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 (ESA) Section 7(a)(2) Biological Opinion
Office of Naval Research (ONR) Arctic Activities

NMFS Consultation Number: AKRO-2022-01871

Action Agencies: U.S. Navy ONR and Office of Protected Resources, Permits and Conservation Division

Affected Species and Determinations:

ESA-Listed Species and Distinct Population Segments (DPS) or Evolutionarily Significant Units (ESU)	Status	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Bowhead whale (*Balaena mysticetus*)	Endangered	No	N/A	No	N/A
Fin whale (*Balaenoptera physalus*)	Endangered	No	N/A	No	N/A
Blue whale (*Balaenoptera musculus*)	Endangered	No	N/A	No	N/A
Sei whale (*Balaenoptera borealis*)	Endangered	No	N/A	No	N/A
North Pacific right whale (*Eubalaena japonica*)	Endangered	No	No	No	No
Gray whale, Western North Pacific DPS (*Eschrichtius robustus*)	Endangered	No	N/A	No	N/A
Sperm whale (*Physeter macrocephalus*)	Endangered	No	N/A	No	N/A
Humpback whale, Western North Pacific DPS (*Megaptera novaeangliae*)	Endangered	No	No	No	No
Humpback whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	No	No	No	No
Ringed seal, Arctic subspecies (*Phoca hispida hispida*)	Threatened	Yes	No	No	No

ESA-Listed Species and Distinct Population Segments (DPS) or Evolutionarily Significant Units (ESU)	Status	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Bearded seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	No	No	No	No
Steller sea lion, Western DPS (*Eumetopias jubatus*)	Endangered	No	No	No	No

Consultation Conducted By: National Marine Fisheries Service, Alaska Region (AKR)

Issued By:

Jonathan M. Kurland
Administrator, Alaska Region

Date: September 13, 2022

Accessibility of this Document

Every effort has been made to make this document accessible to individuals of all abilities and compliant with Section 508 of the Rehabilitation Act. The complexity of this document may make access difficult for some. If you encounter information that you cannot access or use, please email us at Alaska.webmaster@noaa.gov or call us at 907-586-7228 so that we may assist you.

Table of Contents

List of Tables

List of Figures

Terms and Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
AIS	Automatic Identification System
AKR	(NMFS) Alaska Regional Office
ASAMM	Aerial Surveys of Arctic Marine Mammals
BA	Biological Assessment
BSAI	Bering Sea/Aleutian Islands
CFR	Code of Federal Regulations
CO_2	Carbon dioxide
CV	Coefficient of variation
CWA	Clean Water Act of 1972
dB re 1µPa	Decibel referenced 1 microPascal
dB	Decibel
DPS	Distinct Population Segment
EEZ	(U.S.) Exclusive Economic Zone
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESCA	Endangered Species Conservation Act
°F	Fahrenheit
FR	Federal Register
ft	Feet
GOA	Gulf of Alaska
GPS	Global Positioning System
HF	High-frequency (cetacean hearing group)
hr	Hour(s)
Hz	Hertz
IHA	Incidental Harassment Authorization
IPCC	Intergovernmental Panel on Climate Change
ITS	Incidental Take Statement
IWC	International Whaling Commission
kHz	kiloHertz
km	kilometer

kn	Knots
L_E	Cumulative sound exposure at reference value of 1μPa^{2}s
L_{pk}	Peak sound pressure at 1 μPa
LF	Low frequency (cetacean hearing group)
μPa	Micro Pascal
m	meter
MF	Mid-frequency (cetacean hearing group)
mi	mile
MLLW	Mean lower low water
MMPA	Marine Mammal Protection Act
mph	Miles per hour
nm	Nautical mile
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OW	Otariid pinniped underwater (hearing group)
PBF	Physical or Biological Feature
PCB	polychlorinated biphenyls
PCE	Primary Constituent Element
PK	Peak sound level
PSO	Protected Species Observer
PTS	Permanent threshold shift
PW	Phocid pinniped underwater (hearing group)
rms	Root mean square
RPA	Reasonable and prudent alternative
SD	Standard deviation
SEL	Sound exposure level
SPL	Sound pressure level
SSV	Sound source verification
TTS	Temporary threshold shift
UME	Unusual Mortality Event
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service
UUV	Unmanned underwater vehicle

1 Introduction

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. §1536(a)(2)) requires each Federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action "may affect" a protected species, 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 agency's action 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, specifies those reasonable and prudent measures necessary or appropriate to minimize such impact, and sets forth terms and conditions to implement those measures.

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 (87 FR 44339). When issued, the IHA will be valid from mid-September 2022 through mid-September 2023 and will authorize the incidental harassment of the threatened Arctic ringed seal. The consulting agency for this proposal is NMFS Alaska Region. This opinion represents NMFS's biological opinion on the effects of this proposal on endangered and threatened species and designated critical habitat that might be affected by the proposed action.

On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019 regulations adopting changes to 50 CFR part 402 (84 FR 44976, August 27, 2019). This consultation was initiated when the 2019 regulations were still in effect. As reflected in this document, we are now applying the section 7 regulations that governed prior to adoption of the 2019 regulations. For purposes of this consultation, we considered whether the substantive analysis and its conclusions regarding the effects of the proposed actions articulated in the biological opinion and incidental take statement would be any different under the 2019 regulations. We have determined that our analysis and conclusions would not be any different.

The opinion and ITS were prepared by NMFS Alaska Region in accordance with section 7(b) of the ESA (16 U.S.C. §1536(b)) and implementing regulations at 50 CFR part 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 is based on information provided in the IHA application (ONR 2022), the proposed IHA (87 FR 44339), the 2022 Biological Evaluation that covers ONR's Arctic Research Activities from 2022-2025, and the draft Overseas Environmental Assessment for ONR's Arctic Research Activities. Other sources of information include emails, recent biological opinions completed in the same region, and Arctic marine mammal surveys. A complete record of the consultation is on file at NMFS's Anchorage, Alaska office.

The proposed IHA for this project would cover the fifth year of a larger project for which ONR obtained prior IHAs (83 FR 48799, September 27, 2018; 84 FR 50007, September 24, 2019; 85 FR 53333, August 28, 2020; 86 FR 54931, October 5, 2021) (Figure 1). The IHA would be valid for a period of one year from the date of issuance (mid-September 2022 to mid-September 2023). The larger project involves several scientific objectives that support ONR's Arctic and Global Prediction Program, as well as the Arctic Mobile Observing System (AMOS). ONR has complied with the requirements (e.g., mitigation, monitoring, and reporting) of the previous IHAs and biological opinions.

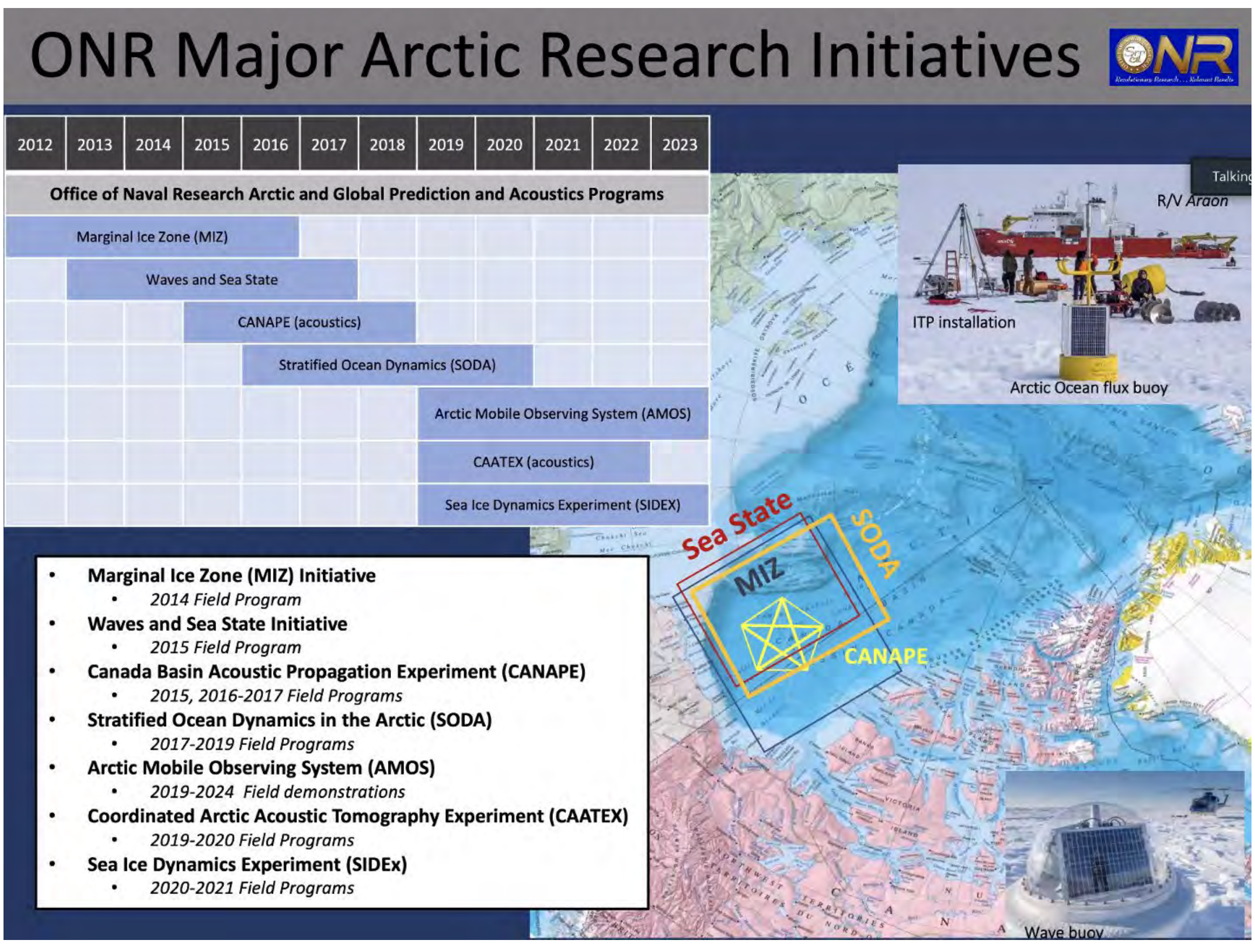

Figure 1. ONR's Arctic initiatives (graphic courtesy of Craig M. Lee, University of Washington)

The consulting agency for this proposal is NMFS's Alaska Region (AKR). AKR completed a biological opinion in 2018 (AKR-2018-9725) for the overarching research activities that were to be conducted from 2018-2021. In that consultation we acknowledged that ONR research activities might continue after 2021, but that the nature of the platforms and the locations of future deployments were unknown, and that such future activities would be covered under future environmental planning documents. Modifications to research activities were submitted by ONR in 2019 and we completed another biological opinion (AKRO-2019-00688), to cover those modifications and the time frame from 2019-2021. This opinion considers the effects of activities associated with ONR's proposed Arctic Research Activities (ARA), from mid-September 2022 to mid-September 2023 and the associated proposed issuance of an IHA for these activities. We expect that similar research activities with similar acoustic effects will continue until at least 2025 (Navy 2022) as the Navy monitors and tracks changes in ice, currents, and temperature in the Arctic Ocean.

The research vessel (R/V) Sikuliaq will be used in the September 2022 cruise and most likely the Coast Guard Cutter (CGC) Healy would be used in September 2023. The vessels will be used to deploy and retrieve moored, drifting, and ice-tethered active acoustic sources. The R/V Sikuliaq will deploy from Nome, Alaska and travel across the northeastern portion of the Bering Sea, across the southeastern portion of the Chukchi Sea, and into the Beaufort Sea. The CGC Healy would likely leave from Seward, Alaska. Although ice breaking operations are not expected, they are considered in this opinion. The ARA will take place primarily in the Beaufort Sea where the active acoustic sources will be deployed (Figure 2). However, we also consider the effects of vessel transit through habitat occupied by listed marine mammals. Consequently, these actions have the potential to affect the endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered blue whale (*Balaenoptera musculus*), endangered sei whale (*Balaenoptera borealis*), endangered North Pacific right whale (*Eubalaena japonica*), endangered Western North Pacific distinct population segment (DPS) gray whales (*Eschrichtius robustus*), endangered sperm whale (*Physeter macrocephalus*), endangered Western North Pacific DPS humpback whale (*Megaptera novaeangliae*), threatened Mexico DPS humpback whale (*Megaptera novaeangliae*), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), threatened Beringia DPS bearded seal (*Erignathus barbatus nauticus*), endangered Western DPS Steller sea lion (*Eumetopias jubatus*), and critical habitat for North Pacific right whale, Western North Pacific and Mexico DPS's of humpback whales, ringed seal, bearded seal, and Steller sea lion.

1.2 Consultation History

- March 21, 2022. The Permits Division received IHA application from ONR.
- April 18, 2022. The IHA application was forwarded to AKR
- June 7, 2022. Early Review Team (ERT), with participants from the Permits Division and AKR, met to discuss the project.
- June 14, 2022. Questions developed from ERT meeting were sent to ONR.
- June 28, 2022. Responses to questions received from ONR.
- June 29, 2022. Draft Overseas Environmental Assessment received.

- July 21, 2022. Request for consultation, revised IHA application, and draft IHA received from the Permits Division.
- July 22, 2022. Updated version of draft Overseas Environmental Assessment received.
- July 22 -27. Email communication with ONR about ship speed and observers.
- July 26, 2022. Proposed IHA published in Federal Register
- July 27, 2022. Consultation initiated

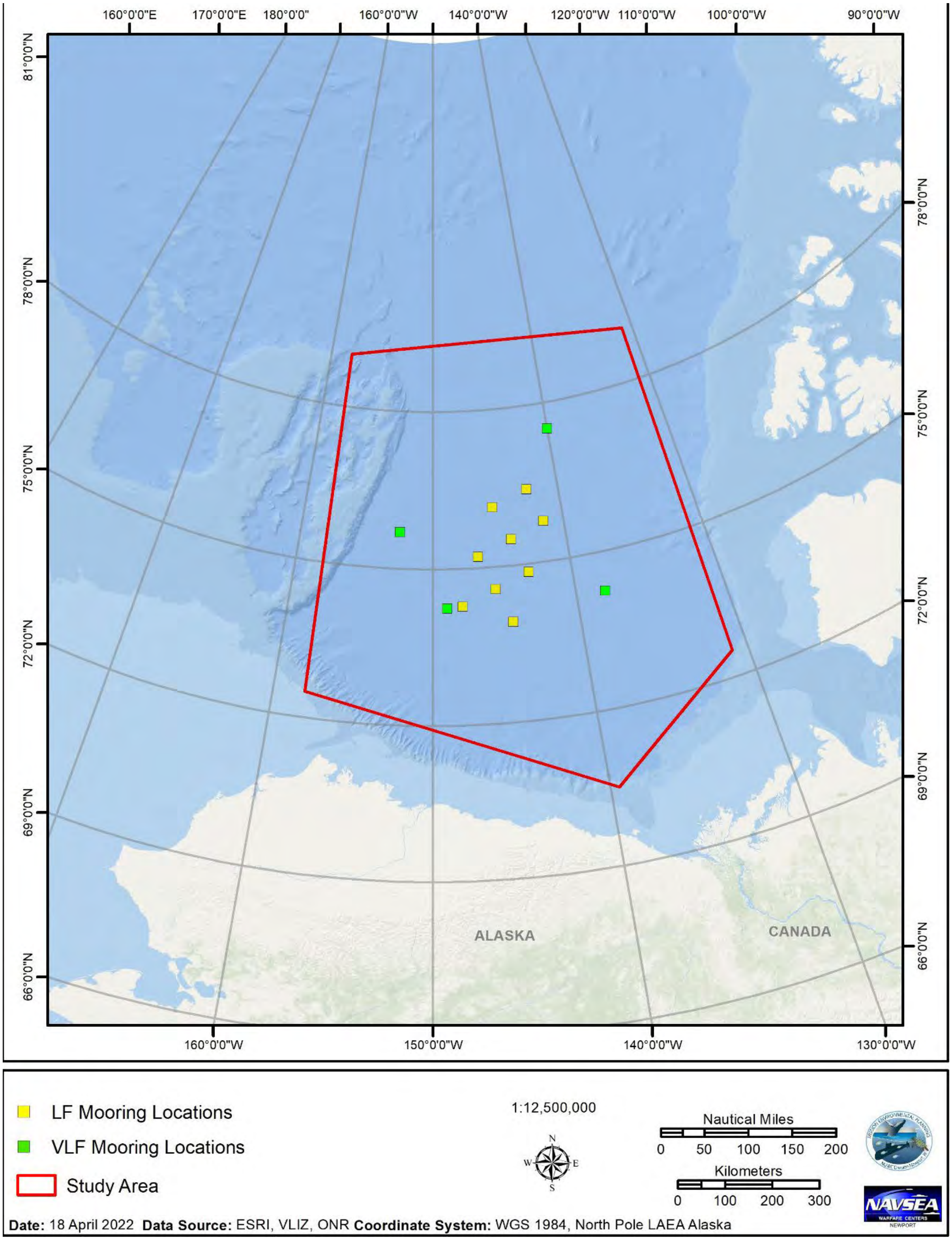

Figure 2. Study area for the Office of Naval Research's Arctic Research Activities showing low frequency (LF) and very low frequency (VLF) mooring locations.

2 Description of the Proposed Action and Action Area

2.1 Proposed Action

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas (50 CFR 402.02).

The Proposed Action includes multiple scientific objectives that support ONR’s Arctic and Global Prediction Program. The Proposed Action constitutes the continued development of a system under the ONR Arctic Mobile Observing System (AMOS) involving very low, low, and mid frequency transmissions (35 Hertz [Hz], 900 Hz, and 10 kilohertz [kHz] respectively). The AMOS project would utilize acoustic sources and receivers to provide a means of performing under-ice navigation for gliders and unmanned undersea vehicles (UUVs) (Figure 3).

This would allow for the possibility of year-round scientific observations of Arctic environmental conditions. As an environment particularly affected by climate change, year-round observations under a variety of ice conditions are required to study the effects of this changing environment for military readiness, as well as the implications of environmental change to humans and animals. Very low-frequency technology is an important method of observing ocean warming, and the continued development of these types of acoustic sources would allow for characterization of larger areas. The technology also has the potential to allow for development and use of navigational systems that would not be heard by some marine species, and therefore would be less impactful overall.

The proposed action will also include vessel transit of the R/V Sikuliaq to and from Nome, Alaska. Although it is uncertain if a cruise will be made in the summer or next fall utilizing the CGC Healy, we also consider the effects of that vessel and ice breaking in case it is used.

2.1.1 Proposed Activities

The research activities involve both research vessels and the deployment of a variety of devices described below.

2.21.1 Research Vessels

The R/V Sikuliaq is the ship that will be used in September 2022. Acoustic sources will be tested during the cruise, and sources for a year-round, underwater navigation system will be left behind. The ship to be used in September 2023 is yet to be determined but the most probable option would be the CGC Healy and that ship and its transit route will also be described.

The R/V Sikuliaq has a maximum speed of approximately 12 knots with a cruising speed of 11 knots (https://en.wikipedia.org/wiki/RV_Sikuliaq). The R/V Sikuliaq is not an ice breaking ship, but an ice strengthened ship. It would depart and return to Nome, Alaska. More information about the ship can be found here: (https://www.uaf.edu/cfos/sikuliaq/about-rv-sikuliaq.php).

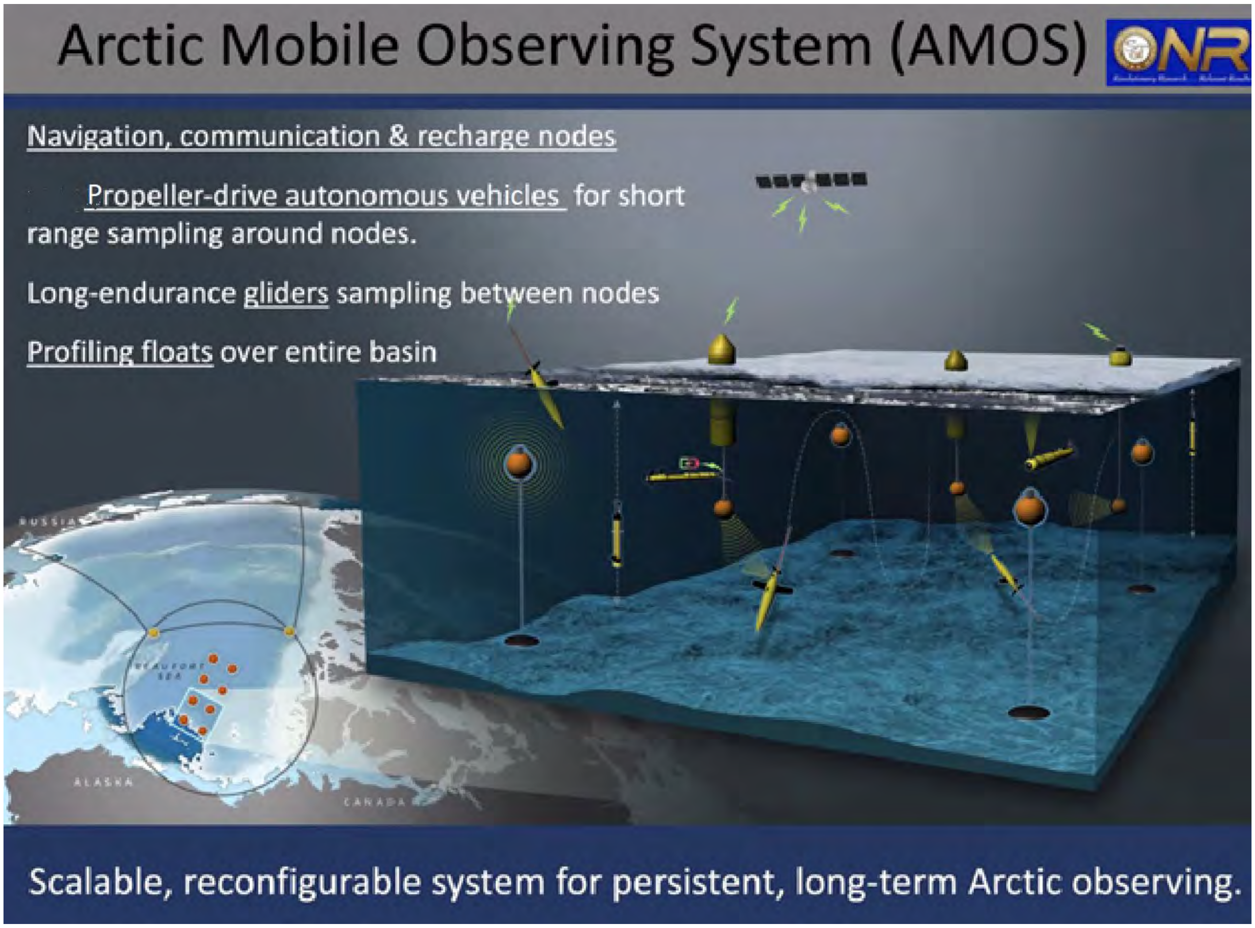

Figure 3. Devices used in the AMOS project. (graphic courtesy of Craig M. Lee, University of Washington)

CGC Healy travels at a maximum speed of 17 knots with a cruising speed of 12 knots and a maximum speed of 3 knots when traveling through 3.5 feet (ft; 1.07 meters [m]) of sea ice. While it is not known with certainty whether the Healy will be used, in their IHA application ONR included up to 8 days of icebreaking activities. For each icebreaking day, the Navy modeled 1 hour of icebreaking and 3 hours off for a total of 6 hours of icebreaking per day to reflect the likely icebreaking scenario. CGC Healy can break ice up to 8 ft (2.4 m) thick while backing and ramming (Roth et al. 2013). Icebreaking will only occur in deep water, off the continental shelf while transiting to and servicing the moorings (Figure 2). While in transit in open water we expect the sound source level will be around 180 dB re 1 µPa at 1 m depending on vessel speed (Roth et al. 2013). More information about the ship can be found here: https://www.pacificarea.uscg.mil/Our-Organization/Area-Cutters/CGC-Healy/Ship/.

The R/V Sikuliaq, CGC Healey, or any other vessel operating a research cruise associated with the proposed action may perform the following activities during their research cruises:

- 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;

- Deployment of unmanned underwater vehicles;
- Deployment of drifting boys, with or without acoustic sources;
- Recovery of equipment.

2.1.1.2 Glider surveys

Long-endurance, autonomous seagliders (Figure 4, Figure 5) are intended for extended missions in ice-covered waters. Gliders are buoyancy-driven, equipped with satellite modems providing two-way communication, and are capable of transiting to depths of up to 1,000 m. Gliders would collect data in the area of the moored sources, moving at a speed of 0.25 meters per second (m/s; 23 km/day). A combination of recent advances in seaglider technology enables full-year endurance. 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. Gliders measure temperature, salinity, dissolved oxygen, and other physical characteristics of the water related to temperature.

Up to six gliders would be deployed during the research cruise, though unlikely all at once; up to half would overwinter in the Study Area. All gliders would be recovered; some may be recovered by the R/V Sikuliaq during the cruise, but the remainder would be recovered during the September 2023 cruise. One REMUS 600 UUV would be used for engineering tests during the September 2022 cruise.

The REMUS 600 is a 12-inch diameter autonomous vehicle that has a depth capability of 600 m. The vehicle is approximately 14 ft (4.3 m) long and weighs 240 kg (530 lbs) in air. It can travel at a speed up to 5 knots. The vehicle is equipped with communications equipment including Iridium and Wi-Fi for above water, and multiple acoustic systems for communications while submerged. Emergency systems include a strobe and backup battery for extended tracking while drifting on the surface. Sensors installed in this vehicle include conductivity, temperature and depth, plus a five-beam Nortek Signature sonar that can be configured in an upward or downward orientation. The vehicle is powered by rechargeable lithium-ion batteries. One device will be deployed and retrieved before the research vessel leaves the action area.

Figure 4. Sea gliders.

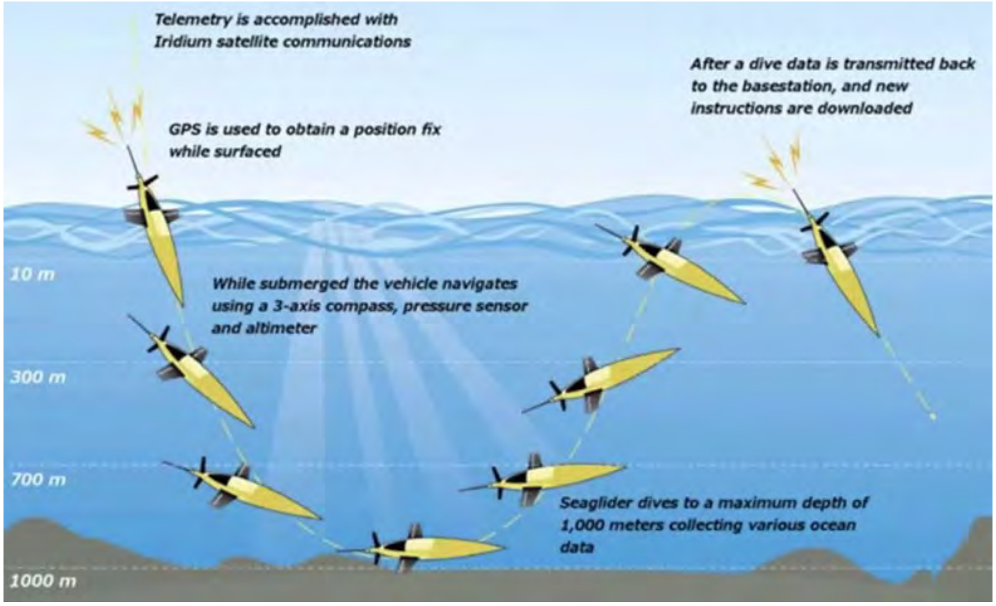

Figure 5. Sea glider operations

2.1.1.3 Active Acoustic Sources

Active acoustic sources would be lowered from a cruise vessel, deployed on gliders and UUVs, or deployed on fixed moorings. During the September 2022 and subsequent cruises, acoustic sources could be deployed from the ship for intermittent testing of the system components. The total amount of active source testing for ship-deployed sources used during a cruise would be 120 hours. The testing would take place in the vicinity of the source locations in Figure 2, with UUVs running tracks within the red polygon. During this testing, 35 Hz, 900 Hz and 10 kHz sources would be employed.

Up to seven fixed acoustic navigation sources, transmitting at 900 Hz, would remain in place for a year. These moorings would be anchored on the seabed and held in the water column with subsurface buoys. Moored sensors would measure 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. Ice velocity and surface waves would be measured by 500 kHz multibeam sonars from Nortek Signatures. Moored sources would be deployed by shipboard winches, which would lower sources and receivers in a controlled manner. Anchors would be steel “wagon wheels” typically used for this type of deployment. Up to two very low frequency (VLF) sources, transmitting at 35 Hz, would be deployed in a similar manner. These sources would be deployed in two of the three VLF source positions in Figure 2. Two drifting Ice Gateway Buoys (IGB) would also be configured with active acoustic sources at 900 Hz and 10 kHz.

Autonomous vehicles would be able to navigate by receiving acoustic signals from multiple locations and triangulation. This is needed for vehicles that are under ice and cannot communicate with satellites. Source transmits would be offset by 15 minutes from each other (i.e. sources would not be transmitting at the same time). All navigation sources would be recovered. The purpose of the navigation sources is to orient UUVs and gliders in situations when they are under ice and cannot communicate with satellites. Acoustic parameters for active acoustic sources are described in Table 1.

Table 1. Characteristics of the modeled acoustic sources for the proposed action

Platform (total number deployed)	**Acoustic Source**	**Purpose/Function**	**Frequency (tones or BB)**	**Signal Strength (dB re1uPa @1 m)**	**Bandwidth**	**Pulse Width/Duty Cycle**
REMUS 600 UUV (1)	WHOI Micro-modem	Acoustic communications	900-950 Hz	NTE 180 dB by sys design limits	50 Hz	5 pings/hour with 30 sec pulse length.
	UUV/WHOI Micro- modem	Acoustic communications	8-14 kHz	NTE 185 dB by sys design limits	5 kHz	10% average duty cycle, with 4 sec pulse length
IGB (drifting) (2)	WHOI Micro-modem	Acoustic communications	900-950 Hz	NTE 180 dB by sys design limits	50 Hz	Transmit every 4 hours, 30 sec pulse length
	WHOI Micro-modem	Acoustic communications	8-14 kHz	NTE 185 dB by sys design limits	5 kHz	Typically receive only. Transmit is very intermittent.
Mooring (9)	WHOI Micro-modem (7)	Acoustic Navigation	900-950 Hz	NTE 180 dB by sys design limits	50 Hz	Transmit every 4 hours, 30 sec pulse length
	VLF (2)	Acoustic Navigation	35 Hz	NTE 190 dB	6 Hz	Up to 4 times per day, 10 minutes each.

Note: dB re 1 µPa at 1 m= decibels referenced to 1 micropascal at 1 meter; Hz= Hertz; IGB= Ice Gateway Buoy; kHz= kilohertz; NTE= not to exceed; VLF= very low frequency; WHOI= Woods Hole Oceanographic Institution. The VLF is below the hearing range of ringed seals.

2.1.1.4 *De minimis* sources

De minimis sources have the following parameters: low source levels, narrow beams, downward directed transmission, short pulse lengths, frequencies above (outside) known marine mammal hearing ranges, or some combination of these factors (Navy 2013). Additionally, any sources 200 kHz or above in frequency and 160 decibels (dB) or below in source level are automatically considered *de minimis*. Sources 200 kHz or above are considered outside of marine mammal hearing ranges. Assuming spherical spreading for a 160 dB re 1 µPa source, the sound will attenuate to less than 140 dB within 32 ft (10 m) and less than 120 dB within 328 ft (100 m) of the source. Ranges would be even shorter for a source less than 160 dB re 1 µPa source level. In addition to attenuating in a short distance, the beam is narrow and directed downward, 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), and sounds with a very low duty cycle are less likely to elicit responses from marine mammals than the equivalent sounds with high duty cycles. All of the sources described in this section are considered de minimis by ONR, the Permits Division, and AKR (Table 2).

The following are the planned *de minimis* sources which would be used during the Proposed Action: 1) Woods Hole Oceanographic Institution (WHOI) micromodem, 2) Acoustic Doppler Current Profilers (ADCPs) and 3) ice profilers. ADCPs may be used on moorings. Ice-profilers measure ice properties and roughness. The ADCPs and ice-profilers (150 and 200 kHz) use frequencies above the hearing range of ringed seals. The 75 kHz ADCP which has the characteristics and *de minimis* justification listed in Table 2. The 75 kHz ADCP may be employed on moorings or UUVs.

A WHOI micromodem (see Table 1) will be employed throughout the proposed action. When it is employed during the leave behind period it is used for very intermittent communication with vehicles to communicate vehicle status for safety of navigation purposes. In other words, it acts as an on-off switch for the moored systems (activating only 5 times). Because of the very short interval of usage it is considered *de minimis* for this usage.

Table 2. Parameters for *de minimis* non-impulsive sources, 2022.

Source Name	Frequency Range (kHz)	Sound Pressure Level (dB re 1 µPa at 1 m)	Pulse Length (seconds)	Duty Cycle (Percent)	De minimis Justification
ADCP	>200, 150, or 75	190	<0.001	<0.1	Very low pulse length, narrow beam, moderate source level
Nortek Signature 500 kHz Doppler Velocity Log	500	214	<0.1	<13	Very high frequency
CTD Attached Echosounder	5-20	160	0.004	2	Very low source level

2.1.1.5 Drifting Oceanographic Sensors

Observations of ocean-ice interactions require the use of sensors that are moored and embedded in the ice. For the proposed action, it will not be required to break ice to do this, as deployments can be performed in areas of low ice-coverage or free floating ice. Sensors are deployed within a few dozen meters of each other on the same ice floe. Three types of sensors would be used: autonomous ocean flux buoys, Integrated Autonomous Drifters, and ice tethered profilers. The autonomous ocean flux buoys (Figure 6) measure oceanographic properties just below the ocean-ice interface. The autonomous ocean flux buoys would 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 have a 200 m long string of thermistors that measure temperature at discrete points along its length. Part of the string is frozen into the sea ice, the rest extends into the ocean below. Differences in temperature are used to infer the properties of sea ice and to distinguish ice from water. The ice tethered profilers would collect information on ocean temperature, salinity and velocity down to 1,600 - 2625 ft (500 - 800 m) depth.

Up to 20 Argo-type autonomous profiling floats may be deployed in the central Beaufort Sea. Argo floats drift at 4,921 ft (1,500 m) depth, profiling from 6,562 ft (2,000 m) to the sea surface once every 10 days to collect profiles of temperature and salinity.

