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-2022-00873

Action Agencies: U.S. Navy, Office of Naval Research

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
Bearded seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	No	No	No	No
Steller sea lion, Western DPS (*Eumetopias jubatus*)	Endangered	No	No	No	No

https://doi.org/10.25923/3k7n-kc31

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

Issued By:

Jonathan M. Kurland
Regional Administrator
for Protected Resources

Date: June 17, 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

Acronym	Definition
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
AMOS	Arctic Mobile Observing System
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^2s
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

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 agency is the U.S. Navy's Office of Naval Research (ONR) which proposes to conduct Arctic Research Activities (ARA). This consultation is a re-initiation of AKRO-2021-01926 which covered ARA from October 2021 to October 2022. Consultation was re-initiated because activities proposed for July 2022 include icebreaking, which was not considered in the prior consultation. In addition, a final rule for critical habitat for ringed and bearded seals published on April 1, 2022. The NMFS Office of Protected Resources, Permits and Conservation Division (OPR) issued 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 (86 FR 54931). The IHA is valid through early October 2022 and authorizes the incidental harassment of the threatened Arctic ringed seal. The OPR decided that a modification to the existing IHA for the inclusion of icebreaking was not necessary because:

1. No Level A harassment is expected based on the modeling performed by ONR;
2. Inclusive of icebreaking, the numbers estimated Level B harassment would decrease substantially from what was initially authorized in the IHA (from 6,050 to 1,413 for ringed seals partially due to the removal of some of the previously planned acoustic source deployments for the July cruise;
3. The anticipated effects of icebreaking are not different from the anticipated effects of other aspects of ONR's activity, and which are authorized through the IHA;
4. The modeling results presented by ONR did not contradict or change previously made determinations related to the negligible impact determinations (the small numbers determination is not relevant as this is a military readiness project);
5. Modeling performed by ONR did not demonstrate any take occurring to any other species

of marine mammals in the region (i.e., bearded seals) only those for which take was previously authorized under the present IHA;

6. NMFS has previously determined that vessel transit would not constitute take and the only take of marine mammals would come from the deployment and activation of acoustic signals from deployed buoyed and moored sources; and
7. Icebreaking is not anticipated to cause effects to marine mammal habitat beyond those previously evaluated in support of the issued IHA.

Furthermore, the OPR determined that there was no need to reinitiate the Section 7 consultation as there were no changes to OPR's action and no other reinitiation triggers were met. Consequently, this consultation is solely between ONR and AKR and only considers vessel transit and icebreaking activities that are proposed for July 2022.

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. The opinion and ITS were prepared by NMFS 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 is 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 August IHA application ONR (2021), the analysis included in the biological opinion written for the ONR Arctic Research Activities October 2021- October 2022 (AKRO-2021-01926), the final IHA (86 FR 54931), the 2017 Biological Assessment and the Supplemental Overseas Environmental Assessment for ONR's Arctic Research Activities in the Beaufort Sea October 2021 – October 2022, the 2018 Biological Evaluation that was submitted to cover ONR's Arctic Research Activities from 2018-2021, and information provided to us by the Navy in a PowerPoint presentation on February 25, 2022. 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 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 from 2019-2021. Additional modifications to the research activities were submitted to us for October 2021 to October 2022 and analyzed in our associated biological opinion (AKRO-2021-01926). The 2021-2022 request did not include icebreaking activities. Because AKRO-2021-01926 considered all actions involving active acoustic sources deployed in the Beaufort Sea and no new or different sources are proposed, this opinion only considers three new aspects of the project; icebreaking, a new vessel transit route, and effects to the newly designated ringed and bearded seal critical habitat.

