H., C. Lydersen, B. A. Krafft, and K. M. Kovacs. 2006. Spring haul-out behavior of ringed seals (*Pusa hispida*) in Kongsfjorden, Svalbard. Marine Mammal Science **22**:379-393.
Chapskii, K. K. 1938. The bearded seal (*Erignathus barbatus* Fabr.) of the Kara and Barents seas. . Game mammals of the Barents and Kara Seas. . Arctic Institute Glavsevmorputi, Leningrad, USSR.
Christiansen, F., L. Rojano-Doñate, P. T. Madsen, and L. Bejder. 2016. Noise Levels of Multi-Rotor Unmanned Aerial Vehicles with Implications for Potential Underwater Impacts on Marine Mammals. Frontiers in Marine Science **3**.
Clark, C., W. T. Ellison, B. Southall, L. Hatch, S. M. Van Parijs, A. S. Frankel, D. Ponirakis, and G. C. Gagnon. 2009. Acoustic masking of baleen whale communications: potential impacts from anthropogenic sources. Page 56 Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.
Clarke, J., A. Brower, M. Ferguson, A. Kennedy, and A. Willoughby. 2015. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2014. Annual Report, OCS Study BOEM **40**:98115-96349.
Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2017. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2016. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA.
Cleator, H. J., and I. Stirling. 1990. Winter distribution of bearded seals (*Erignathus barbatus*) in the Penny Strait area, Northwest Territories, as determined by underwater vocalizations. Canadian Journal of Fisheries and Aquatic Sciences **47**:1071-1076.
Cleator, H. J., I. Stirling, and T. Smith. 1989. Underwater vocalizations of the bearded seal (*Erignathus barbatus*). Canadian Journal of Zoology **67**:1900-1910.
Comiso, J. C. 2012. Large decadal decline of the Arctic multiyear ice cover. Journal of Climate **25**:1176-1193.
Comiso, J. C., and D. K. Hall. 2014. Climate trends in the Arctic as observed from space. Wiley Interdisciplinary Reviews: Climate Change **5**:389-409.
Cowan, D., and B. Curry. 2008. Histopathology of the alarm reaction in small odontocetes. Journal of Comparative Pathology **139**:24-33.
Cowan, D. F., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery. National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS SWFSC administrative report LJ-02-24C.
Crawford, J. A., K. J. Frost, L. T. Quakenbush, and A. Whiting. 2012. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biology **35**:241-255.
Cummings, W. C., D. Holliday, and B. Lee. 1984. Potential impacts of man-made noise on ringed seals: Vocalizations and reactions. Anchorage, AK: USDOI, MMS, Alaska OCS Region:86-0021.
Curry, B. E., and E. F. Edwards. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean: Research planning. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Davies, C. E., K. M. Kovacs, C. Lydersen, and S. M. Van Parijs. 2006. Development of display behavior in young captive bearded seals. Marine Mammal Science **22**:952-965.

Deecke, V. B., P. J. Slater, and J. K. Ford. 2002. Selective habituation shapes acoustic predator recognition in harbour seals. Nature **420**:171.

Dehn, L.-A., G. G. Sheffield, E. H. Follmann, L. K. Duffy, D. L. Thomas, G. R. Bratton, R. J. Taylor, and T. M. O'hara. 2005. Trace elements in tissues of phocid seals harvested in the Alaskan and Canadian Arctic: influence of age and feeding ecology. Canadian Journal of Zoology **83**:726-746.

Dehnhardt, G., B. Mauck, and H. Bleckmann. 1998. Seal whiskers detect water movements. Nature **394**:235.

Department of Fisheries and Oceans Canada. 1979. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. Department of Fisheries and Oceans.

Department of the Navy. 2013a. Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement. Naval Facilities Engineering Command Atlantic., Norfolk, VA.

Department of the Navy. 2013b. Hawaii-Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement. Naval Facilities Engineering Command, Pearl Harbor, HI.

Derocher, A. E., N. J. Lunn, and I. Stirling. 2004. Polar Bears in a Warming Climate. Integrative and Comparative Biology **44**:163-176.

Dubrovskii, A. 1937. The nuptial call of the bearded seal. Priroda:124-124.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2014. Evidence of a Lombard response in migrating humpback whales (*Megaptera novaeangliae*). The Journal of the Acoustical Society of America **136**:430-437.

Efroymson, R. A., and G. W. Suter. 2001. Ecological risk assessment framework for low-altitude aircraft overflights: II. Estimating effects on wildlife. Risk Analysis **21**:263-274.

Ellison, W., B. Southall, C. Clark, and A. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology **26**:21-28.

Elsner, R., D. Wartzok, N. B. Sonafrank, and B. P. Kelly. 1989. Behavioral and physiological reactions of arctic seals during under-ice pilotage. Canadian Journal of Zoology **67**:2506-2513.

Engelhardt, F. 1987. Assessment of the vulnerability of marine mammals to oil pollution. Pages 101-115 Fate and Effects of Oil in Marine Ecosystems. Springer.

Engelhardt, F. R., J. R. Geraci, and T. G. Smith. 1977. Uptake and clearance of petroleum hydrocarbons in the ringed seal, Phoca hispida. Journal of the Fisheries Board of Canada **34**:1143-1147.

Fay, F. H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. Oceanography of the Bering Sea:383-399.

Fay, F. H. 1982. Ecology and biology of the Pacific walrus, Odobenus rosmarus divergens Illiger. North American Fauna:1-279.

Fay, F. H., J. L. Sease, and R. L. Merrick. 1990. Predation on a ringed seal, *Phoca hispida*, and a black guillemot, *Cepphus grylle*, by a Pacific walrus, *Odobenus rosmarus divergens*. Marine Mammal Science **6**:348-350.

Fedoseev, G. 1965. The ecology of the reproduction of seals on the northern part of the Sea of Okhotsk. Izvestiya Tinro **65**:212-216.

Fedoseev, G. 1984. Population structure, current status, and perspectives for utilization of the ice-inhabiting forms of pinnipeds in the northern part of the Pacific Ocean. Marine mammals:130-146.