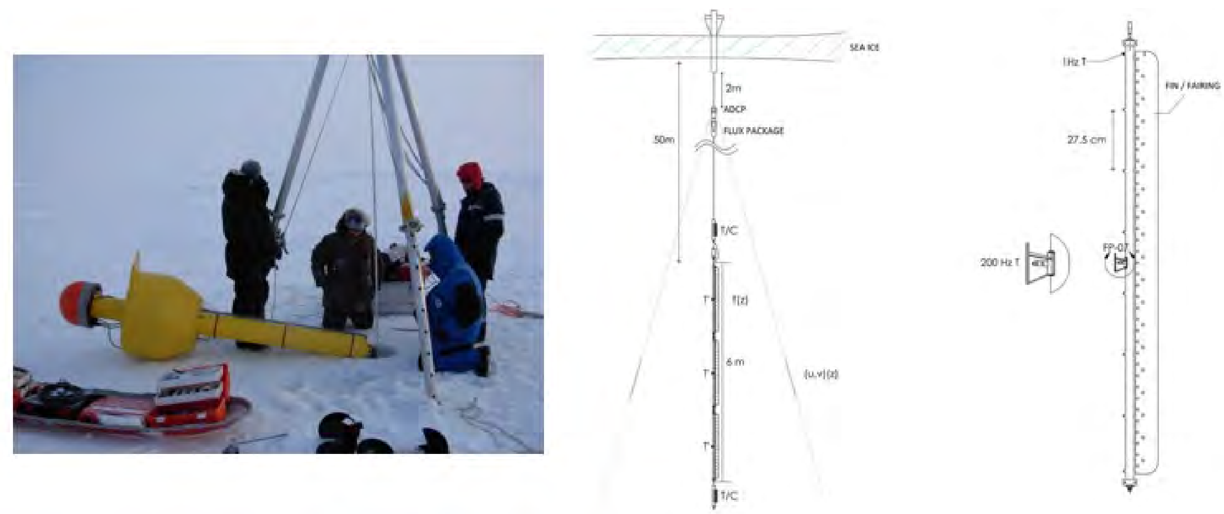

Figure 6. Autonomous Ocean Flux Buoy deployment, with schematic depicting system components.

2.1.1.6 On-ice Measurement Systems

On-ice measurement systems would be used to collect weather data. These would include an Autonomous Weather Station and an Ice Mass Balance Buoy. The Autonomous Weather Station would be deployed on a tripod; the tripod has insulated foot platforms that are frozen into the ice. The system would 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 2 in (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 altimeter and snow depth sensor. Autonomous Weather Stations and Ice Mass Balance Buoys will be deployed, 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 destroyed they cannot be recovered and will sink to the seafloor as their host ice floes melt.

2.2 Standard Operating Procedures and Mitigation Measures

While in transit the CGC Healy and R/V Sikuliaq will follow the U.S. Coast Guard's Standard Operating Procedures for operating in Alaska (see pgs. 5-6, USCG (2011)). Once at the study area (Figure 2), ONR will follow both the USCG standard operating procedures and this proposed project's mitigation measures. 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). In addition, the Coast Guard has promulgated written avoidance measures designed to avoid take of marine mammals; the negligent or intentional disregard of which would place the Commanding Officer of a Coast Guard vessel in jeopardy of disciplinary action or even criminal prosecution under the Uniform Code of Military Justice (USCG 2017). Watch personnel are trained 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 observed marine mammals that have the potential to be in the path of the ship as a standard collision avoidance procedure.

Mitigation Measures

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

1. All ships operated by or for the Navy must have personnel assigned to stand watch at all times while underway. Watch personnel must employ visual search techniques using binoculars. While underway using active acoustic sources at least one person with access to binoculars is required to be on watch at all times.

2. Ship captains and vessel personnel must remain alert at all times, proceed with extreme caution, and operate at a safe speed so that the ship can take proper and effective action to avoid any collisions with marine mammals.
3. During moored and drifting acoustic source deployment, ONR must implement a shutdown zone of 180 feet (55 meters) around the deployed source. Deployment must cease if a marine mammal is visually detected within the shutdown zone. Deployment may recommence if any one of the following conditions are met:
    a. The animal is observed exiting the shutdown zone;
    b. The animal is thought to have exited the shutdown zone based on its course and speed;
    c. The shutdown zone remains clear from any additional sightings for a period of 15 minutes for pinnipeds and 30 minutes for cetaceans.
4. Ships will avoid approaching marine mammals head-on and must maneuver to remain at least 500 yards (457 meters) from all observed cetaceans and 200 yards (183 meters) from all other observed marine mammals, provided it is safe to do so.
5. The CGC Healy will avoid transiting through designated North Pacific right whale critical habitat if practicable (50 CFR 226.215). If traveling through North Pacific right whale critical habitat cannot be avoided, vessels will:
    a. travel through North Pacific right whale critical habitat at 5 knots or less; or at 10 knots or less while PSOs maintain a constant watch for marine mammals from the bridge
    b. maintain a log indicating the time and geographic coordinates at which vessels enter and exit North Pacific right whale critical habitat. This may be accomplished by providing automatic identification system (AIS) data.
6. Activities must cease if a marine mammal species for which take was not authorized, or a species for which authorization was granted but the authorized number of takes have been met, is observed approaching or within the mitigation zone. Activities must not resume until the animal is confirmed to have left the area.
7. Ship captains must maintain at-sea communication with subsistence whalers to avoid conflict of ship transit with hunting activity.
8. Vessels will not approach within 5.5 km (3 nm) of Steller sea lion rookery sites listed in (50 CFR § 224.103(d)).
9. Vessels will not approach within 914 m (3,000 ft) of any Steller sea lion haulout or rookery which is not listed in 50 CFR § 224.103(d).

Monitoring

ONR is required to conduct marine mammal monitoring during Arctic Research Activities. Monitoring and reporting must be conducted in accordance with its Integrated Comprehensive Monitoring Program (ICMP).

10. While underway, all ships must have at least one person trained through the U.S. Navy

Marine Species Awareness Training Program on watch during all activities.

11. Data Collection. Watch personnel must use standardized data collection forms, whether hard copy or electronic. Watch personnel must distinguish between sightings that occur during transit or during deployment of acoustic sources. Data must be recorded on all days of activities even if marine mammals are not sighted. At a minimum, the following will be recorded:
    a. Vessel name
    b. Watch personnel names and affiliations
    c. Activity (i.e. transit or device deployment)
    d. Environmental conditions: at the beginning of watch, personnel shift, and whenever conditions change significantly, record Beaufort Sea state and other relevant conditions affecting visibility including cloud cover, fog, sun glare, precipitation
    e. Visibility distance
    f. Marine mammal sighting: upon observation of any marine mammal, the following information must be recorded;
        i. Date/time of sighting;
        ii. Identification of animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
        iii. Location (latitude/longitude) of sighting;
        iv. Estimated number of animals (high/low/best);
        v. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
        vi. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling, length of time observed in the harassment zone, note any observed changes in behavior);
        vii. Distance from ship to animal;
        viii. Direction of animal's travel relative to the vessel;
        ix. Platform activity at time of sighting (i.e., transit, deployment); and
        x. Weather conditions (i.e., Beaufort Sea State, cloud cover).

Reporting

ONR will:

12. Submit a draft report to the Permits Division and AKR on all monitoring conducted under the IHA within 90 calendar days of the completion of the cruise or sixty days prior to the issuance of any subsequent IHA for this project, whichever comes first. The report must

include data regarding acoustic source use, the number of shutdowns during monitoring, any marine mammal sightings (including the marine mammal's location (latitude and longitude)), and the number of individuals of each species observed during source deployment and operation, and their behavior and distance from the project activities. ONR must review all reported information and check information for accuracy and completion prior to submission to NMFS Permits Division and NMFS AKR. A final report must be prepared and submitted to NMFS Permits Division and NMFS AKR within thirty days following resolution of comments on the draft report.

13. 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 addressing those comments must be submitted within 30 days after receipt of comments.
14. Report injured or dead marine mammals unrelated to project activities to the Stranding Hotline (Table 3).
15. In the unanticipated event that the specified activity 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 NMFS Permits Division and the Alaska Regional Stranding Hotline (Table 3). The following information will be included:
    a. Time, date, and location of the discovery;
    b. Species identification (if known) or description of the animal(s) involved;
    c. Condition of the animal(s) (including carcass condition if the animal is dead);
    d. Observed behaviors of the animal(s), if alive;
    e. If available, photographs or video footage of the animal(s); and
    f. General circumstances under which the animal(s) was discovered (e.g., deployment of moored or drifting sources, during on-ice experiments, or by transiting vessel).

Table 3. Summary of Agency Contact Information

Reason for Contact	**Contact Information**
Consultation Questions & Unauthorized Take	Greg Balogh: greg.balogh@noaa.gov Marilyn Myers: Marilyn.myers@noaa.gov and Jessica Taylor: Jessica.taylor@noaa.gov
Reports & Data Submittal	AKR.section7@noaa.gov (please include NMFS consultation number AKRO 2021-09126)
Stranded, Injured, or Dead Marine Mammal *(not related to project activities)*	Stranding Hotline (24/7 coverage) 877-925-7773

Reason for Contact	**Contact Information**
Oil Spill & Hazardous Materials Response	U.S. Coast Guard National Response Center: 1-800-424-8802 (or U.S. Coast Guard 17th District Command Center: 907-463-2000) & NMFS AKR Protected Resources Oil Spill Response Coordinator: 907-586-7630 AKRNMFSSpillResponse@noaa.gov and/or Sadie.wright@noaa.gov

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.

The Proposed Action would occur within the Study Area (Figure 2), which overlaps portions of the U.S. Exclusive Economic Zone (EEZ), international waters, and the Canadian EEZ. The Proposed Action would primarily occur in the Beaufort Sea, but the analysis considers the drifting of active sources on buoys into the Chukchi Sea. The closest point of the Study Area to the Alaska coast is 110 nautical miles (nm; 204 km). To allow for the equipment drift or the need to navigate around ice, small areas of the Canadian EEZ are also included in the Study Area; the appropriate permission for conducting scientific research in the Canadian EEZ would be obtained from Canada in the form of a Marine Scientific Research (MSR) permit. Figure 2 shows the positions of fixed sources and the initial positions at which drifting sources will transmit. The anticipated movement of drifting sources is included in the analysis. The action area also includes the transit routes of the R/V Sikuliaq and CGC Healy. The R/V Sikuliaq would travel to and from the study area from Nome, Alaska and we assume the Healy will be traveling from Seward to the Beaufort Sea.

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 the designated critical habitat.

To jeopardize the continued existence of a listed species means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR § 402.02). As NMFS explained when it promulgated this definition, NMFS considers the likely impacts to a species' survival as well as likely impacts to its recovery. Further, it is possible that in certain, exceptional circumstances, injury to recovery alone may result in a jeopardy biological opinion (51 FR 19926, 19934; June 3, 1986).

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 feature essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR § 402.02).

The designations of critical habitat for North Pacific right whales and Steller sea lions use the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (81 FR 7414; February 11, 2016) replaced 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 use 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 effects on listed species or critical habitat. As part of this step, we identify the action area – the spatial and temporal extent of these 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 action. 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 PBFs. 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) appreciably diminish 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. 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 primarily relied on:

- The Navy's IHA application
- The Draft Supplemental Overseas Environmental Assessment for ONR Research Arctic Research Activities in the Beaufort Sea October 2022 – October 2025
- The Permits Division Federal Register notice for the proposed IHA
- Stock Assessment Reports
- Published and unpublished scientific information on endangered and threatened species and their surrogates
- Scientific information such as reports from government agencies and peer-reviewed literature

4 Rangewide Status of the Species and Critical Habitat

Because we assume the CGC Healy will depart from Seward, Alaska, it will pass through habitat that may be occupied by all of the listed whales in Alaska, except the Cook Inlet beluga whale (Table 4). The route will also pass though critical habitat for Steller sea lion, Western North Pacific humpback whale, Mexico DPS humpback whale, North Pacific right whale, ringed seal and bearded seal. We assume the routes of the CGC Healy and R/V Sikuliaq will be essentially the same from Nome to the Beaufort Sea. This opinion considers the effects of the proposed action on the species and designated critical habitats specified in Table 4.

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

Species	Status	Listing	Critical Habitat
Bowhead Whale (*Balaena mysticetus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Fin Whale (*Balaeneoptera physalus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Blue whale (*Balaenoptera musculus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Sei whale (*Balaenoptera borealis*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
North Pacific Right Whale (*Eubalaena japonica*)	Endangered	NMFS 2008, 73 FR 12024	NMFS 2008, 73 FR 19000
Gray whale, Western North Pacific DPS (*Eschrichtius robustus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Sperm whale (*Physeter macrocephalus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Humpback Whale, Western North Pacific DPS (*Megaptera novaeangliae*)	Endangered	NMFS 2016, 81 FR 62260	NMFS 2021, 86 FR 21082
Humpback Whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	NMFS 2016, 81 FR 62260	NMFS 2021, 86 FR 21082
Ringed Seal, Arctic Subspecies (*Phoca hispida hispida*)	Threatened	NMFS 2012, 77 FR 76706	NMFS 2022 87 FR 19232
Bearded Seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	NMFS 2012, 77 FR 76740	NMFS 2022 87 FR 19180
Steller sea lion, Western DPS (*Eumetopias 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

As described in the Approach to the Assessment section of this opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitats that are likely to be adversely affected. The first criterion is exposure or some reasonable expectation of a co-occurrence between one or more potential stressors associated with ONR's Arctic Research Activities and a listed species or designated critical habitat.

The second criterion is the probability of a response given exposure. For endangered or threatened species, we consider the susceptibility of the species that may be exposed; for example, species that are exposed to sound produced by vessels, but are not likely to exhibit physical, physiological, or behavioral responses given that exposure (at the combination of sound pressure levels and distances associated with an exposure), are not likely to be adversely affected by the exposure. We determine that an action would not likely adversely affect an animal if one could not meaningfully measure or detect the effects or if the effects are extremely unlikely to occur. In addition, if proposed activities are not likely to destroy or adversely modify critical habitat, further analysis is not required.

For this consultation we must also consider that this operation carried out by ONR is considered a military readiness exercise. The National Defense Authorization Act of Fiscal Year 2004 (PL 108-136) amended the definition of "harassment" under the Marine Mammal Protection Act (MMPA), specifically as it applies to military readiness activities or scientific research activities conducted by or on behalf of the federal government (16 U.S.C. §1362 (18)(B)). Research activities within the study area are composed of military readiness activities, as that term is defined in section 315(f) of PL 107-314, because activities constitute realistic testing of military equipment, vehicles, and sensors for proper operation and suitability for combat use. For military readiness activities, the relevant definition of harassment under the MMPA is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment"); or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") (16 U.S.C. § 1362(18)(B)(i) and (ii)).

In this section we only consider vessel transit and if it is likely to disturb a listed marine mammal to the point that natural behavioral patterns are abandoned or significantly altered. Vessel transit is the only aspect of this project that could potentially impact the cetaceans, bearded seals and Steller sea lions, as none are expected to be in the deep water of the Beaufort Sea where the moorings will be deployed, active acoustic sources will be used, or where icebreaking may be needed. Only the ringed seal will potentially overlap with those activities. We discuss the effects of vessel noise on all sub-Arctic cetaceans and pinnipeds in sections 4.1.1 and vessel strike on both groups in section 4.1.2. Because project effects are more likely to overlap with bowhead whales and bearded seals, we discuss them in more detail in sections 4.1.4 and 4.1.5. Effects to critical habitat are discussed in section 4.1.3. Effects of the project specific to the ringed seal are discussed in detail in section 6.

4.1.1 Vessel Noise

For this project we assume the CGC Healy (or similar vessel) will make one round trip from Seward, Alaska to the Beaufort Sea and the R/V Sikuliaq will make one round trip from Nome to the Beaufort Sea. Given that the R/V Sikuliaq departs from Nome, the likelihood that it will encounter a subarctic cetacean is greatly reduced compared to a vessel departing from Seward, Alaska.

4.1.1.1 Sub-Arctic Cetaceans

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 at frequencies below the best hearing ranges of the marine mammals. Because the vessel will be in transit, the duration of the exposure will be very brief. NMFS calculates that at 10 knots, the project vessel will ensonify a given point to levels above 120 dB for less than 9 minutes. The area of ensonification around the vessel is difficult to predict as many factors such as depth, bathymetry, temperature, and salinity affect transmission loss. A study of vessel noise in Glacier Bay National Park indicated the vessel speed was the most important variable effecting noise level (Kipple and Gabriele 2004; Frankel and Gabriele 2017). The importance of ship speed was illustrated by the finding that the median sound exposure values for simulations with 2 slow (10-13 knots) cruise ships were lower than those with a single fast cruise ship (20 knots) even though the fast ship passed through the area in less time (Frankel and Gabriele 2017).

To examine the probability of exposure of the blue whale, sei whale, North Pacific right whale, sperm whale, Western North Pacific gray whale, humpback whales and fin whale to vessel noise, we estimated whale density based on the population estimates given in Muto et al. (2021). For this density calculation we used the population estimate for fin whales over their range in Alaska to act as a surrogate for the subarctic whales. Although humpback whales are more abundant than fin whales across the transit route, the number of individuals in the listed Western North Pacific DPS (2 percent of population) and Mexico DPS (7 percent) are far outnumbered by those in the Hawaii DPS (91 percent) which is not listed (Wade 2021). Consequently, the number of listed humpback whales is much smaller than the fin whale population. In addition, not only are fin whales the most likely whale to be encountered over the entire transit route given the typical summer distribution of subarctic whales, their population is greater than that for blue whales, sei whales, North Pacific right whales, sperm whales, Western North Pacific gray whales or listed humpback whales, thus giving us the most conservative estimate of potential exposure.

Muto et al. (2021) provide a population estimate of 3,168 for fin whales. This estimate was based on surveys done in the Gulf of Alaska which were more recent and provided a higher estimate than estimates based on surveys done in Western Alaska and the Aleutian Islands (Muto et al. 2021). For area, we used Google maps to determine a rough estimate of occupied habitat in the Gulf of Alaska, the eastern half of the Bering Sea, and the Chukchi Sea and determined the range covered approximately 3,725,000 km^2 resulting in a density estimate of 0.0008 fin whales per km^2. Based on Roth et al. (2013), we estimate that when in transit the sound source level of the CGC Healy will be approximately 180 dB 1 re µPa. Because the ship will be traveling primarily in deep ocean water, we can use a spherical spreading loss of 20 because sound will propagate equally in all directions in deep water. With these values it will take approximately 1000 m on each side of the vessel for the received level to reach 120 dB or less. Given an ensonified swath along the vessel route that is 2 km wide and a density of 0.0008 whales per km^2, we can calculate how many fin whales may temporarily be exposed to sound greater than 120 dB. We estimate that the route from Seward up to the Chukchi Sea is 2,850 km leading to an estimate that approximately 4.6 whales could be exposed (route length x ensonified width x whale density, or 2,850 km x 2 km x 0.0008 whales per km^2) on the transit up and 4.6 on the way back for a total 9.2 fin whales that might be exposed to sound. These estimates show the maximum number of subarctic whales of each listed species considered in this opinion that might be exposed to vessel noise because fin whales are most likely to be encountered compared to the other species and their population number is the highest. For example, the sperm whale population in Alaska is approximately 345 (Muto et al. 2021). Because their density is far less than the fin whale's, we would expect less than one sperm to be exposed to vessel noise.

Behavioral reactions of marine mammals to vessels 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 (e.g. feeding, traveling, resting) prior to the disturbance from the vessel. Studies of resting mother and calf humpback whales in Australia (Sprogis et al. 2020), vocalizing humpback whales in Glacier Bay National Park (Fournet et al. 2018), and feeding humpback whales in the North Atlantic (Blair et al. 2016) showed no, to strong, behavioral reactions to vessel noise depending on ambient noise levels and received sound levels. Considerable variability in response type and magnitude has been observed for similar noise exposures as a function of species, age/sex class, individual behavioral state, and a host of interacting biological and ecological contextual factors (Southall et al. 2021). Individual animals' past experiences with vessels also appear to be important in determining an individual's response (LGL 2014). For example, according to Nowacek et al. (2004), North Atlantic right whales show neither a behavioral response to the sounds of an approaching vessel nor to actual vessels and suggest that they may be habituated to vessel noise and ignore it.

Ships in transit typically travel in a consistent and predictable direction and speed, essentially providing a gradually increasing signal of their approach. Consequently, we would not expect a startle response from any individual cetacean. Individuals may exhibit deflection from the noise source, engage in low level avoidance behavior, exhibit short-term vigilance behavior, or experience and respond to short-term acoustic masking behavior, but these behaviors are expected to be very short in duration and not likely to result in significant disruption of normal behavioral patterns.

In compliance with the mitigation measures, ships will avoid approaching cetaceans head on and will maneuver to remain at least 500 yd (457 m) from all whales, reducing the level of sound exposure the whales may temporarily receive. As demonstrated by our exposure calculations, although a few whales may be exposed to short-term vessel noise, the effects are anticipated to be too small to detect or measure and are not likely to significantly disrupt normal whale behavioral patterns. Based on the improbable overlap of the R/V Sikuliaq with sub-Arctic cetaceans, the low number of transits (2) for CGC Healy, the implementation of mitigation measures, the transitory and short-term exposure, and the expected low level of response, NMFS concludes that any disturbance of sub-Arctic cetaceans from vessel noise will be temporary and have a minor, if any, effect on their behavior.

4.1.1.2 Pinnipeds

For medium to large vessels, frequencies up to 50 Hz dominate the noise they produce

(Richardson et al. 1995; Halliday et al. 2021b). The CGC Healy is most likely to encounter Steller sea lions as it transits through Unimak Pass in the Aleutian Islands. The R/V Sikuliaq will depart and return to Nome and will not transit through Steller sea lion habitat. The generalized hearing range of Steller sea lions is from 60 Hz to 39 kH. Consequently, it is unlikely that underwater noise alone would create a strong reaction from Steller sea lions. Presence of the vessel might create a reaction, but the adherence to the mitigation measures which will keep the vessel at least 3 nm from any rookery listed in 50 CFR § 224.103(d)) and 914 m from any haulout or rookery not listed in 50 CFR § 224.103(d). In addition, the use of a regularly traveled shipping route is expected to minimize any reaction to in-air noise or the presence of the vessel as vessel passage would be a common occurrence.

Bearded seals are most likely to be encountered in the Chukchi and Beaufort seas and are often associated with ice. Similar to Steller sea lions, the generalized hearing range for ringed and bearded seals is higher (from 50 to 86 kH) than the dominant frequency expected from the ship (< 50 Hz) and best underwater sensitivity occurs around 10 kHz, much higher than the dominate noise created by the ship. In addition, phocids do not echolocate (Schusterman et al. 2000) so masking to find food or communicate through high frequency sounds is less likely to occur. Phocids are most vocal during breeding which occurs in spring (MacIntyre et al. 2013; Jones et al. 2014). Because the cruises will occur in the fall, vessel noise would not interfere with vocalizations related to breeding.

As explained for sub-Arctic cetaceans, the short duration of passage past an occupied location and being exposed to only one or two temporary passages reduces the potential for behavioral disturbance. Consequently, based on the hearing characteristics of pinnipeds, the timing of their vocalizations related to breeding, and the implementation of the mitigation measures which ensure a safe distance is maintained from all marine mammals, we expect that disturbance to any individual will be very short in duration, too small to detect or measure, and not likely to significantly disrupt normal pinniped behavioral patterns.

4.1.2 Vessel strike

4.1.2.1 Sub-Arctic Cetaceans

Vessel strike is an ongoing source of mortality for large cetaceans (Vanderlaan and Taggart 2007; Schoeman et al. 2020). Vessel speed is a principal factor in whether a vessel strike results in death (Laist et al. 2001; Vanderlaan and Taggart 2007). Over the 35 years from 1978-2012, there were at least 108 recorded whale-vessel collisions in Alaska (Neilson et al. 2012). Among large whales, humpback whales were the most frequent victims of ship strikes in Alaska, and accounted for 86 percent of all reported collisions. The majority of reported vessel strikes have occurred in Southeast Alaska where vessel traffic is much greater (Neilson et al. 2012). From 2014 to 2018, 20 large whales were struck by vessels in Alaska leading to mortalities or serious injuries (Young et al. 2020). Of these, 14 were humpback whales. Humpback whales may be relatively common on the first and last legs of the transit from Seward through Unimak Pass. Although not common, fin whale, blue whale, sei whale, and sperm whales would most likely be seen in these locations as well. Western North Pacific gray whale and North Pacific right whale are more likely to be seen in the Bering Sea but their exceedingly small population sizes (300 and 30, respectively) make it highly unlikely that they will be encountered. Humpback whales as well as the other subarctic cetaceans are much less common along the western and north coast of

Alaska and very few are observed in the Beaufort Sea (Clarke et al. 2020).

Mitigation measures that apply to all cetaceans stipulate that: (1) ships will avoid approaching marine mammals head-on and will maneuver to maintain an exclusion zone of 500 yards (457 m) around observed whales, (2) ships operated by or for the Navy will have personnel assigned to stand watch at all times, day and night when in transit, and (3) ships will use extreme caution and proceed at a safe speed. We expect that these mitigation measures will greatly reduce the probability of ship strike.

With the low number of transits (one north, one south), the implementation of the mitigation measures, the low occurrence of subarctic whales over the majority of the route, and the absence of any documentation of whale strike over the majority of the cruise route, we conclude the probability of either the R/V Sikuliaq or the CGC Healy striking a sub-arctic whale is very low.

4.1.2.2 Pinnipeds

Bearded seals will likely be able to hear the R/V Sikuliaq and the CGC Healy from a distance well beyond where it may cause harassment. If the vessel sound disturbs them, they would be expected to move away from the vessel (unless something else, like abundant food, compels them to remain in place). Although Sternfeld (2004) documented a single spotted seal stranding in Bristol Bay, Alaska, that may have resulted from a propeller strike, no incidents of ship strike for bearded or ringed seals are noted in the Stock Assessment Reports (Muto et al. 2021) or in recent reports of human caused mortality and serious injury of listed marine mammals in Alaska (Freed et al. 2022). Seals are extremely agile and capable of moving quickly in the water, greatly reducing the probability of being struck by a vessel.

Funk et al. (2010) noted among vessels operating in the Chukchi Sea where received sound levels were <120 dB, 40% of observed seals showed no response to a vessel's presence, slightly more than 40% swam away from the vessel, 5% swam towards the vessel, and the movements of 13% of the seals were unidentifiable. Bisson et al. (2013) reported a total of 938 seals observed during vessel-based monitoring of exploratory drilling activities by Shell in the Chukchi Sea during the 2012 open-water season. This total includes animals seen outside of the leased area during transits to and from the drill site. The majority of seals (42%) responded to moving vessels by looking at the vessel, while the second most noted behavior was no observable reaction (38%). Personnel will be watching for marine mammals whenever the ship is underway. Based on observed seal reactions to ships and the lack of evidence of ship strike, we conclude that the probability of the R/V Sikuliaq or the CGC Healy striking a seal is very small, and adverse effects to seals from vessel transit are extremely unlikely to occur.

As noted earlier, Steller sea lions are most likely to be encountered from Seward to Unimak Pass and potentially near Dutch Harbor. This area overlaps with the listed Western DPS. One report of a serious injury in Alaska of a Steller sea lion was documented in 2016 but it was for the Eastern DPS; no serious injuries or mortalities have been reported for the Western DPS. Like seals, Steller sea lions are extremely agile in the water and it is unlikely that they would be struck by a vessel moving at 10 knots. The extremely rare occurrence of Steller sea lion vessel strikes combined with the mitigation measures that will help prevent potential strikes from occurring indicate that the CGC Healy is extremely unlikely to collide with a Steller sea lion.

In summary, we conclude that vessel noise and vessel strike are not likely to adversely affect the fin whale, blue whale, sei whale, North Pacific right whale, Western North Pacific gray whale, sperm whale, Western North Pacific DPS or Mexico DPS humpback whale, bearded seal or Western Steller sea lions. They will not be discussed further.

4.1.3 Vessel Effects to Critical Habitat

The CGC Healy will pass through or go near critical habitat for the Western North Pacific DPS humpback whale, Mexico DPS humpback whale, Steller sea lion, North Pacific right whale, Beringia DPS bearded seal and Arctic ringed seal. The R/V Sikuliaq will transit across Beringia DPS bearded and Arctic ringed seal critical habitat. For the humpback whales and the North Pacific right whale the primary biological features that were found essential to their critical habitat are an abundance of preferred prey; small schooling fishes or aggregations of zooplankton, respectively. There is nothing about the passage of the ship on the surface of the water that would have a measureable effect on aggregations of these prey species. The eddies or wake of the vessels across the surface of the water may cause temporary mixing or displacement of a relatively small number of zooplankton but we do not expect that this disturbance would affect the prey distribution or abundance in a meaningful or measurable way.

The essential features of Beringia DPS bearded and Arctic ringed seal critical habitat focus on the presence and characteristics of sea ice and prey resources. The majority of the transit will be across open water. Sea ice may be encountered in the deep water of the Beaufort Sea, but this area is excluded from critical habitat on the basis of military readiness. The passage of the ship on the surface of the water will have no effect on the fish and benthic organisms that are prey for bearded and ringed seals and thus, no effect on bearded and ringed seal critical habitat.

Mitigation measures #8 and #9 are in place to protect Steller sea lion critical habitat from vessel disturbance. In addition, we expect the CGC Healy will be traveling in normal shipping lanes when in Steller sea lion range and that Steller sea lions at haulouts or rookeries near those shipping lanes are habituated to shipping traffic. The ship may pass through one of the special aquatic foraging areas for Steller sea lions if it goes through Shelikof Strait. However, passage of the ship on the surface of the water is not expected to disrupt or disturb any of the primary prey species which Steller sea lions depend upon and therefore the quality of their prey resources will not be diminished. For these reasons we conclude that there is no aspect of the passage of the CGC Healy over or near critical habitat that will negatively impact the essential features of Steller sea lion critical habitat.

In summary we find that the temporary passage of the CGC Healy and/or the R/V Sikuliaq over the water surface of critical habitat for Western North Pacific DPS humpback whale, Mexico DPS humpback whale, Steller sea lion, North Pacific right whale, Beringia DPS bearded seal, and Arctic ringed seal will have an immeasurably small effect on the features determined to be essential for these species. Therefore, we determine that this proposed action is not likely to adversely affect critical habitat for Western North Pacific DPS humpback whale, Mexico DPS humpback whale, Steller sea lion, North Pacific right whale, Beringia DPS bearded seal, and Arctic ringed seal. As such, critical habitat will not be discussed further in this opinion.

4.1.4 Bearded Seals

4.1.4.1 Status and Population Structure

There are two recognized subspecies of the bearded seal: *E. b. barbatus*, often described as inhabiting the Atlantic sector (Laptev, Kara, and Barents seas, North Atlantic Ocean, and Hudson Bay; (Rice 1998)); and *E. b. nauticus*, which inhabits the Pacific sector (remaining portions of the Arctic Ocean and the Bering and Okhotsk seas; (Ognev 1935; Scheffer 1958; Manning 1974; Heptner et al. 1976). 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. NMFS listed the Beringia DPS of bearded seals as threatened under the ESA on December 28, 2012 (77 FR 76740).

A reliable 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.

4.1.4.2 Distribution

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 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. 1976; 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; Burns and Frost 1979; Burns 1981; Smith 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. In comparison, suitable ice conditions and water depths occur in limited areas of the Chukchi Sea, and over much broader areas in the Bering Sea (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. 1976, 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 1967; Burns and Frost 1979; Burns 1981; Cameron and Boveng 2007; Cameron and Boveng 2009; Cameron et al. 2018). The overall summer distribution is quite broad, with seals rarely hauled out on land (Burns 1967, Heptner et al. 1976, 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 2000), near Wainwright (Nelson 1981), and on sandy islands near Barrow (Cameron et al. 2010).

4.1.4.3 Occurrence in the Action Area

Bearded seals are expected to be present along the vessel transit route through the Bering, Chukchi, and Beaufort seas. Although bearded seal vocalizations (produced by adult males) have been recorded nearly year-round in the Beaufort Sea (MacIntyre et al. 2013; MacIntyre et al. 2015), all the recorders were on the shelf area in water depths ranging from 46 to 131 m and less than 100 km from shore. The area where the active acoustic sources will be deployed for this project is more than 200 km offshore in water depths greater than 500 m (Figure 2). Bearded seals are primarily benthic feeders and are typically found in relatively shallow water (< 200 m) of the shelf areas of the Bering, Chukchi, and Beaufort seas, presumably because their prey is more accessible to them in the shallower water. Research activities will be taking place in water depths 500 m and greater. Tagging studies of juvenile bearded seals has shown that they move south beginning in the fall, following the ice edge (Breed et al. 2018; Olnes et al. 2020). Consequently, we do not expect bearded seals to overlap with the area affected by the project’s active acoustic sources. However, they could be exposed to the effects of the vessels.

4.1.4.4 Hearing and Vocalizations

Bearded seals vocalize underwater in association with territorial and mating behaviors. The predominant calls produced by males during breeding, termed trills, are described as frequency modulated vocalizations. Trills show marked individual and geographical variation, are uniquely identifiable over long periods, can propagate up to 30 km (19 mi), are up to 60 seconds in duration, and are usually associated with stereotyped dive displays (Cleator et al. 1989; Van Parijs et al. 2001; Van Parijs 2003; Van Parijs et al. 2003; Van Parijs et al. 2004; Van Parijs and Clark 2006).

Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, and make calls between 90 Hz and 16 kHz (Richardson et al. 1995). NMFS defines the functional hearing range for phocids as 50 Hz to 86 kHz (NMFS 2018b). 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 (Gordon et al. 2003).

4.1.4.5 Effects

As discussed above (section 4.1.4.3) bearded seals are not expected to be exposed to the active acoustic sources proposed for this action. Consequently, they will only be exposed to effects of vessel transit; noise and strike. These effects were discussed above in sections 4.1.1 and 4.1.2. Therefore, we conclude that the proposed action is not likely adversely affect bearded seals.

4.1.5 Bowhead whale

4.1.5.1 Status and Population Structure

The International Whaling Commission (IWC) recognizes four stocks of bowhead whale for management purposes. The Western Arctic stock (also known as the Bering-Chukchi-Beaufort stock) is the largest and only stock found in U.S. waters and the action area (Muto et al. 2021).

The bowhead whale was listed as endangered under the Endangered Species Conservation Act (ESCA) of 1969 on December 2, 1970 (35 FR 18319). Congress replaced the ESCA with the ESA in 1973, and bowhead whales continued to be listed as endangered. Critical habitat has not been designated for bowhead whales. The bowhead whale became endangered because of past commercial whaling. The IWC placed a moratorium on commercial whaling, and called for a ban on subsistence whaling in 1977. The United States requested a modification of the ban on subsistence whaling, resulting in a limited quota for aboriginal subsistence whaling countries, including the U.S., promulgated and managed by the IWC.