The July 2022 Arctic Research Activities require one vessel that will deploy moored active acoustic sources and use unmanned aircraft and underwater rovers. The research vessel will deploy from Seward, Alaska and travel through the Bering Sea, across the Chukchi Sea, and into the Beaufort. Anchored moorings will be deployed in the Beaufort Sea 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 DPS gray whale (*Eschrichtius robustus*), endangered sperm whale (*Physeter macrocephalus*), endangered Western North Pacific distinct population segment (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*), 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

- January 25, 2022. Teleconference with the Navy and OPR to discuss changes to existing project.
- February 17, 2022. Request for re-initiation of consultation AKRO-2021-01926 received.
- February 23-April 11, 2022. Emails were exchanged between the Navy and AKRO to clarify details of new proposed action and discuss the density value used for ringed seals.
- April 13, 2022. Consultation was initiated and communication continued so that take caused by ice breaking could be re-evaluated.
- April 29, 2002. Navy sent new take numbers for icebreaking activities and clarification of other project details.
- May 6 to June 9, 2022. Coordinated with ONR and OPR on monitoring.
- May 11 to May 13, 2022. Corresponded with the Coast Guard about standard operating procedures for vessel operations.

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 travel of the CGC Healy from Seward, Alaska, to the Beaufort Sea, a return trip that will end in Dutch Harbor, Unalaska, potential icebreaking in the Beaufort Sea, and the deployment of four acoustic moorings. Due to sea ice conditions during the October 2021 cruise, only three of seven proposed leave-behind Arctic Mobile Observing System (AMOS) sources were deployed. All of the Naval Research Laboratory (NRL) acoustic sources (labeled "NRL Drifting Buoys" in Figure 1) have been removed. The purpose of the July cruise is to deploy four leave-behind AMOS sources, to reach a total of seven deployed. All other aspects of the overall project, including the devices to be deployed, were previously consulted on (AKRO-2021-01926).

The overall project supports the Arctic and Global Prediction Program and the Acoustics Division of NRL in their development of the AMOS involving very low, low, and mid frequency transmissions (35 Hertz (Hz), 900 Hz, and 10 kilohertz (kHz), respectively). The AMOS project utilizes acoustic sources and receivers to provide a means of performing under-ice navigation for gliders and UUVs. This capability would create the possibility of year-round scientific observations of Arctic environmental conditions. Because the Arctic is 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. These observations will also inform changes that affect marine mammals and humans. Very low-frequency technology is an important method of observing ocean warming, and the 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.

2.1.1. Proposed Activities

2.1.1.1. Research Vessel

The Coast Guard Cutter (CGC) Healy would perform the research cruise in July 2022 and leave behind four moored acoustic sources. The vessel would depart from Seward, Alaska, travel to the study area in the Beaufort Sea (Figure 1), and return to Dutch Harbor, Unalaska.

The 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 (https://www.pacificarea.uscg.mil/Our-Organization/Area-Cutters/CGC-Healy/Ship/). The CGC Healy may need to break ice in the deep water of the Beaufort Sea to reach the deployment sites (Figure 1). The Navy expects that up to 8 days of icebreaking will be needed in July. 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). The highest noise levels resulted while the ship was engaged in backing and ramming maneuvers, owing to cavitation when operating the propellers astern or in opposing directions. In frequency bands centered near 10, 50 and 100 Hz, source levels reached 190 to 200 dB re 1 µPa at 1 m (Roth et al. 2013b). Icebreaking will only occur in the deep water area, off the continental shelf while transiting to the Study Area (Figure 1). While in transit in open water we expect the sound source level will be closer to 180 dB re 1 µPa at 1 m depending on vessel speed (Roth et al. 2013a).

Icebreaking can cause substantial increases in noise out to 5 km in the range of 120 to 140 dB (Richardson et al. 1995). Ice breakers when pushing ice radiate noise 10-15 dB stronger than when underway in open water. Physical crushing of the ice contributes little to the overall increase in noise during ice breaking (Richardson et al. 1995).