Fedoseev, G. A. 2000. Population biology of ice-associated forms of seals and their role in the northern Pacific ecosystems. Center for Russian Environmental Policy.

Feltz, E. T., and F. H. Fay. 1966. Thermal requirements in vitro of epidermal cells from seals. Cryobiology **3**:261-264.

Ferguson, S., J. Higdon, and E. Chmelnitsky. 2010. The rise of killer whales as a major Arctic predator. Pages 117-136 A little less Arctic. Springer.

Fernandez, L. 2014. Marine invasive species in the Arctic. Nordic Council of Ministers.

Finneran, J., D. Carder, and S. Ridgway. 2003. Temporary Threshold Shift (TTS) measurements in bottlenose dolphins (*Tursiops truncatus*), belugas (*Delphinapterus leucas*), and California sea lions (*Zalophus californianus*). Pages 12-16 *in* Environmental Consequences of underwater Sound (ECOUS) Symposium, San Antonio Texas.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. J. Acoust. Soc. Am **118**:2696-2705.

Finneran, J. J., and C. E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). The Journal of the Acoustical Society of America **133**:1819-1826.

Finneran, J. J., C. E. Schlundt, B. Branstetter, and R. L. Dear. 2007. Assessing temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) using multiple simultaneous auditory evoked potentials. Journal of the Acoustical Society of America **122**:1249-1264.

Folkens, P., R. Reeves, B. Stewart, P. Clapham, and J. Powell. 2002. National Audubon Society guide to marine mammals of the world. Alfred A. Knopf, Inc., New York, USA and Random House of Canada, Limited, Toronto, Canada:358-361.

Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. Frontiers in Ecology and the Environment **11**:305-313.

Freitas, C., K. M. Kovacs, R. A. Ims, M. A. Fedak, and C. Lydersen. 2008. Ringed seal post-moulting movement tactics and habitat selection. Oecologia **155**:193-204.

Freuchen, P. 1935. Mammals. Part II. Field notes and biological observations. Mammals. Gyldendalske Boghandel, Nordisk Forlag, Copenhagen, Denmark.

Fritz, L. 2012. Traffic impacts to Steller sea lions and deisgnated critical habitat around Dutch Harbor. Email from Lowell Fritz (NMML) to Alicia Bishop (NMFS AKR). Received April 6, editor.

Frost, K., L. Lowry, and J. Burns. 1979. Ringed seals in the Alaskan Beaufort Sea: Feeding patterns, trophic relationships and possible effects of offshore petroleum development. Page 22 *in* Third Biennial Conference on the Biology of Marine Mammals, The Olympic Hotel, Seattle, Washington.

Frost, K. J. 1985. The ringed seal (*Phoca hispida*). Pages 79-87 *in* J. J. Burns, K. J. Frost, and L. F. Lowry, editors. Marine Mammals Species Accounts. Alaska Department of Fish and Game, Juneau, AK.

Frost, K. J., and L. F. Lowry. 1981. Ringed, Baikal and Caspian seals. Handbook of marine mammals **2**:29-54.

Frost, K. J., and L. F. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea.

Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. Arctic **57**:115-128.

Frost, K. J., L. F. Lowry, E. H. Sinclair, J. Ver Hoef, and D. C. McAllister. 1994a. Impacts on distribution, abundance, and productivity of harbor seals. Pages 97-118 Marine mammals and the Exxon Valdez. Elsevier.

Frost, K. J., C.-A. Manen, and T. L. Wade. 1994b. Petroleum hydrocarbons in tissues of harbor seals from Prince William Sound and the Gulf of Alaska. Pages 331-358 Marine mammals and the Exxon Valdez. Elsevier.

Gaden, A., S. Ferguson, L. Harwood, H. Melling, and G. Stern. 2009. Mercury trends in ringed seals (*Phoca hispida*) from the western Canadian Arctic since 1973: associations with length of ice-free season. Environmental science & technology **43**:3646-3651.

Gardiner, K. J., and A. J. Hall. 1997. Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). Canadian Journal of Zoology **75**:1773-1780.

Geraci, J. 2012. Sea mammals and oil: confronting the risks. Elsevier.

Gjertz, I., K. Kovacs, C. Lydersen, and Ø. Wiig. 2000. Movements and diving of bearded seal (*Erignathus barbatus*) mothers and pups during lactation and post-weaning. Polar Biology **23**:559-566.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M. P. Simmonds, R. Swift, and D. Thompson. 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal **37**:16-34.

Götz, T., and V. M. Janik. 2010. Aversiveness of sounds in phocid seals: psycho-physiological factors, learning processes and motivation. Journal of Experimental Biology **213**:1536-1548.

Götz, T., and V. M. Janik. 2011. Repeated elicitation of the acoustic startle reflex leads to sensitisation in subsequent avoidance behaviour and induces fear conditioning. BMC neuroscience **12**:30.

Gray, L. M., and D. S. Greeley. 1980. Source level model for propeller blade rate radiation for the world’s merchant fleet. The Journal of the Acoustical Society of America **67**:516-522.

Greene, C. 1981. Underwater acoustic transmission loss and ambient noise in arctic regions. Pages 234-258 *in* The Question of Sound from Icebreaker Operations, Proceedings of a Workshop. NM Peterson, ed., Toronto, Ont., Canada.

Greene, C. R. J., and S. E. Moore. 1995. Man-made noise. Pages 101-158 *in* W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego, CA.

Halliday, W. D., S. J. Insley, R. C. Hilliard, T. de Jong, and M. K. Pine. 2017. Potential impacts of shipping noise on marine mammals in the western Canadian Arctic. Marine Pollution Bulletin **123**:73-82.

Hammill, M. O., K. Kovacs, and C. Lydersen. 1994. Local movements by nursing bearded seal (*Erignathus barbatus*) pups in Kongsfjorden, Svalbard. Polar Biology **14**:569-570.

Hansen, D. J. 1985. Potential effects of oil spills and other chemical pollutants on marine mammals occurring in Alaskan waters. Minerals Management Service, Anchorage, AK (USA). Alaska Outer Continental Shelf Region.