Woodby and Botkin (1993) summarized efforts to determine a minimum worldwide population estimate prior to commercial whaling and reported a minimum pre-exploration estimate for all stocks of 50,000 whales, with 10,400 to 23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling). Subsequently, Brandon and Wade (2006) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 (9,190 to 13,950; 5th and 95th percentiles, respectively) bowheads in 1848 at the start of commercial whaling.

Givens et al. (2013) estimated that, from 1978 to 2011, the Western Arctic stock of bowhead whales increased at a rate of 3.7 percent (95 percent confidence interval of 2.8 to 4.7 percent) during which time abundance tripled from approximately 5,000 to approximately 16,000 whales. Similarly, using sight-resight analysis of aerial photographs, Schweder et al. (2010) estimated the yearly growth rate of this stock between 1984 and 2003 to be 3.2 percent. Based on corrected counts of bowhead whales by ice-based observers in 2001, the abundance of the Western Arctic stock was estimated to be 10,545 individuals (coefficient of variation, 0.128) (updated from George et al. (2004) by Zeh and Punt (2005)). Ten years later in 2011, the ice-based abundance estimate was 16,820 individuals (95 percent confidence interval, 15,704 to 18,928) (Givens et al. 2013). Using the 2011 population estimate of 16,820 and its associated coefficient of variation of 0.052, the most recent minimum population estimate for the Western Arctic stock of bowhead whales is 16,100 (Muto et al. 2021).

4.1.5.2 Distribution

Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984; Moore and Reeves 1993). During winter and spring, bowhead whales are closely associated with pack ice or in polynyas (large, semi-stable open areas of water within the ice), and move north as the sea ice breaks up and recedes during the spring. During summer, most of the population is in relatively ice-free waters in the southeastern Beaufort Sea; however, some whales move back and forth between the Alaskan and Canadian Beaufort Sea during the summer feeding season (Quakenbush et al. 2010).

The majority of the Western Arctic stock migrates annually from wintering areas (December to March) in the northern Bering Sea, through the Chukchi Sea in the spring (April through May), to the eastern Beaufort Sea where they spend much of the summer feeding (June through early to mid-October) before returning again to the Bering Sea in the fall (September through December) to overwinter (Muto et al. 2021) (Figure 7).

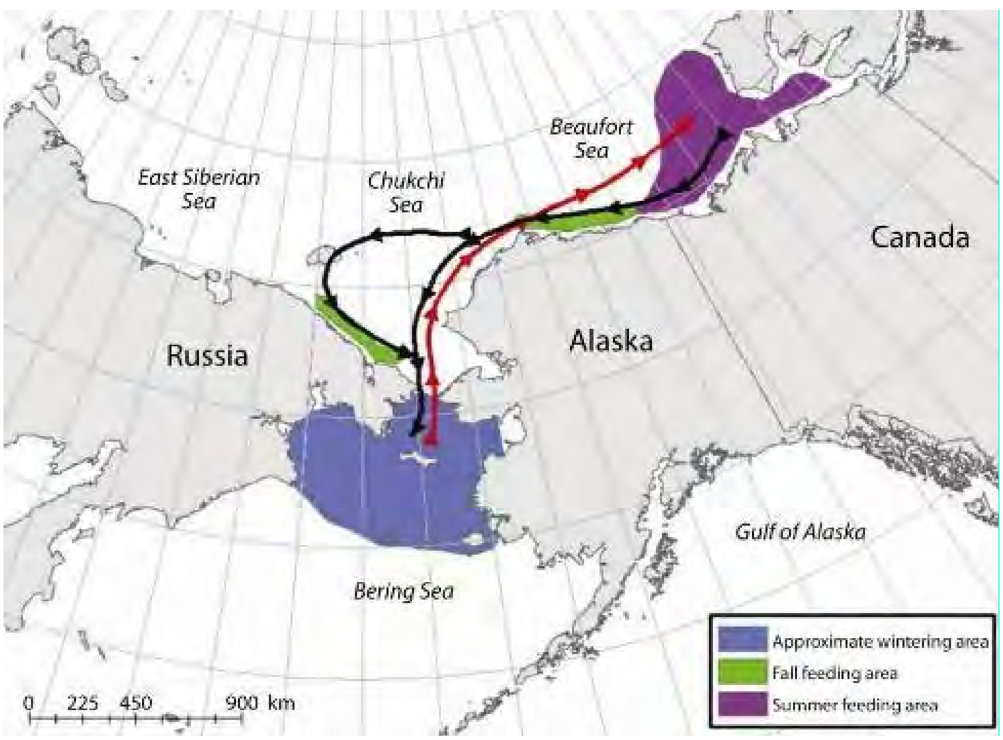

Figure 7. Generalized migration route, feeding areas, and wintering area for Western Arctic bowhead whale (Moore et al. 2006).

4.1.5.3 Occurrence in the Action Area

The vast majority of the bowhead population migrate to the Bering Sea during the fall and do not return eastwards through the Beaufort Sea again until the spring. During the eastward (spring) migration, the whales are distributed farther offshore. While a few whales may occur in the Central Beaufort Sea area throughout the summer, most of the population spends the summer in the eastern Beaufort Sea before passing through again during the latter part of summer and fall as they migrate west to over winter in the Bering Sea. Bowhead whales are most likely to be encountered during the fall migration when they travel closer to shore in water ranging from 15 to 200 m deep (50 to 656 ft) (Miller et al. 2002; Clarke et al. 2012; Clarke et al. 2020; Brower et al. 2022). The fall migration trajectory varies annually and is influenced by ice presence (Moore and Reeves 1993). Treacy et al. (2006) found that the main migration corridor for bowhead whales during the fall migration was 73.4 km (46 mi) offshore in years of heavy ice conditions, 49.3 km (31 mi) offshore during moderate ice conditions, and 31.2 km (19 mi) offshore during light ice conditions.

Clarke et al. (2015) evaluated biologically important areas (BIAs) for bowheads in the U.S. Arctic region and identified nine BIAs. The fall (September-October) migratory corridor BIA (western Beaufort on and north of the shelf) for bowheads is close to shore (Figure 8, cross hatched area). Three bowhead feeding BIAs were identified (Clarke et al. 2015). The September-October feeding BIA (Figure 9) is similarly situated near shore where food resources are concentrated. Based on the route taken, it is unlikely that the research vessels would overlap with the migratory corridor or the September-October feeding BIA as the transit route to the Beaufort is father offshore.

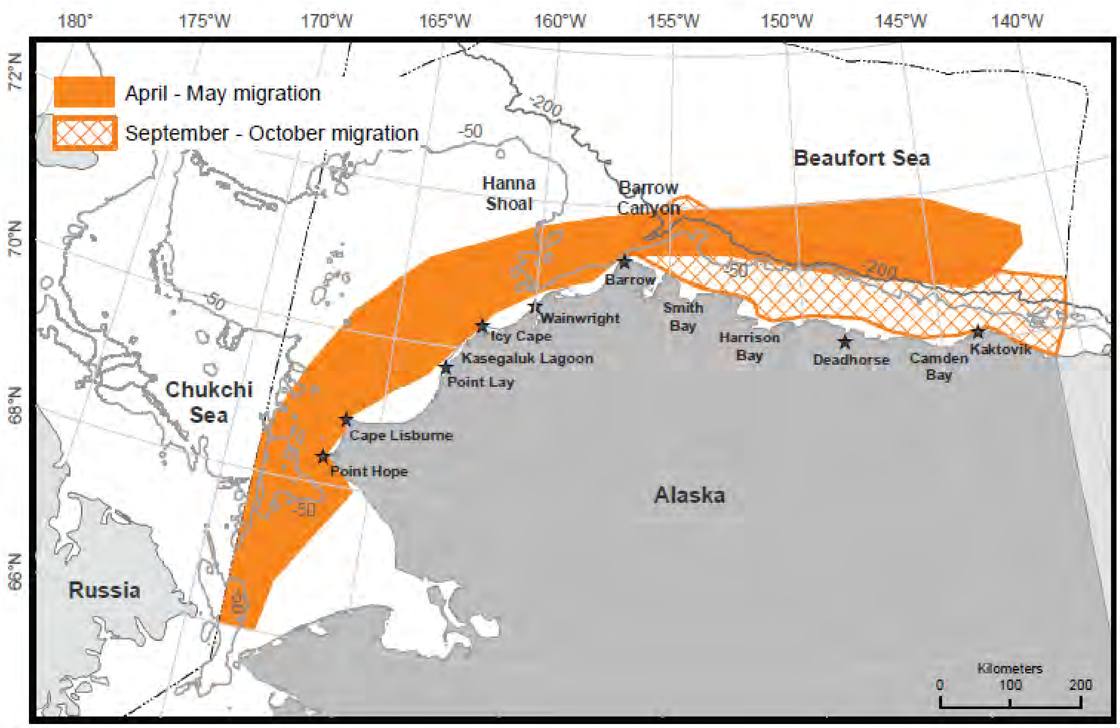

Figure 8. Bowhead whale migratory corridor BIAs for spring (April-May) and fall (September-October, cross-hatched area), determined from aerial- and ice-based surveys, satellite telemetry, and passive acoustic monitoring; also shown are the 50- and 200-m depth contours. (Clarke et al. 2015b, Figure 8.3)

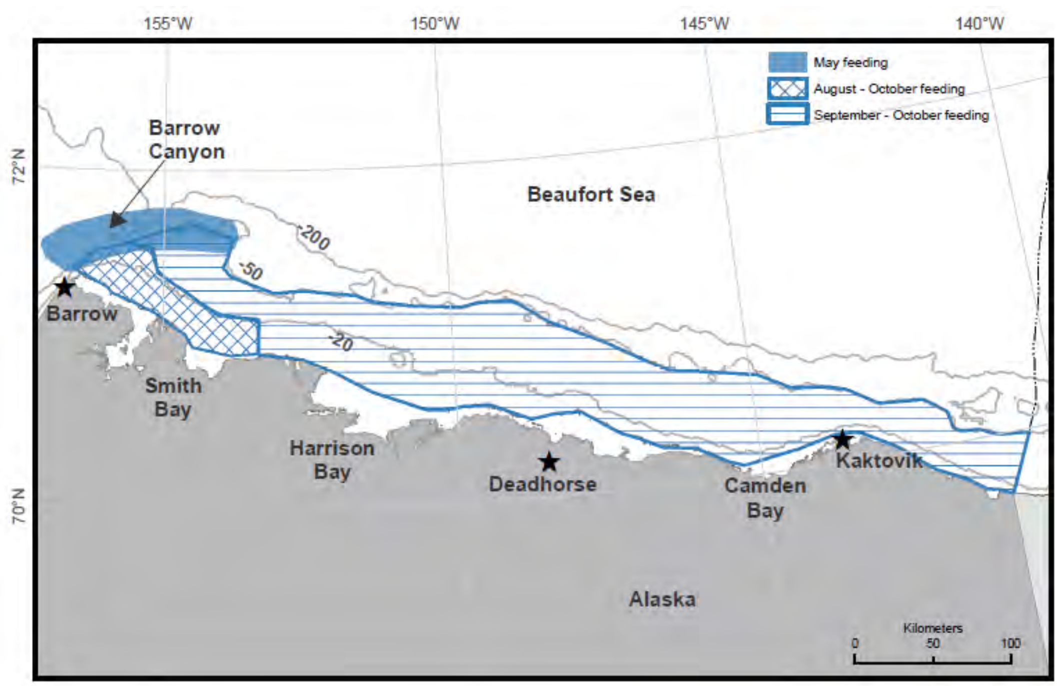

Figure 9. Bowhead whale feeding BIAs identified during the eastward spring migration in May near Barrow Canyon; from Smith Bay to Point Barrow in August through October, generally shoreward of the 20-m isobaths; and during the westward fall migration from September through October, generally shoreward of the 50-m isobath. BIAs were determined using aerial survey data. Also shown are the 20-, 50-, and 200-m depth contours (Clarke et al. 2015, Figure 8.2).

The Aerial Surveys of Arctic Marine Mammals (ASAMM) project typically occur from July through October. The distribution of bowhead whales recorded by these surveys is shown in Figure 10 and indicates that although the research vessels would not transit through a BIA, the route of the research vessels in September could intersect with bowhead whale individuals as they move westward in their fall migration. Halliday et al. (2021b) found that within the Beaufort and Chukchi Seas during the shipping seasons in 2015-2017, the greatest ship traffic and modeled underwater noise from ships occurred in the southern Chukchi Sea near the Bering Strait. Because bowheads are in this area in September and October, the whales likely experience the highest number of underwater noise events and greatest overlap with ship traffic at this time.

George at al. (2017) found that about 2% of subsistence-harvested bowheads bore signs of vessel strike. Bowheads that were fatally struck were not part of the sampled population, suggesting that this estimate may be biased low. George et al. (1994) suggested that the most probable areas for bowheads to encounter large vessel traffic are the far eastern end of the Northern Sea Route (along the north shore of the Chukotka Peninsula) during autumn and the Eastern Canadian Beaufort Sea during August and September (Richardson et al. 1987). Areas of high use vary by year but in the fall of 2020 most bowhead sightings occurred in water depths of 5-26 m within 30 km of shore. Figure 10 indicates that there is a much higher likelihood of the bowheads being over the continental shelf where food resources are concentrated than in the deep water of the Beaufort Sea.

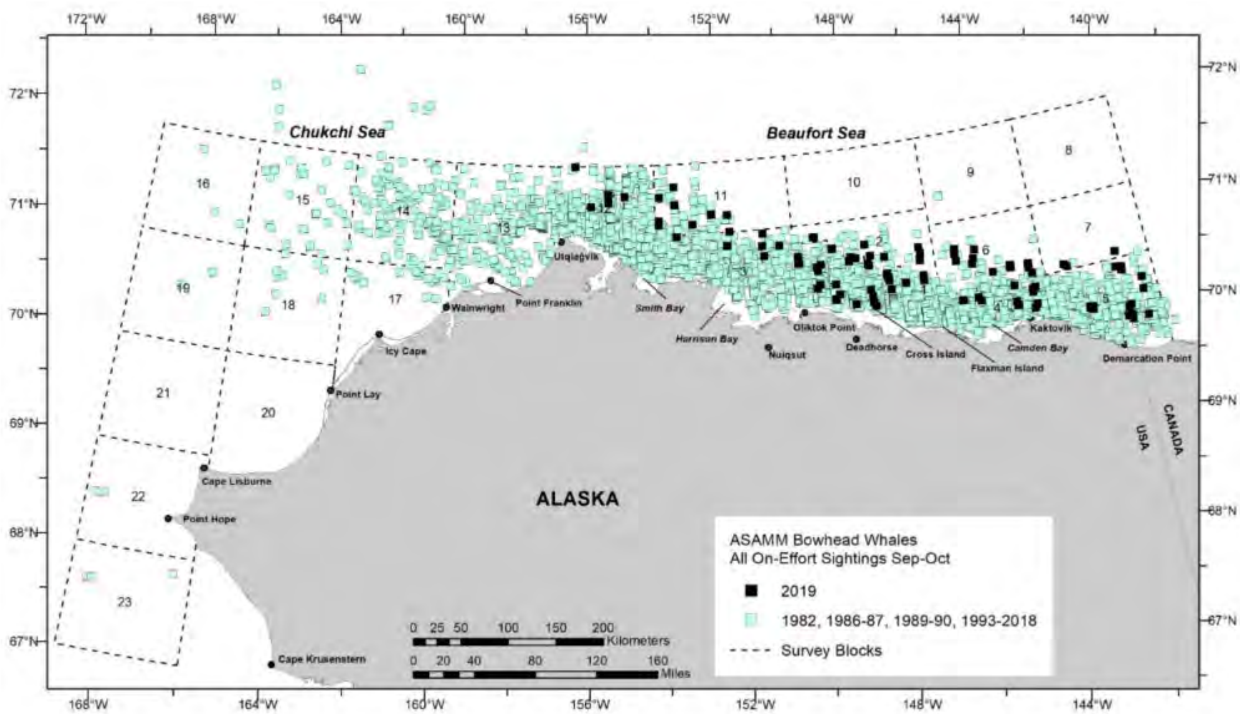

Figure 10. ASAMM bowhead whale sightings in the ASAMM study area, fall (September-October)

4.1.5.4 Hearing, Vocalizations, and Other Sensory Abilities

Bowhead whales are among the more vocal of the baleen whales (Clark and Johnson 1984). Most underwater calls are at a fairly low frequency and easily audible to the human ear.

Vocalization is made up of moans of varying pitch, intensity and duration, and occasionally higher-frequency screeches. Bowhead whale songs have a bandwidth of 20 to 5000 Hz with the dominant frequency at approximately 500 Hz and duration lasting from 1 minute to hours. Pulsive vocalizations range between 25 and 3,500 Hz and lasts 0.3 to 7.2 seconds (Clark and Johnson 1984; Würsig and Clark 1993; Erbe 2002).

NMFS categorizes bowhead whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group, with an estimated hearing range of 7 Hz to 35 kHz (NMFS 2018b). Inferring from their vocalizations, bowhead whales should be most sensitive to frequencies between 20 Hz and 5 kHz, with maximum sensitivity between 100 Hz and 500 Hz (Erbe 2002).

4.1.5.5 Effects

Vessel Noise

The proposed action includes one roundtrip from Nome to the Beaufort Sea in September 2022 and potentially one from Seward and back and the fall of 2023. Ice breaking may occur when the CGC Healy is used but icebreaking is not expected to be needed over the shallow shelf water where thin, first year ice may be forming in September. If needed, ice breaking will be farther north over the deep water of the Beaufort where multi-year ice may be encountered. We do not expect bowheads to overlap with icebreaking activities. As described above, mitigation measures during transit stipulate that: 1) ships will avoid approaching marine mammals head-on and will maneuver to maintain an exclusion zone of 500 yards (yd; 457 m) around observed whales; 2) personnel will stand watch at all times, day and night, when in transit; and 3) ships must use extreme caution and proceed at a safe speed.

Disturbance to individual bowhead whales from vessel noise could occur during the vessel transit. Behavioral reactions of marine mammals to vessels 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 exposed to the same sound. Individual animals' past experiences with vessels appear to be important in determining an individual's response (Shell 2012). Richardson et al. (1987) report that most bowheads show avoidance reactions to approaching ships more than 1 km distant in the Eastern Canadian Beaufort, which would decrease the likelihood of a ship collision. This observation, along with the ship's offshore route, greatly decreases the potential overlap of a bowhead with effects from the vessel.

The amount of underwater noise produced by large vessels ranges from 161 dB re 1 μPa at 1 m for military vessels to 192 dB re 1 μPa at 1 m for icebreakers (Halliday et al. 2021b). 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. Because the vessels will be in transit, the duration of the exposure to ship noise will be temporary. NMFS calculates that at 10 knots, the project vessel will ensonify a given point in space to levels above 120 dB for less than 9 minutes. The project vessel will emit continuous sound while in transit, which will alert marine mammals to the vessel's presence well 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. Although it is more likely that bowhead whales will be exposed to vessel noise than the sub-Arctic cetaceans, based on the low number of transits (4), the implementation of mitigation measures as specified in Section 2.2, the transitory and short-term exposure, and the expected response, NMFS concludes that the effects to bowhead whales from vessel noise are expected to be too small to detect or measure and are not likely to significantly disrupt normal whale behavioral patterns.

Vessel strike

Vessel strike is an ongoing problem for large cetaceans. Vessel speed is a principal factor in whether a vessel strike results in death (Laist et al. 2001; Vanderlaan and Taggart 2007; Halliday et al. 2021b). The research vessels used in this project will have an observer on watch when the vessels are underway so that marine mammals can be spotted and avoided. In addition, ships will avoid approaching marine mammals head-on and will maneuver to maintain an exclusion zone of 500 yards (yd; 457 m) around observed whales. We expect that these mitigation measures will greatly reduce the probability of ship strike.

As discussed above, the research vessel will pass through the bowhead migratory path in its transit across the coastal shelf of the Chukchi Sea in September 2022 and potentially in September 2023. The vessels will be crossing the migratory path of the bowheads for approximately 450 km, exposing the bowheads to strike for approximately 24 hours. Although there is annual overlap between ships using the Northern Sea Route and the Northwest Passage, scars associated with ship strike are seen on about 2 percent of harvested whales (George et al. 2017). Some whales may be fatally struck and removed from the sampled population, suggesting that the estimated strike rate of 2% may be biased low. However, the bowhead whale population grew at a rate of 3.7 percent from 1978 to 2011, during which time abundance tripled from approximately 5,000 to approximately 16,820 whales (Givens et al. 2016), indicating that although bowhead whales may be struck, killed, and undetected, their loss is not impeding continued population growth or recovery of the species.

Because of the protective mitigation measures and the limited spatial and temporal overlap between the bowheads and the vessels, we conclude that it is extremely unlikely that a bowhead whale will be struck by a research vessel. Thus we determine that the proposed action is not likely to adversely affect bowhead whales.

4.2 Climate Change

One threat common to all the species we discuss in this opinion is global climate change. Because of this commonality, we present an overview of this shared threat here rather than in each of the species-specific narratives. A vast amount of literature is available on climate change and for more detailed information we refer the reader to these websites which provide the latest data and links to the current state of knowledge on the topic in general, and in the Arctic specifically:

https://www.ipcc.ch/reports/

https://climate.nasa.gov/evidence/

http://nsidc.org/arcticseaicenews/

https://arctic.noaa.gov/Report-Card

The listed marine mammals we consider in this opinion live in the ocean and depend on the ocean for nearly every aspect of their life history. Factors which affect the ocean, like temperature and pH, can have direct and indirect impacts on marine mammals and the resources they depend upon. Global climate change may affect all the species we consider in this opinion, but it is expected to affect them differently. First, we provide background on the physical effects climate change has caused on a broad scale; then we focus on changes that have occurred in Alaska. Finally, we provide an overview of how these physical changes translate to biological effects.

4.2.1 Physical Effects

4.2.1.1 Air Temperature

There is consensus throughout the scientific community that atmospheric temperatures are increasing, and will continue to increase, for at least the next several decades (Watson and Albritton 2001; Oreskes 2004). The Intergovernmental Panel on Climate Change (IPCC) estimated that since the mid-1800s, average global land and sea surface temperature has increased by 0.85°C (±0.2°C), with most of the change occurring since 1976 (IPCC 2019). This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000).

Continued emission of greenhouse gases is expected to cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems (IPCC 2019). The decadal global land and ocean surface average temperature anomaly for 2011–2020 indicates that it was the warmest decade on record for the globe, with a surface global temperature of +0.82°C (+1.48°F) above the 20th century average[1]. This surpassed the previous decadal record (2001–2010) value of +0.62°C (+1.12°F)[2]. The 2020 Northern Hemisphere land and ocean surface temperature was the highest in the 141-year record at +1.28°C (+2.30°F) above average. This was 0.06°C (0.11°F) higher than the previous record set in 2016[2].

The impacts of climate change are especially pronounced at high latitudes. Since 2000, the Arctic (latitudes between 60ºN and 90ºN) has been warming at more than two times the rate of lower latitudes because of "Arctic amplification," a characteristic of the global climate system influenced by changes in sea ice extent, atmospheric and oceanic heat transports, cloud cover, albedo, black carbon, and many other factors[3] (Serreze and Barry 2011; Overland et al. 2017). Across Alaska, average air temperatures have been increasing, and the average annual temperature is now 1.65-2.2°C (3-4°F) warmer than during the early and mid-century (Thoman and Walsh 2019). Winter temperatures have increased by 3.3°C (6˚F) (Chapin et al. 2014) and the snow season is shortening (Thoman and Walsh 2019). The statewide average annual temperature in 2020 was 27.5°F, 1.5°F above the long-term average even though it was the coldest year since 2012[4]. Some of the most pronounced effects of climate change in Alaska include disappearing sea ice, shrinking glaciers, thawing permafrost, and changing ocean

[1] https://www.ncdc.noaa.gov/sotc/global/202013 viewed on 5/31/2021
[2] https://www.ncdc.noaa.gov/sotc/global/202013 viewed on 5/31/2021
[3] NASA wepbage. State of the Climate: How the World Warmed in 2019. Available at https://www.carbonbrief.org/state-of-the-climate-how-the-world-warmed-in-2019, accessed January 20, 2020.
[4] https://www.ncdc.noaa.gov/sotc/national/202013 viewed on 5/31/2021

temperatures and chemistry (Chapin et al. 2014).

4.2.1.2 Ocean Heat

Higher air temperatures have led to higher ocean temperatures. More than 90% of the excess heat created by global climate change is stored in the world's oceans, causing increases in ocean temperature (IPCC 2019; Cheng et al. 2020). The upper ocean heat content, which measures the amount of heat stored in the upper 2000 m (6,561 ft) of the ocean, was the highest on record in 2019 by a wide margin, and is the warmest in recorded human history (Cheng et al. 2020). The seas surrounding Alaska have been unusually warm in recent years, with unprecedented warmth in some cases (Thoman and Walsh 2019). This effect can be seen throughout the Alaska region, including the Bering, Chukchi, and Beaufort seas (Figure 11) (Thoman and Walsh 2019).

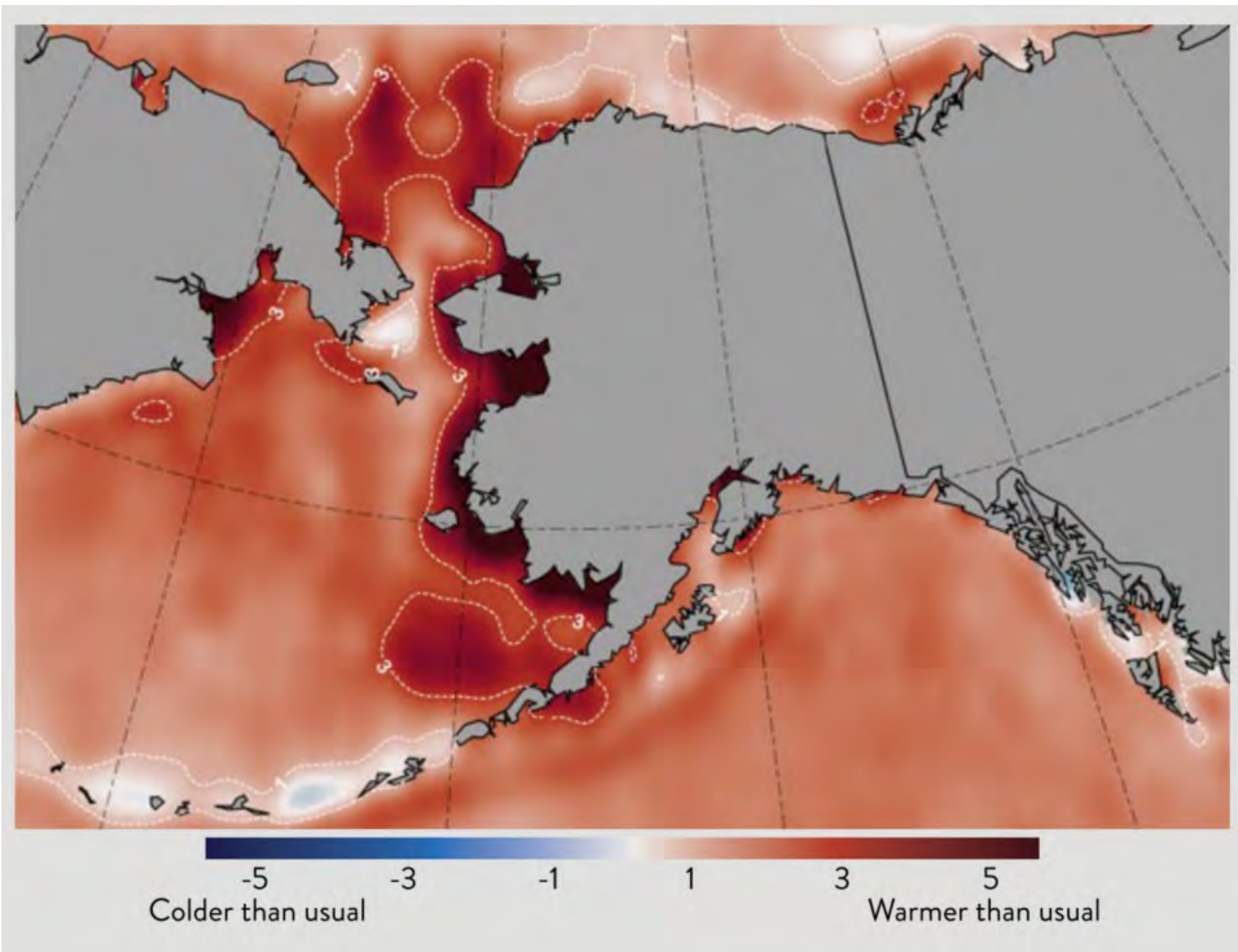

Figure 11. Arctic summer sea surface temperatures, 2019 (Thoman and Walsh 2019).

Warmer ocean water affects sea ice formation and melt. In the first decade of the 21st century, Arctic sea ice thickness and annual minimum sea ice extent (i.e., September sea ice extent) declined at a considerably accelerated rate and continues to decline (Stroeve et al. 2007; Stroeve and Notz 2018) (Figure 12). Approximately three-quarters of summer Arctic sea ice volume has been lost since the 1980s (IPCC 2013). In addition, old ice (> 4 years old), which is thicker and more resilient to melting than young ice, constituted 33% of the ice pack in 1985, but by March

2019, it represented only 1.2% of the ice pack in the Arctic Ocean (Perovich et al. 2019). Multiyear ice for 2021 in the Artic as a whole is at a record low[5]. Overland (2020) suggests that the loss of the thicker older ice makes the Arctic ecosystem less resilient. Both the maximum sea ice extent (March) and the minimum (September) have consistently been decreasing, although the summer minimums are more pronounced (Perovich et al. 2019) (Figure 12). The minimum Arctic sea ice extent in 2019 was effectively tied with 2007 and 2016 for second lowest, only behind 2012, which is the record minimum[6].

Wang and Overland (2009) estimated that the Arctic will become essentially ice-free (i.e., sea ice extent will be less than 1 million km^2) during the summer between the years 2021 and 2043 and modeling with the new generation climate models provides independent support of an ice-free Arctic in mid-century or earlier (Notz and Stroeve 2016; Guarino et al. 2020; SIMIP Community 2020). Once the entire Arctic Ocean becomes a seasonal ice zone, its ecosystem will change fundamentally as sea ice is the key forcing factor in polar oceans (Wassmann et al. 2011).

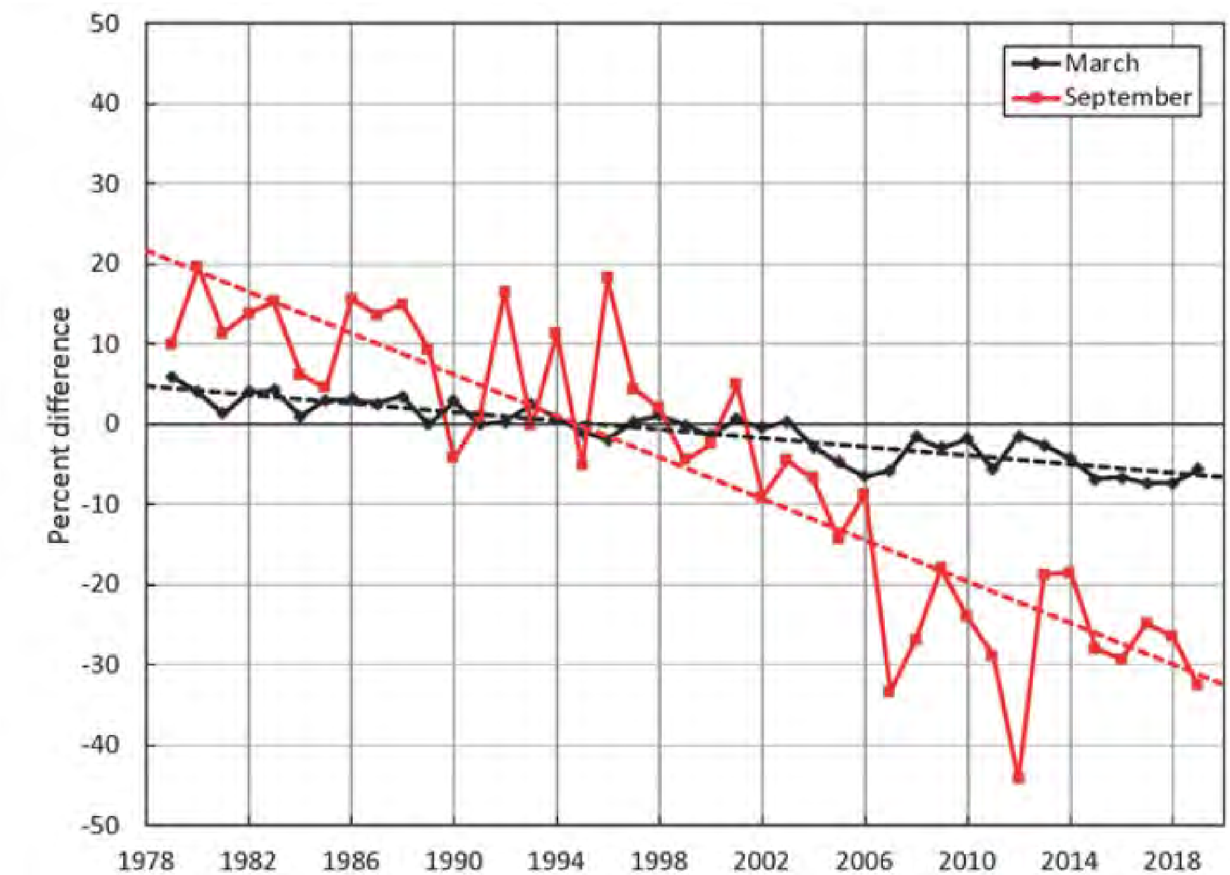

Figure 12. Arctic ice extent declines in September (red) and in March (black). The value for each year is the difference in percent in ice extent relative to the mean values for 1981-2010. Both trends are significant at the 99% confidence level. The slopes of the lines indicate losses of -2.7 for the maximum ice extent and -12.9 percent for the minimum ice extent, per decade.

[5] http://nsidc.org/arcticseaicenews/ viewed August 23, 2021

[6] National Snow and Ice Data Center. Monthly Archives. http://nsidc.org/arcticseaicenews/2019/09/

Related to the loss of sea ice is the northward shift and near loss of the cold-water pool in the eastern Bering Sea. Winter sea ice creates a pool of cold (<2ºC) bottom water that is protected from summer mixing by a thermocline (Mueter and Litzow 2008). With the reduction in winter sea ice, the cold-water pool has shrunk (Figure 13). Many temperate species, especially groundfish, are intolerant of the low temperatures so the extent of sea ice determines the boundary between arctic and subarctic seafloor communities and demersal vs pelagic fish communities (Grebmeier et al. 2006). In the Pacific Arctic, large scale, northward movements of commercial stocks are underway as previously cold-dominated ecosystems warm and fish move northward to higher latitude, relatively cooler environments (Grebmeier et al. 2006; Eisner et al. 2020). Not only fish, but plankton, crabs and ultimately, sessile invertebrates like clams are affected by these changes in water temperature (Grebmeier et al. 2006; Fedewa et al. 2020).