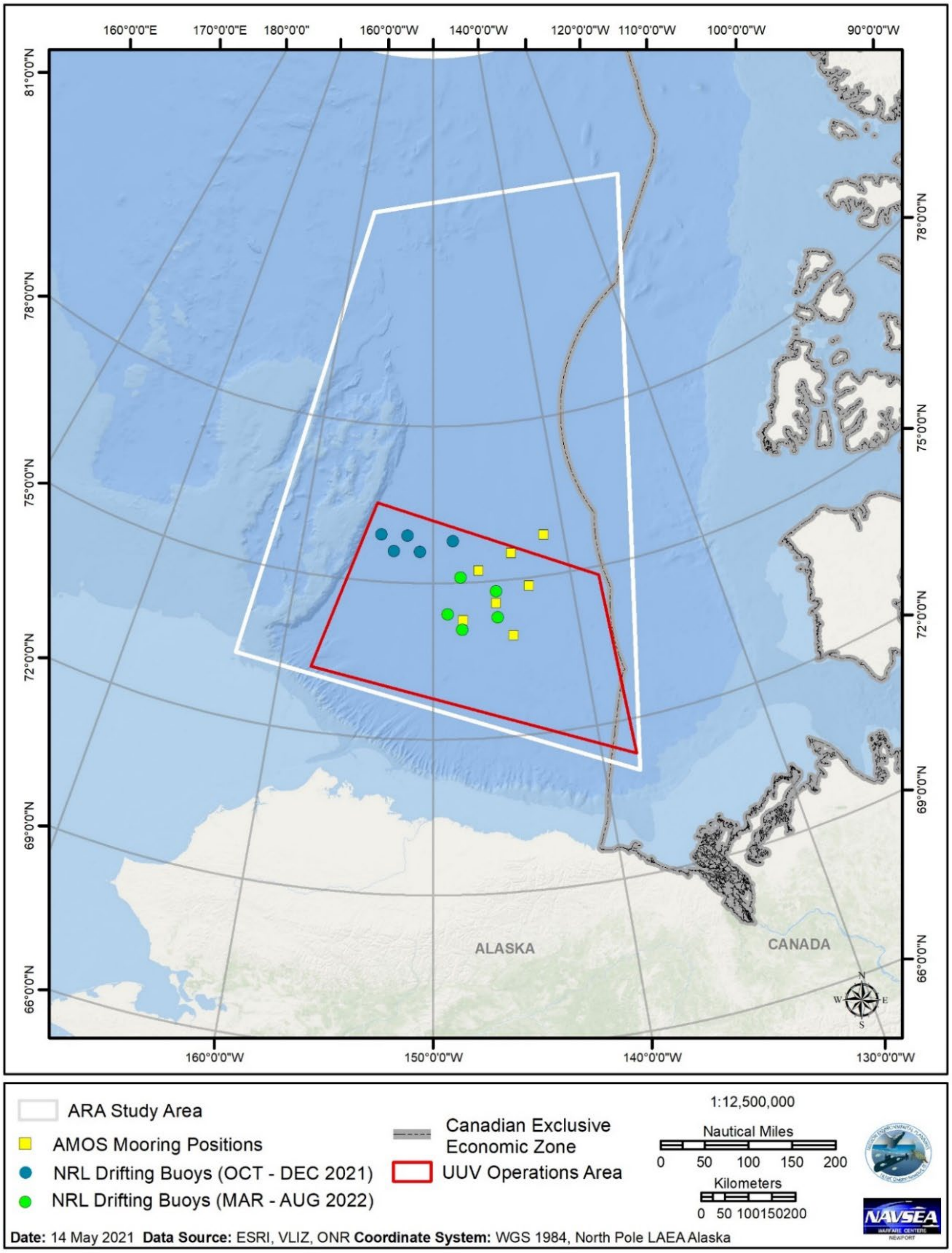

Figure 1. Study area for Office of Naval Research's Arctic Research Activities.