Harwood, L. A., F. McLaughlin, R. M. Allen, J. Illasiak, and J. Alikamik. 2005. First-ever marine mammal and bird observations in the deep Canada Basin and Beaufort/Chukchi seas: expeditions during 2002. Polar Biology **28**:250-253.

Harwood, L. A., T. G. Smith, J. Auld, H. Melling, and D. J. Yurkowski. 2015. Seasonal movements and diving of ringed seals, *Pusa hispida*, in the Western Canadian Arctic, 1999-2001 and 2010-11. Arctic:193-209.

Harwood, L. A., T. G. Smith, and J. C. Auld. 2012. Fall Migration of Ringed Seals (*Phoca hispida*) through the Beaufort and Chukchi Seas, 2001—02. Arctic:35-44.

Harwood, L. A., and I. Stirling. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Canadian Journal of Zoology **70**:891-900.

Hashagen, K. A., G. A. Green, and B. Adams. 2009. Observations of humpback whales, Megaptera novaeangliae, in the Beaufort Sea, Alaska. Northwestern Naturalist **90**:160-162.

Helker, V. T., B. M. Allen, and L. A. Jemison. 2015. Human Caused Injury and Mortality of NMFS-managed Alaska Marine Mammal Stocks, 2009-2013. N. O. a. A. A. U.S. Department of Commerce, National Marine Fisheries Service, Alaska Fisheries Science Center, editor. NOAA Technical Memorandum NMFS-AFSC-300.

Heptner, L., K. Chapskii, V. Arsen'ev, and V. Sokolov. 1976a. Ringed seal, *Phoca (Pusa) hispida*. Pages 218-260 *in* L. Heptner, N. Naumov, and J. Mead, editors. Mammals of the Soviet Union. Vysshaya Shkola Publishers, Moscow, Russia.

Heptner, L. V. G., K. K. Chapskii, V. A. Arsenev, and V. T. Sokolov. 1976b. Bearded seal. *Erignathus barbatus* (Erxleben, 1777). Pages 166-217 *in* L. V. G. Heptner, N. P. Naumov, and J. Mead, editors. Mammals of the Soviet Union. Vysshaya Shkola Publishers, Moscow, Russia.

Héroux, O. 1960. Mitotic rate in the epidermis of warm-and cold-acclimated rats. Canadian journal of biochemistry and physiology **38**:135-142.

Herráez, P., E. Sierra, M. Arbelo, J. Jaber, A. E. De Los Monteros, and A. Fernández. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. Journal of Wildlife Diseases **43**:770-774.

Hezel, P., X. Zhang, C. Bitz, B. Kelly, and F. Massonnet. 2012. Projected decline in spring snow depth on Arctic sea ice caused by progressively later autumn open ocean freeze-up this century. Geophysical Research Letters **39**.

Hjelset, A., M. Andersen, I. Gjertz, C. Lydersen, and B. Gulliksen. 1999. Feeding habits of bearded seals (*Erignathus barbatus*) from the Svalbard area, Norway. Polar Biology **21**:186-193.

Holst, M., I. Stirling, and K. A. Hobson. 2001. Diet of ringed seals (*Phoca hispida*) on the east and west sides of the North Water Polynya, northern Baffin Bay. Marine Mammal Science **17**:888-908.

Holt, M. M., D. P. Noren, V. Veirs, C. K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. The Journal of the Acoustical Society of America **125**:EL27-EL32.

Hunt, K. E., R. M. Rolland, S. D. Kraus, and S. K. Wasser. 2006. Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). General and comparative endocrinology **148**:260-272.

Huntington, H. P. 2009. A preliminary assessment of threats to arctic marine mammals and their conservation in the coming decades. Marine Policy **33**:77-82.

Huntington, H. P., and C. Sookiayak. 2000. Traditional ecological knowledge of seals in Norton Bay, Alaska. Elim-Shaktoolik-Koyuk Marine Mammal Commission.

Hyvärinen, H. 1989. Diving in darkness: whiskers as sense organs of the ringed seal (*Phoca hispida saimensis*). Journal of Zoology **218**:663-678. http://dx.doi.org/10.1111/j.1469-7998.1989.tb05008.x

ICCT. 2015. A 10-Year Projection of Maritime Activtiy in the U.S. Arctic Region. Contracted and coordinated under the U.S. Committee of the Marine Transportation System. Prepared by the International Council on Clean Transportation. Washington, DC. .

Ice Seal Committee. 2016. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2014.

Ice Seal Committee. 2017. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2015.

Intergovernmental Panel on Climate Change. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change C. U. Press.

Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change IPCC.

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.

IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. IPCC Working Group II contribution to AR5. Intergovernmental Panel on Climate Change. http://www.ipcc.ch/report/ar5/wg2/

Isaac, J. L. 2009. Effects of climate change on life history: implications for extinction risk in mammals. Endangered Species Research **7**:115-123.

Jansen, J. K., P. L. Boveng, S. P. Dahle, and J. L. Bengtson. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management **74**:1186-1194.

Jansen, J. K., G. M. Brady, J. M. Ver Hoef, and P. L. Boveng. 2015. Spatially estimating disturbance of harbor seals (*Phoca vitulina*). PLoS One **10**:e0129798.

Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler. 2005. Sounding the depths II: The rising toll of sonar, shipping and industrial ocean noise on marine life. Natural Resources Defense Council, New York, New York.

Jeffries, M. O., J. Richter-Menge, and J. E. Overland. 2014. Arctic report card 2014. http://www.arctic.noaa.gov/reportcard

Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. . N. T. M. N.-O. U.S. Department of Commerce, editor.

Jenssen, B. M. 1996. An overview of exposure to, and effects of, petroleum oil and organochlorine pollution in grey seals (Halichoerus grypus). Science of the Total Environment **186**:109-118.

Jenssen, B. M., J. U. Skaare, M. Ekker, D. Vongraven, and S.-H. Lorentsen. 1996. Organochlorine compounds in blubber, liver and brain in neonatal grey seal pups. Chemosphere **32**:2115-2125.