Another ocean water anomaly is described as a marine heat wave. Marine heat waves are described as a coherent area of extreme warm temperature at the sea surface that persists (Frölicher et al. 2018). Marine heatwaves are a key ecosystem driver and there has been an increase from 30 percent in 2012 to nearly 70 percent of global oceans in 2016 experiencing strong or severe heatwaves (Suryan et al. 2021). The largest recorded marine heat wave occurred in the northeast Pacific Ocean from 2013-2015 (Frölicher et al. 2018). Initially called "the blob" the northeast Pacific marine heatwave (PMH) first appeared off the coast of Alaska in the winter of 2013-2014 and by the end of 2015 it stretched from Alaska to Baja California. In mid-2016, the PMH began to dissipate, based on sea surface temperature data but warming re-intensified in late-2018 and persisted into fall 2019 (Suryan et al. 2021). Consequences of this event included an unprecedented harmful algal bloom that extended from the Aleutian Islands to southern California, mass strandings of marine mammals, shifts in the distribution of invertebrates and fish, and shifts in abundance of several fish species (Cavole et al. 2016). Cetaceans, forage fish (capelin and herring), Steller sea lions, adult cod, chinook and sockeye salmon in the Gulf of Alaska were all impacted by the PMH (Bond et al. 2015; Peterson et al. 2016; Sweeney et al. 2018).

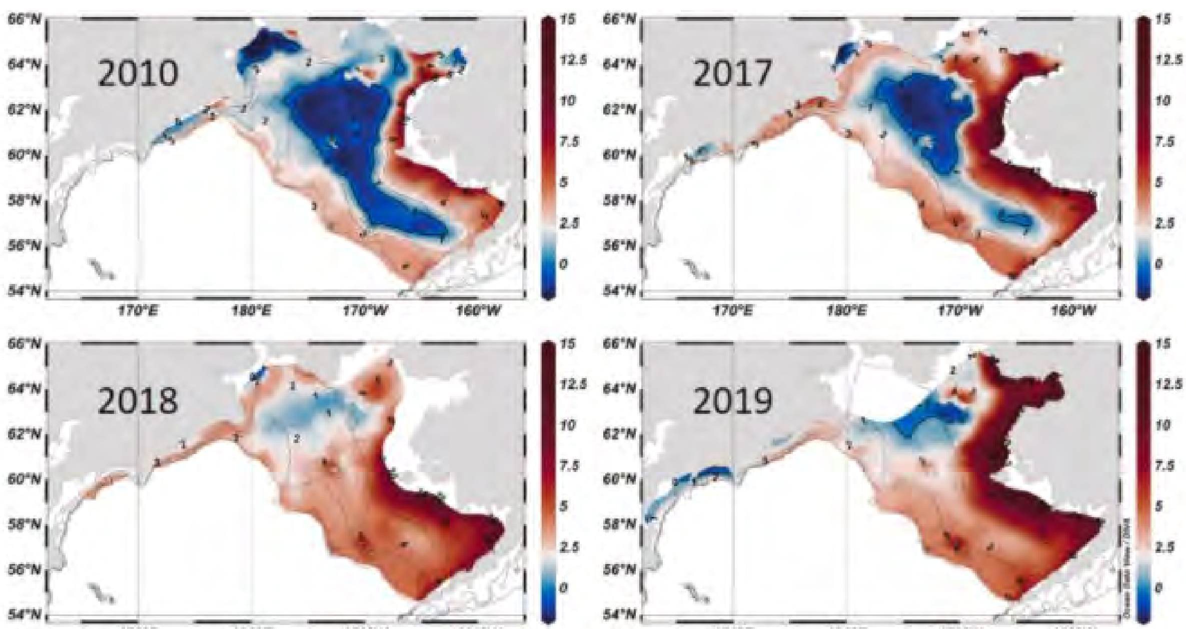

Figure 13. Bottom temperatures from summer oceanographic surveys. Graphic display of the shrinkage of the cold pool over time. From (Eisner et al. 2020).

The 2018 Pacific cod stock assessment[7] estimated that the female spawning biomass of Pacific cod (an important prey species for Steller sea lions) was at its lowest point in the 41-year time series, following three years of poor recruitment and increased natural mortality as a result of the PMH. In 2020 the spawning stock biomass dropped below 20 percent of the unfished spawning biomass and the federal Pacific cod fishery in the Gulf of Alaska was closed by regulation to directed Pacific cod fishing (Barbeaux et al. 2020). Twenty percent is a minimum spawning stock size threshold instituted to help ensure adequate forage for the endangered western stock of Steller sea lions.

4.2.1.3 Ocean Acidification

For 650,000 years or more, the average global atmospheric carbon dioxide (CO_2) concentration varied between 180 and 300 parts per million (ppm), but since the beginning of the industrial revolution in the late 1700s, atmospheric CO_2 concentrations have been increasing rapidly, primarily due to anthropogenic inputs (Fabry et al. 2008; Lüthi et al. 2008). The world's oceans have absorbed approximately one-third of the anthropogenic CO_2 released, which has buffered the increase in atmospheric CO_2 concentrations (Feely et al. 2004; Feely et al. 2009). Despite the oceans' role as large carbon sinks, the CO_2 level continues to rise and is currently over 410 ppm[8].

As the oceans absorb CO_2, the pH of seawater is reduced. This process is referred to as ocean acidification. Ocean acidification reduces the saturation states of certain biologically important calcium carbonate minerals like aragonite and calcite that many organisms use to form and maintain shells (Bates et al. 2009; Reisdorph and Mathis 2014). When seawater is supersaturated with these minerals, calcification (growth) of shells is favored. Likewise, when the sea water becomes undersaturated, dissolution is favored (Feely et al. 2009).

High latitude (colder) oceans have naturally lower saturation states of calcium carbonate minerals than more temperate or tropical waters, making Alaska's oceans more susceptible to the effects of ocean acidification (Fabry et al. 2009; Jiang et al. 2015). Model projections indicated that aragonite undersaturation would start to occur by about 2020 in the Arctic Ocean and by 2050, all of the Arctic will be undersaturated with respect to aragonite (Feely et al. 2009; Qi et al. 2017). Large inputs of low-alkalinity freshwater from glacial runoff and melting sea ice contribute to the problem by reducing the buffering capacity of seawater to changes in pH (Reisdorph and Mathis 2014). As a result, seasonal undersaturation of aragonite was already detected in the Bering Sea at sampling stations near the outflows of the Yukon and Kuskokwim Rivers, and the Chukchi Sea (Fabry et al. 2009). Models and observations indicate that rapid sea ice loss will increase the uptake of CO_2 and exacerbate the problem of aragonite undersaturation in the Arctic (Yamamoto et al. 2012; DeGrandpre et al. 2020).

Undersaturated waters are potentially highly corrosive to any calcifying organism, such as corals, bivalves, crustaceans, echinoderms and many forms of zooplankton such as copepods and pteropods, and consequently may affect Arctic food webs (Fabry et al. 2008; Bates et al. 2009). Pteropods, which are often considered indicator species for ecosystem health, are prey for many species of carnivorous zooplankton, fishes including salmon, mackerel, herring, and cod, and

[7] NOAA Fisheries, Alaska Fisheries Science Center website. Available at https://apps-afsc.fisheries.noaa.gov/REFM/stocks/Historic_Assess.htm, accessed December 2, 2020.
[8] NOAA Global Monitoring Laboratory website. Trends in Atmospheric Carbon Dioxide. Available at https://www.esrl.noaa.gov/gmd/ccgg/trends/, accessed November 10, 2020.

baleen whales (Orr et al. 2005). Because of their thin shells and dependence on aragonite, under increasingly acidic conditions, pteropods may not be able to grow and maintain shells (Lischka and Riebesell 2012). It is uncertain if these species, which play a large role in supporting many levels of the Alaskan marine food web, may be able to adapt to changing ocean conditions (Fabry et al. 2008; Lischka and Riebesell 2012)

4.2.2 Biological Effects

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Hinzman et al. 2005; Burek et al. 2008; Doney et al. 2012; Huntington et al. 2020). The physical effects on the environment described above have impacted, are impacting, and will continue to impact marine species in a variety of ways (IPCC 2014), such as:

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

Some of the biological consequences of the changing Arctic conditions are shown in Table 5.

Table 5. A summary of possible direct and indirect health effects for Arctic marine mammals related to climate change, adapted from (Burek et al. 2008).

Effect	Result
Direct	
Increase in ocean temperature	Changes in distribution and range (fish, whales) Increase in harmful algal blooms (all affected) Loss of suitable habitat Change in prey base
Loss of sea ice platform (seals)	Reduction of suitable habitat for feeding, resting, molting, breeding Movement, distribution, life history may be affected
Changes in weather	Reduction in snow on sea ice, loss of suitable lair habitat for ringed seals
Ocean acidification	Changes in prey base (all affected)
Indirect	

Effect	Result
Changes in infectious disease transmission (changes in host–pathogen associations due to altered pathogen transmission or host resistance)	Increased host density due to reduced habitat, increasing density-dependent diseases. Epidemic disease due to host or vector range expansion. Increased survival of pathogens in the environment. Interactions between diseases, loss of body condition, and increased immunosuppressive contaminants, resulting in increased susceptibility to endemic or epidemic disease.
Alterations in the predator–prey relationship	Affect body condition and, potentially, immune function.
Changes in toxicant pathways (harmful algal blooms, variation in long-range transport, biotransport, runoff, increased use of the Arctic)	Mortality events from biotoxins Toxic effects of contaminants on immune function, reproduction, skin, endocrine systems, etc.
Other negative anthropogenic impacts related to longer open water period	Increased likelihood of ship strikes, fisheries interactions, acoustic injury Chemical and pathogen pollution due to shipping or aquaculture practices. Introduction of nonnative species

Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2009). For species that rely primarily on sea ice for major parts of their life history, we expect that the loss of sea-ice would negatively impact those species' ability to thrive. Consequently, we expect the future population viability of at least some ESA-listed species to be affected with global warming.

Changes in ocean surface temperature may impact species migrations, range, prey abundance, and overall habitat quality. For ESA-listed species that undertake long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperature regimes, the timing of migration can change. For example, cetaceans with restricted distributions linked to cooler water temperatures may be particularly exposed 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 (Macleod 2009).

4.3 Status of Listed Species Likely to be Adversely Affected by the Action

This opinion examines the status of the species likely to 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. The opinion also examines the condition of critical habitat throughout the designated area and discusses the current function of the essential Physical and Biological Features that help to form that conservation value (discussed above).

For each species, we present a summary of information on the population structure and distribution to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether an action's effects are likely to increase the species' probability of becoming extinct.

The only species likely to be adversely affected by the proposed action is the ringed seal. More detailed background information on the status of ringed seal can be found in a number of published documents including stock assessment reports on Alaska marine mammals by Muto et al. (2021). Kelly et al. (2010b) provided a status review of ringed seals. Richardson et al. (1995), Tyack (2000), and Tyack (2009) provided detailed analyses of the functional aspects of cetacean communication and their responses to anthropogenic noise.

4.3.1 Ringed seal

4.3.1.1 Status and Population Structure

Under the MMPA, NMFS recognizes one stock of Arctic ringed seals, the Alaska stock, in U.S. waters (and the action area). 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). NMFS has not prepared a Recovery Plan for the Arctic ringed seal.

Ringed seal population surveys in Alaska used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current and comprehensive 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 et al. (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 Alaska 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 reliable 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. For the purposes of the IHA, the Permits Division used a conservative population estimate of 171,418 (95 percent CI: 141,588-201,090) based on a subsample of data collected from the U.S. portion of the Bering Sea in 2012 (Conn et al. 2014).

4.3.1.2 Distribution

Arctic ringed seals have a circumpolar distribution and are found throughout the Arctic basin and in adjacent seasonally ice-covered seas. 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. 2010).

4.3.1.3 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 1988), and therefore are in the study area. 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). At the onset of the fall freeze, ringed seal movements become increasingly restricted and seals will often move west and south with the advancing ice pack into the Chukchi and Bering Seas, while some remain in the Beaufort Sea (Frost and Lowry 1984; Crawford et al. 2012; Harwood et al. 2012).

A density estimate of 0.3958 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.

4.3.1.4 Feeding, Diving, Hauling out and Social Behavior

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 for 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). After a 5 to 8 week lactation period, pups are weaned (Lydersen and Hammill 1993; Lydersen and Kovacs 1999).

Mating is thought to take place under the ice in the vicinity of birth lairs while mature females are still lactating (Kelly et al. 2010a). 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 ice (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). Figure 14 summarizes the approximate annual timing of Arctic ringed seal reproduction and molting (Kelly et al. 2010a).

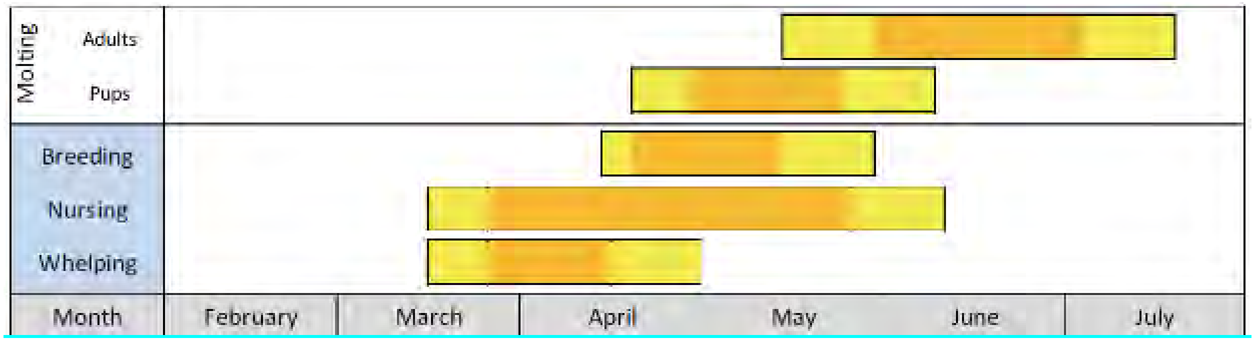

Figure 14. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the “normal” range over which each event is reported to occur and orange bars indicate the “peak” timing of each event (Kelly et al. 2010a).

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 tended to be true during the late summer, fall, and winter (Kelly and Quakenbush 1990; Lydersen 1991; Teilmann et al. 1999; Carlens et al. 2006; Kelly et al. 2010a; Kelly et al. 2010b).

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, and preferred prey tends to be schooling species that form dense aggregations. 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 (Lowry et al. 1980; Smith 1987; Holst et al. 2001; Labansen et al. 2007). Quakenbush et al. (2011) reported evidence that in general, the diet of Arctic ringed seals sampled from Alaska waters consisted of cod, amphipods, and shrimp. Fish are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by availability of various types of prey during particular seasons as well as preference, which in part is guided by energy content of various available prey (Reeves 1998; Wathne et al. 2000). Invertebrate prey seem to become more important in the diet of Arctic ringed seals in the open-water season and often dominate the diet of young animals (e.g., Lowry et al. 1980; Holst et al. 2001).

4.3.1.5 Hearing, Vocalizations, and Other Sensory Capabilities

Ringed seals vocalize underwater in association with territorial and mating behaviors. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, and make calls between 90 Hz and 16 kHz (Richardson et al. 1995). NMFS defines the function hearing range for phocids as 50 Hz to 86 kHz (NMFS 2018).

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

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).

5.1 Climate Change

All areas of the action area are being affected by climate change. Although the species living in the Arctic successfully adapted to the slow changes in the climate that occurred over thousands of years, the current rate of change is accelerated (Simmonds and Eliott. 2009). As described in Section 4.2, effects to Arctic ecosystems are very pronounced, wide-spread, and well documented. While a changing climate may create opportunities for range expansion for some species, the life cycles and physiological requirements of many specialized polar species are closely linked to the annual cycles of sea ice and photoperiod and they may be less adaptable (Doney et al. 2009; Wassmann et al. 2011). Because the rate of change is occurring so quickly, the changes may exceed species' ability to adapt. Additionally, the loss of sea ice as a barrier increases the potential for further anthropogenic impacts as vessel traffic for transportation and tourism increases, resource extraction activities expand, and pathogens or disease have a path into newly ice-free regions.

As discussed in Section 4.2, the Arctic is warming at two or more times the global average. One consequence of the warming is a reduction in the length of the snow season (Figure 15). The depth and duration of snow cover are projected to continue to decline substantially throughout the range of the Arctic ringed seal, reducing the areas with suitable snow depths for their lairs by an estimated 70 percent by the end of this century (Hezel et al. 2012). It has been observed that the mean thickness of snow accumulating on sea ice has declined from approximately 35 to 22 cm in the western Arctic and 33 to 15 cm in the Beaufort and Chukchi Seas since the mid-1900s (Webster et al. 2014). A decrease in the availability of suitable sea ice conditions (including depth of snow on ice available for lair formation) may not only lead to high mortality of ringed seal pups, but may also produce behavioral changes in seal populations (Loeng et al. 2005). The persistence of this species will likely be challenged as decreases in ice and, especially, snow cover lead to increased juvenile mortality from premature weaning, hypothermia, and predation (Kelly et al. 2010b; Reimer et al. 2019). For example, 2018 and 2019 were two anomalously warm years in Kotzebue Sound. Although there was deep snow sufficient for lairs, the weight of the snow on thin ice created widespread surface flooding, an unfavorable situation for young ringed seal pups (Mahoney et al. 2021). Situations such as this could have an additional negative effect on ringed seal pup survival if alternative dry lairs are unavailable.

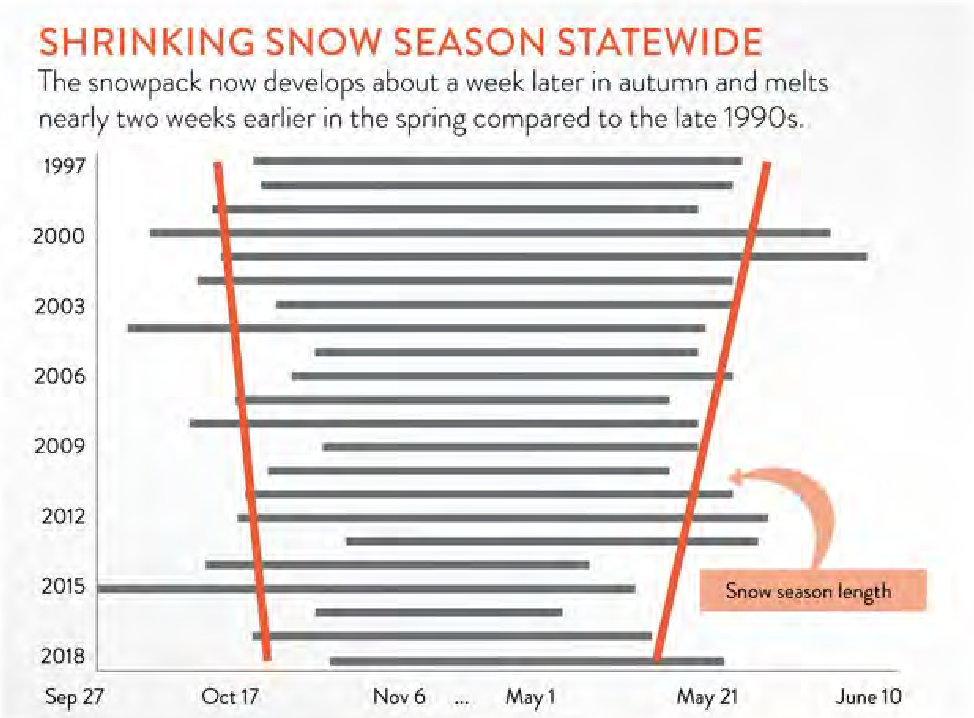

Figure 15. Length of the snow season (gray bars) in Alaska each year from 1997-2018. Orange slanting bars show the trends of the date when the state becomes 50 percent snow covered in fall and when half the winter snow has melted in spring. Image by Rick Thoman, Alaska Center for Climate and Policy.

Because the sea ice extent and thickness have been decreasing consistently, vessel traffic, and more importantly for seals, ice breaker traffic will be increasing in the Arctic (U.S. Committee on the Marine Transportation System 2019; NMFS 2020). Although seals are maneuverable enough to avoid vessels in open water, icebreakers could be lethal to nursing pups through collisions or crushing by displaced ice (Wilson et al. 2017; Wilson et al. 2020). In a study of Caspian seals (*Pusa capsica)* from 2006-2013, Wilson et al. (2017) documented the response of seals to ice breakers that made regular transits across the Caspian Sea. The ice breaking route had high densities of breeding seals in most years. A whole range of impacts to mothers and their pups was documented including being struck by the ice breaker, moving away from the ice breaker as it approached, and having mothers and pups separated. Vessel passage may destroy birth sites, water access holes, and pup shelters replacing those features with brash ice or open water. Often pups were marooned on fragments of intact ice or wetted in brash ice. Fragmented brash ice may cause disorientation, stress, and increased energetic demands (Wilson et al. 2017). With the Northern Sea Route and Northwest Passage being available more often and with the potential of a trans-Arctic route and an increase in icebreakers, we would expect that ice dependent seals could be affected.

In addition to these observations, passive acoustic monitors (PAM) have been recording the presence of subarctic species, including killer whales, in various parts of the Chukchi Sea (Delarue et al. 2013; Hannay et al. 2013; Crance et al. 2015; Tsujii et al. 2016). These species generally arrive in the southern Chukchi Sea after the sea ice melts (late July) and leave before it extends over the area in October or early November (Hannay et al. 2013; Tsujii et al. 2016). PAM also recorded the farthest northeast record of fin whale calls in the Alaskan Arctic (Crance et al. 2015). We would expect as sea ice continues to decline, presence of these subarctic species in more northerly latitudes will increase.

5.1.1 Biotoxins

As temperatures in the Arctic waters warm and sea ice diminishes, marine mammal health may be compromised through nutritional and physiological stress, toxins from harmful algal blooms, and exposure to new pathogens. As mentioned in Section 4.2.1.2, an unprecedented harmful algal bloom extended from the Aleutian Islands to southern California as a result of the Pacific marine heatwave causing mass strandings of marine mammals (Cavole et al. 2016). Fey et al. (2015) found that across all animal taxa, biotoxicity from harmful algal blooms was one of the events most often associated with mass mortality events. Two of the most common biotoxins along the West Coast of the Pacific are the neurotoxins domoic acid and saxitoxin (Lefebvre et al. 2016). Although these toxins can cause death, they can also cause sublethal effects including reproductive failure and chronic neurological disease (Broadwater et al. 2018).

Domoic acid was first recognized as a threat to marine mammal health in 1998 when hundreds of California sea lions (*Zalophus californianus*) died along beaches in central California or exhibited signs of neuroexcitotoxicity including seizures, head weaving, and ataxia (Scholin et al. 2000). Along the west coast of the United States and Canada, a coastwide bloom of the toxigenic diatom *Pseudo-nitzschia* in spring 2015 resulted in the largest recorded outbreak of domoic acid. Record-breaking concentrations of the marine neurotoxin caused unprecedented widespread closures of commercial and recreational shellfish and finfish fisheries and contributed to the stranding of numerous marine mammals along the U.S. west coast (McCabe et al. 2016).

Lefebvre et al. (2016) examined 13 species of marine mammals from Alaska including humpback whales, bowhead whales, beluga whales, harbor porpoises, northern fur seals, Steller sea lions, harbor seals, ringed seals, bearded seals, spotted seals, ribbon seals, Pacific walruses, and northern sea otters (Figure 16). Domoic acid was detected in all 13 species examined and had the greatest prevalence in bowhead whales (68%) and harbor seals (67%). Saxitoxin was detected in 10 of the 13 species, with the highest prevalence in humpback whales (50%) and bowhead whales (32%) and 5% of the animals tested had both toxins present (Lefebvre et al. 2016). It is not known if exposure to multiple toxins result in additive or synergistic effects or perhaps suppress immunity to make animals more vulnerable to secondary stressors (Broadwater et al. 2018). With declining sea ice, warmer water temperatures, and changes in ocean circulation patterns, NOAA anticipates that harmful algal blooms in the Arctic will likely worsen in the future[9].

[9] NOAA Arctic Program. Arctic Report Card: Update for 2018, Available at https://arctic.noaa.gov/Report-Card/Report-Card-2018/ArtMID/7878/ArticleID/789/Harmful-Algal-Blooms-in-the-Arctic, accessed November 10, 2020.

Figure 16. Algal toxins detected in 13 species of marine mammals from southeast Alaska to the Arctic from 2004 to 2013 (Lefebvre et al. 2016).Marine mammal species are listed as follows: (A) humpback whales, (B) bowhead whales, (C) beluga whales, (D) harbor porpoises, (E) northern fur seals, (F) Steller sea lions, (G) harbor seals, (H) ringed seals, (I) bearded seals, (J) spotted seals, (K) ribbon seals, (L) Pacific walruses and (M) northern sea otters.

5.1.2 Disease

In addition to influencing animal nutrition and physiological stress, environmental shifts caused by climate change may foster exposure to new pathogens in Arctic marine mammals. Through altered animal behavior and absence of physical barriers, loss of sea ice may create new pathways for animal movement and introduction of infectious diseases into the Arctic. The health impacts of this new normal in the Arctic are unknown, but new open water routes through the Arctic suggest that opportunities for Phocine distemper virus (PDV) and other pathogens to cross between North Atlantic and North Pacific marine mammal populations may become more common (VanWormer et al. 2019). PDV is a pathogen responsible for extensive mortality in European harbor seals (*Phoca vitulina vitulina*) in the North Atlantic. Prior to 2000, serologic surveys of Pacific harbor seals (*Phoca vitulina richardsii*), Steller sea lions, and northern sea otters off Alaska showed little evidence of exposure to distemper viruses, and PDV had not been identified as a cause of illness or death. PDV was not confirmed in the North Pacific Ocean until it was detected in northern sea otters sampled in 2004 (VanWormer et al. 2019). In addition to PDV, *Brucella*, and Phocid herpesvirus-1 have been found in Alaskan marine mammals (Zarnke et al. 2006). Herpesviruses were implicated in fatal and nonfatal infections of harbor seals in the North Pacific (Zarnke et al. 2006).

Ringed and bearded seals have co-evolved with numerous parasites and diseases, and these relationships are presumed to be stable. However, 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 and deaths has been identified.

Likewise, in 2019, a UME was declared for bearded, ringed, and spotted seals in the Bering and Chukchi seas because of elevated mortality documented starting in June 2018 and continuing through the summer of 2019[10]. Since June 1, 2018, NMFS confirmed 368 strandings[11] (Table 6). The cause of the UME has not been determined but many of the seals had low fat thickness suggesting illness or inadequate prey. All age classes were affected. The seals that were sampled did not have the hair loss or skin lesions that were prominent in the prior UME. Subsistence hunters noted that some of the seals had less fat than normal. The lowest sea ice maximums occurred in 2017 and 2018 when the retreat of sea ice was very rapid. It is unknown if these extreme sea ice conditions played a role in the health of the seals.

Table 6. Stranded seals in the Bering and Chukchi seas from 2018-2021.

Year	Bearded	Ringed	Spotted	Unidentified	Total
2018 (June 1-Dec 31)	35	29	20	28	112
2019	49	36	23	57	165
2020	10	9	8	11	38
2021	11	22	8	14	55
2022 (as of January 7)	0	0	0	0	0
Total*	**106**	**95**	**62**	**105**	**368**
*June 1, 2018 - 7 January 2022. Source: https://www.fisheries.noaa.gov/alaska/marine-life-distress/2018-2020-ice-seal-unusual-mortality-event-alaska					

5.2 Fisheries

Commercial, subsistence, and recreational fisheries along the marine transit route portion of the action area may harm or kill listed marine species through direct bycatch, gear interactions (entrapments and entanglements), vessel strikes, contaminant spills, habitat modification, competition for prey, and behavioral disturbance or harassment.

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). Fisheries interactions have an impact on

[10] Barbara Mahoney, 2019, unpublished document. Ice Seal UME Update in the Alaska Region Marine Mammal Stranding Network Fall/Winter 2019 newsletter.
[11] NOAA Fisheries. 2018-2020 Ice seal unusual mortality event in Alaska webpage. Available at: https://www.fisheries.noaa.gov/alaska/marine-life-distress/2018-2020-ice-seal-unusual-mortality-event-alaska, accessed November 10, 2020.

many marine mammal species. More than 97 percent of whale entanglements are caused by derelict fishing gear (Baulch and Perry 2014). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002a). Mortality from entanglement may be underreported, as many marine mammals that die from entanglement tend to sink rather than strand ashore. Entanglement may also make marine mammals more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed.

Entanglement can include many different gear interaction scenarios, but the following have occurred with listed species covered in this opinion:

- Ingestion of gear and/or hooks causing serious injury depending on whether the gear worked its way into the gastrointestinal tract, whether the gear penetrated the gastrointestinal tract lining, was lodged in the esophagus, and the location of the hooking (e.g., embedded in the animal's stomach or other internal body parts) (Andersen et al. 2008; Helker et al. 2019).
- Gear loosely wrapped around the marine mammal's body that moved or shifted freely with the marine mammal's movement and did not indent the skin in a way that caused disfigurement.
- Gear that encircled any body part and had sufficient tension to either indent the skin or to not shift with marine mammal's movement, causing lacerations, partial or complete fin amputation, organ damage, or muscle damage and interfered with mobility, feeding, and breathing.

From 2013 to 2017, the minimum estimated mean annual mortality and serious injury rate for bearded seals in U.S. commercial fisheries was 1.6 from three federally-managed US commercial fisheries in the Bering Sea and Aleutian Islands (Bering Sea/Aleutian Islands (BSAI) pollock trawl, BSAI flatfish trawl, and BSAI Pacific trawl fisheries) (Muto et al. 2020). During the same timeframe, the minimum estimated mean annual mortality and serious injury rate for ringed seals by the U.S. commercial fisheries was 2.4 for BSAI flatfish trawl (Muto et al. 2020). Entanglement and entrapment in trawl fishery gear was the leading cause of human-caused serious injury and mortality for all phocids analyzed (Freed et al. 2022).

Because no commercial fisheries occur in the Chukchi and Beaufort seas, any observed serious injury or mortality to listed species in the Arctic that can be associated with commercial fisheries is currently attributable to interactions with fisheries in other areas, including in the Bering Sea/Aleutian Islands (BSAI) management area and Gulf of Alaska (GOA). For example, George et al. (2017) analyzed scarring data for bowhead whales harvested between 1990 and 2012 to estimate the frequency of line entanglement. Approximately 12 percent of the harvested whales examined had scar patterns that were identified with high confidence as entanglement injuries. The authors suspected the entanglement scars were largely the result of interactions with derelict fishing/crab gear in the Bering Sea.

5.3 Oil & Gas

Oil and gas exploration activities have occurred on the North Slope since the early 1900s, and oil production started at Prudhoe Bay in 1977. Oil production has occurred for over 40 years in the region, and presently spans from the Alpine field, which is approximately 96 km (60 mi) west of Prudhoe Bay, to the Point Thomson project, which is approximately 96 km east of Prudhoe Bay. Additionally, onshore gas production from the Barrow gas field began over 60 years ago. Associated industrial development has included the creation of industry-supported community airfields at Deadhorse and Kuparuk, and an interconnected industrial infrastructure that includes roadways, pipelines, production and processing facilities, gravel mines, and docks.

Offshore oil and gas development in Alaska poses a number of threats to listed marine species, including increased ocean noise, risk of hydrocarbon spills, production of waste liquids, habitat alteration, increased vessel traffic, risk of ship strike, and increased greenhouse gas emissions. NMFS reviewed the potential effects of oil and gas development in a Final Environmental Impact Statement for the effects of oil and gas activities in the Arctic Ocean (NMFS 2013) and has conducted numerous Section 7 consultations on oil and gas activities in the Chukchi and Beaufort Seas (available at https://www.fisheries.noaa.gov/alaska/consultations/section-7-biological-opinions-issued-alaska-region).

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. Geophysical seismic survey activity has been described as one of the loudest man-made underwater noise sources, with the potential to harass or harm marine mammals (Richardson et al. 1995). Controlled-source, deep-penetration reflection seismology, similar to sonar and echolocation, is the primary tool used for onshore and offshore oil exploration (Smith et al. 2017). Seismic surveys are conducted by towing long arrays of sensors affixed to wires at approximately 10 knots behind large vessels following a survey grid. High power air cannons are fired below the water surface, and the sound waves propagate through the water and miles into the seafloor. When those soundwaves encounter strong impedance contrasts (e.g., between water and the ocean floor, or between different densities of substrates), a reflection signal is detected by the sensors. Those signals can be interpreted to determine the stratigraphy of the substrate and identify oil and gas deposits.

Seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea since the late 1960s and early 1970s, resulting in extensive coverage over the area. Seismic surveys vary, but a typical two-dimensional/three-dimensional (2D/3D) seismic survey with multiple guns emits sound at frequencies of about 10 Hz to 3 kHz (Austin et al. 2015). Seismic airgun sound waves are directed towards the ocean bottom, but can propagate horizontally for several kilometers (Greene and Richardson 1988; Greene and Moore 1995). Analysis of sound associated with seismic operations in the Beaufort Sea and central Arctic Ocean during ice-free conditions also documented propagation distances up to 1,300 km (808 mi) (Richardson 1998; Richardson 1999; Thode et al. 2010). Because the Chukchi Sea continental shelf has a highly uniform depth of 30 to 50 m (98 to 164 ft), it strongly supports sound propagation in the 50 to 500 Hz frequency band (Funk et al. 2008). The noise generated from seismic surveys has been linked to behavioral disturbance of wildlife and potential auditory injury to marine mammals in the marine environment (Smith et al. 2017). Seismic surveys are often accompanied by test drilling. Test drilling involves fewer direct impacts than seismic exploration, but the potential risks of test drilling, such as oil spills, may have broader consequences (Smith et al. 2017). Oil and gas exploration, including seismic surveys, occur within the action area.

NMFS has conducted numerous ESA section 7 consultations related to oil and gas activities in the Chukchi and Beaufort seas. Many of the consultations have estimated take of ringed and bearded seals from sounds produced during geophysical (including seismic) surveys and other exploration and development activities. Although large numbers of take for ringed and bearded seals have been estimated for seismic surveys related to oil and gas exploration, several of those projects never came to fruition, and the ones that did occur, reported that a small fraction of the estimated take actually happened or was observed to have happened (NMFS unpublished data). Currently we have no evidence that the take which has occurred from oil and gas exploration has had a lasting adverse effect on bearded and ringed seal individuals or populations.

5.3.1 Pollution 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 ringed and bearded seals 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). Polycyclic aromatic hydrocarbons are also emitted to the atmosphere by flaring waste gases at production platforms or gas treatment facilities. For example, approximately 162,000 million standard cubic feet of waste gas was flared at Northstar in 2004 (Neff 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 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 General Permit (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 outer continental shelf (OCS) is also the CWA. Discharges are covered under the Vessel Incidental Discharge Act, which is in the new CWA Section 312(p)[12]. 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.