2.2. Standard Operating Procedures and Mitigation Measures

While in transit the CGC Healy will follow the U.S. Coast Guard's Standard Operating

Procedures (SOPs) for operating in Alaska (USCG 2011). Once at the study area (Figure 1), ONR will follow the standard operating procedures and mitigation measures as outlined in their Biological Evaluation (ONR 2018), IHA application (ONR 2021) and this biological opinion. 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 marine mammals sighted that have the potential to be in the path of the ship as a standard collision avoidance procedure.

Mitigation Measures

The final IHA (86 FR 54931) included the following mitigation, monitoring, and reporting requirements. Additional mitigation measures have been added in this biological opinion to address activities not included in the IHA (icebreaking and new vessel route) and to provide clear guidance on what NMFS expects to receive from ONR regarding monitoring and reporting for these activities.

1. Ships operated by or for the Navy will have personnel assigned to stand watch at all times, day and night, when moving through the water. While in transit, ships must use extreme caution and proceed at a safe speed (1-3 knots in ice; <10 knots in open ice-free waters) such that the ship can take proper and effective action to avoid a collision with any marine mammal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
2. During mooring deployment, ONR shall implement a shutdown zone of 60 yards (55 m) around the deployed mooring. Deployment will cease if a marine mammal comes within or approaches 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 shutdown zone has been clear from any additional sightings for a period of 15 minutes.

3. Ships will avoid approaching marine mammals head on and will maneuver to remain at least 500 yd (457 m) from all whales, and 200 yd (183 m) around all other marine mammals.
4. 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.
5. These requirements do not apply if a vessel's safety is at risk, such as when a change of course would create an imminent and serious threat to safety, person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. No further action is necessary if a marine mammal other than a whale continues to approach a vessel after there has already been one maneuver and/or speed change to avoid the animal. Avoidance measures shall continue for any observed whale in order to maintain an exclusion zone of 500 yd (457 m).
6. Vessels will not approach within 5.5 km (3 nm) of rookery sites listed in (50 CFR § 224.103(d)).
7. 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 will conduct marine mammal monitoring during Arctic Research Activities. Monitoring and reporting shall be conducted in accordance with these mitigation measures.

8. During deployment of moored sources, visual observation shall begin 15 minutes prior to deployment and continue throughout the source deployment by an assigned observer.

Although only basic information about marine mammals (latitude, longitude, species, number, behavior) will be recorded when ships are under way, the Navy will have an assigned observer record the following additional information during deployments of the scientific instruments and whenever icebreaking occurs:

9. Weather parameters (e.g., percent cloud cover, percent glare, visibility, percent ice cover) and sea state where the Beaufort Wind Force Scale will be used to determine sea-state (https://www.weather.gov/mfl/beaufort) affecting visibility and detectability of marine mammals;

10. Species numbers, and, if possible, sex and age class of observed marine mammals, along with the date, time, and location of the marine mammal observation;
11. The predominant sound-producing activities occurring during each marine mammal sighting;
12. Marine mammal behavior patterns observed, including bearing and direction of travel;
13. Behavioral reactions of marine mammals just prior to, or during, sound producing activities;
14. Initial, closest, and last location of marine mammals, including distance from observer to the marine mammal, and distance from the predominant sound-producing activity or activities to marine mammals;
15. Whether the presence of marine mammals necessitated the implementation of mitigation measures, and the duration of time that normal operations were affected by the presence of marine mammals;
16. Geographic coordinates for the observed animals, with the position recorded by using the most precise coordinates practicable (coordinates must be recorded in decimal degrees, or similar standard and defined coordinate system);
17. Estimates of "take by harassment" and "take by mortality" (if applicable);
18. For each icebreaking event, the start and ending time will be recorded as well as all the information requested in # 9 through 14, 16 and 17. If no marine mammals are sighted this will also be recorded for each icebreaking event and;
19. ONR is responsible for data quality assurance/quality control of the monitoring log as well as the accuracy and quality of the monitoring report submitted.