Jones, J. M., B. J. Thayre, E. H. Roth, M. Mahoney, I. Sia, K. Merculief, C. Jackson, C. Zeller, M. Clare, and A. Bacon. 2014. Ringed, bearded, and ribbon seal vocalizations north of Barrow, Alaska: seasonal presence and relationship with sea ice. Arctic:203-222.

Karpovich, S. A., J. P. Skinner, J. E. Mondragon, and G. M. Blundell. 2015. Combined physiological and behavioral observations to assess the influence of vessel encounters on harbor seals in glacial fjords of southeast Alaska. Journal of Experimental Marine Biology and Ecology **473**:110-120.

Kaschner, K. 2004. Modelling and mapping resource overlap between marine mammals and fisheries on a global scale. University of British Columbia.

Kaschner, K., R. Watson, A. Trites, and D. Pauly. 2006. Mapping world-wide distributions of marine mammal species using a relative environmental suitability (RES) model. Marine Ecology Progress Series **316**:285-310.

Kastelein, R. A., L. Hoek, C. A. de Jong, and P. J. Wensveen. 2010. The effect of signal duration on the underwater detection thresholds of a harbor porpoise (Phocoena phocoena) for single frequency-modulated tonal signals between 0.25 and 160 kHz. The Journal of the Acoustical Society of America **128**:3211-3222.

Kelly, B. 1988a. Ringed seal, *Phoca hispida* Pages 57-75 *in* L. JW, editor. Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, D.C.

Kelly, B. P. 1988b. Bearded Seal Page 77 *in* L. J.W., editor. Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations.

Kelly, B. P., O. H. Badajos, M. Kunnasranta, J. R. Moran, M. Martinez-Bakker, D. Wartzok, and P. Boveng. 2010a. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology **33**:1095-1109. http://dx.doi.org/10.1007/s00300-010-0796-x

Kelly, B. P., J. Bengtson, P. Boveng, M. Cameron, S. Dahle, J. Jansen, E. Logerwell, J. Overland, C. Sabine, and G. Waring. 2010b. Status review of the ringed seal (*Phoca hispida*). U.S. Department of Commerce.

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. 2010c. Status review of the ringed seal (*Phoca hispida*). U.S. Department of Commerce, Seattle, WA. http://www.afsc.noaa.gov/publications/AFSC-TM/NOAA-TM-AFSC-212.pdf

Kelly, B. P., and L. T. Quakenbush. 1990. Spatiotemporal use of lairs by ringed seals (*Phoca hispida*). Canadian Journal of Zoology **68**:2503-2512.

Kelly, B. P., L. T. Quakenbush, and J. R. Rose. 1986. Ringed seal winter ecology and effects of noise disturbance. Outer Continental Shelf Environmental Assessment:447-536.

King, J. E. 1983. Seals of the world. British Museum of Natural History, London, United Kingdom.

Kortsch, S., R. Primicerio, M. Fossheim, A. V. Dolgov, and M. Aschan. 2015. Climate change alters the structure of arctic marine food webs due to poleward shifts of boreal generalists. Proc. R. Soc. B **282**:20151546.

Kovacs, K. M. 2007. Background document for development of a circumpolar ringed seal (*Phoca hispida*) monitoring plan.

Kovacs, K. M. 2009. Bearded Seal: *Erignathus barbatus*. Pages 97-101 Encyclopedia of Marine Mammals (Second Edition). Elsevier.

Kovacs, K. M., C. Lydersen, and I. Gjertz. 1996. Birth-site characteristics and prenatal molting in bearded seals (*Erignathus barbatus*). Journal of Mammalogy **77**:1085-1091.

Kovacs, K. M., C. Lydersen, J. E. Overland, and S. E. Moore. 2011. Impacts of changing sea-ice conditions on Arctic marine mammals. Marine Biodiversity **41**:181-194.

Kryter, K. D., W. D. Ward, J. D. Miller, and D. H. Eldredge. 1966. Hazardous exposure to intermittent and steady-state noise. The Journal of the Acoustical Society of America **39**:451-464.

Kvadsheim, P. H., E. M. Sevaldsen, L. P. Folkow, and A. S. Blix. 2010. Behavioural and Physiological Responses of Hooded Seals (Cystophora cristata) to 1 to 7 kHz Sonar Signals. Aquatic Mammals **36**.

Labansen, A. L., C. Lydersen, T. Haug, and K. M. Kovacs. 2007. Spring diet of ringed seals (*Phoca hispida*) from northwestern Spitsbergen, Norway. ICES Journal of Marine Science **64**:1246-1256.

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.

Learmonth, J. A., C. D. MacLeod, M. B. Santos, G. J. Pierce, H. Crick, and R. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology **44**:431.

Lentfer, J. W. 1972. Alaska polar bear research and managment., IUCN Supplementary Paper Number 35, IUCN, Morges, Switzerland.

Ling, J. K. 1970. Pelage and molting in wild mammals with special reference to aquatic forms. The Quarterly Review of Biology **45**:16-54.

Ling, J. K. 1972. Adaptive functions of vertebrate molting cycles. American Zoologist **12**:77-93.

Loeng, H., K. Brander, E. Carmack, S. Denisenko, K. Drinkwater, B. Hansen, K. M. Kovacs, P. Livingston, F. McLaughlin, and E. Sakshaug. 2005. Chapter 9: Marine Ecosystems. Cambridge University Press, Cambridge, U.K.

Loughlin, T. R., and A. E. York. 2000. An accounting of the sources of Steller sea lion, *Eumetopias jubatus*, mortality. Marine Fisheries Review **62**:40-45.

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., K. J. Frost, and K. W. Pitcher. 1994. Observations of oiling of harbor seals in Prince William Sound. Pages 209-225 Marine mammals and the Exxon Valdez. Elsevier.

Lydersen, C. 1991. Monitoring ringed seal (*Phoca hispida*) activity by means of acoustic telemetry. Canadian Journal of Zoology **69**:1178-1182.

Lydersen, C. 1998. Status and biology of ringed seals (*Phoca hispida*) in Svalbard. NAMMCO Scientific Publication **1**:46-62.