5.3.2 Spills

BOEM and BSEE define small oil spills as <1,000 barrels (bbl). Large oil spills are defined as 1,000-150,000 bbl, and very large oil spills (VLOS) are defined as ≥ 150,000 bbl (BOEM 2017). Offshore petroleum exploration activities have been conducted in State of Alaska waters adjacent of the Beaufort and Chukchi seas since the late 1960s. Based on a review of potential discharges and on the historical oil spill occurrence data for the Alaska OCS and adjacent State of Alaska waters, several small spills in the Beaufort Sea from refueling operations (primarily at West Dock) were reported to the National Response Center. Small oil spills have occurred with routine frequency and are considered likely to occur (BOEM 2017).

In the past 30 years, 43 wells have been drilled in the Beaufort and Chukchi seas lease program areas. From 1985 to 2013, eight crude oil spills of ≥ 550 bbl were documented along the Alaska North Slope, one of which was ≥ 1,000 bbl. During the same time period, total North Slope production was 12.80 billion bbl (Bbbl) of crude oil and condensate. From 1971 through 2011, the highest mean volume of North Slope spills was from pipelines. The mean spill size for pipelines was 145 bbl. The spill rate for crude oil spills ≥ 500 bbl from pipelines (1985 to 2013) was 0.23 pipeline spills per Bbbl of oil produced (BOEM 2016).

From 1995 to 2012, approximately 400 spills (100 to 300,000 gallons) occurred in Alaska's marine waters. Most were in nearshore and shallow coastal waters and were primarily diesel (BLM 2019). Only 1 percent of the spills were crude oil. If a pinniped came in direct contact with a small, refined oil spill it could experience inhalation and respiratory distress from hydrocarbon vapors, or ingestion directly or indirectly by consuming contaminated prey, and less likely skin and conjunctive tissue irritation (Engelhardt 1987). Oil may also foul pinniped pelage and be ingested during cleaning. Small offshore spills of refined petroleum products are expected to dissipate rapidly. A small spill could impact pinnipeds through their ingestion of contaminated prey, but prey contamination likely would be localized and temporary.

Marine mammals can ingest spilled compounds while feeding, inhale the volatile components, or be affected by direct contact. Effects of oil ingestion on marine mammals can range from progressive organ damage to death, depending on the quantity and composition of the ingested

[12] https://www.epa.gov/vessels-marinas-and-ports/vessel-incidental-discharge-act-vida

oil (Geraci and St. Aubin 1990). The effects of an oil spill on ringed or bearded seals would depend largely on the size, season, and location of the spill. Surface contact with oil spills can damage mucous membranes and eyes of seals, or disrupt thermoregulation in seal pups (Geraci and St. Aubin 1990). If a spill were to occur during the ice free, open water season, seals may be exposed to oil through direct contact, or perhaps through contaminated food items. However, St. Aubin (1990) notes that with their keen sense of olfaction and good sense of vision ringed and bearded seals may be able to detect and avoid oil spills in the open water season (St. Aubin 1990).

Immersion studies by Geraci and Smith (1976a) found ringed seals may develop mild liver injury, kidney lesions, and eye injury from immersion in crude oil. The eye damage was often severe, suggesting permanent eye damage might occur with longer periods of exposure to crude oil, and the overall severity of the injuries was most likely associated with the exposure duration to crude oil. Geraci and Smith (1976a) concluded the direct effects of an oil blow-out or spill may result in transient eye damage to healthy seals in open water; however, ringed seals exposed to a slick of crude oil showed no impairment in locomotion or breathing. It is expected that weathering would quickly break up or dissipate small oil or fuel spills to residual levels that eventually become undetectable.

If ringed seals have encountered any of the spills that have occurred, they have not been observed or documented. The small size of the spills and the dispersive action of waves and currents likely has reduced the probability of an encounter and adverse reaction to extremely low levels. While the potential for a large spill exists, and could have devastating effects on ringed seals, we have no evidence that the spills which have occurred are negatively affecting ringed seals at this time.

5.3.3 Contaminants Found in Listed Species

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).

Heavy metals can enter marine mammals through uptake from the atmosphere through the lungs, absorption through the skin, across the placenta before birth, via milk during lactation, ingestion of sea water, and ingestion of food (Vos et al. 2003). The major route of heavy metal contamination for marine mammals seems to be via feeding. Additionally, being a top predator in the food web can influence heavy metal levels, such as mercury, especially in marine mammals relying on fish (Vos et al. 2003).

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

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. 2010). Gaden et al. (2009) suggested that during ice-free periods the seals eat more Arctic cod (and mercury). They also found that mercury levels increased with age for both sexes (Dehn et al. 2005; Gaden et al. 2009). Becker et al. (1995) reported ringed seals had higher levels of arsenic in Norton Sound (inlet in the Bering Sea) than ringed seals taken by residents of Point Hope, Point Lay, and Barrow (now Utqiaġvik). Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals, which might reflect localized natural arsenic sources. Climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic (Tynan and Demaster 1997).

5.4 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 increasing (Azzara et al. 2015; Silber and Adams 2019; Gunnarsson 2021; Halliday et al. 2021b). This includes the northern Bering Sea, the Bering Strait, Chukchi Sea, and Beaufort Sea to the Canadian border. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the near-shore waters off Prudhoe Bay from oil and gas exploration activity was particularly pronounced in 2012 because of offshore exploratory drilling conducted by Shell on the OCS of the Chukchi Sea that year (Azzara et al. 2015; ICCT 2015) Figure 17.

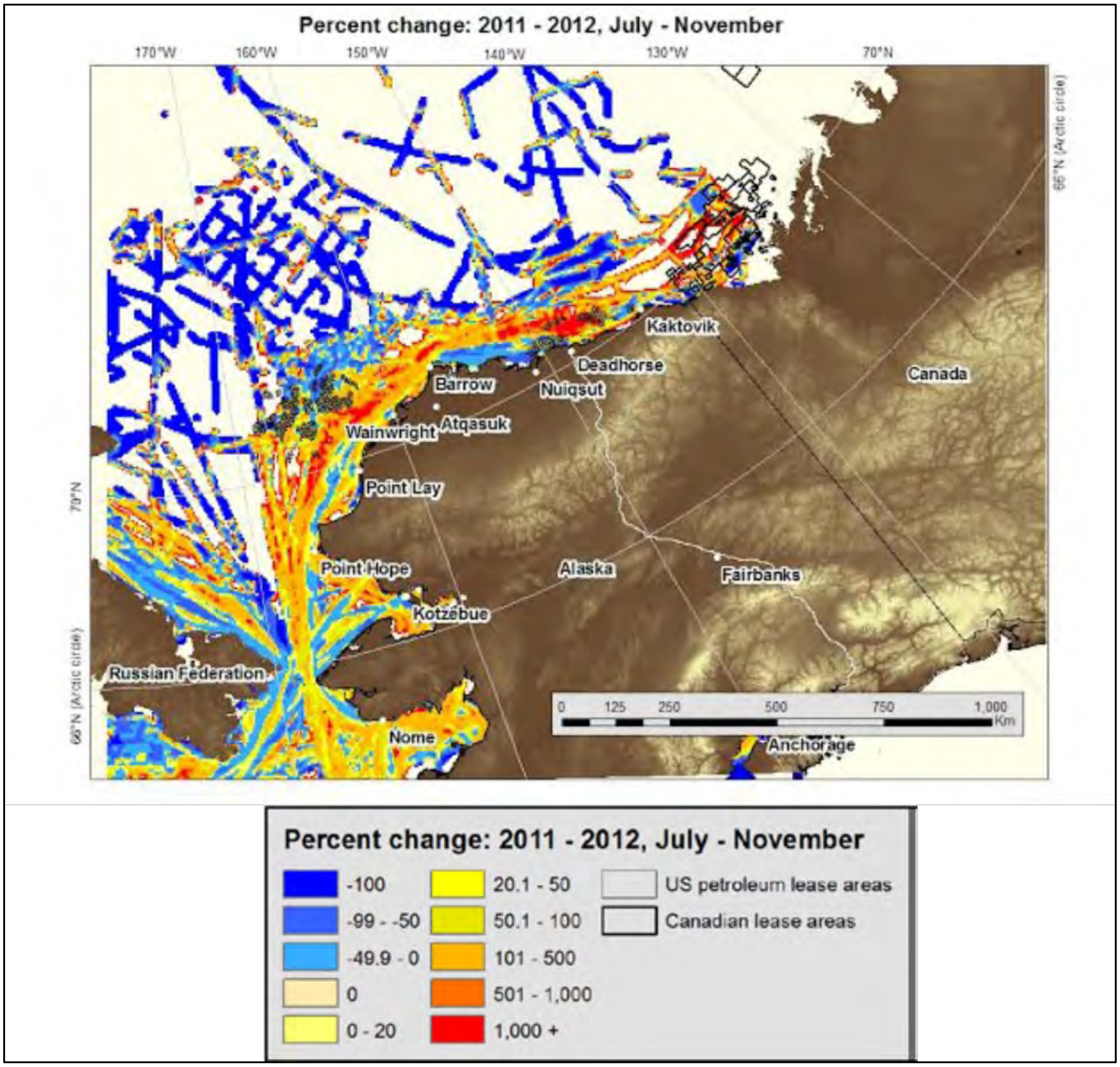

Figure 17. Percent difference in vessel activity between 2011 and 2012 using 5-km grid cells. (Azzara et al. 2015)

Marine vessel traffic may pose a threat to pinnipeds and cetaceans in the action area, because of ship strikes and vessel noise (Halliday et al. 2021b). Vessel traffic in the Chukchi and Beaufort seas is currently limited to late spring, summer, and early autumn. However, surface air temperatures in the Arctic Region are increasing at double the rate of the global average (Adams and Silber 2017). Continued expansion of the duration and extent of seasonal ice-free waters in the Chukchi and Beaufort seas is anticipated over the coming decades, likely resulting in increased vessel traffic and increased duration of the navigation season (Gunnarsson 2021; Cao et al. 2022). As seasonal ice-free waters expand, the international commercial transport of goods and people in the area is projected to increase 100-500 percent in some Arctic areas by 2025 (Adams and Silber 2017).

The U.S. Committee on the Marine Transportation System (CMTS) reported that the number of vessels operating in the Chukchi and Beaufort seas has increased 128% from 2008 to 2018. The vessels include those used for research, natural resource exploration and extraction, commercial shipping, government/law enforcement/search and rescue, and tourism. Of the 255 vessels that transited through the US Arctic and surrounding region from 2015-2017, over 50% were tug, towing, and cargo vessels. Thirty-two flag states transited the region, although US flagged vessels were the most prevalent. The length of the navigation season has been growing by as much as 7-10 days annually, which, extrapolated over the next decade, could result in 2.5 months of additional navigation season over what was seen in 2019 (U.S. Committee on the Marine Transportation System 2019).

In the projections developed by the CMTS for the most plausible scenario, 72 vessels are expected to be active annually by 2030 in natural resource exploration and development, which is also the activity ranked as the largest contributor to projected traffic growth. More than 50% of this growth is anticipated to be from non-US natural resource extraction (Russian exports of LNG and mineral extraction in Canada). By 2030 in the most plausible scenario, 28 vessels are expected to be active for rerouted shipping through the Arctic and 17 vessels in the expansion of the Arctic fleet (icebreakers, and ice-hardened cruise ships). However, these estimates do not include the small vessel transits used for commercial fishing, subsistence harvest, or lightering goods from large barges to shore using smaller vessels.

5.4.1 Vessel Noise

Vessel noise can create auditory interference, or masking, in which the noise can interfere with an animal’s ability to understand, recognize, or even detect sounds of interest. This can lead to behavioral changes in marine mammals, such as increasing their communication sound levels or causing them to avoid noisy areas. 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 (BOEM 2011) 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.

5.4.2 Vessel Strikes

Current shipping activities in the Arctic pose varying levels of threats to marine mammals 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.

5.5 Ocean Noise

In addition to vessel noise described above, ESA-listed species in the action area are exposed to several other sources of natural and anthropogenic noise. Natural sources of underwater noise include sea ice, wind, waves, precipitation, and biological noise from marine mammals, fishes, and crustaceans. Other anthropogenic sources of underwater noise of concern to listed species in the action area include in-water construction activities such as drilling, dredging, and pile driving; oil, gas, and mineral exploration and extraction; Navy sonar and other military activities; geophysical seismic surveys; and ocean research activities. Levels of anthropogenic sound can vary dramatically depending on the season, type of activity, and local conditions. The combination of anthropogenic and natural noises contributes to the total noise at any one place and time. Noise impacts to listed marine mammal species from many of these activities are mitigated through ESA Section 7 consultations.

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. As described in greater detail later in this opinion, noise may cause marine mammals to leave a habitat, impair their ability to communicate, reduce their survival rate, or cause stress. Noise can cause behavioral disturbances, can mask other sounds, including their own vocalizations, may result in injury, and, in some cases, may result in behaviors that ultimately lead to death. The severity of these impacts can vary greatly between minor impacts that have no real cost to the animal, to more severe impacts that may have lasting consequences.

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). 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 (Sullivan 1980; Allen 1984; Henry and Hammill 2001; Edrén et al. 2010; London et al. 2012). (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 (i.e., masking). 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.

Because noise is a primary source of disturbance to marine mammals, and the category of disturbance most focused on in Incidental Harassment Authorizations and Letters of Authorization, this opinion considers it as a separate category of the Environmental Baseline.

5.5.1 Ambient Noise

Ambient sound, as it is considered here, refers to naturally produced sound in the absence of measurable anthropogenic sound. Ambient sound is different from “background sound” which can include anthropogenic sounds that are typical for a particular location.

The presence of ice can contribute significantly 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 generally become higher compared to open water (Richardson et al. 1995; Blackwell and Greene 2001). Urick (1996) 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 ground-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 (BOEM 2011). 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.

There are many marine mammals in the Arctic marine environment whose vocalizations contribute to ambient sound including bowhead whales, gray whales, beluga whales, walrus, ringed seals, bearded seals, and spotted seals. 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. 1986; Thomson and Richardson 1995).

Sound levels recorded during the open-water season (July 6 through September 22) in Foggy Island Bay varied from approximately 88 to 103 dB re uPa broadband (Aerts et al. 2008). These sound levels may have been influenced by vessel activities occurring nearby (Aerts et al. 2008), and may therefore be better characterized as background sound rather than ambient sound. Broadband background sound levels recorded in the water under the ice at 9.4 km (5.8 mi) from Northstar Island were 77 dB 1 re μPa and 76 dB re μPa in 2001 and 2002, respectively (Blackwell et al. 2004).

The presence of sea ice, which has limited anthropogenic activities, has kept anthropogenic noise in the Arctic at some of the lowest underwater sound levels on the planet. Consequently, arctic marine mammals have historically been exposed to lower levels of ship traffic and other underwater noise than marine mammals occupying more temperate waters and thus may be more at risk from the threats of underwater noise (Halliday and Ferguson 2020; Halliday et al. 2021a).

5.5.2 Oil and Gas Exploration, Drilling, and Production Noise

As introduced in section 5.3, oil and gas exploration activities began on the North Slope in the early 1900s, and oil production started at Prudhoe Bay in 1977. NMFS reviewed the potential effects of oil and gas development in a Final Environmental Impact Statement for the effects of oil and gas activities in the Arctic Ocean (NMFS 2013) and has conducted numerous Section 7 consultations on oil and gas activities in the Chukchi and Beaufort Seas. (Southam et al. 2022) provides a comprehensive summary of oil and gas activities in the Arctic. Here we present the most recent and relevant consultations regarding oil and gas drilling, exploration, and production noise.

In 2018, NMFS Alaska Region completed a consultation with BOEM, BSEE, EPA, and USACE for oil and gas exploration activities for the Liberty Project taking place from December 2020 to November 2045 (NMFS 2018a). In 2019, the NMFS Alaska Region reinitiated consultation with BOEM, BSEE, EPA, and USACE for the Liberty Project and conducted a consultation with the NMFS Permits Division on the issuance of a letter of authorization (LOA) to take marine mammals incidental to oil and gas exploration activities for the Liberty Oil and Gas Development and Production Activities (NMFS 2019). The biological opinion estimates take of ringed seals: 831 by Level B harassment due to noise and physical presence, 8 by Level A harassment due to noise, and 10 by mortality.

In 2019, NMFS Alaska Region completed a programmatic consultation with the Bureau of Land Management for the implementation of the oil and gas lease sales for the Arctic National Wildlife Refuge coastal plain (NMFS 2019b). The consultation was based on the most likely scenario for oil exploration, development, production, and abandonment. An incidental take statement is not issued for programmatic consultations; however, consultations will be required for future oil and gas activities within the refuge boundaries that may affect listed species and new lease sales for the area have not occurred.

Hilcorp and Eni proposed the construction and maintenance of ice roads and trails over five years (2020-2025) for three drilling sites in the North Slope of Alaska. It was determined that this project could incidentally harass up to 125 Arctic ringed seals and could result in the mortality or serious injury of 12 Arctic ringed seals (85 FR 2988, AKRO-2019-00194). In 2020, Hilcorp reported two ringed seals were observed from a distance, but were not disturbed. No reports of disturbed ringed seals were received in 2021. In 2022, a ringed seal lair appeared in the middle of an ice trail after the trail had been in daily use for three months. The location was monitored and mitigation measures were implemented to protect the seal. No other seals were reported near the ice trails.

In 2019, the Alaska Gasoline Development Corporation proposed a liquid natural gas pipeline that would extend from Prudhoe Bay, generally following the existing Trans Alaska Pipeline System through interior Alaska, to end at the Liquefaction Facilities in Nikiski in Southcentral Alaska (84 FR 30991). The project would increase shipping traffic through the Bering, Chukchi, and Beaufort seas and could incidentally harass 1765 ringed seals and 300 bearded seals (AKRO-2018-01319). Project activities were permitted from 2021-2025. Construction on this project has not begun.

As described in section 5.10, high numbers of take for ringed seals is often estimated but the actual number taken can be 0, or a small fraction of the estimates. This happens because the amount of time project effects will occur is often overestimated and because very conservative (high) estimates of seal density are used. Although some ringed seal individuals may have been affected by oil and gas exploration and development activities, we do not have evidence that these activities have had a lasting negative effect on ringed seal individuals or populations.

5.5.3 Seismic Activity Noise

Seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea since the late 1960s and early 1970s, resulting in extensive coverage over the area. Seismic surveys vary, but a typical two-dimensional/three-dimensional (2D/3D) seismic survey with multiple guns emits sound at frequencies of about 10 Hz to 3 kHz (Austin et al. 2015). Seismic airgun sound waves are directed towards the ocean bottom, but can propagate horizontally for several kilometers (Greene and Richardson 1988; Greene and Moore 1995). Analysis of sound associated with seismic operations in the Beaufort Sea and central Arctic Ocean during ice-free conditions also documented propagation distances up to 1,300 km (808 mi) (Richardson 1998; Richardson 1999; Thode et al. 2010). Because the Chukchi Sea continental shelf has a highly uniform depth of 30 to 50 m (98 to 164 ft), it strongly supports sound propagation in the 50 to 500 Hz frequency band (Funk et al. 2008).

In August through September 2021, the National Science Foundation conducted a low-energy and high-energy marine seismic survey using an airgun array and other acoustic sound sources in the Beaufort Sea. The two-dimensional seismic survey towed a two or six airgun array with a maximum discharge volume of approximately 51,127.6 cubic centimeters (3,120 cubic inches) at a depth of nine meters (29.5 feet). The low-energy and high-energy seismic survey took place in waters depths of approximately 200 to 4,000 m (656.2 to 13,123.4 ft). The seismic survey activities lasted approximately 45 days, including approximately 30 days of airgun array operations and approximately seven days of equipment deployment and recovery. The seismic survey activities were conducted along approximately 5,850 kilometers (3,158.7 nautical miles) of tracklines approximately 250 to 900 km offshore. Take was authorized for 907 bearded seals and 10,269 ringed seals. The monitoring report indicated 6 bearded seals and 9 ringed seals were seen and of these, no bearded seals were taken and a maximum of 7 ringed seals were potentially taken. Sightings of two of the ringed seals resulted in a shutdown of seismic activity for 20 minutes.

5.5.4 Aircraft Noise

The sound and visual presence of aircraft can result in behavioral changes in whales and seals such as diving, altering course, vigorous swimming, and breaching (Patenaude et al. 2002). Oil and gas development projects often involve helicopters and fixed-winged aircraft, and aircraft are used for surveys of natural resources. Airborne sounds do not transfer well to water because much of the sound is attenuated at the surface or is reflected where angles of incidence are greater than 13°; however, loud aircraft noise can be heard underwater when aircraft are within or near the 13° overhead cone and surface conditions are calm (Richardson et al. 1995). Richardson et al. (1995) and Richardson and Malme (1993) observed that bowhead whales in the Beaufort Sea will dive or swim away when low-flying (500 m (1640 ft)) aircraft pass above them.

Ringed seals departed their lairs in response to a helicopter flying 5 km from the lair, and during helicopter landings and take-offs as far away as 3 km (Kelly et al. 1988). They are most adversely affected by noise disturbance in late March through June when they spend greater amounts of time out of the water and their movements are limited to small areas due to their dependent offspring (Kelly et al. 1988). One study indicated that the risk of scaring ringed seals into the water can be substantially reduced if small-type helicopters do not approach closer than 1500 m and small fixed-wing aircraft do not approach closer than 500 m (Born et al. 1999).

5.6 Direct Mortality

Within the proposed action area there are several potential sources of direct mortality of listed species, including subsistence harvest, stranding, and predation. Direct mortality associated with vessels strikes is addressed in Section 5.4.2.

5.6.1 Subsistence Harvest

The ESA and MMPA allow for the harvest of marine mammals by Alaska Natives for subsistence purposes and for the creation of traditional handicrafts. Ringed 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 (Nelson et al. 2019). Estimates of subsistence harvest of ringed seals are available for several of these communities based on annual household surveys, but more than 50 other communities that harvest these species for subsistence were not surveyed within this time period or have never been surveyed. From 2012-2017, only 4 percent (3 of 64) of the coastal communities that harvest ice seals have been surveyed in two or more consecutive years (Ice Seal Committee 2019). 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 2019). In 2015, the total annual ringed seal harvest estimate across surveyed communities was 6,454 (Table 7). Nelson et al. (2019) determined this level of harvest is sustainable.

Table 7. Average regional and statewide subsistence harvest (including struck and lost animals) of Arctic ringed seals in 2015 (summarized from Nelson et al. (2019)).

Community	Estimated Ringed Seal Harvest					Estimated Bearded Seal Harvest				
	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Nuiqsut	-	58	-	-	-	-	26	-	-	-
Utqiaġvik	-	428	-	-	-	-	1,070	-	-	-
Point Hope	-	246	-	-	-	-	183	-	-	-
Kotzebue	-	69	-	-	-	-	228	-	-	-
Shishmaref	-	296	-	-	-	-	319	-	-	-
Hooper Bay	667	158	185	546	193	171	64	148	118	114
Tununak	-	-	-	117	-	-	-	-	19	-
Tuntutuliak	75	-	-	-	-	53	-	-	-	-

Community	Estimated Ringed Seal Harvest					Estimated Bearded Seal Harvest				
	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Quinhagak	160	51	-	26	-	49	16	-	38	-
Total	**902**	**1,306**	**185**	**689**	**193**	**273**	**1,176**	**148**	**175**	**114**
Source: adapted from Ice Seal Committee (2019). Villages with no landings were not included.										

5.6.2 Stranding

As discussed in Section 5.1.1.2 the NMFS AKR Stranding Network received reports of many stranded ice seals in spring and summer 2019. In September 2019, NMFS declared an Unusual Mortality Event (UME) for ringed, bearded, and spotted seals, dating back to June 1, 2018. The cause, or causes, of these deaths is currently being investigated by NMFS.

5.6.3 Predation

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. 1976; 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 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).

Polar bear predation on ringed seal pups tripled when pups were prematurely exposed as a consequence of unseasonably warm conditions. Hammill and Smith (1991) further noted that polar bear predation on ringed seal pups increased four-fold when average snow depths in their study area decreased from 23 cm to 10 cm. Gulls, ravens, and possibly snowy owls prey on ringed seal pups when the latter are forced out of subnivean lairs prematurely because of low snow accumulation and/or early melts (Lydersen et al. 1987; Lydersen and Smith 1989; Lydersen and Ryg 1990; Lydersen 1998). Avian predation is facilitated not only by lack of sufficient snow cover but also by conditions favoring influxes of birds (Kelly et al. 2010b).

5.7 Plastics

A growing source of contaminants in the Arctic comes from plastics. Approximately 8,300 million metric tons (MT) of plastics have been produced to date with approximately 6,300 million MT becoming waste (Geyer et al. 2017). Jambeck et al. (2015), in an analysis of plastic waste generated by 20 coastal communities world-wide, estimated that 4.8 to 12.7 million MT of plastic waste entered the ocean in 2010. It is estimated that between 62,000 to 105,000 tons of plastic are transported to the Arctic Ocean each year (Zarfl and Matthies 2010). Larger sized plastics such as bottle caps, plastic bags, bottles, and strapping are problems for marine sea birds, turtles, and mammals because of ingestion and entanglement (Laist 1997; Derraik 2002b; Law 2017; Peeken et al. 2018). We have no documented reports of strandings of ringed or bearded seals caused by entanglement or plastic ingestion within the action area. However, entanglement of Northern fur seals (*Callorbinus ursinus*) from around the Pribilof Islands is well documented (Laist 1997; Savage 2019). With increased development in the Beaufort and Chukchi Seas, increased vessel traffic through the Northwest passage, an increased number of observers (tourists, scientists, employees), and longer periods of open water which can promote delivery of plastics to the Arctic, ingestion and entanglement of ringed and bearded seals is more likely to be documented in coming years.

Microplastics, defined as < 5 mm in size, occur due to the release of manufactured plastic particles in various products (primary microplastics) and the fragmentation of larger plastic pieces (secondary microplastics) (Cole et al. 2011). Microplastics are distributed globally. In an examination of ice cores from widely dispersed locations across the Arctic Ocean, Obbard et al. (2014) found from 38 to 234 particles per cubic meter of ice. The microplastic concentrations were several orders of magnitude greater than those reported in the North Pacific Subtropical Gyre (0.12 particles per cubic meter of water). The highest concentration of microplastics ever determined in sea ice was found in from the Makarov Basin in the central Arctic Ocean (Peeken et al. 2018). The ice core there contained concentrations comparable to those from South Korean waters, which were previously the highest levels recorded (Peeken et al. 2018). The types of microplastics found in the Arctic included polystyrene, acrylic, polyethylene, polypropylene, nylon, polyester, and rayon (Obbard et al. 2014; Peeken et al. 2018). Microplastics are also abundant in Arctic benthic substrates (Lusher et al. 2015; Bergmann et al. 2017) and water (La Daana et al. 2018; La Daana et al. 2020).

Marine plastic debris is associated with a 'cocktail of chemicals', including chemicals added or produced during manufacturing (Lithner et al. 2011; Rochman 2015) and those present in the marine environment that accumulate onto the debris from surrounding seawater (Mato et al. 2001; Hirai et al. 2011). Persistent organic pollutants, including PCBs, and metals have been well documented as sorbing onto plastic particles in studies dating back to 1972 (Mato et al. 2001; Ogata et al. 2009; Zarfl and Matthies 2010). Microplastics and the persistent bioaccumulative toxins they carry have been documented in filter feeders including zooplankton, mussels, planktivorus fish and humpback whales (Besseling et al. 2014; Besseling et al. 2015; Fang et al. 2021) and benthic invertebrates from the shelf of the Bering and Chukchi Seas (Fang et al. 2018). There is evidence that the sorbed contaminants are bioavailable to a variety of marine mammals and invertebrates (Teuten et al. 2009; Rochman 2015). Researchers are actively investigating whether these plastic-associated contaminants biomagnify in higher trophic levels as a direct result of plastic ingestion and how important bioaccumulation from plastic is relative to bioaccumulation from other sources of chemical contamination in the environment (Avio et al. 2015; Rochman 2015; Miller et al. 2020).

5.8 Other Arctic Projects

In the winters of 2014, 2017, 2018, 2020, and 2022 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. An IHA was issued to the U.S. Navy to incidentally harass (level B only) marine mammals during submarine training and testing activities associated with each of these biennial activites. Monitoring reports from the projects indicate that no ringed or bearded seals were observed.

In 2016, NMFS Alaska Region conducted internal consultations with NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to anchor retrieval in the Chukchi, and Beaufort seas during the 2016 open water season. The biological opinion estimated takes (by harassment) of 6,895 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. Based on the number of actual hours that noise was produced it was estimated that 316 ringed seals may have been harassed by the sounds produced by the project. However, protected species observers saw no ringed or bearded seals during the anchor retrieval process.

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 biological opinion estimated takes (by harassment) of 922 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 2016). Monitoring reports from the project indicated that 50 ringed seals were taken by harassment.

These projects indicate that although high numbers of take of ringed seals are often estimated to occur, the estimated numbers of take have not been realized and actual take can vary from 0 animals to a small percent of estimated amount. Currently we have no evidence that the projects occurring in the Arctic which have been consulted on and authorized take are having a lasting impact on Arctic ringed seal individuals or populations.

5.9 Scientific Research

Research provides essential information on the life history, distribution, health, and abundance of threatened and endangered species. However, research activities can also harass and harm the animals. Research on marine mammals often requires boats, adding incrementally to the vessel traffic, noise, and pollution 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 biological 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 are similar to those described below.

Pinnipeds

Steller sea lions, ringed seals, and bearded seals are exposed to research activities documenting their population status and trends, health, movements, habitat use, foraging ecology, response to recovery activities, distribution, and movements throughout their ranges.

There are several active scientific research permits for marine mammals in Alaska (Table 8). Their activities may include behavioral observations, counting/surveying, photo-identification, and capture and restraint (e.g. by hand, net, or trap). The following samples may be collected from marine mammals: blood, hair, urine and feces, nasal and oral swabs, whiskers, skin, blubber, or muscle biopsies, and weight and body measurements. Drugs are administered if necessary (e.g. intramuscular, subcutaneous, or topical) for pain, restraint, or to prevent infection, instruments are attached to hair or flippers, and ultrasound may be used to measure blubber thickness.

Table 8. Current NMFS scientific research and enhancement permits authorizing take of Beringia DPS beard seals and Arctic ringed seals.

File Number	Applicant	Project Title
18890	ADFG	Movements, habitat use, and stock structure of cetaceans (bowhead, gray, humpback, and beluga) in Alaska
18902	Long Marine Laboratory	Psychological and physiological studies of captive pinnipeds at Long Marine Laboratory, Santa Cruz, CA and Alaska SeaLife Center, Seward, AK
19309	MML	Application for a Permit for Scientific Research under the MMPA for the Assessment, Capture, and Handling of Harbor, Spotted, Ringed and Bearded Seals in Alaska
20466	ADFG	Population Status, Health, Movements, and Habitat Use of Ringed, Bearded, Spotted and Ribbon Seals in the Bering, Chukchi, and Beaufort Seas

These activities may cause stress to individual pinnipeds and cause behavioral responses. Two ringed seals have died as a consequence of research activities over the last 10 years. Protocols are modified when a mortality occurs. All research is evaluated and permitted. Take is authorized if appropriate.

5.10 Summary of Environmental Baseline

The Arctic ecosystem is currently undergoing many changes at an unprecedented rate. The most important of the changes are related to global warming and include diminishment in the extent and thickness of sea ice, increasing surface water temperatures, shrinkage of the cold water pool, increased harmful algal blooms, increased vessel traffic, and increased levels of plastics. Other activities like subsistence harvest, oil and gas activities, and predation have been ongoing for decades. Counting ringed seals is extremely difficult and for that reason it has not been possible to determine an accurate count for the species. Consequently, trends in abundance are unknown. Estimates of abundance for the species is still well above 100,000, giving researchers a window of opportunity to increase our knowledge about the species and refine methods to better estimate their population numbers. Ringed seals appear to be resilient to the perturbations they have faced thus far. The UME may be an indicator of challenges seals may face in the future related to climate change but the physical and biological etiologies for the UME remain unknown.

6 Effects of the Action

Effects of the action refers to 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. 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. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

This 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).

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.

NMFS identified and addressed all potential stressors; and considered all consequences of the proposed action, individually and cumulatively, in developing the analysis and conclusions in this opinion regarding the effects of the proposed action on ESA-listed species and designated critical habitat.

6.1 Project Stressors

Stressors are any physical, chemical, or biological entity that can induce an adverse response. The proposed activities will expose ringed seals to the sounds and physical presence of autonomous sea gliders, an unmanned underwater vehicle, research vessels transiting to and from the project area, moored active acoustic sources, drifting oceanographic sensors, on-ice measurement systems, and ice breaking.

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

1. sound fields produced by non-impulsive noise sources such as vessels, ice auguring, icebreaking
2. sound fields produced by *de minimis* sources
3. physical disruption of ice habitat

4. vessel strike and in-water device strikes
5. entanglement with cables or other marine debris from tethered and abandoned instrumentation
6. pollution from unauthorized spills from vessel activities
7. sound field produced by active non-impulsive acoustic sources

6.1.1 Minor Stressors on ESA-Listed Species

The response of ringed seals to the following minor stressors are expected to be too small to detect or measure and are not likely to significantly disrupt their normal behavioral patterns.

6.1.1.1 Noise

Vessel Noise

The proposed action includes one roundtrip of a research vessel from Nome to the Beaufort Sea and back in early September 2022 using the R/V Sikuliaq, and potentially one other roundtrip from Seward, Alaska, using the CGC Healy which may include icebreaking.

As explained in section 4.1.1.2 for pinnipeds, we expect the disturbance by noise to ringed seals from passage of either vessel in transit to be minimal. However, underwater sounds created by icebreaking would be much louder and are considered below in section 6.1.2, Major Stressors.

Ice Auguring

Holes will be bored through the ice for deployment of the Autonomous Ocean Flux Buoys (Figure 2) and the Autonomous Weather Stations (Figure 3). Autonomous Ocean Flux Buoys will be deployed requiring holes approximately 5 cm in diameter. Three holes are augured per weather station. It takes approximately 30-60 minutes to auger through the ice, depending on its thickness. Greene et al. (2008) recorded underwater noise from an ice auger during ice road construction at the Northstar Development (Beaufort Sea) and found noise levels at the source were below 100 dB re 1µPa. These levels are below the behavioral threshold for underwater noise and in-air harassment for seals.

de minimis Acoustic Sources

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 2013). 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).

Although an active source when the research vessels are in the Beaufort Sea because of its regular use, the WHOI micromodem is considered *de minimis* during the leave behind period. During the leave behind period it just acts as an on-off switch for the moored systems, activating only five times. Because of the very short interval of usage it is considered *de minimis*.