Lydersen, C., and M. O. Hammill. 1993. Diving in ringed seal (*Phoca hispida*) pups during the nursing period. Canadian Journal of Zoology **71**:991-996.

Lydersen, C., M. O. Hammill, and K. M. Kovacs. 1994. Diving activity in nursing bearded seal (*Erignathus barbatus*) pups. Canadian Journal of Zoology **72**:96-103.

Lydersen, C., P. Jensen, and E. Lydersen. 1987. Studies of the ringed seal (*Phoca hispida*) population in the Van Mijen fiord, Svalbard, in the breeding period 1986. Norsk Polarinstitutt Rapportserie:89-112.

Lydersen, C., and K. M. Kovacs. 1999. Behaviour and energetics of ice-breeding, North Atlantic phocid seals during the lactation period. Marine Ecology Progress Series:265-281.

Lydersen, C., and M. Ryg. 1990. An evaluation of Tempelfjorden and Sassenfjorden as breeding habitat for ringed seals (*Phoca hispida*). Environmental atlas Gipsdalen, Svalbard **3**:33-40.

Lydersen, C., and T. G. Smith. 1989. Avian predation on ringed seal *Phoca hispida* pups. Polar Biology **9**:489-490.

Macdonald, R. W. 2005. Climate change, risks and contaminants: a perspective from studying the Arctic. Human and Ecological Risk Assessment **11**:1099-1104.

MacIntyre, K. Q., K. M. Stafford, C. L. Berchok, and P. L. Boveng. 2013. Year-round acoustic detection of bearded seals (*Erignathus barbatus*) in the Beaufort Sea relative to changing environmental conditions, 2008–2010. Polar Biology **36**:1161-1173.

MacIntyre, K. Q., K. M. Stafford, P. B. Conn, K. L. Laidre, and P. L. Boveng. 2015. The relationship between sea ice concentration and the spatio-temporal distribution of vocalizing bearded seals (*Erignathus barbatus*) in the Bering, Chukchi, and Beaufort Seas from 2008 to 2011. Progress in Oceanography **136**:241-249.

MacLeod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: a review and synthesis. Endangered Species Research **7**:125-136.

Manning, T. H. 1974. Variations in the skull of the bearded seal. University of Alaska. Institute of Arctic Biology.

Mansfield, A. W. 1983. The Effects of Vessel Traffic in the Arctic on Marine Mammals and Recommendations for Future Research: A Report Commissioned by the Arctic Research

Directors Committee of the Department of Fisheries and Oceans. Department of Fisheries and Oceans, Arctic Biological Station.
Marshall, C. D., H. Amin, K. M. Kovacs, and C. Lydersen. 2006. Microstructure and innervation of the mystacial vibrissal follicle-sinus complex in bearded seals, *Erignathus barbatus* (Pinnipedia: Phocidae). The Anatomical Record Part A: Discoveries in Molecular, Cellular, and Evolutionary Biology **288**:13-25.
Marshall, C. D., K. M. Kovacs, and C. Lydersen. 2008. Feeding kinematics, suction and hydraulic jetting capabilities in bearded seals (*Erignathus barbatus*). Journal of Experimental Biology **211**:699-708.
McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America **120**:711-718.
McLaren, I. A. 1958. Some aspects of growth and reproduction of the bearded seal, *Erignathus barbatus* (Erxleben). Journal of the Fisheries Board of Canada **15**:219-227.
Melnikov, V., and I. Zagrebin. 2005. Killer whale predation in coastal waters of the Chukotka Peninsula. Marine Mammal Science **21**:550-556.
Metzger, F. B. 1995a. An assessment of propeller aircraft noise reductin technology. National Aeronautics and Space Administration, Hampton, VA.
Metzger, F. B. 1995b. An assessment of propeller aircraft noise reduction technology.
Miksis-Olds, J. L., and L. E. Madden. 2014. Environmental predictors of ice seal presence in the Bering Sea. PLoS One **9**:e106998.
Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fishes. Philosophy of Science **46**:263-286.
Moore, S. E., and H. P. Huntington. 2008. Arctic marine mammals and climate change: impacts and resilience. Ecological Applications **18**.
Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS), joint US-Russian aerial surveys for ice-associated seals, 2012-13. Alaska Fisheries Science Center Quarterly Report July:1-6.
Moulton, V. D. 2002. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites in 2001 (and 1997-2001 combined).
Mouy, X., D. Hannay, M. Zykov, and B. Martin. 2012. Tracking of Pacific walruses in the Chukchi Sea using a single hydrophone. The Journal of the Acoustical Society of America **131**:1349-1358.
Murphy, D. 2010. U.S. Coast Guard Cutter Healy. http://www.whoi.edu/vanishingarctic/page.do?pid=47775
Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. NOAA Tech. Memo. NMFS-AFSC-355, Alaska Fisheries Science Center 7600 Sand Point Way N.E. Seattle, WA 98115. http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-355.pdf
Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2016.

Alaska Marine Mammal Stock Assessments, 2015. A. F. S. C. National Marine Mammal Laboratory, editor., Seattle, WA.

Nachtigall, P. E., J. L. Pawloski, and W. W. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). The Journal of the Acoustical Society of America **113**:3425-3429.

Nachtigall, P. E., A. Y. Supin, J. Pawloski, and W. W. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using evoked auditory potentials. Marine Mammal Science **20**:673-687.

National Research Council. 1994. Improving the management of US marine fisheries. Committee on Fisheries, National Research Council of the National Academies.

National Research Council. 1996. The Bering Sea Ecosystem. National Academies Press.

National Research Council. 2001. Marine mammals and low-frequency sound: progress since 1994. ASA.

National Research Council. 2003. Ocean noise and marine mammals. National Academies Press.

National Research Council. 2005. Marine mammal populations and ocean noise: determining when noise causes biologically significant effects. National Academies Press, Washington, D.C.

National Snow and Ice Data Center. 2016. Sea ice hits record lows. http://nsidc.org/arcticseaicenews/2016/

National Snow and Ice Data Center. 2018. Springtime for the Arctic. http://nsidc.org/arcticseaicenews/2018/

Naval Sea Systems Command. 2015. Speed Series Starboard Aspect One-third Octave Signature.