The Acoustic Doppler Current Profilers (ADCPs) will be moored or deployed on unmanned underwater vehicles. Two of the three types of ADCPs and the ice profiler used in this project produce signals above 150 kHz; sound that is out of the hearing range of Arctic ringed seals. The other type of ADCP produces signals at 75 kHz which is within the hearing range of ringed seals. NMFS calculated that sound from this device 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 cone of water 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.

6.1.1.2 Physical disruption of ice habitat

If icebreaking occurs, it will break through relatively solid and potentially thick ice. The CGC Healy's icebreaking capability was designed for breaking through 1.4 m (4.5 ft) thick ice at 3 kn (1.5 m/s). Best performance is in ice 1.7 m (5.5 ft) at 2.6 kn (1.3m/s) but the ship is capable of breaking ice up to 2.4 m (8 ft) thick while backing and ramming. Although ice is an important resting and molting platform for ringed seals, we have no information that indicates the passage of an ice breaker through the ice would decrease the value or function of the ice. If an icebreaker is needed, ice will be available for the seals to haul out. We expect that if an ice breaker is used it will be in the late summer or fall, well after pups are weaned and independent. Consequently, separation of moms and pups as seen in the Caspian Sea in the winter (Wilson et al. 2017) will not be an issue. Given the time of year we expect all affected individuals would be fully independent and adept both in the water and on ice.

It is possible the ship could destroy breathing holes created by the ringed seals. However, the breaking of solid ice also provides the potential for creating new breathing holes between the fractured pieces of ice with far less effort than digging through solid ice. Because of the slow vessel speed through ice, exposure to the icebreaker is expected to be longer than the passage of the ship in open water. However, the disturbance would be temporary. It is likely that individuals resting on ice or near the path of the icebreaker could be temporarily displaced but we do not expect this would lead to a measurable effect.

6.1.1.3 Vessel strike

As explained in section 4.1.2.2 regarding potential vessel strike of pinnipeds, we conclude that it is highly improbable that either research vessel would strike a ringed seal.

The project's seagliders are small and slow moving (0.25 meters per second). The Unmanned Underwater Vehicle (Remus 600) is larger and can travel at a faster speed (5 knots) which is about equal to the average swimming speed of a ringed seal. Given the very large action area, the low density of ringed seals, the use of a maximum of 6 gliders and one underwater vehicle, the probability of a seal encountering one of these devices is exceedingly low. The gliders and underwater vehicle are bright yellow, will be traveling in a predictable manner without major changes in speed or direction and if a ringed seal were to encounter one of these devices, we expect it could easily avoid it. In the unlikely event that a ringed seal encountered one of these devices, there is no reason to expect that they would be struck and while seals might investigate the device out of curiosity, we have no information that would cause us to expect the device would cause a significant disruption of normal ringed seal behavior.

6.1.1.4 Entanglement

The project activities require a variety of lines and cables. The longest ones will anchor moorings and these will be retrieved. However, some devices with cables will be jettisoned as a consequence of the project activities. While functional, 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.

Although there is a potential for entanglement from an expended material, the amount of materials expended will be low compared to the size of the Beaufort Sea. All of the cables/lines are metal coated with plastic. We assume that the weight of the metal will cause these cables to sink to the sea floor. The water depth in the area of deployment is 1,000 to over 3,000 m deep, greater than ringed seals dive. Therefore, it is extremely unlikely that ringed seals would be exposed to this expended material. In addition, we note that jettisoning this material adds to the plastic debris and ultimately to the mircoplastics found in the Arctic Ocean.

6.1.1.5 Pollution

Increased vessel activity in the action area will temporarily increase the risk of accidental fuel and lubricant spills from the research 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. Sea ice impedes response efforts. 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 1976b; 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 lower molecular weight 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, and their ability to clean up spilled petroleum products before they reach marine waters, the probability of harassment or harm to marine mammals resulting from project related pollution is very small. Adverse impacts to ringed seals are therefore extremely unlikely to occur.

6.1.2 Major Stressors on ESA-Listed Species

The following sections analyze the stressors likely to adversely affect the ringed seal due to underwater sounds created by the scientific instruments and ice breaking activities, if performed.

First, we provide a brief explanation of the sound measurements and acoustic thresholds used in the discussions of acoustic effects in this opinion.

For the proposed action, the activities which could result in underwater acoustic disturbance to ringed seals include: active non-impulsive acoustic sources (Table 1) and icebreaking. The proposed action involves the use of low-(35 Hz), mid-(850-1050 Hz), and high-(8-14 kHz) frequency sources in the deep ocean area (Figure 2). The 35 Hz sources are below ringed seal hearing ability. The mid and high frequency sources are within their hearing range. Decibel source levels range from 180 to 185 re 1 µPa at 1 m and have various duty cycles and pulse lengths (Table 1). The total amount of active source testing for ship-deployed sources used during the cruise would be 120 hours. Acoustic stressors from these active sources and from icebreaking are responsible for all instances of ringed seal take expected to result from this project.

Impulsive sound sources (e.g., explosions, sonic booms, impact pile driving) produce signals that are brief (typically considered to be less than one second), broadband, and occur either as isolated events or repeated in some succession. Impulsive sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury as compared with sounds that lack these features. No impulsive acoustic sources will be used during ONR’s proposed action.

Non-impulsive sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous. Some of these non-impulsive sounds can be transient signals of short duration but without the essential properties of pulses (e.g., rapid rise time). Examples of non-impulsive sounds include those produced by vessels, aircraft, and active sonar sources that intentionally direct a sound signal at a target that is reflected back in order to discern physical details about the target. These active sources are used in navigation, military training and testing, and other research activities such as the activities planned by ONR as part of the proposed action.

6.1.2.1 Acoustic Thresholds

Since 1997, NMFS has used generic sound exposure thresholds to determine whether an activity produces underwater and in-air sounds that might result in impacts to marine mammals (70 FR 1871, 1872; January 11, 2005). NMFS revised the comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary threshold shifts (PTS and TTS; Level A harassment) (83 FR 28824; June 21, 2018) (NMFS 2018b). 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[13], expressed in rms[14] from broadband sounds that cause

[13] 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.
[14] Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.

behavioral disturbance, and referred to as Level B harassment under section 3(18)(A)(ii) of the MMPA (16 U.S.C § 1362(18)(A)(ii)):

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

Under the PTS/TTS Technical Guidance, NMFS uses the following thresholds for underwater sounds that cause injury, referred to as Level A harassment under section 3(18)(A)(i) of the MMPA (16 U.S.C § 1362(18)(A)(i)). Different thresholds and auditory weighting functions are provided for different marine mammal hearing groups, which are defined in the Technical Guidance (NMFS 2018b). The generalized hearing range for ringed seals is in Table 9.

Table 9. Underwater hearing group for ringed seals (NMFS 2018b).

Hearing Group	**Generalized Hearing Range[1]**
Phocid pinnipeds (PW) *(true seals)*	50 Hz to 86 kHz
[1]Respresents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).	

The PTS onset acoustic thresholds for ringed seals are presented in Table 10, 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. Level A harassment radii can be calculated using the optional user spreadsheet[15] associated with NMFS Technical Guidance, or through modeling.

[15] The Optional User Spreadsheet can be downloaded from the following website: http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm

Table 10. PTS Onset Acoustic Thresholds for ringed seals (NMFS 2018b).

Hearing Group	**PTS Onset Acoustic Thresholds*** **(Received Level)**	
	Impulsive	**Non-impulsive**
Phocid Pinnipeds (PW) (Underwater)	$L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	$L_{E,PW,24h}$: 201 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 1µPa^{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.

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 (16 U.S.C § 1362(18)(A)(ii)):

- 100 dB re 20µPa$_{rms}$ for non-harbor seal pinnipeds

There is no established in-air acoustic threshold for Level A injury. For the proposed action, in-air acoustic disturbance could be caused by or ice auguring or icebreaking. Ice auguring noise was consider under minor stressors (section 6.1.1). Icebreaking noise is considered in section 6.3.

The National Defense Authorization Act of Fiscal Year 2004 (PL 108-136) amended the definition of "harassment" under the MMPA, specifically as it applies to military readiness activities or scientific research activities conducted by or on behalf of the federal government (16 U.S.C. §1362 (18)(B)). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (PL 107-314). Research activities within the study area are composed of military readiness activities, as that term is defined in section 315(f) of PL 107-314, because activities constitute realistic testing of military equipment, vehicles, and sensors for proper operation and suitability for combat use. For military readiness activities, the relevant definition of harassment under the MMPA is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment"); or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") (16 U.S.C. § 1362(18)(B)(i) and (ii)).

While the ESA does not define “harass,” NMFS issued guidance interpreting the term “harass” under the ESA to mean: “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, including any exposure to sounds that are above the Level A or Level B thresholds described below; take that must be authorized by the ITS (Section 10 of this opinion). It is important to note, however, that take of NMFS-managed threatened species, such as the Arctic ringed seal, is not prohibited because the agency did not promulgate ESA section 4(d) regulations subsequent to its listing.

6.2 Exposure Analysis

As discussed in the *Approach to the Assessment* section of this opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action’s effects and the populations or subpopulations those individuals represent. As discussed in Section 2.2 above, the Navy proposed mitigation measures to avoid or minimize exposure of ringed seals to one or more stressors from the proposed action.

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 original Biological Evaluation (ONR 2018) and IHA application (ONR 2018b) for the 4 year project. The take presented in this biological opinion used analysis provide in the new application for an IHA (ONR 2022) and the Federal Register notice for this project (87 FR 44339). Because of the remote location and because several of the active sound sources are left drifting in the Beaufort Sea when direct observation is not possible, modeling is the best way to estimate exposure of ringed seals to the sound sources.

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 2022). 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. More information on the details of the NAEMO modelling can be found in (ONR 2022), 83 FR 40234, and 87 FR 44339.

There are limitations to the data used in the acoustic effects model, and the results must be interpreted within this context. While the best available data and appropriate input assumptions have been used in the modeling, when there is a lack of definitive data to support an aspect of the modeling, conservative modeling assumptions have been chosen (i.e., assumptions that may result in an overestimate of acoustic exposures):

- Animats are modeled as being underwater, stationary, and facing the source and therefore always predicted to receive the maximum potential sound level at a given location (i.e., no porpoising or pinnipeds' heads above water);
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model;
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in PTS;
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating potential threshold shift, because there are not sufficient data to estimate a hearing recovery function for the time between exposures; and
- Mitigation measures were not considered in the model. In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected by visual monitoring.

NAEMO then records the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects on the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given animat is assumed. Each scenario, or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine mammal (as represented by an animat in the model environment) could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the proposed study location, sound may propagate beyond the boundary of the study area. Any exposures occurring outside the boundary of the study area are counted as if they occurred within the study area boundary. NAEMO provides the initial estimated impacts on marine species with a static horizontal distribution (i.e., animats in the model environment do not move horizontally).

As discussed above, within NAEMO, animats do not move horizontally or react in any way to avoid sound. Furthermore, mitigation measures that are implemented during testing activities that reduce the likelihood of physiological impacts are not considered in quantitative analysis. Therefore, the current model overestimates non-impulsive acoustic impacts, especially physiological impacts near the sound source. The behavioral criteria used as a part of this analysis acknowledges that a behavioral reaction is likely to occur at levels below those required to cause hearing loss (TTS or PTS). At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around the sound source is the assumed behavioral response for most cases.

In previous environmental analyses the Navy has implemented analytical factors to account for avoidance behavior and the implementation of mitigation measures. The application of avoidance and mitigation factors has only been applied to model-estimated PTS exposures given the short distance over which PTS is estimated. Given that no PTS exposures were estimated during the modeling process for this proposed action, the implementation of avoidance and mitigation factors were not included in this analysis.

Table 11 provides a range to effects for noise produced through use of the proposed sources to pinniped-specific criteria. Range to effects is important information in predicting non-impulsive acoustic impacts. Therefore, the ranges in Table 11 provide realistic maximum distances over which the specific effects from the use of non-impulsive active sources during the proposed action would be possible.

Table 11. Range to PTS, TTS, and Behavioral Effects in the Project Area based on Cutoff Distances for Non-Impulsive Active Acoustic Sources

Source Type	Range to Behavioral Effects (meters)	Range to TTS Effects (meters)[c]	Range to PTS Effects (meters)[c]
	Ringed seal	Ringed seal	Ringed seal
On-site drifting sources [b]	10,000[a]	0	0
Fixed sources	5,000[a]	0	0

a – Cutoff distance applied (U.S. Department of the Navy, 2017a)
b – Assessed under the assumption that some of the on-site drifting sources would become closer together.
c – No effect (and therefore, no distance from source) is anticipated based on the NAEMO modeling.

Southall et al. (2007) reported that pinnipeds do not exhibit strong reactions to Sound Pressure Levels (SPLs) up to 140 dB re 1 µPa from non-impulsive sources. While there are limited data on pinniped behavioral responses beyond about 3 km in the water, the Navy used a conservative distance cutoff of 2.7 nm (5 km) for moderate source level, single platform training and testing events, and 5.4 nm (10 km) for all other events, including the proposed Arctic Research Activities (U.S. Department of the Navy, 2017a). The Permits Division and AKR have also adopted this approach in support of their proposed IHA and biological opinion, respectively.

Regardless of the received level at the cutoff distances described above, take is not estimated to occur beyond 10 km from the source for pinnipeds. No instances of PTS or TTS were modeled and thus, no take by Level A harassment is anticipated or proposed to be authorized. Further information on cutoff distances can be found in (ONR 2021).

The marine mammal density numbers utilized for quantitative modeling of take are from the Navy Marine Species Density Database (U.S. Department of the Navy, 2014). Density estimates are based primarily on habitat-based modeling by Kaschner et al. (2006) and Kaschner (2004). We note that no surveys for ringed seal population estimates have occurred over the deep water of the Beaufort Sea. Surveys for bowhead whales that are conducted every year in the fall over the continental shelf of the Beaufort and Chukchi seas record seal presence, but because ringed seals are small and hard to identify from airplanes, surveys do not distinguish them from other small pinnipeds (e.g., ringed, ribbon, or spotted seals) or from unidentified pinniped (e.g. (Clarke et al. 2020)). Consequently we do not have reliable estimates of ringed seal density for the action area. The habitat based modeling which the Navy used to estimate ringed seal density ranged from 0.1108 - 0.3562 ringed seals/km^2 (the range for the density values accounts for the drifting sources). However, based on the life history of ringed seals, the very deep water at which the proposed activities will occur, monitoring reports from past cruises, and the results of tagging studies that continental shelf waters were occupied by ringed seals for greater than 96 percent of tracking days (Von Duyke et al. 2020), the density estimates used by the Navy are higher than we expect to occur, thus providing a very conservative estimate (overestimate) of ringed seal exposures to project effects. Table 12 shows the exposures expected for the ringed seal based on NAEMO modeled results.

Table 12. Quantitative Modeling Results of Potential Exposures

Species	Non-Impulsive Active Acoustics (Behavioral)	Icebreaking (behavioral)	Icebreaking (TTS)
Ringed Seal	2,839	538	1

6.3 Response Analysis

6.3.1 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 or from accumulated effects of non-pulsed sound from a continuous sound source.

Based on the modeling done by the Navy one ringed seal may experience TTS from noise associated with icebreaking. In addition, 538 ringed seals could exhibit behavioral responses to icebreaking noise. We do not expect PTS or TTS from the active acoustic sources.

Wilson et al. (2020), in assessing the risk of ice-breeding pinnipeds to shipping in the Arctic, found that the greatest risk was in the spring pupping season. Icebreaking, should it be needed for this project would likely occur in the late summer or fall when pups are independent. In addition, ringed seals will have completed their annual molt which typically occurs in May and June. Von Duyke et al. (2020) found that tagged ringed seals made trips across the open water of the Beaufort Sea to reach the retreating ice edge in July. Once there, they spent the majority of their time basking.

If an icebreaker came near ringed seals when they are basking on the ice, we expect that the most likely response would be a dive into the water. The noise generated by the icebreaker and the acute hearing of the ringed seals in air (Sills et al. 2015) ensures that they will be aware of the vessel long before it nears them, so a startle response is not expected. For that same reason, and because noise in air dissipates rapidly, we do not expect ringed seals to be exposed to in-air sound from icebreaking activities above 100 dB re 20μPa_{rms}. If they dive into the water they would be exposed temporarily to the underwater noise of icebreaking. We expect most seals would swim away from the vicinity of the ship. As discussed below, acoustic masking could occur, but breeding season will have concluded prior to the ship's arrival in the Beaufort, and ringed seal vocalizations occur infrequently at other times of the year (MacIntyre et al. 2013; Jones et al. 2014; Stafford et al. 2022).

Ringed seals may occur in the action area and could overlap with noise associated with icebreaking. We assume that some individuals will be exposed and respond to these continuous noise sources. As discussed above (section 4.1.3), because of the military readiness exclusion, vessel operations will not overlap with ringed seal critical habitat. Due to the short duration of the icebreaking (about 8 days), its offshore location (far from favored ringed seal habitat), and its timing (occurring outside of the main molting and breeding periods when 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 will be minimized, should icebreaking activities occur. However, some seals may exhibit behavioral reactions to the ice breaking or be exposed to harmful levels of sound for a brief time.

6.3.2 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).

The hearing acuity of ringed seals rivals the acute hearing abilities of some fully aquatic and terrestrial species in their respective habitats. Critical ratios, a measure of the relative ability of an animal to extract signals from noise, have been determined for pinnipeds (Southall et al. 2000; Southall et al. 2003; Sills et al. 2014; Sills et al. 2015; Sills et al. 2020). Ringed seals have an excellent ability to detect target signals within background noise (Sills et al. 2015; Sills et al. 2020). Ringed seals do not echolocate to find food, consequently the vessel noise will not mask vocalizations needed for feeding. In-air icebreaking noise could theoretically mask the sounds of an approaching polar bear. However, because of the noise and physical presence of a vessel it is unlikely that polar bears would actively hunt with a large ice-breaking ship in the vicinity.

Ringed seal calls are primarily barks in winter and yelps in spring (Jones et al. 2014). Stirling et al. (1983) hypothesized that the calls are involved in intraspecific competition to maintain social structure around breathing holes and that they may also serve a purpose during reproduction. As noted above, the majority of ringed seal vocalizations are recorded in the spring (MacIntyre et al. 2013; Jones et al. 2014; Stafford et al. 2022). Because ringed seals breed in the spring and the project activities will in late summer or fall, vessel noise will not interfere with vocalizations related to breeding.

6.3.3 Behavioral Response

NMFS expects that ringed seals may have a behavioral response to the sounds created by the icebreaking and the research devices. 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 (e.g., Nowacek et al. 2007; Southall et al. 2007; Southall et al. 2009; Ellison et al. 2012; Southall et al. 2019) 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, a flight response is likely to be coupled with an increased respiration rate. 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.

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 did not react or became 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.

In cases where the seal response is brief (i.e., changing from one behavior to another, relocating a short distance, or ceasing vocalization), effects could rise to the level of take of individuals but are not likely to be significant at the population level.

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). Southall et al. (2007) reported that pinnipeds do not exhibit strong reactions to SPLs up to 140 dB re 1 µPa from non-impulsive sources. Data on hooded seals (*Cystophora cristata*) indicate avoidance responses to signals above 160–170 dB re 1 µPa (Kvadsheim et al. 2010), and data on gray (*Halichoerus grypus*) and harbor seals indicate avoidance response at received levels of

135–144 dB re 1 μPa (Götz et al. 2010). In each instance where food was available, which provided the seals motivation to remain near the source, habituation to the signals occurred rapidly. In the same study, it was noted that habituation was not apparent in wild seals where no food source was available (Götz et al. 2010). This implies that the motivation of the animal is necessary to consider in determining the potential for a reaction.

In one study aimed to investigate the under-ice movements and sensory cues associated with under-ice navigation of ice seals, acoustic transmitters (60–69 kHz at 159 dB re 1 μPa at 1 m) were attached to ringed seals (Wartzok et al. 1992). An acoustic tracking system then was installed in the ice to receive the non-impulsive acoustic signals and provide real-time tracking of ice seal movements. Although the frequencies used in the study are at the upper limit of ringed seal hearing, the ringed seals appeared unaffected by the non-impulsive acoustic sources, as they maintained normal behaviors (e.g., finding breathing holes).

In studies by Goetz and Janik (2010) and Kvadsheim et al. (2010), seals that were exposed to non-impulsive acoustic sources with a received sound pressure level between 142–193 dB re 1 μPa, changed their behavior by modifying diving activity and avoidance of the sound source. Although a minor change to a behavior may occur as a result of exposure to the active acoustic sources in the proposed action, these changes would be within the normal range of behaviors for the animal (e.g., the use of a breathing hole further from the source, rather than one closer to the source, would be within the normal range of behavior) (Kelly et al. 1988).

These studies indicate that depending on a variety of factors including availability of food, past experiences with anthropogenic sound, and distance from the source, ringed seals may avoid the sounds created by the proposed project or they may exhibit very little reaction.

6.3.4 Non-Auditory 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). 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).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. For example, various efforts have investigated the impact of vessels on marine mammals (both whale-watching and general vessel traffic noise) and demonstrated that impacts do occur (Erbe 2002; Williams et al. 2002; Bain et al. 2006; Noren et al. 2009; Pirotta et al. 2015). In an analysis of energy costs to killer whales, Williams and Noren (2009) suggested that whale-watching in the Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, suggesting that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to their previous level within 24 hours after the resumption of shipping traffic. Exposure to loud noise can also adversely affect reproductive and metabolic physiology (Kight and Swaddle 2011). In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight and Swaddle 2011).

If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Whales and seals 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 that noise introduced by the active acoustic sources and icebreaking may result in ringed seals temporarily exhibiting behavioral responses. Therefore, we expect ringed seals may experience stress responses. If ringed seals are not displaced and remain in a stressful environment (i.e., within the behavioral harassment zone), we expect the stress response will dissipate shortly after the individual leaves the area or after the cessation of the acoustic stressor.

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 seal to continue. 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 and will likely increase. On June 25, 2021 a multilateral, multinational agreement to prevent unregulated fishing in the high seas of the central Arctic Ocean entered into force. Based on this agreement, we assume any commercial fishing that may be allowed after the agreement expires would occur under principles of sustainable management and closely monitored.

As discussed in section 5.4, continued expansion of the duration and extent of seasonal ice-free waters in the Chukchi and Beaufort seas is expected over the coming decades, likely resulting in increased vessel traffic and increased duration of the navigation season. As seasonal ice-free waters expand, the international commercial transport of goods and people in the area is projected to increase 100-500 percent in some Arctic areas by 2025 (Adams and Silber 2017). The U.S. Committee on the Marine Transportation System (CMTS) reported that the number of vessels operating in the Chukchi and Beaufort seas has increased 128% from 2008 to 2018. The length of the navigation season has been growing by as much as 7-10 days annually, which, extrapolated over the next decade, could result in 2.5 months of additional navigation season over what was currently seen in 2019 (U.S. Committee on the Marine Transportation System 2019). Cao et al. (2022) also determined that trans-Arctic shipping routes are expanding faster than predicted by climate model projections. Although some vessels are related to federal actions, vessels related to commercial shipping and tourism, which have no federal nexus, are expected to increase substantially.

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 5.1).

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

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 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 direct or indirect alterations that appreciably diminish the value of designated critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species (Section 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 (Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). Therefore, if we conclude that individuals of the listed species are not likely to experience reductions in their fitness, we would conclude our assessment because we would not expect the effects of the action to affect the performance of the populations those individuals represent or the species those population comprise. If, however, we conclude that 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.

We assume that existing regulations or similar regulatory requirements will apply over the life of the ONR's Arctic Research Activities from September 2022 to September 2023. Regulatory changes may require reinitiation of consultation per 50 CFR 402.16. In addition, we assume that all required mitigation measures will be implemented. If required mitigation measures are not incorporated into the proposed action, ONR will need to reinitiate consultation per 50 CFR 402.16.

As discussed in Section 4.1, we concluded that the vessel transit may affect but will not adversely affect bowhead whales, fin whales, blue whales, sei whales, North Pacific right whales, Western North Pacific DPS gray whales, sperm whales, Western North Pacific DPS humpback whales, Mexico DPS humpback whales, Beringia DPS bearded seals, and Western DPS Steller sea lions. We also concluded that vessel traffic would not adversely affect critical habitat for North Pacific right whales, Western North Pacific DPS and Mexico DPS humpback whales, ringed seals, bearded seals and Steller sea lions. We came to this conclusion based on the implementation of protective mitigation measures, the low likelihood of overlap with the subarctic species, the lack of evidence of vessel strikes throughout the route, and the low number of transits through potentially occupied habitat.

8.1 Ringed Seal Risk Analysis

Based on the results of the exposure analysis (see Section 6), we expect ringed seals may be exposed to underwater noise from vessels in transit, drifting and moored non-impulsive active acoustic sources, and icebreaking. Exposure to noise from moored and drifting acoustic sources may result in Level B harassment (and therefore takes) due to project sounds (Table 13). Exposure to noise from icebreaking may result in Level B harassment and one TTS.

Ringed seals may be exposed to project vessels or project equipment, or entangled in lines, cables, or expended materials associated with this project. However, because of the low density of ringed seals in the deep water of the Beaufort Sea, the low number of vessel transits and devices, the probability of a project vessel striking a ringed seal is extremely small, as is the probability of a ringed seal becoming entangled in project-related marine debris, lines, cables or in-water devices. Thus, adverse effects to ringed seals from strikes or entanglement are extremely unlikely to occur.

There is the potential of exposure to vessel noise, ice auguring, *de minimis* sources, and small oil spill discharge as part of the proposed action, but the effects are considered minor or extremely unlikely to occur, and would not rise to the level of take. Similarly, physical disruption of ice habitat from potential icebreaking activity could be temporarily displace individual ringed seals but we do not expect this would lead to a measurable effect on those individuals.

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. 2010b). Fall and early winter overlap with the time period when a vessel 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 seals. As a result, the ringed seal’s probable responses (tolerance, avoidance, short-term masking, and short-term vigilance behavior) to close approaches by a vessel or 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, ringed seals will not have begun constructing lairs. While individual ringed seals may be impacted by behavioral responses to vessels, 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 ringed seals may be harassed by the proposed activities. NMFS relied upon ONR's NAEMO modeled exposures to calculate all takes. Table 13 shows the number of takes based on the exposure analysis associated with the proposed project.

Table 13. Take of ringed seals for active acoustic sources and icebreaking

Species	Non-Impulsive Active Acoustics (Behavioral)	Icebreaking (behavioral)	Icebreaking (TTS)	Total
Ringed Seal	2,839	538	1	3,378

These estimates represent the total number of exposure events (instances) that will occur, not necessarily the number of individual seals exposed, as an individual seal may be "exposed" 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. In addition, in section 6.2, Exposure Analysis, we provided several reasons why the modeled exposure estimates are overestimates.

No reduction in the distribution of Arctic subspecies of ringed seals from the Arctic Ocean is expected because of ONR's Arctic Research Activities and the Permits Division's issuance of an incidental harassment authorization and possible renewal.

The Arctic subspecies of ringed seal is threatened due to climate change especially from the expected loss of sea ice and snow cover over the ensuing decades. Ringed seals are an important species for Alaska Native subsistence hunters. The current level of subsistence harvest is not known and there are no efforts to quantify statewide harvest numbers. The highest number of ringed seals taken in a year was 1,306 in 2014. Additional threats to the species which may increase over time with the loss of sea ice include fisheries interactions (including entanglement), disturbance from vessels, sound from seismic exploration, and oil spills.

The Arctic subspecies of ringed seal has an apparently large population, making it resilient to immediate perturbations. However, threatened by climate change in the long-term, the species is likely to become endangered in the future.

There are no precise population estimates for the entire Arctic subspecies of ringed seal population due to the species' widespread distribution across political boundaries. In the status review (Kelley et al. 2010a), the population was estimated at approximately 2,000,000 individuals; however, NMFS considers this a rough estimate, as it relies on old data collected in a variety of ways and does not include all areas of its range. In the status review, the population of ringed seals in Alaska waters of the Chukchi and Beaufort seas was estimated to be at least 300,000 individuals. This is most likely an underestimate of the true abundance because surveys in the Beaufort Sea were limited to within 40 kilometers (21.6 nautical miles) of the shore (Kelly et al. 2010a).

Due to insufficient data, population trends for the Arctic subspecies of ringed seal cannot be calculated. It is unknown if the population is stable increasing, or declining. The genetic population structure of the Arctic subspecies of ringed seal is poorly understood. It is likely that population structuring exists in the species, but the extent to which it occurs is unknown.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. We expect that 3,378 individuals will be harassed from the proposed research activities. Because we do not expect a reduction in numbers or reproduction of Arctic subspecies of ringed seals as a result of the proposed research activities and the Permits Division's issuance of an incidental harassment authorization and possible renewal, a reduction in the species' likelihood of survival is not expected.

Because no mortalities or effects on the abundance, distribution, and reproduction of Arctic subspecies of ringed seal populations are expected as a result of the proposed action, we do not anticipate the proposed Arctic Research Activities, including icebreaking, and the Permits Division's issuance of an incidental harassment authorization and possible renewal will impede the recovery objectives for Arctic subspecies of ringed seals. In conclusion, we believe the effects associated with the proposed actions are not likely to appreciably reduce the likelihood of survival or recovery of Arctic subspecies of ringed seals in the wild, when considered along with the environmental baseline and cumulative effects.

9 Conclusion

After reviewing the current status of the listed species, the environmental baseline for the action area, the effects of the proposed action, and the 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 Arctic ringed seal.

In addition, the proposed action is not likely to adversely affect the bowhead whale, fin whale, blue whale, sei whale, North Pacific right whale, Western North Pacific DPS gray whale, sperm whale, Western North Pacific DPS humpback whale, Mexico DPS humpback whale, Beringia DPS bearded seal, or Western DPS Steller sea lion. We expect no effects to critical habitat for any species under NMFS jurisdiction.

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 (16 U.S.C. § 1532(19)). "Incidental take" is defined as take that results from, but is not the purpose of, the carrying out of an otherwise lawful activity conducted by the action agency or applicant (50 CFR § 402.02). Based on 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 National Defense Authorization Act of Fiscal Year 2004 (PL 108-136) amended the definition of "harassment" under the MMPA, specifically as it applies to military readiness activities or scientific research activities conducted by or on behalf of the federal government (16 U.S.C. §1362 (18)(B)). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (PL 107-314). Research activities within the study area are composed of military readiness activities, as that term is defined in section 315(f) of PL 107-314, because activities constitute realistic testing of military equipment, vehicles, and sensors for proper operation and suitability for combat use. For military readiness activities, the relevant definition of harassment under the MMPA is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment"); or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") (16 U.S.C. § 1362(18)(B)(i) and (ii)).

For this consultation, the Permits Division expects 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 seals; therefore, ESA section 9 take prohibitions do not apply. This ITS includes numeric limits on the take of this species because specific amounts of take were analyzed in our jeopardy analysis. These numeric limits provide guidance to the action agencies on their requirement to re-initiate 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 this threatened species.

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized under section 101(a)(5) of the MMPA. Accordingly, the reasonable and prudent measures and terms and conditions 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.

ONR has a continuing duty to regulate the activities covered by this ITS. In order to monitor the impact of incidental take, ONR must monitor the progress of the action and its impact on the species as specified in the ITS (50 CFR 402.14(i)(3)).

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 (e.g., other species, habitat, or ecological conditions) 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 expects the proposed ONR project in the Beaufort Sea, Alaska, in September 2022 and another potential cruise in late summer or fall 2023, is likely to result in the incidental take of ringed seals 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 or temporary hearing impairment; 2) the range to which behavioral effects were anticipated to reach; and 3) the density or occurrence of marine mammals within these ensonified areas. AKR and the Permits Division relied heavily on the NAEMO model developed by the Navy for assessing the impacts of underwater sound (ONR 2021)

NMFS has determined that the proposed action is expected to take by harassment from icebreaking: one Arctic ringed seal by causing TTS and 538 Arctic ringed seals through behavioral harassment. Through the use of active acoustic sources 2,839 Arctic ringed seals may be taken through behavioral harassment.

Harassment of these individuals will occur by exposure to sound from acoustic sources with received sound levels of 120 - 190 dB_{rms} re 1 μPa within the ensonified area. NAEMO modelling indicated that ringed seals would have to be within 10 km from the source to elicit any behavioral reaction (e.g., flushing from a lair) (87 FR 44339). If exposure were to occur, ringed seals may exhibit behavioral responses such as avoidance, increased swimming speeds, increased surfacing time, or decreased foraging or on-ice resting time.

Any incidental take of ringed seals considered in this consultation is restricted to the permitted action as proposed. If the actual incidental take exceeds the estimated level or type of take, ONR and the Permits Division may be required to reinitiate consultation. Likewise, if the action deviates from what is described in Section 2 of this biological opinion, ONR and the Permits Division may be required to reinitiate consultation. All anticipated takes will be by harassment, as described previously, involving temporary changes in behavior.

10.2 Effect of the Take

In section 9 of this Opinion, NMFS determined that the level of anticipated incidental take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the ESA-listed species.

The 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 population, or the species' survival or recovery.

10.3 Reasonable and Prudent Measures

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

RPMs are distinct from the mitigation measures that are included in the proposed action (described in Section 2.2). We presume that the mitigation measures will be implemented as described in this opinion. The failure to do so will constitute a change to the action that may require reinitiation of consultation pursuant to 50 CFR § 402.16.

The RPMs included below, along with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS concludes that the following RPMs are necessary and appropriate to minimize or to monitor the incidental take of Arctic ringed seals resulting from the proposed action.

ONR will:

1. Verify implementation of the mitigation measures,
2. Monitor for the effects of the action on listed marine mammals,
3. Monitor for and report unauthorized take (i.e. unexpected harm or harassment that occurs to a marine mammal and was not analyzed in this biological opinion), and
4. Submit a report to NMFS AKR that evaluates the mitigation measures and reports the results of the monitoring program.

10.4 Terms and Conditions

These terms and conditions are in addition to the mitigation measures included in the proposed action, as set forth in Section 2.2 of this opinion. The Navy and the Permits Division has 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(i)(3))).

These terms and conditions constitute no more than a minor change to the proposed action because they are consistent with the basic design of the proposed action.

To carry out the RPM 1 listed in Section 10.3 (Verify implementation of the mitigation measures), the following must occur:

1.1 To verify compliance with ship speed and critical habitat mitigation measures, ONR must submit AIS data for the cruises to NMFS AKR.

1.2 To verify compliance with marine mammal avoidance when the vessel is in transit, a complete and accurate log, including the following information, must be submitted to NMFS AKR (see table x for contact information):

   i. Date, time, geographic coordinates and species ID of all marine mammal observations made during the transit;

   ii. Distance of the marine mammal from the ship;

   iii. Behavior, including any reactions to vessel;

   iv. Percent ice cover;

   v. Weather and Beaufort Wind Force Scale;

   vi. A record for everyday of the cruise. If no marine mammals are sighted on a given day, that information will be recorded and;

   vii. Date and time that icebreaking starts and stops and 1.2 i.-vi.

1.3 To verify compliance with mitigation measures related to device deployment, a complete and accurate log must be kept during project activities which includes:

   i. Date and time that mooring and device deployment begin and end.

   ii. If a marine mammal is spotted during device deployment, Terms and Conditions 1.2 ii-vii, and the mitigation measures taken, will be recorded.

To carry out the RPM 2 listed in Section 10.3 (Monitor for the effects of the action on listed marine mammals), the following must occur:

2.1 To monitor for the effects of the action on listed marine mammals, a monitoring log must be kept which contains a record of all behavioral reactions that marine mammals have to vessel passage, icebreaking, and device deployment. The monitoring log will be submitted to NMFS AKR as part of the final report (see Term and Condition 4.1)

   i. ONR will document when active acoustic testing starts and ends. If any marine animals are observed during testing, Term and Conditions 1.2 ii.-vi will be recorded.

To carry out the RPM 3 listed in Section 10.3 (Monitor for and report all unauthorized take), the following must occur:

3.1 To monitor and report all unauthorized take (e.g. take of endangered whales or sea lions, ONR must report the taking within 48 hours to NMFS AKR, Protected Resources Division (Table 14) at 907-586-7638, by email to akr.section7@noaa.gov, to greg.balogh@noaa.gov, to the Marine Mammal Stranding Hotline at 877-925-7773, and to NMFS Permits Division (Jaclyn Daly, Jaclyn.daly@noaa.gov or 301-427-8484) (Table 14).

The report must include the following information:

i. Time, date, and geographic coordinates of the incident;

ii. details on the nature and cause of the take (e.g., vessels or equipment in use at the time of take);

iii. environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);

iv. description of marine mammal observations in the 24 hours preceding the incident;

v. species identification or description of the animal(s) involved;

vi. the fate of the animal(s);

vii. and any photographs or video footage of the animal obtained.

To carry out the RPM 4 listed in Section 10.3 (Submit a report to NMFS AKR that evaluates the mitigation measures and reports the results of the monitoring program), the following must occur:

4.1 The ONR must submit to NMFS AKR a final report summarizing ESA-listed marine mammal sightings and annual takes of listed marine mammals to AKR.section7@noaa.gov (please include NMFS consultation number AKRO 2022-01871) (Table 14). The final report will be submitted within 90 days of the cessation of in-water work. The draft final report will be subject to review and comment by NMFS AKR. Comments and recommendations made by NMFS AKR must be addressed in the final report prior to NMFS acceptance of the report. The draft report will be considered final for the activities described in this opinion if NMFS AKR has not provided comments and recommendations within 30 days of receipt of the draft report. This final report must contain the following information:

i. A description of the implementation and qualitative assessment of the effectiveness of mitigation measures for minimizing adverse effects of the action on ESA-listed species;

ii. A digital file that can be queried containing all observer monitoring data and associated metadata.

11 Conservation Recommendations

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

1. ONR should review all new and relevant marine mammal population and density data from the Arctic to ensure that inputs into NAEMO are updated with the most current available information.
2. We suggest that ONR utilize standardized monitoring forms to record information associated with marine mammal observations as described in Mitigation Measure #8.
3. ONR should provide training or ensure observers take an approved protected species observer course so that those responsible for marine mammal observation throughout the cruise are qualified and capable of accurate data recording.
4. ONR should provide funding and logistical support needed to obtain improved estimates of marine mammal densities in the Chukchi and Beaufort seas.

In order to keep NMFS's Protected Resources Division, Alaska Region informed of actions minimizing or avoiding adverse effects or benefiting ESA-listed species or their habitats, ONR should notify NMFS of any conservation recommendations those agencies implement.

Table 14. NMFS Contact Information

Reason for Contact	**Contact Information**
Consultation Questions & Unauthorized Take	Greg Balogh: greg.balogh@noaa.gov Marilyn Myers: Marilyn.myers@noaa.gov and
Reports & Data Submittal	AKR.section7@noaa.gov (please include NMFS consultation number AKRO 2021-09126)
Stranded, Injured, or Dead Marine Mammal *(not related to project activities)*	Stranding Hotline (24/7 coverage) 877-925-7773
Oil Spill & Hazardous Materials Response	U.S. Coast Guard National Response Center: 1-800-424-8802 (or U.S. Coast Guard 17th District Command Center: 907-463-2000) & NMFS AKR Protected Resources Oil Spill Response Coordinator: 907-586-7630 AKRNMFSSpillResponse@noaa.gov and/or Sadie.wright@noaa.gov

12 Reinitiation of Consultation

As provided in 50 CFR § 402.16, reinitiation of consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount of incidental take is exceeded, section 7 consultation must be reinitiated immediately (50 CFR § 402.14(i)(4)).

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 NOAA, the Navy, 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.

14 References

Adams, J. D., and G. K. Silber. 2017. 2015 vessel activity in the Arctic. U.S. Dept. of Commerce, NOAA, NMFS, Office of Protected Resources, Silver Spring, MD, July 2017. NOAA Tech. Memo. NMFS-OPR-57, 171 p.

Aerts, L., M. Blees, S. Blackwell, C. Greene, K. Kim, D. Hannay, and M. Austin. 2008. Marine mammal monitoring and mitigation during BP Liberty OBC seismic survey in Foggy Island Bay, Beaufort Sea, July-August 2008: 90-day report.

Allen, S. G. 1984. The effect of disturbance on harbor seal haul out patterns at Bolinas Lagoon, California. Fishery Bulletin 82(3):493-500.

Andersen, M. S., K. A. Forney, T. V. N. Cole, T. Eagle, R. Angliss, K. Long, L. Barre, L. V. Atta, D. Borggaard, T. Rowles, B. Norberg, J. Whaley, and L. Engleby. 2008. Differentiating serious and non-serious injury of marine mammals: Report of the Serious Injury Technical Workshop, 10-13 September 2007, Seattle, Washington, NOAA Technical Memorandum NMFS-OPR-39. 94 p.

Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs 70(3):445-470.

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 AECOM and NMFS Alaska Region, JASCO Document #01003, Anchorage, AK, 90 p.

Avio, C. G., S. Gorbi, M. Milan, M. Benedetti, D. Fattorini, G. d'Errico, M. Pauletto, L. Bargelloni, and F. Regoli. 2015. Pollutants bioavailability and toxicological risk from microplastics to marine mussels. Environmental Pollution 198:211-222.

Azzara, A. J., H. Wang, and D. Rutherford. 2015. A 10-Year Projection of Maritime Activity in the U.S. Arctic Region. U.S. Committee on the Marine Transportation System, Washington, D.C., 163-178.

Bain, D. E., J. C. Smith, R. Williams, and D. Lusseau. 2006. Effects of vessels on behavior of Southern Resident killer whales (*Orcinus* spp.), NMFS Contract Report No. AB133F-03-SE-0959 and AB133F-04-CN-00040, March 4, 2006, 62 p.

Barbeaux, S. J., K. Holsman, and S. Zador. 2020. Marine heatwave stress test of ecosystem-based fisheries management in the Gulf of Alaska Pacific Cod Fishery. Frontiers in Marine Science 7:703.

Bates, N. R., J. T. Mathis, and L. W. Cooper. 2009. Ocean acidification and biologically induced seasonality of carbonate mineral saturation states in the western Arctic Ocean. Journal of Geophysical Research 114(C11007).

Baulch, S., and C. Perry. 2014. Evaluating the impacts of marine debris on cetaceans. Marine Pollution Bulletin 80(1-2):210-221.

Becker, P. R., E. A. Mackey, M. M. Schantz, R. Demiralp, R. R. Greenberg, B. J. Koster, S. A. Wise, and D. C. G. Muir. 1995. Concentrations of chlorinated hydrocarbons, heavy metals and other elements in tissues banked by the Alaska Marine Mammal Tissue Archival Project. U.S. Department of Commerce, NOAA and National Institute of Standards and Technology, Silver Spring, MD. OCS Study MMS 95-0036, NISTIR 5620.

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(11):833-845.

Bergmann, M., V. Wirzberger, T. Krumpen, C. Lorenz, S. Primpke, M. B. Tekman, and G.

Gerdts. 2017. High quantities of microplastic in Arctic deep-sea sediments from the HAUSGARTEN Observatory. Environmental Science and Technology 51(19):11000-11010.

Besseling, E., E. Foekema, J. Van Franeker, M. Leopold, S. Kühn, E. B. Rebolledo, E. Heße, L. Mielke, J. IJzer, and P. Kamminga. 2015. Microplastic in a macro filter feeder: humpback whale *Megaptera novaeangliae*. Marine Pollution Bulletin 95(1):248-252.

Besseling, E., B. Wang, M. Lürling, and A. A. Koelmans. 2014. Nanoplastic affects growth of *S. obliquus* and reproduction of *D. magna*. Environmental Science and Technology 48(20):12336-12343.

Bisson, L. N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M. L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July–November 2012: Draft 90-Day Report. Report from LGL Alaska Research Associates Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC, for Shell Offshore Inc, Houston, TX, NMFS, Silver Spring, MD, and U.S. Fish and Wild. Serv., Anchorage, AK, LGL Rep. P1272D–1, 266 p. + appendices.

Blackwell, S. B., and C. R. Greene. 2001. Sound Measurements, 2000 Break-up and Open-water Seasons. Pages 55 *in* Monitoring of Industrial Sounds, Seals, and Whale Calls During Construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2000, volume LGL Report TA 2429-2. LGL Ecological Research Associates, Inc., King City, Ont., Canada.

Blackwell, S. B., C. R. G. Jr., and W. J. Richardson. 2004. Drilling and operational sounds from an oil production island in the ice-covered Beaufort Sea. Journal of Acoustical Society of America 116(5):3199-3211.

Blair, H. B., N. D. Merchant, A. S. Friedlaender, D. N. Wiley, and S. E. Parks. 2016. Evidence for ship noise impacts on humpback whale foraging behaviour. Biology letters 12(8):20160005.

BLM. 2019. Biological Evaluation for the Implementation of the Oil and Gas Lease Sales for the Arctic Wildlife Refuge Coastal Plain. Submitted to NMFS Alaska Region, Anchorage, AK, May 10, 2019.

BOEM. 2011. Biological evaluation for oil and gas activities on the Beaufort and Chukchi sea planning areas, September 2011. OCS EIS/EA BOEMRE 2011.

BOEM. 2016. Outer Continental Shelf, Oil and Gas Leasing Program: 2017-2022, Final Programmatic Environmental Impact Statement. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Sterling, VA, November 2016. OCS EIS/EA BOEM 2016-060.

BOEM. 2017. Liberty Development and Production Plan Biological Assessment. Prepared by U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska OCS Region and submitted to National Marine Fisheries Service and U.S. Fish and Wildlife Service, Anchorage, AK, December 2017, 235 p.

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters 42(9):3414-3420.

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(3):171-178.

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, Final Report. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Anchorage, AK. Report prepared by NMFS Marine

Mammal Laboratory for BOEM, BOEM Report 2016-077, 119 p. plus appendices.
Braham, H. W. 1984. The bowhead whale, *Balaena mysticetus*. Marine Fisheries Review 46(4):45-53.
Brandon, J., and P. R. Wade. 2006. Assessment of the Bering-Chukchi-Beaufort Sea stock of bowhead whales using Bayesian model averaging. Journal of Cetacean Research and Management 8(3):225-239.
Brandon, R. 1978. Adaptation and evolutionary theory. Studies in the History and Philosophy of Science 9:181-206.
Bratton, G. R., C. B. Spainhour, W. Flory, M. Reed, and K. Jayko. 1993. Presence and potential effects of contaminants. Pages 701-744 *in* J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The Bowhead Whale. The Society for Marine Mammalogy, Special Publication Number 2, Lawrence, KS.
Breed, G. A., M. F. Cameron, J. M. Ver Hoef, P. L. Boveng, A. Whiting, and K. J. Frost. 2018. Seasonal sea ice dynamics drive movement and migration of juvenile bearded seals Erignathus barbatus. Marine Ecology Progress Series 600:223-237.
Broadwater, M. H., F. M. Van Dolah, and S. E. Fire. 2018. Vulnerabilities of marine mammals to harmful algal blooms. Pages 191-222 *in* S. E. Shumway, J. M. Burkholder, and S. L. Morton, editors. Harmful Algal Blooms: A Compendium Desk Reference. John Wiley and Sons, Hoboken, NJ.
Brower, A., A. Willoughby, and M. Ferguson. 2022. Distribution and relative abundance of bowhead whales and other marine mammals in the western Beaufort Sea, 2020.
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. Final report to U.S. Dept. of Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK. Contract No. M04PC00001, OCS Study MMS 2010-004, 241 p.
Burek, K. A., F. Gulland, and T. M. O'Hara. 2008. Effects of climate change on Arctic marine mammal health. Ecological Applications 18(sp2).
Burns, J. J. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Pittman-Robertson Project Report W-6-R and W-14-R, Juneau, AK, 66 p.
Burns, J. J. 1981. Bearded seal *Erignatus barbatus* Erxleben, 1777. Handbook of Marine Mammals Volume 2: Seals: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 *in* Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976, volume 1-Marine Mammals, 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 25(4):279-290.
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, Seattle, WA, April-May-June 2007, pages 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, Seattle, WA, October-November-December 2009, pages 1-4.

Cameron, M. F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (*Erignathus barbatus*). U.S. Department of Commerce, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, December 2010. NOAA Tech. Memo. NMFS-AFSC-211, 246 p.

Cameron, M. F., K. J. Frost, Jay M. Ver Hoef, B. G. A., A. V. Whiting, J. Goodwin, and P. L. Boveng. 2018. Habitat selection and seasonal movements of young bearded seals (*Erignathus barabatus*) in the Bering Sea. PLoS One 13(2):e0192743.

Cao, Y., S. Liang, L. Sun, J. Liu, X. Cheng, D. Wang, Y. Chen, M. Yu, and K. Feng. 2022. Trans-Arctic shipping routes expanding faster than the model projections. Global Environmental Change 73:102488.

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(2):379-393.

Cavole, L. M., A. M. Demko, R. E. Diner, A. Giddings, I. Koester, C. M. Pagniello, M.-L. Paulsen, A. Ramirez-Valdez, S. M. Schwenck, and N. K. Yen. 2016. Biological impacts of the 2013–2015 warm-water anomaly in the Northeast Pacific: winners, losers, and the future. Oceanography 29(2):273-285.

Chapin, F. S., III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze. 2014. Ch. 22: Alaska. Pages 514-536 *in* J. M. Melillo, T. C. Richmond, and G. W. Yohe, editors. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program.

Cheng, L., J. Abraham, J. Zhu, K. E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M. E. Mann. 2020. Record-Setting Ocean Warmth Continued in 2019. Advances in Atmospheric Sciences 37(2):137-142.

Clark, C. W., W. T. Ellison, B. L. Southall, L. Hatch, S. M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Clark, C. W., and J. H. Johnson. 1984. The sounds of the bowhead whale, *Balaena mysticetus*, during the spring migrations of 1979 and 1980. Canadian Journal of Zoology-Revue Canadienne De Zoologie 62(7):1436-1441.

Clarke, J., A. Brower, M. Ferguson, A. Willoughby, and A. Rotrock. 2020. Distribution and relative abundance of marine mammals in the eastern Chukchi Sea, eastern and western Beaufort Sea, and Amundsen Gulf, 2019 annual report. U.S. Dept. of Interior, Bureau of Ocean Energy Management (BOEM), Alaska OCS Region, Anchorage, AK, June 2020. OCS Study BOEM 2020-027 prepared under Interagency Agreement M17PG00031 by the NOAA, Alaska Fisheries Science Center, Marine Mammal Laboratory.

Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2012. Distribution and relative abundance of marine mammals in the Alaskan Chukchi and Beaufort Seas, 2011 Annual Report. Report prepared by U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, National Marine Mammal Laboratory for the U.S. Dept. of Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Alaska OCS Region, Anchorage, AK, March 2012. OCS Study BOEMRE 2012-009, 358 p.

Clarke, J. T., M. C. Ferguson, C. Curtice, and J. Harrison. 2015. 8. Biologically Important Areas for Cetaceans Within US Waters-Arctic Region. Aquatic Mammals 41(1):94.

Cleator, H. J., I. Stirling, and T. G. Smith. 1989. Underwater vocalizations of the bearded seal (*Erignathus barbatus*). Canadian Journal of Zoology 67(8):1900-1910.

Cole, M., P. Lindeque, C. Halsband, and T. S. Galloway. 2011. Microplastics as contaminants in the marine environment: a review. Marine Pollution Bulletin 62(12):2588-2597.

Conn, Paul B., Jay M. Ver Hoef, Brett T. McClintock, Erin E. Moreland, Josh M. London, Michael F. Cameron, Shawn P. Dahle, and Peter L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods in Ecology and Evolution 5(12):1280-1293.

Cowan, D., and B. Curry. 2008. Histopathology of the alarm reaction in small odontocetes. Journal of Comparative Pathology 139(1):24-33.

Cowan, D. F., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical Pacific tuna fishery. Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California. Administrative Report LJ-02-24C, 31.

Crance, J. L., C. L. Berchok, J. Bonnel, and A. M. Thode. 2015. Northeasternmost record of a North Pacific fin whale (Balaenoptera physalus) in the Alaskan Chukchi Sea. Polar Biology 38(10):1767-1773.

Crawford, J. A., K. J. Forst, L. 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.

Crowley, T. J. 2000. Causes of climate change over the past 1000 years. Science 289(5477):270-277.

Cummings, W. C., D. V. Holliday, and B. J. Lee. 1986. Potential impacts of man-made noise on ringed seals: vocalizations and reactions. Pages 95-230 in Outer Continental Shelf Environmental Program, Final Reports of Principal Investigators, Volume 37, Anchorage, AK, March 1986. OCS Study MMS 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. Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-254, La Jolla, California, 67.

DeGrandpre, M., W. Evans, M.-L. Timmermans, R. Krishfield, B. Williams, and M. Steele. 2020. Changes in the Arctic Ocean Carbon Cycle With Diminishing Ice Cover. Geophysical Research Letters 47(12):e2020GL088051.

Dehn, L. A., 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(6690):235-236.

Delarue, J., B. Martin, D. Hannay, and C. L. Berchok. 2013. Acoustic occurrence and affiliation of fin whales detected in the Northeastern Chukchi Sea, July to October 2007-10. Arctic 66(2):159-172.

Derocher, A. E., N. J. Lunn, and I. Stirling. 2004. Polar bears in a warming climate. (Ursus maritimus). Integrative and Comparative Biology 44(2):163-176.

Derraik, J. G. 2002a. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin 44(9):842-852.

Derraik, J. G. B. 2002b. The pollution of the marine environment by plastic debris: a review.

Marine Pollution Bulletin 44(9):842-852.

Dietrich, K. S., V. R. Cornish, K. S. Rivera, and T. A. Conant. 2007. Best practices for the collection of longline data to facilitate research and analysis to reduce bycatch of protected species: report of a workshop held at the International Fisheries Observer Conference Sydney, Australia, November 8, 2004. NOAA Technical Memorandum NMFS-OPR-35.

Doney, S. C., V. J. Fabry, R. A. Feely, and J. A. Kleypas. 2009. Ocean Acidification: The Other CO_2 Problem. Annual Review of Marine Science 1(1):169-192.

Doney, S. C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate change impacts on marine ecosystems. Annual Reviews in Marine Science 4:11-37.

Edrén, S. M. C., S. M. Andersen, J. Teilmann, J. Carstensen, P. B. Harders, R. Dietz, and L. A. Miller. 2010. The effect of a large Danish offshore wind farm on harbor and gray seal haul-out behavior. Marine Mammal Science 26(3):614-634.

Eisner, L. B., Y. I. Zuenko, E. O. Basyuk, L. L. Britt, J. T. Duffy-Anderson, S. Kotwicki, C. Ladd, and W. Cheng. 2020. Environmental impacts on walleye pollock (*Gadus chalcogrammus*) distribution across the Bering Sea shelf. Deep Sea Research Part II: Topical Studies in Oceanography:104881.

Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology 26(1):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(10):2506-2513.

Engelhardt, F. R. 1987. Assessment of the vulnerability of marine mammals to oil pollution. Pages 101-115 *in* J. Kuiper, and W. van den Brink, editors. Fate and effects of oil in marine ecosystems: Proceedings of the Conference on Oil Pollution organized under the auspices fo the International Association on Water Pollution Research and Control (IAWPRC) by the Netherlands Organization for Applied Scientific Research TNO Amsterdam, The Netherlands, 23-27 February 1987.

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(8):1143-1147.

Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Fabry, V. J., J. B. McClintock, J. T. Mathis, and J. M. Grebmeier. 2009. Ocean acidification at high latitudes: the Bellweather. Oceanography 22(4):160-171.

Fabry, V. J., B. A. Seibel, R. A. Feely, and J. C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science 65:414-432.

Fang, C., R. Zheng, F. Hong, Y. Jiang, J. Chen, H. Lin, L. Lin, R. Lei, C. Bailey, and J. Bo. 2021. Microplastics in three typical benthic species from the Arctic: Occurrence, characteristics, sources, and environmental implications. Environmental Research 192:110326.

Fang, C., R. Zheng, Y. Zhang, F. Hong, J. Mu, M. Chen, P. Song, L. Lin, H. Lin, and F. Le. 2018. Microplastic contamination in benthic organisms from the Arctic and sub-Arctic

regions. Chemosphere 209:298-306.
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(4):348-350.
Fedewa, E. J., T. M. Jackson, J. I. Richar, J. L. Gardner, and M. A. Litzow. 2020. Recent shifts in northern Bering Sea snow crab (Chionoecetes opilio) size structure and the potential role of climate-mediated range contraction. Deep Sea Research Part II: Topical Studies in Oceanography:104878.
Fedoseev, G. A. 1965. The ecology of the reproduction of seals on the northern part of the Sea of Okhotsk. Izvestiya TINRO 65:212-216.
Fedoseev, G. A. 1984. Population structure, current status, and perspective for utilization of the ice-inhabiting forms of pinnipeds in the northern part of the Pacific Ocean. Pages 130-146 *in* A. V. Yablokov, editor. Marine mammals. Nauka, Moscow.
Feely, R. A., S. C. Doney, and S. R. Cooley. 2009. Ocean acidification: present conditions and future changes in a high-CO_2 world. Oceanography 22(4):37-47.
Feely, R. A., C. L. Sabine, K. Lee, W. Berelson, J. Kleypas, V. J. Fabry, and F. J. Millero. 2004. Impact of anthropogenic CO2 on the CaCO3 system in the oceans. Science 305(5682):362-366.
Feltz, E. T., and F. H. Fay. 1966. Thermal requirements in vitro of epidermal cells from seals. Cryobiology 3(3):261-264.
Fey, S. B., A. M. Siepielski, S. Nusslé, K. Cervantes-Yoshida, J. L. Hwan, E. R. Huber, M. J. Fey, A. Catenazzi, and S. M. Carlson. 2015. Recent shifts in the occurrence, cause, and magnitude of animal mass mortality events. Proceedings of the National Academy of Sciences 112(4):1083-1088.
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(3):1819-1826.
Fournet, M. E., L. P. Matthews, C. M. Gabriele, S. Haver, D. K. Mellinger, and H. Klinck. 2018. Humpback whales Megaptera novaeangliae alter calling behavior in response to natural sounds and vessel noise. Marine Ecology Progress Series 607:251-268.
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(6):305-313.
Frankel, A. S., and C. M. Gabriele. 2017. Predicting the acoustic exposure of humpback whales from cruise and tour vessel noise in Glacier Bay, Alaska, under different management strategies. Endangered Species Research 34:397-415.
Freed, J., N. Young, B. Delean, V. Helker, M. Muto, K. Savage, S. Teerlink, L. Jemison, K. Wilkinson, and J. Jannot. 2022. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2016-2020.
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(1):193-204.
Frölicher, T. L., E. M. Fischer, and N. Gruber. 2018. Marine heatwaves under global warming. Nature 560(7718):360-364.
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 Mammal 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. P. W. Barnes, D. M. Schell, and E. Reimnitz, editors. The Alaskan Beaufort Sea: Ecosystems and Environments. Academic Press, Inc., New York, NY.
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(2):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 *in* 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 *in* Marine mammals and the Exxon Valdez. Elsevier.
Funk, D., D. Hannay, D. Ireland, R. Rodrigues, and W. R. Koski. 2008. Marine mammal monitoring during open water seismic exploration by Shell Offshore, Inc. in the Chukchi and Beaufort Seas, July-November 2007: 90 day report. LGL Alaska Research Assoc., Inc., Anchorage, AK.
Funk, D. W., D. S. Ireland, R. Rodrigues, and W. R. Koski. 2010. Joint monitoring program in the Chukchi and Beaufort Seas, open water seasons, 2006-2008. Draft final report prepared by LGL Alaska Research Associates Inc., Greenridge Sciences, and JASCO Applied Sciences for the National Marine Fisheries Service and U.S. Fish and Wildlife Service, LGL Draft Final Report P1050-2, March 2010, 529 p.
Gaden, A., S. H. Ferguson, L. Harwood, H. Melling, and G. A. 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 and Technology 43(10):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(11):1773-1780.
George, J. C., L. M. Philo, K. Hazard, D. Withrow, G. M. Carroll, and R. Suydam. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock. Arctic 47(3):247-255.
George, J. C., G. Sheffield, D. J. Reed, B. Tudor, R. Stimmelmayr, B. T. Person, T. Sformo, and R. Suydam. 2017. Frequency of injuries from line entanglements, killer whales, and ship strikes on Bering-Chukchi-Beaufort seas bowhead whales. Arctic 70(1):37-46.
George, J. C. C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of western Arctic bowhead whales surveyed near Barrow, Alaska. Marine Mammal Science 20(4):755-773.
Geraci, J. 2012. Sea mammals and oil: confronting the risks. Elsevier.
Geraci, J. R., and T. Smith. 1976a. Direct and Indirect Effects of Oil on Ringed Seals (*Phoca hispida*) of the Beaufort Sea. Journal of the Fisheries Research Board of Canada 33:1976-1984.
Geraci, J. R., and T. G. Smith. 1976b. Behavior and pathophysiology of seals exposed to crude oil. Pages 447-462 *in* Symposium American University: Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment. The American Institute of Biological Sciences, Washington, D.C., 9-11 August 1976.

Geraci, J. R., and D. J. St. Aubin. 1990. Sea Mammals and Oil: Confronting the Risks. Academic Press, Inc., San Deigo, CA.

Geyer, R., J. R. Jambeck, and K. L. Law. 2017. Production, use, and fate of all plastics ever made. Science Advances 3(7):e1700782.

Givens, G. H., S. L. Edmondson, J. C. George, R. Suydam, R. A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R. A. Delong, and C. W. Clark. 2013. Estimate of 2011 abundance of the Bering-Chukchi-Beaufort Seas bowhead whale population. IWC Scientific Committee, Jeju, Korea, 3-15 June 2013, 30.

Givens, G. H., S. L. Edmondson, J. C. George, R. Suydam, R. A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R. A. DeLong, and C. W. Clark. 2016. Horvitz–Thompson whale abundance estimation adjusting for uncertain recapture, temporal availability variation, and intermittent effort. Environmetrics 27(3):134-146.

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

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(4):16-34.

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(1):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(2):516-522.

Grebmeier, J. M., J. E. Overland, S. E. Moore, E. V. Farley, E. C. Carmack, L. W. Cooper, K. E. Frey, J. H. Helle, F. A. McLaughlin, and S. L. McNutt. 2006. A major ecosystem shift in the northern Bering Sea. Science 311(5766):1461-1464.

Greene, C. R. 1981. Underwater Acoustic Transmission Loss and Ambient Noise in Arctic Regions. Pages 234-258 *in* N. M. Peterson, editor The Question of Sound from Icebreaker Operations, Proceedings of a Workshop. Canada: Arctic Pilot Project, Petro-Canada, Toronto, Ont., Canada.

Greene, C. R., and W. J. Richardson. 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. Journal of the Acoustical Society of America 83(6):2246-2254.

Greene, C. R. J., S. B. Blackwell, and M. W. McLennan. 2008. Sounds and vibrations in the frozen Beaufort Sea during gravel island construction. Journal of Acoustical Society of America 123(2):687-695.

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.

Guarino, M.-V., L. C. Sime, D. Schröeder, I. Malmierca-Vallet, E. Rosenblum, M. Ringer, J. Ridley, D. Feltham, C. Bitz, and E. J. Steig. 2020. Sea-ice-free Arctic during the Last Interglacial supports fast future loss. Nature Climate Change 10:928-932.

Gunnarsson, B. 2021. Recent ship traffic and developing shipping trends on the Northern Sea Route—Policy implications for future arctic shipping. Marine Policy 124:104369.

Halliday, W. D., D. Barclay, A. N. Barkley, E. Cook, J. Dawson, R. C. Hilliard, N. E. Hussey, J. M. Jones, F. Juanes, and M. Marcoux. 2021a. Underwater sound levels in the Canadian Arctic, 2014–2019. Marine Pollution Bulletin 168:112437.

Halliday, W. D., and S. Ferguson. 2020. Literature review of ship strike risk to whales. Report written for Fisheries and Oceans Canada 28.

Halliday, W. D., M. K. Pine, J. J. Citta, L. Harwood, D. D. Hauser, R. C. Hilliard, E. V. Lea, L. L. Loseto, L. Quakenbush, and S. J. Insley. 2021b. Potential exposure of beluga and bowhead whales to underwater noise from ship traffic in the Beaufort and Chukchi Seas. Ocean and Coastal Management 204:105473.

Hannay, D. E., J. Delarue, X. Mouy, B. S. Martin, D. Leary, J. N. Oswald, and J. Vallarta. 2013. Marine mammal acoustic detections in the northeastern Chukchi Sea, September 2007–July 2011. Continental Shelf Research 67:127-146.

Hansen, D. J. 1985. The Potential Effects of Oil Spills and Other Chemical Pollutants on Marine Mammals Occurring in Alaskan Waters. USDOI, MMS, Alaska OCS Region, Anchorage, AK, 22.

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 65:35-44.

Harwood, L. A., T. G. Smith, J. C. Auld, H. Melling, and Yurkowski. 2015. Seasonal movements and diving of ringed seals, Pusa hispida, in the western Canadian Arctic, 1999-2001 and 2010-11. Arctic 68(2):193-209.

Harwood, L. A., and I. Stirling. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Canadian Journal of Zoology-Revue Canadienne De Zoologie 70(5):891-900.

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2019. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2012-2016. U. S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, Seattle, WA, May 2019. NOAA Tech. Memo. NMFS-AFSC-392, 71 p.

Henry, E., and M. O. Hammill. 2001. Impact of small boats on the haulout activity of harbour seals (Phoca vitulina) in Metis Bay, Saint Lawrence Estuary, Quebec, Canada. Aquatic Mammals 27(2):140-148.

Heptner, L. V. G., K. K. Chapskii, V. A. Arsenev, and V. T. Sokolov. 1976. 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, volume II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti. Vysshaya Shkola Publishers, Moscow, Russia.

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(4):770-774.

Hezel, P. J., X. Zhang, C. M. Bitz, B. P. 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(L17505).

Hinzman, L. D., N. D. Bettez, W. R. Bolton, F. S. Chapin, M. B. Dyurgerov, C. L. Fastie, B. Griffith, R. D. Hollister, A. Hope, H. P. Huntington, A. M. Jensen, G. J. Jia, T. Jorgenson, D. L. Kane, D. R. Klein, G. Kofinas, A. H. Lynch, A. H. Lloyd, A. D. McGuire, F. E. Nelson, W. C. Oechel, T. E. Osterkamp, C. H. Racine, V. E. Romanovsky, R. S. Stone, D. A. Stow, M. Sturm, C. E. Tweedie, G. L. Vourlitis, M. D. Walker, D. A. Walker, P. J. Webber, J. M. Welker, K. S. Winker, and K. Yoshikawa. 2005. Evidence and Implications of Recent Climate Change in Northern Alaska and Other Arctic Regions. Climatic Change 72(3):251-298.

Hirai, H., H. Takada, Y. Ogata, R. Yamashita, K. Mizukawa, M. Saha, C. Kwan, C. Moore, H.

Gray, and D. Laursen. 2011. Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. Marine Pollution Bulletin 62(8):1683-1692.

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(4):888-908.

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(2):260-272.

Huntington, H. P. 2000. Traditional ecological knowledge of seals in Norton Bay, Alaska. Elim-Shaktoolik-Koyuk Marine Mammal Commission and the National Marine Fisheries Service.

Huntington, H. P., S. L. Danielson, F. K. Wiese, M. Baker, P. Boveng, J. J. Citta, A. De Robertis, D. M. Dickson, E. Farley, and J. C. George. 2020. Evidence suggests potential transformation of the Pacific Arctic ecosystem is underway. Nature Climate Change 10(4):342-348.

Hyvärinen, H. 1989. Diving in darkness: whiskers as sense organs of the ringed seal (*Phoca hispida saimensis*). Journal of Zoology 218(4):663-678.

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 (ICCT), Washington, DC., January 1, 2015. Contract No. DTMA91P140125, 73 p.

Ice Seal Committee. 2019. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2017, 86 p.

IPCC. 2013. Summary for policymakers. Pages 3-39 *in* D. Q. T. F. Stocker, G. K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley, editor. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York.

IPCC. 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, Geneva, Switzerland, 151 p.

IPCC. 2019. Summary for Policymakers. Pages 1-36 *in* D. C. R. H.- O. Pörtner, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer, editor. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Intergovernmental Panel on Climate Change.

Isaac, J. L. 2009. Effects of climate change on life history: implications for extinction risk in mammals. Endangered Species Research 7(2):115-123.

Jambeck, J. R., R. Geyer, C. Wilcox, T. R. Siegler, M. Perryman, A. Andrady, R. Narayan, and K. L. Law. 2015. Plastic waste inputs from land into the ocean. Science 347(6223):768-771.

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(6):1186-1194.

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(1-2):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(11):2115-2125.

Jiang, L., R. A. Feely, B. R. Carter, D. J. Greeley, D. K. Gledhill, and K. M. Arzayus. 2015. Climatological distribution of aragonite saturation state in the global oceans. Global Biogeochemical Cycles 29:1656-1673.

Jones, J. M., B. J. Thayre, E. H. Roth, M. Mahoney, I. A. N. Sia, K. Merculief, C. Jackson, C. Zeller, M. Clare, A. Bacon, S. Weaver, Z. O. E. Gentes, R. J. Small, I. A. N. Stirling, S. M. Wiggins, J. A. Hildebrand, and N. Giguère. 2014. Ringed, bearded, and ribbon seal vocalizations north of Barrow, Alaska: seasonal presence and relationship with sea ice. Arctic 67(2):203-222.

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. W. 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(5):3211-3222.

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

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(8):1095-1109.

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. 2010b. Status review of the ringed seal (*Phoca hispida*). U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, December 2010. NOAA Tech. Memo. NMFS-AFSC-212, 250 p.