Neff, J. M. 2010. Fate and effects of water based drilling muds and cuttings in cold water environments. Houston (TX): Report to Shell Exploration and Production Company.

Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. Straley. 2012. Summary of Reported Whale-Vessel Collisions in Alaskan Waters. Journal of Marine Biology **2012**:18.

Nelson, R., J. Burns, and K. Frost. 1984. The bearded seal (*Erignathus barbatus*). Marine mammal species accounts, wildlife technical bulletin:1-6.

Nelson, R. K. 1982. Harvest of the sea: coastal subsistence in modern Wainwright, a report for the North Slope Borough's Coastal Management Program. North Slope Borough.

NMFS. 2006. Endangered Species Act section 7 consultation biological opinion on the United States Navy's 2006 Rim-of-the-Pacific Joint Training Exercises. N. M. F. S. Office of Protected Resources, editor. National Oceanic and Atmospheric Administration, Department of Commerce, , Silver Spring, MD.

NMFS. 2008. Recovery Plan for the Steller Sea Lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Servies, Silver Spring, MD.

NMFS. 2013. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion on Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska. A. R. O. National Marine Fisheries Service, editor., Juneau, Alaska.

NMFS. 2014a. Endangered Species Act section 7 consultation biological opinion for the issuance of Incidental Harassment Authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to SAExploration, Inc. (SAE) for marine 3D ocean bottom node seismic activities in the U.S. Beaufort Sea, Colville River Delta, Alaska, during the 2014 open water season. N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Juneau, Alaska., editor.

NMFS. 2014b. Endangered Species Act section 7(a)(2) biological opinion on the issuance of an incidental harassment authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to

BP Exploration (Alaska), Inc. (BPXA) for shallow geohazard survey in the U.S. Beaufort Sea, Foggy Island Bay, Alaska, during the 2014 open water season. D. o. Commerce, editor. National Marine Fisheries Service, Alaska Region, National Oceanic and Atmospheric Administration, Juneau, Alaska.

NMFS. 2014c. ESA Sect 7 Biological Opinion on the Issuance of Incidental Harassment Authorization under Section 101(a)(5)(D) of the Marine Mammal Protection Act to BP Exploration (Alaska), Inc. (BPXA) for Marine 3D Ocean Bottom Sensor Seismic Activities in the U.S. Beaufort Sea, Prudhoe Bay, Alaska, during the 2014 Open Water Season. National Marine Fisheries Service, Alaska Regional Office, Juneau, AK.

NMFS. 2015a. Endangered Species Act section 7(a)(2) biological opinion on the issuance of incidental harassment authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell for the non-lethal taking of whales and seals in conjuction with planned exploration drilling activities during 2015 Chukchi Sea, Alaska. N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, editor., Juneau, Alaska.

NMFS. 2015b. Endangered Species Act section 7(a)(2) consultation biological opinion and section 7(a)(4) conference opinion on the issuance of incidental harassment authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell Gulf of Mexico and Shell Offshore Inc. (Shell) for aviation operations associated with ice condition monitoring over the Beaufort and Chukchi Seas from May 2015 through April 2016. N. O. a. A. A. Alaska Region, U.S. Department of Commerce, editor., Juneau, Alaska.

NMFS. 2016a. Effects of Oil and Gas Activities in the Arctic Ocean, Environmental Impact Statement. N. U.S. Dep. Commer., NMFS, editor., Silver Spring, MD.

NMFS. 2016b. Endangered Species Act Section 7(a)(2) Biological Opinion Quintillion Subsea Operations, LLC, Proposed Subsea Fiber Optic Cable-laying Activities and Associated Proposed Issuance of an Incidental Harassment Authorization in the Bering, Chukchi, and Beaufort Seas, Alaska. N. O. a. A. A. NMFS Alaska Region, editor., Juneau, Alaska.

NMFS. 2016c. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

NOAA National Centers for Environmental Information. 2016. State of the Climate: National Climate Report for Annual 2015. published online January 2016, retrieved on June 12, 2018 https://www.ncdc.noaa.gov/sotc/national/201513

NOAA National Centers for Environmental Information. 2017. State of the Climate: Global Climate Report for Annual 2017. published online January 2018, retrieved on June 12, 2018. https://www.ncdc.noaa.gov/sotc/global/201713

Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review **37**:81-115. http://dx.doi.org/10.1111/j.1365-2907.2007.00104.x

NRC. 2003. Ocean Noise and Marine Mammals. National Academy Press, Washington, D.C.

Nuka Research and Planning Group, L. 2016. Bering Sea vessel traffic risk analysis.

Office of Naval Research. 2018a. Biological Evaluation for Species Listed under the Endangered Species Act under National Marine Fisheries Jurisdiction Formal Consultation: Office of Naval Research Arctic Research Activities in the Beaufort Sea 2018-2012.

Office of Naval Research. 2018b. Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from Office of Naval Research Arctic Research Activities 2018-2019.85.

Ognev, S. I. 1935. Mammals of U.S.S.R. and adjacent countries. Carnivora. Glavpushnina NKVT, Moscow, Russia.

Oreskes, N. 2004. Beyond the ivory tower. The scientific consensus on climate change. Science **306**:1686. http://www.ncbi.nlm.nih.gov/pubmed/15576594

Outridge, P., R. Macdonald, F. Wang, G. Stern, and A. Dastoor. 2008. A mass balance inventory of mercury in the Arctic Ocean. Environmental Chemistry **5**:89-111.

Parks, S. E. 2003. Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. Marine Mammal Science **19**:563-580. https://doi.org/10.1111/j.1748-7692.2003.tb01321.x

Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research.

Pepper, C. B., M. A. Nascarella, and R. J. Kendall. 2003. A review of the effects of aircraft noise on wildlife and humans, current control mechanisms, and the need for further study. Environmental Management **32**:418-432.