Kelly, B. P., J. J. Burns, and L. T. Quakenbush. 1988. Responses of ringed seals (*Phoca hispida*) to noise disturbance. Pages 27-38 *in* W. M. Sackinger, M. O. Jeffries, J. L. Imm, and S. D. Treacy, editors. Symposium on Noise and Marine Mammals, Fairbanks, Alaska.

Kelly, B. P., L. Quakenbush, and J. R. Rose. 1986. Ringed seal winter ecology and effects of noise disturbance. Institute of Marine Science, Fairbanks, Alaska.

Kelly, B. P., and L. T. Quakenbush. 1990. Spatiotemporal use of lairs by ringed seals (*Phoca hispida*). Canadian Journal of Zoology 68(12):2503-2512.

Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. Ecology Letters 14(10):1052-61.

Kipple, B., and C. Gabriele. 2004. Underwater noise from skiffs to ships. Pages 172-175 *in* Proc. of Glacier Bay Science Symposium. Citeseer.

Kovacs, K. M. 2007. Background document for development of a circumpolar ringed seal (*Phoca hispida*) monitoring plan. Marine Mammal Commission, L'Oceanogràfic, Valencia, Spain, 4-6 March 2007, 45.

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(3).

La Daana, K. K., K. Gardfeldt, T. Krumpen, R. C. Thompson, and I. O’Connor. 2020.

Microplastics in sea ice and seawater beneath ice floes from the Arctic Ocean. Scientific Reports 10(1):1-11.

La Daana, K. K., K. Gårdfeldt, O. Lyashevska, M. Hassellöv, R. C. Thompson, and I. O'Connor. 2018. Microplastics in sub-surface waters of the Arctic Central Basin. Marine Pollution Bulletin 130:8-18.

Labansen, A. L., C. Lydersen, T. Haug, and K. M. Kovacs. 2007. Spring diet of ringed seals (Phoca hispida) from northwestern Spitsbergen, Norway. ICES (International Council for the Exploration of the Seas) Journal of Marine Science 64(6):1246-1256.

Laist, D. W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. Pages 99-139 *in* J. M. Coe, and D. B. Rogers, editors. Marine Debris - sources, impacts, and solutions. Springer-Verlag, New York.

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(1):35-75.

Law, K. L. 2017. Plastics in the marine environment. Annual Review of Marine Science 9:205-229.

Learmonth, J. A., C. D. Macleod, M. B. Santos, G. J. Pierce, H. Q. P. Crick, and R. A. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: An Annual Review 44:431-464.

Lefebvre, K. A., L. Quakenbush, E. Frame, K. B. Huntington, G. Sheffield, R. Stimmelmayr, A. Bryan, P. Kendrick, H. Ziel, T. Goldstein, J. A. Snyder, T. Gelatt, F. Gulland, B. Dickerson, and V. Gill. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae 55:13-24.

Lentfer, J. W. 1972. Alaska polar bear research and management, Morges, Switzerland, 21-39.

LGL. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012, 354.

Lischka, S., and U. Riebesell. 2012. Synergistic effects of ocean acidification and warming on overwintering pteropods in the Arctic. Global change biology 18(12):3517-3528.

Lithner, D., Å. Larsson, and G. Dave. 2011. Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Science of The Total Environment 409(18):3309-3324.

Loeng, H., K. Brander, E. Carmack, S. Denisenko, K. Drinkwater, B. Hansen, K. Kovacs, P. Livingston, F. McLaughlin, and E. Sakshaug. 2005. Marine Ecosystems. Arctic Climate Impact Assessment (ACIA), Cambridge.

London, J. M., J. M. Ver Hoef, S. J. Jeffries, M. M. Lance, and P. L. Boveng. 2012. Haul-out behavior of harbor seals (Phoca vitulina) in Hood Canal, Washington. PLoS One 7(6):e38180.

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(12):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 *in* Marine mammals and the Exxon Valdez. Elsevier.

Lusher, A. L., V. Tirelli, I. O'Connor, and R. Officer. 2015. Microplastics in Arctic polar waters: the first reported values of particles in surface and sub-surface samples. Scientific Reports 5(1):1-9.

Lüthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, and T. F. Stocker. 2008. High-resolution carbon dioxide concentration record 650,000–800,000 years before present. Nature 453(7193):379-382.

Lydersen, C. 1991. Monitoring ringed seal (*Phoca hispida*) activity by means of acoustic telemetry. Canadian Journal of Zoology 69(5):1178-1182.

Lydersen, C. 1998. Status and biology of ringed seals (*Phoca hispida*) in Svalbard. Pages 46-62 *in* M. P. Heide-Jorgensen, and C. Lydersen, editors. Ringed Seals in the North Atlantic. NAMMCO Scientific Publications.

Lydersen, C., and M. O. Hammill. 1993. Diving in ringed seal (Phoca hispida) pups during the nursing period. Canadian Journal of Zoology 71(5):991-996.

Lydersen, C., P. M. Jensen, and E. Lydersen. 1987. Studies of the ringed seal *(Phoca hispida)* population in the Van Mijen fiord, Svalbard, in the breeding period 1986, 1987, 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 187:265-281.

Lydersen, C., and M. S. Ryg. 1990. An evaluation of Tempelfjorden and Sassenfjorden as breeding habitat for ringed seals *Phoca hispida*. Pages 33-40 *in* T. Severinsen, and R. Hansson, editors. Environmental Atlas Gipsdalen, Svalbard, volume III: Reports on the Fauna of Gipsdalen. Norsk Polarinstitutt Rapportserie.

Lydersen, C., and T. G. Smith. 1989. Avian predation on ringed seal *Phoca hispida* pups. Polar Biology 9(8):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(2):125-136.

Mahoney, A. R., K. E. Turner, D. D. Hauser, N. J. Laxague, J. M. Lindsay, A. V. Whiting, C. R. Witte, J. Goodwin, C. Harris, and R. J. Schaeffer. 2021. Thin ice, deep snow and surface flooding in Kotzebue Sound: landfast ice mass balance during two anomalously warm winters and implications for marine mammals and subsistence hunting. Journal of Glaciology 67(266):1013-1027.

Manning, T. H. 1974. Variation in the skull of the bearded seal, Erignathus barbatus (Erxleben). Biological Papers of the University of Alaska 16:1-21.

Mansfield, A. W. 1983. The effects of vessel traffic in the Arctic on marine mammals and recommendations for future research, Canadian Technical Report of Fisheries and Aquatic Sciences 1186, Quebec, 107 p.

Mato, Y., T. Isobe, H. Takada, H. Kanehiro, C. Ohtake, and T. Kaminuma. 2001. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environmental Science and Technology 35(2):318-324.

McCabe, R. M., B. M. Hickey, R. M. Kudela, K. A. Lefebvre, N. G. Adams, B. D. Bill, F. M. Gulland, R. E. Thomson, W. P. Cochlan, and V. L. Trainer. 2016. An unprecedented coastwide toxic algal bloom linked to anomalous ocean conditions. Geophysical

Research Letters 43(19):10,366-10,376.

McDonald, T. L., W.J. Richardson, C.R. Greene, and S. B. Blackwell. 2006. Evidence of Subtle Bowhead Whale Deflection near Northstar at High-Noise Times based on Acoustic Localization Data, 2001–2004. W.J. Richardson, ed. LGL Report TA4256A-9. King City, Ont., Canada: LGL, pp. 9–1 to 9–38.

Melnikov, V., and I. Zagrebin. 2005. Killer whale predation in coastal waters of the Chukotka Peninsula. Marine Mammal Science 21(3):550-556.

Miller, G., R. Elliott, T. Thomas, V. Moulton, and W. Koski. 2002. Distribution and numbers of bowhead whales in the eastern Alaskan Beaufort Sea during late summer and autumn, 1979-2000. Pages 2002-2012 *in* W. Richardson, and D. Thomson, editors.

Miller, M. E., M. Hamann, and F. J. Kroon. 2020. Bioaccumulation and biomagnification of microplastics in marine organisms: a review and meta-analysis of current data. PLoS One 15(10):e0240792.

Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fitness. Philosophy of Science 46(2):263-286.

Moore, S. E., and R. R. Reeves. 1993. Distribution and movement. Pages 313-386 *in* J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The Bowhead Whale, volume 2. Special Publication No. 2. The Society of Marine Mammalogy. Allen Press, Inc., Lawrence, KS, US.

Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS) joint U.S.-Russian aerial surveys for ice-associated seals, 2012-13. AFSC Quarterly Report, Seattle, WA, July-August-September 2013, 6 p.

Moulton, V. D., R. E. Elliot, W. J. Richardson, and T. L. McDonald. 2002. Fixed-wing aerial surveys of seals near BP’s Northstar and Liberty sites in 2001 (and 1997-2001 combined). In: Richardson, W.J. and M.T. Williams (eds.) 2002. Monitoring of industrial sounds, seals, and whale calls during construction of BP’s Northstar Oil Development, Alaskan Beaufort Sea, 2001., 5-1 to 5-60.

Mueter, F. J., and M. A. Litzow. 2008. Sea ice retreat alters the biogeography of the Bering Sea continental shelf. Ecological Applications 18(2):309-320.

Muto, M. M., V. T. Helker, B. J. Delean, R. P. Angliss, P. L. Boveng, J. M. Breiwick, B. M. Brost, 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. Ivaschenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2020. Alaska marine mammal stock assessments, 2019. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, July 2020. NOAA Technical Memorandum NMFS-AFSC-404, 395 p.

Muto, M. M., V. T. Helker, B. J. Delean, N. C. Young, J. C. Freed, R. P. Angliss, N. A. Friday, P. L. Boveng, J. M. Breiwick, B. M. Brost, M. F. Cameron, P. J. Clapham, J. L. Crance, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, K. T. Goetz, 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, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2021. Alaska marine mammal stock assessments, 2020. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, July 2021. NOAA Technical Memorandum NMFS-AFSC-421, 398 p.

Navy, D. o. 2013. Hawaii-Southern California Training and Testing Activities Final

Environmental Impact Statement/Overseas Environmental Impact Statement.

Navy, U. 2022. Overseas Environmental Assessment for Office of Naval Research Arctic Research Activities in the Beaufort and Chukchi Seas 2022-2025. Navy, 167.

Neff, J. M. 2010. Fate and effects of water based drilling muds and cuttings in cold water environments. A Scientific Review prepared for Shell Exploration and Production Company, Houston, Texas.

Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. M. Straley. 2012. Summary of reported whale-vessel collisions in Alaskan waters. Journal of Marine Biology:106282.

Nelson, M. A., L. T. Quakenbush, B. D. Taras, and Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endangered Species Research 40:1-16.

Nelson, R. K. 1981. Harvest of the sea: Coastal subsistence in modern Wainwright. North Slope Borough, Coastal Management Program, North Slope Borough, Alaska, 112.

Nelson, R. R., J. J. Burns, and K. J. Frost. 1984. The bearded seal (*Erignathus barbatus*). Pages 1-6 *in* J. J. Burns, editor. Marine Mammal Species Accounts, Wildlife Technical Bulletin, volume 7. Alaska Department of Fish and Game, Juneau, AK.

NMFS. 2006. Endangered Species Act Section 7(a)(2) Biological Opinion on the United States Navy's 2006 Rim-of-the-Pacific Joint Training Exercises. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, 123.

NMFS. 2013. Effects of oil and gas activities in the Arctic Ocean: supplemental draft Environmental Impact Statement. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, March 21, 2013.

NMFS. 2016. 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. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, NMFS Alaska Region, Juneau, Alaska, October 4, 2016. NMFS Consultation Number AKR-2016-9590, 99 p.

NMFS. 2018a. Endangered Species Act (ESA) Section 7(a)(2) biological opinion for Liberty oil and gas development and production plan activities, Beaufort Sea, Alaska. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Alaska Region, Juneau, AK, July 31, 2018. NMFS Consultation Number: AKR-2018-9747.

NMFS. 2018b. Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA, NMFS, Office of Protected Resources, Silver Spring, MD. NOAA Tech. Memo. NMFS-OPR-55, 178 p.

NMFS. 2019. Endangered Species Act (ESA) Section 7(a)(2) biological opinion for Liberty oil and gas development and production plan activities, Beaufort Sea, Alaska. U.S. Dept. of Commerce, NOAA, NMFS, Alaska Regional Office, Juneau, AK, August 30, 2019. NMFS Consultation Number: AKR-2019-00004 (Previously AKR-2018-9747).

NMFS. 2020. Endangered Species Act Section 7 programmatic biological and conference opinion on construction and operation of up to six new icebreakers to support Coast Guard Missions in the Arctic and Antarctic. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected

Resources, Endangered Species Act Interagency Cooperation Division, Silver Spring, MD. September 3, 2020. Consultation Tracking Number: OPR-2017-00023.

Noren, D., A. Johnson, D. Rehder, and A. Larson. 2009. Close approaches by vessels elicit surface active behaviors by southern resident killer whales. Endangered Species Research 8(3):179-192.

Notz, D., and J. Stroeve. 2016. Observed Arctic sea-ice loss directly follows anthropogenic CO_2 emission. Science 354(6313):747-750.

Nowacek, D. P., M. P. Johnson, and P. L. Tyack. 2004. North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London. Series B: Biological Sciences 271(1536):227-231.

Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

NRC. 2003. Ocean Noise and Marine Mammals. National Research Council, Ocean Study Board, National Academy Press, Washington, D.C.

Obbard, R. W., S. Sadri, Y. Q. Wong, A. A. Khitun, I. Baker, and R. C. Thompson. 2014. Global warming releases microplastic legacy frozen in Arctic Sea ice. Earth's Future 2(6):315-320.

Ogata, Y., H. Takada, K. Mizukawa, H. Hirai, S. Iwasa, S. Endo, Y. Mato, M. Saha, K. Okuda, and A. Nakashima. 2009. International Pellet Watch: Global monitoring of persistent organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs. Marine Pollution Bulletin 58(10):1437-1446.

Ognev, S. I. 1935. Mammals of U.S.S.R. and adjacent countries. Volume 3. Carnivora, volume 3. Glavpushnina NKVT, Moscow, Russia.

Olnes, J., J. J. Citta, L. T. Quakenbush, J. C. George, L. A. Harwood, E. V. Lea, and M. P. Heide-Jørgensen. 2020. Use of the Alaskan Beaufort Sea by bowhead whales (Balaena mysticetus) tagged with satellite transmitters, 2006–18. Arctic 73(3):278-291.

ONR. 2018. Biological Evaluation for Office of Naval Research Arctic research activities in the Beaufort Sea 2018-2021. Office of Naval Research, December 2017, 62 p.

ONR. 2021. Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from Office of Naval Research Arctic Research Activities October 2021– October 2022, August 2021, 61.

ONR. 2022. Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals resulting from ONR's Arctic Research Activities, Sept 2022- Sept 2023, 62.

Oreskes, N. 2004. The scientifc consensus on climate change. Science 306:1686.

Orr, J. C., V. J. Fabry, O. Aumont, L. Bopp, S. C. Doney, R. A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, R. M. Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R. G. Najjar, G.-K. Plattner, K. B. Rodgers, C. L. Sabine, J. L. Sarmiento, R. Schlitzer, R. D. Slater, I. J. Totterdell, M.-F. Weirig, Y. Yamanaka, and A. Yool. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437:681-686.

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(2):89-111.

Overland, J. E. 2020. Less climatic resilience in the Arctic. Weather and Climate Extremes 30:100275.

Overland, J. E., E. Hanna, I. Hanssen-Bauer, S. J. Kim, J. E. Walsh, M. Wang, U. S. Bhatt, and R. L. Thoman. 2017. Arctic Report Card 2017.

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(3):563-580.

Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. Report prepared by the Pennsylvania State University Applied Research Laboratory for the Office of Naval Research under award number N00014-08-1-0967, State College, PA.

Patenaude, N. J., W. J. Richardson, M. A. Smultea, W. R. Koski, G. W. Miller, B. Würsig, and C. R. Greene Jr. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Marine Mammal Science 18(2):309-335.

Peeken, I., S. Primpke, B. Beyer, J. Gütermann, C. Katlein, T. Krumpen, M. Bergmann, L. Hehemann, and G. Gerdts. 2018. Arctic sea ice is an important temporal sink and means of transport for microplastic. Nature Communications 9(1):1-12.

Perovich, D., W. Meier, M. Tschudi, S. Farrell, S. Hendricks, S. Gerland, L. Kaleschke, R. Ricker, X. Tian-Kunze, M. Webster, and K. Wood. 2019. Arctic Report Card: Update for 2019 Sea Ice.

Peterson, W., N. Bond, and M. Robert. 2016. The blob (part three): Going, going, gone? PICES Press 24(1):46.

Pirotta, E., N. D. Merchant, P. M. Thompson, T. R. Barton, and D. Lusseau. 2015. Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. Biological Conservation 181:82-89.

Plomp, R., and M. Bouman. 1959. Relation between hearing threshold and duration for tone pulses. The Journal of the Acoustical Society of America 31(6):749-758.

Qi, D., L. Chen, B. Chen, Z. Gao, W. Zhong, Richard A. Feely, Leif G. Anderson, H. Sun, J. Chen, M. Chen, L. Zhan, Y. Zhang, and W.-J. Cai. 2017. Increase in acidifying water in the western Arctic Ocean. Nature Climate Change 7(3):195-199.

Quakenbush, L., J. Citta, and J. Crawford. 2011. Biology of the ringed seal (*Phoca hispida*) in Alaska, 1960-2010. Final report from Alaska Dept. of Fish and Game Arctic Marine Mammal Program to the National Marine Fisheries Service, Fairbanks, AK.

Quakenbush, L., J. Citta, J. C. George, R. J. Small, M. P. Heide-Jorgensen, L. Harwood, and H. Brower. 2010. Western Arctic bowhead whale movements and habitat use throughout their migratory range: 2006–2009 satellite telemetry results. Pages 108 *in* Alaska Marine Science Symposium, Anchorage, Alaska.

Reeves, R. R. 1998. Distribution, abundance and biology of ringed seals (*Phoca hispida*): an overview. Pages 9-45 *in* M. P. Heide-Jørgensen, and C. Lydersen, editors. Ringed Seals in the North Atlantic, volume 1. NAMMCO Scientific Publications, Volume 1, Tromsø, Norway.

Reimer, J. R., H. Caswell, A. E. Derocher, and M. A. Lewis. 2019. Ringed seal demography in a changing climate. Ecological Applications 29(3):e01855.

Reisdorph, S. C., and J. T. Mathis. 2014. The dynamic controls on carbonate mineral saturation states and ocean acidification in a glacially dominated estuary. Estuarine, Coastal and Shelf Science 144:8-18.

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

Richardson, W. J. 1998. Marine mammal and acoustical monitoring of BP Exploration (Alaska)‘s open-water seismic program in the Alaskan Beaufort Sea, 1997. LGL Rep.

TA2150-3. Rep. from LGL Ltd., King City, Ontario, and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK, and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD, November 1998, 318 p.

Richardson, W. J. 1999. Marine mammal and acoustical monitoring of Western Geophysical's openwater seismic program in the Alaskan Beaufort Sea, 1998. Report from LGL Ltd., King City, Ontario, and Greeneridge Sciences Inc., Santa Barbara, CA, for western Geophysical, Houston, TX and National Marine fisheries Service, Anchorage, AK, TA2230-3, 390.

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.

Richardson, W. J., and C. I. Malme. 1993. Man-made noise and behavioral responses. Pages 631-700 *in* J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The Bowhead Whale, volume Special Publication Number 2. Society for Marine Mammology, Allen Press, Inc., Lawrence, KS.

Riedman, M. 1990. The pinnipeds: Seals, sea lions, and walruses. University of California Press, Berkeley, CA. 439pgs. ISBN 0-520-06498-4.

Rochman, C. M. 2015. The complex mixture, fate and toxicity of chemicals associated with plastic debris in the marine environment. Pages 117-140 *in* M. Bergmann, L. Gutow, and M. Klages, editors. Marine Anthropogenic Litter. Springer Open.

Rolland, R. M., S. E. Parks, K. E. Hunt, M. Castellote, P. J. Corkeron, D. P. Nowacek, S. K. Wasser, and S. D. Kraus. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B: Biological Sciences 279(1737):2363-2368.

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(2):R614-R622.

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(4):1971-80.

Savage, K. 2019. 2018 Alaska Region Marine Mammal Stranding Summary. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK, January 28, 2019.

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

Schoeman, R. P., C. Patterson-Abrolat, and S. Plön. 2020. A global review of vessel collisions with marine animals. Frontiers in Marine Science 7:292.

Scholin, C. A., F. Gulland, G. J. Doucette, S. Benson, M. Busman, F. P. Chavez, J. Cordaro, R. DeLong, A. De Vogelaere, and J. Harvey. 2000. Mortality of sea lions along the central California coast linked to a toxic diatom bloom. Nature 403(6765):80-84.

Schusterman, R. J., D. Kastak, D. H. Levenson, C. J. Reichmuth, and B. L. Southall. 2000. Why pinnipeds don't echolocate. The Journal of the Acoustical Society of America 107(4):2256-2264.

Schweder, T., D. Sadykova, D. Rugh, and W. Koski. 2010. Population estimates from aerial photographic surveys of naturally and variably marked bowhead whales. Journal of Agricultural, Biological and Environmental Statistics 15(1):10-19.

Serreze, M. C., and R. G. Barry. 2011. Processes and impacts of Arctic amplification: a research synthesis. Global and Planetary Change 77(1):85-96.

Silber, G. K., and J. D. Adams. 2019. Vessel operations in the Arctic, 2015–2017. Frontiers in Marine Science 6:573.

Sills, J. M., C. Reichmuth, B. L. Southall, A. Whiting, and J. Goodwin. 2020. Auditory biology of bearded seals (*Erignathus barbatus*). Polar Biology 43(11):1681-1691.

Sills, J. M., B. L. Southall, and C. Reichmuth. 2014. Amphibious hearing in spotted seals (Phoca largha): underwater audiograms, aerial audiograms and critical ratio measurements. Journal of Experimental Biology 217(5):726-734.

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 218(Pt 14):2250-9.

SIMIP Community. 2020. Arctic Sea Ice in CMIP6. Geophysical Research Letters 47(10):e2019GL086749.

Simmonds, M. P., and W. J. Eliott. 2009. Climate change and cetaceans: concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom 89(1):203-210.

Simmonds, M. P., and J. D. Hutchinson. 1996. The Conservation of Whales and Dolphins - Science and Practice. John Wiley & Sons.

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(9):577-586.

Smiley, B. D., and A. R. Milne. 1979. LNG transport in Parry Channel: possible environmental hazards. Institute of Ocean Sciences, Sydney, Canada, 47 p.

Smith, M. A., M. S. Goldman, E. J. Knight, and J. J. Warrenchuk. 2017. Ecological Atlas of the Bering, Chukchi, and Beaufort Seas, 2nd Ed. Audubon Alaska, Anchorage, AK.

Smith, T. G. 1976. Predation of ringed seal pups (*Phoca hispida*) by the Arctic fox (*Alopex agopus*). Canadian Journal of Zoology 54(10):1610-1616.

Smith, T. G. 1981. Notes on the bearded seal, *Erignathus barbatus*, in the Canadian Arctic. Canadian Technical Report of Fisheries and Aquatic Sciences 1042:49 p.

Smith, T. G. 1987. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. Bulletin Fisheries Research Board of Canada, 0660124637, Ottawa, Canada, 81.

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(2):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(9):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(4):411-521.

Southall, B. L., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. P. Nowacek, and P. L. Tyack. 2019. Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. Aquatic Mammals 45(2):125-232.

Southall, B. L., D. P. Nowacek, A. E. Bowles, V. Senigaglia, L. Bejder, and P. L. Tyack. 2021. Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. Aquatic Mammals 47(5):421-464.

Southall, B. L., R. J. Schusterman, and D. Kastak. 2000. Masking in three pinnipeds: Underwater, low-frequency critical ratios. The Journal of the Acoustical Society of America 108(3):1322-1326.

Southall, B. L., R. J. Schusterman, and D. Kastak. 2003. Auditory masking in three pinnipeds: Aerial critical ratios and direct critical bandwidth measurements. The Journal of the Acoustical Society of America 114(3):1660-1666.

Southam, A. L., S. Ban, M. Payne, and D. DeMaster. 2022. Comprehensive synthesis of effects of oil and gas activities on marine mammals on the Alaska outer continental shelf. ECO49 Consulting, LLC. for U.S. Dept. of Interior, Bureau of Ocean Energy Management under Contract No. GS-00F-072CA, Anchorage, AK, April 2022. OCS Study BOEM 2022-009, 388 p.

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

Sprogis, K. R., S. Videsen, and P. T. Madsen. 2020. Vessel noise levels drive behavioural responses of humpback whales with implications for whale-watching. Elife 9:e56760.

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):1-13.

St. Aubin, D. J. 1988. Physiologic and toxicologic effects on pinnipeds. Synthesis of Effects of Oil on Marine Mammals.

St. Aubin, D. J. 1990. Physiologic and toxic effects on pinnipeds. Pages 103-127 *in* J. R. a. S. A. Geraci, D. J., editor. Sea mammals and oil, confronting the risks. Academic Press, San Diego, CA.

Stafford, K. M., H. Melling, S. E. Moore, C. L. Berchok, E. K. Braen, A. M. Brewer, and B. M. Kimber. 2022. Marine mammal detections on the Chukchi Plateau 2009–2020. The Journal of the Acoustical Society of America 151(4):2521-2529.

Stearns, S. C. 1992. The evolution of life histories. Oxford University Press, New York, New York.

Stirling, I., W. Calvert, and H. Cleator. 1983. Underwater vocalizations as a tool for studying the distribution and relative abundance of wintering pinnipeds in the High Arctic. Arctic 36(3):262-274.

Stroeve, J., M. M. Holland, W. Meier, T. Scambos, and M. Serreze. 2007. Arctic sea ice decline: Faster than forecast. Geophysical Research Letters 34(9).

Stroeve, J., and D. Notz. 2018. Changing state of Arctic sea ice across all seasons. Environmental Research Letters 13(10):103001.

Sullivan, R. M. 1980. Seasonal occurrence and haul-out use in pinnipeds along Humboldt County, California. Journal of Mammalogy 61(4):754-760.

Suryan, R. M., M. L. Arimitsu, H. A. Coletti, R. R. Hopcroft, M. R. Lindeberg, S. J. Barbeaux, S. D. Batten, W. J. Burt, M. A. Bishop, J. L. Bodkin, R. Brenner, R. W. Campbell, D. A.

Cushing, S. L. Danielson, M. W. Dorn, B. Drummond, D. Esler, T. Gelatt, D. H. Hanselman, S. A. Hatch, S. Haught, K. Holderied, K. Iken, D. B. Irons, A. B. Kettle, D. G. Kimmel, B. Konar, K. J. Kuletz, B. J. Laurel, J. M. Maniscalco, C. Matkin, C. A. E. McKinstry, D. H. Monson, J. R. Moran, D. Olsen, W. A. Palsson, W. S. Pegau, J. F. Piatt, L. A. Rogers, N. A. Rojek, A. Schaefer, I. B. Spies, J. M. Straley, S. L. Strom, K. L. Sweeney, M. Szymkowiak, B. P. Weitzman, E. M. Yasumiishi, and S. G. Zador. 2021. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports 11(1):6235.

Sweeney, K., R. Towell, and T. Gelatt. 2018. Results of Steller Sea Lion Surveys in Alaska, June-July 2018: Memorandum to The Record. U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, Marine Mammal Laboratory, Seattle, WA. December 4, 2018.

Teilmann, J., E. W. Born, and M. Acquarone. 1999. Behaviour of ringed seals tagged with satellite transmitters in the North Water polynya during fast-ice formation. Canadian Journal of Zoology 77(12):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(7):1578-1582.

Teuten, E. L., J. M. Saquing, D. R. Knappe, M. A. Barlaz, S. Jonsson, A. Björn, S. J. Rowland, R. C. Thompson, T. S. Galloway, and R. Yamashita. 2009. Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526):2027-2045.

Thode, A., K. H. Kim, C. R. G. Jr., and E. Roth. 2010. Long range transmission loss of broadband seismic pulses in the Arctic under ice-free conditions. The Journal of the Acoustical Society of America 128(4):EL181-EL187.

Thoman, R., and J. Walsh. 2019. Alaska's Changing Environment: documenting Alaska's physical and biological changes through observations. International Arctic Research Center, University of Alaska Fairbanks.

Thomson, D. H., and W. J. Richardson. 1995. Marine mammal sounds. W. J. Richardson, J. C. R. Greene, C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego, California.

Treacy, S. D., J. S. Gleason, and C. J. Cowles. 2006. Offshore distances of bowhead whales (*Balaena mysticetus*) observed during fall in the Beaufort Sea, 1982-2000: an alternative interpretation. Arctic 59(1):83-90.

Tsujii, K., M. Otsuki, T. Akamatsu, I. Matsuo, K. Amakasu, M. Kitamura, T. Kikuchi, K. Miyashita, and Y. Mitani. 2016. The migration of fin whales into the southern Chukchi Sea as monitored with passive acoustics. ICES Journal of Marine Science 73(8):2085-2092.

Tyack, P. L. 2000. Functional aspects of cetacean communication. Pages 270-307 *in* J. Mann, R. C. Connor, P. L. Tyack, and H. Whitehead, editors. Cetacean societies: field studies of dolphins and whales. The University of Chicago Press, Chicago, Illinois.

Tyack, P. L. 2009. Human-generated sound and marine mammals. Physics Today 62(11):39-44.

Tynan, C. T., and D. P. Demaster. 1997. Observations and predictions of Arctic climatic change: Potential effects on marine mammals. Arctic 50(4):308-322.

U.S. Committee on the Marine Transportation System. 2019. A Ten-Year Projection of Maritime Activity in the U.S. Arctic Region, 2020–2030, Washington, D.C., 118 p.

Urick, R. J. 1996. Principles of underwater sound, 3rd edition. Peninsula Publishing, Los Altos, CA.

USCG. 2017. Environmental Assessment for Arctic Shield 2017, Juneau, Alaska, 163.

Van Parijs, S. M. 2003. Aquatic mating in pinnipeds: A review. Aquatic Mammals 29(2):214-226.

Van Parijs, S. M., and C. W. Clark. 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, Erignathus barbatus. Animal Behaviour 72(6):1269-1277.

Van Parijs, S. M., K. M. Kovacs, and C. Lydersen. 2001. Spatial and temporal distribution of vocalising male bearded seals: Implications for male mating strategies. Behaviour 138(7):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(2):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(1):89-96.

Vanderlaan, A. S. M., and C. T. Taggart. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine Mammal Science 23(1):144-156.

VanWormer, E., J. A. K. Mazet, A. Hall, V. A. Gill, P. L. Boveng, J. M. London, T. Gelatt, B. S. Fadely, M. E. Lander, J. Sterling, V. N. Burkanov, R. R. Ream, P. M. Brock, L. D. Rea, B. R. Smith, A. Jeffers, M. Henstock, M. J. Rehberg, K. A. Burek-Huntington, S. L. Cosby, J. A. Hammond, and T. Goldstein. 2019. Viral emergence in marine mammals in the North Pacific may be linked to Arctic sea ice reduction. Scientific Reports 9(1):15569.

Von Duyke, A. L., D. C. Douglas, J. K. Herreman, and J. A. Crawford. 2020. Ringed seal (Pusa hispida) seasonal movements, diving, and haul-out behavior in the Beaufort, Chukchi, and Bering seas (2011–2017). Ecology and evolution 10(12):5595-5616.

Vos, J. G., G. D. Bossart, M. Fournier, and T. J. O'Shea. 2003. Toxicology of Marine Mammals, volume 3- Systems. Taylor and Francis, London and New York.

Wade, P. R. 2021. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas, NMFS Alaska Fisheries Science Center, Seattle, WA. Paper submitted to the International Whaling Commission SC/68C/IA/03.

Wang, F., and J. E. Overland. 2009. A sea ice free summer Arctic within 30 years? Geophysical Research Letters 36:L07502.

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(9):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(4):6-15.

Wassmann, P., C. M. Duarte, S. Agusti, and M. K. Sejr. 2011. Footprints of climate change in the Arctic marine ecosystem. Global change biology 17(2):1235-1249.

Wathne, J. A., 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 194:233-239.

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.

Webster, M. A., I. G. Rigor, S. V. Nghiem, N. T. Kurtz, S. L. Farrell, D. K. Perovich, and M. Sturm. 2014. Interdecadal changes in snow depth on Arctic sea ice. Journal of

Geophysical Research: Oceans 119(8):5395-5406.

Wieting, D. S. 2016. Interim Guidance on the Endangered Species Act Term "Harass". U.S. Dept. of Commerce, NOAA, NMFS, Office of Protected Resources, Silver Spring, MD, October 21, 2016. Memorandum from the Director of the NMFS Office of Protected Resources to NMFS Regional Administrators.

Wilcox, C., G. Heathcote, J. Goldberg, R. Gunn, D. Peel, and B. D. Hardesty. 2015. Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia. Conservation Biology 29(1):198-206.

Williams, R., D. E. Bain, J. K. B. Ford, and A. W. Trites. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4(3):305-310.

Williams, R., and D. P. Noren. 2009. Swimming speed, respiration rate, and estimated cost of transport in adult killer whales. Marine Mammal Science 25(2):327-350.

Wilson, S. C., I. Crawford, I. Trukhanova, L. Dmitrieva, and S. J. Goodman. 2020. Estimating risk to ice-breeding pinnipeds from shipping in Arctic and sub-Arctic seas. Marine Policy 111:103694.

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

Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling. Pages 387-408 *in* J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The Bowhead Whale, volume Special Publication Number 2. Society for Marine Mammalogy, Allen Press, Inc., Lawrence, KS.

Würsig, B., and C. Clark. 1993. Behavior. Pages 157-199 *in* J. J. Burns, J. J. Montague, and C. J. Cowles, editors. The Bowhead Whale, volume Special Publication Number 2. Society for Marine Mammalogy, Allen Press, Inc., Lawrence, KS.

Yamamoto, A., M. Kawamiya, A. Ishida, Y. Yamanaka, and S. Watanabe. 2012. Impact of rapid sea-ice reduction in the Arctic Ocean on the rate of ocean acidification. Biogeosciences 9(6):2365-2375.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. E. Jannot. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, December 2020. NOAA Tech. Memo. NMFS-AFSC-413, 142 p.

Zarfl, C., and M. Matthies. 2010. Are marine plastic particles transport vectors for organic pollutants to the Arctic? Marine Pollution Bulletin 60(10):1810-1814.

Zarnke, R. L., J. T. Saliki, A. P. Macmillan, S. D. Brew, C. E. Dawson, J. M. Ver Hoef, K. J. Frost, and R. J. Small. 2006. Serologic survey for Brucella spp., phocid herpesvirus-1, phocid herpesvirus-2, and phocine distemper virus in harbor seals from Alaska, 1976-1999. Journal of Wildlife Diseases 42(2):290-300.

Zeh, J. E., and A. E. Punt. 2005. Updated 1978-2001 abundance estimates and their correlations for the BeringChukchi-Beaufort Seas stock of bowhead whales. Pages 10 *in*. submitted to International Whaling Comission Scientific Committee.