Perry, E. A., D. J. Boness, and S. J. Insley. 2002. Effects of sonic booms on breeding gray seals and harbor seals on Sable Island, Canada. The Journal of the Acoustical Society of America **111**:599-609.

Plomp, R., and M. Bouman. 1959. Relation between hearing threshold and duration for tone pulses. The Journal of the Acoustical Society of America **31**:749-758.

Potelov, V. 1975. Reproduction of the bearded seal (*Erignathus barbatus*) in the Barents Sea. Rapp Pv Reun Cons Int Explor Mer **169**:554.

Poulter, T. C. 1968. Underwater vocalization and behavior of pinnipeds.*in* R. J. Harrison, R. C. Hubbard, R. S. Peterson, C. E. Rice, and R. J. Schusterman, editors. The Behavior and Physiology of Pinnipeds. Appleton-Century-Crofts, New York, NY.

Quakenbush, L. 2018. Notes for the Liberty Prospect review. Alaska Department of Fish and Game.

Quakenbush, L., J. Citta, and J. Crawford. 2011a. Biology of the bearded seal (*Erignathus barbatus*) in Alaska, 1961–2009. Final Report to: National Marine Fisheries Service.

Quakenbush, L., J. Citta, and J. Crawford. 2011b. Biology of the ringed seal (*Phoca hispida*) in Alaska, 1960–2010. Final Report to: National Marine Fisheries Service.

Quakenbush, L. T., R. J. Small, and J. J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. OCS Study BOEM 2013-01110, U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK.

Ray, C., W. A. Watkins, and J. J. Burns. 1969. The underwater song of *Erignathus barbatus* (bearded seal). Pages 79-83 Zoologica. New York Zoological Society, New York, NY.

Reeves, R., B. Stewart, and S. Leatherwood. 1992. Bearded seal, *Erignathus barbatus* Erxleben, 1777. The Sierra Club Handbook of Seals and Sirenians. Sierra Club Books, San Francisco, CA:180-187.

Reeves, R. R. 1998. Distribution, abundance and biology of ringed seals (*Phoca hispida*): an overview. NAMMCO Scientific Publications **1**:9-45.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Society for Marine Mammology, Lawrence, Kansas.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, Inc., San Diego, CA.

Richter-Menge, J., J. E. Overland, J. T. Mathis, E. Osborne, and Eds.;. 2017. Arctic Report Card 2017, http://www.arctic.noaa.gov/Report-Card.

Ridgway, S. H., D. A. Carter, R. R. Smith, T. Kamolnick, and C. E. Schlundt. 1997. Behavioral Responses and Temporary Shift in Masked Hearing Threshold of Bottlenose Dolphins, *Tursiops truncatus*, to 1-second Tones of 141 to 201 dB re 1 Micron Pa. Naval Command Control and Ocean Surveillance Center, RDT and E DIV, San Diego, CA.

Risch, D., C. W. Clark, P. J. Corkeron, A. Elepfandt, K. M. Kovacs, C. Lydersen, I. Stirling, and S. M. Van Parijs. 2007. Vocalizations of male bearded seals, *Erignathus barbatus*: classification and geographical variation. Animal Behaviour **73**:747-762.

Romano, T., M. Keogh, C. Kelly, P. Feng, L. Berk, C. Schlundt, D. Carder, and J. Finneran. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences **61**:1124-1134.

Romero, L. M., C. J. Meister, N. E. Cyr, G. Kenagy, and J. C. Wingfield. 2008. Seasonal glucocorticoid responses to capture in wild free-living mammals. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology **294**:R614-R622.

Roth, E. H., J. A. Hildebrand, S. M. Wiggins, and D. Ross. 2012. Underwater ambient noise on the Chukchi Sea continental slope from 2006–2009. The Journal of the Acoustical Society of America **131**:104-110.

Roth, E. H., V. Schmidt, J. A. Hildebrand, and S. M. Wiggins. 2013. Underwater radiated noise levels of a research icebreaker in the central Arctic Ocean. The Journal of the Acoustical Society of America **133**:1971-1980.

Ryg, M., T. G. Smith, and N. A. Øritsland. 1990. Seasonal changes in body mass and body composition of ringed seals (*Phoca hispida*) on Svalbard. Canadian Journal of Zoology **68**:470-475.

Scheffer, V. B. 1958. Seals, sea lions, and walruses: a review of the Pinnipedia. Stanford University Press.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. The Journal of the Acoustical Society of America **107**:3496-3508.

Serreze, M. C., and R. G. Barry. 2011. Processes and impacts of Arctic amplification: a research synthesis. Global and Planetary Change **77**:85-96.

Sills, J. M., B. L. Southall, and C. Reichmuth. 2015. Amphibious hearing in ringed seals (*Pusa hispida*): underwater audiograms, aerial audiograms and critical ratio measurements. Journal of Experimental Biology:jeb. 120972.

Simmonds, M. P., and J. D. Hutchinson. 1996. The conservation of whales and dolphins. John Wiley and Sons, Chichester, U.K.

Simpkins, M. A., L. M. Hiruki-Raring, G. Sheffield, J. M. Grebmeier, and J. L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. Polar Biology **26**:577-586.

Smiley, B. D., and A. R. Milne. 1979. LNG transport in Parry Channel: possible environmental hazards.

Smith, T. G. 1976. Predation of ringed seal pups (*Phoca hispida*) by the arctic fox (*Alopex lagopus*). Canadian Journal of Zoology **54**:1610-1616.

Smith, T. G., and M. O. Hammill. 1981. Ecology of the ringed seal, *Phoca hispida*, in its fast ice breeding habitat. Canadian Journal of Zoology **59**:966-981.

Smith, T. G., and C. Lydersen. 1991. Availability of suitable land-fast ice and predation as factors limiting ringed seal populations, *Phoca hispida*, in Svalbard. Polar research **10**:585-594.

Smith, T. G., and I. Stirling. 1975. The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures. Canadian Journal of Zoology **53**:1297-1305.

Snyder-Conn, E., J. R. Garbarino, G. L. Hoffman, and A. Oelkers. 1997. Soluble trace elements and total mercury in Arctic Alaskan snow. Arctic:201-215.

Southall, B., J. Berkson, D. Bowen, R. Brake, J. Eckman, J. Field, R. Gisiner, S. Gregerson, W. Lang, and J. Lewandowski. 2009. Addressing the effects of human-generated sound on marine life: an integrated research plan for US federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology, Washington, DC 72pp.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals **33**:411-521.

Spraker, T. R., L. F. Lowry, and K. J. Frost. 1994. Gross necropsy and histopathological lesions found in harbor seals. Pages 281-311 Marine mammals and the Exxon Valdez. Elsevier.

St Aubin, D. J. 1990. Physiologic and toxic effects on pinnipeds. Pages 103-127 Sea Mammals and Oil: Confronting the Risks. Elsevier.

St. Aubin, D., S. H. Ridgway, R. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: circulating levels in wild and semidomesticated *Tursiops truncatus*, and influence of sex, age, and season. Marine Mammal Science **12**:1-13.

Stearns, S. C. 1977. The evolution of life history traits: A critique of the theory and a review of the data. Annual Review of Ecology and Systematics **8**:145-171.

Stearns, S. C. 1992. The Evolution of Life Histories. Oxford Press, Oxford. 249.

Sternfeld, M. 2004. Ice Seals in the National Marine Fisheries Service Alaska Region (NMFS AKR) Stranding Records: 1982-2004. USDOC, NOAA, NMFS Alaska Region, Juneau, Alaska.

Sternfield, M. 2004. Ice Seals in the National Marine Fisheries Service Alaska Region (NMFS AKR) Stranding Records: 1982-2004. USDOC, NOAA, NMFS Alaska Region, Juneau, Alaska.

Stirling, I. 1983. The evolution of mating systems in pinnipeds. Advances in the study of mammalian behavior **7**:489-527.

Stirling, I. 1997. The importance of polynyas, ice edges, and leads to marine mammals and birds. Journal of Marine Systems **10**:9-21.

Teilmann, J., E. W. Born, and M. Acquarone. 2000. Behaviour of ringed seals tagged with satellite transmitters in the North Water polynya during fast-ice formation. Canadian Journal of Zoology **77**:1934-1946.

Terhune, J. 1988. Detection thresholds of a harbour seal to repeated underwater high-frequency, short-duration sinusoidal pulses. Canadian Journal of Zoology **66**:1578-1582.

Terhune, J. M. 1999. Pitch separation as a possible jamming-avoidance mechanism in underwater calls of bearded seals (*Erignathus barbatus*). Canadian Journal of Zoology **77**:1025-1034.

Thomas, J. A., R. A. Kastelein, and F. T. Awbrey. 1990. Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. Zoo Biology **9**:393-402.

Thomson, D. H., and W. Richardson. 1995. Marine mammal sounds. WJ Richardson, CRG Jr., CI Malme, and DH Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego:159-204.

Tynan, C. T., and D. P. DeMaster. 1997. Observations and predictions of Arctic climatic change: potential effects on marine mammals. Arctic:308-322.

U.S. Department of Commerce and National Oceanic and Atmospheric Administration. 2015. Aircraft: DeHavilland Twin Otter (DHC-6). http://www.omao.noaa.gov/learn/aircraft-operationsaircraft_otter.htm

University of Alaska Fairbanks. 2014. Sikuliaq Specifications: R/V Sikuliaq Characteristics. https://www.sikuliaq.alaska.edu/ops/?q=node/19

Urick, R. J. 1983. Principles of Underwater Sound. McGraw-Hill.

USCG. 2007. National concept of operations for maritime domain awareness. Retrieved July **11**:2010.

USCG. 2011. Marine Protected Species Program for the Gulf of Alaska, Bering Sea/Aleutian Islands, and Arctic. D. o. H. Security, editor.

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 Vocalising Maile 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.

Vanderlaan, A. S. M., and C. T. Taggart. 2007. Vessel collisions with whales: the probablity of lethal injury based on vessel speed. Marine Mammal Science **23**:144-156.

Wang, M., and J. E. Overland. 2012. A sea ice free summer Arctic within 30 years: An update from CMIP5 models. Geophysical Research Letters **39**.

Ward, W. D. 2007. Effects of High-Intensity Sound. Encyclopedia of Acoustics, Volume Three:1497-1507.

Wartzok, D., R. Elsner, H. Stone, B. P. Kelly, and R. W. Davis. 1992. Under-ice movements and the sensory basis of hole finding by ringed and Weddell seals. Canadian Journal of Zoology **70**:1712-1722.

Wartzok, D., A. N. Popper, J. Gordon, and J. Merrill. 2003. Factors Affecting the Responses of Marine Mammals to Acoustic Disturbance. Marine Technology Society Journal **37**:6-15. https://doi.org/10.4031/002533203787537041

Watanabe, Y., C. Lydersen, K. Sato, Y. Naito, N. Miyazaki, and K. M. Kovacs. 2009. Diving behavior and swimming style of nursing bearded seal pups. Marine Ecology Progress Series **380**:287-294.

Wathne, J., T. Haug, and C. Lydersen. 2000. Prey preference and niche overlap of ringed seals *Phoca hispida* and harp seals *P. groenlandica* in the Barents Sea. Marine Ecology Progress Series:233-239.

Watson, R. T., and D. L. Albritton. 2001. Climate change 2001: Synthesis report: Third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Wieting, D. 2016. Interim Guidance on the Endangered Species Act Term "Harass". National Marine Fisheries Service, Office of Protected Resources. Silver Spring, MD. October 21, 2016.

Wilson, S. C., I. Trukhanova, L. Dmitrieva, E. Dolgova, I. Crawford, M. Baimukanov, T. Baimukanov, B. Ismagambetov, M. Pazylbekov, and M. Jüssi. 2017. Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. Biological Conservation **214**:213-222.

Wollebaeck, A. 1927. The Mammals of Norway, Oslo, Norway.

Yochem, P. K., and B. S. Stewart. 2009. Hair and fur. Pages 529-530 Encyclopedia of Marine Mammals (Second Edition). Elsevier.