Reporting

ONR will:

20. Submit a draft report to the AKR on all monitoring conducted under this consultation within 90 calendar days of the completion of marine mammal monitoring. The report shall include data regarding deployment of the moorings and any marine mammal sightings during transit. If no comments are received from NMFS within 30 days of submission of the draft final report, the draft final report will constitute the final report. If comments are received, a final report must be submitted within 30 days after receipt of comments.
21. Report injured or dead marine mammals unrelated to project activities to the Stranding Hotline (Table 1).
22. 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 Office of Protected Resources, NMFS, and the Alaska Regional Stranding Coordinator. Contact information is in Table 1. The following information will be included:

a. Time, date, and location of the marine mammal injury or death
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 1. 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 Kelsey Potlock: Kelsey.potlock@noaa.gov
Reports & Data Submittal	AKR.section7@noaa.gov (please include NMFS consultation number AKRO 2022-00873)
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

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 action area is shown in Figure 1. The moorings are represented by the yellow squares in Figure 1. The action area also includes a 2 km zone on either side of the vessel for the transit route from Seward to the Beaufort Sea and the return trip, which will end in Dutch Harbor, Unalaska.

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 as a whole for the conservation of a listed species (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 (August 2021 revision)

- Additional information supplied by the Navy regarding ice breaking activities.
- The Draft Supplemental Overseas Environmental Assessment for ONR Research Arctic Research Activities in the Beaufort Sea October 2021 – October 2022
- 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 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 2. The route will also take them though habitat occupied by ringed and bearded seals and Steller sea lion as well as critical habitat for Western North Pacific humpback whale, Steller sea lion, North Pacific right whale, ringed seal and bearded seal. This opinion considers the effects of the proposed action on the species and designated critical habitats specified in Table 2

Table 2. 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

Species	Status	Listing	Critical Habitat
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 habitat 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 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 consider if vessel transit 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 and where icebreaking may be needed. Only the ringed seal will potentially overlap with those activities. We discuss the effects of vessel noise on all cetaceans and pinnipeds in sections 4.1.1 and vessel strike on both groups in section 4.1.2. 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 the CGC Healy will make one trip from Seward, Alaska to the Beaufort Sea and one trip from the Beaufort Sea to Dutch Harbor, Unalaska in July 2022.

4.1.1.1. 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 expected to occur within the action area. In addition, 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 whale, sei whale, North Pacific right whale, sperm whale, Western North Pacific gray whale 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. (2013a), 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 area of 2 km for the transit of the vessel 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 (2,850 km x 0.0008 whales per km^2 x 2 km). For the shorter route back, which will end at Dutch Harbor, approximately 2.6 whales could be exposed to vessel noise above 120 dB (1,600 km x 0.0008 whales per km^2 x 2 km). These estimates show the maximum number of subarctic whales of each listed species considered in this opinion that might be exposed 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). Consequently, their density is far less than the fin whale's and consequently, we would expect less than one sperm to be exposed to vessel noise.

Halliday et al. (2021) examined the potential exposure of beluga and bowhead whales to underwater noise from ship traffic in the Beaufort and Chukchi Seas based on Automatic Identification System data from 2017 and 2018 and noise source levels from 10 vessel classes. They found that in July, ship traffic was very low and whale distributions never had more than two underwater noise events within any single 500 m cell in any year. Because of the expected location of bowhead whales in the Amundsen Gulf and Canadian Beaufort Sea over continental shelf waters in July (Halliday et al. 2021), and the destination of the CGC Healy is the deep water of the Beaufort Sea, we expect no overlap with vessel noise from the CGC Healy and bowhead whales.

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) prior to the disturbance from the vessel. 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. Although whales that might be encountered in the portion of transit from Seward through Unimak Pass and the vicinity of Dutch Harbor may be habituated to vessel traffic, we would expect that whales along the north coast of Alaska would be less so because of the reduced amount of vessel traffic Figure 2.

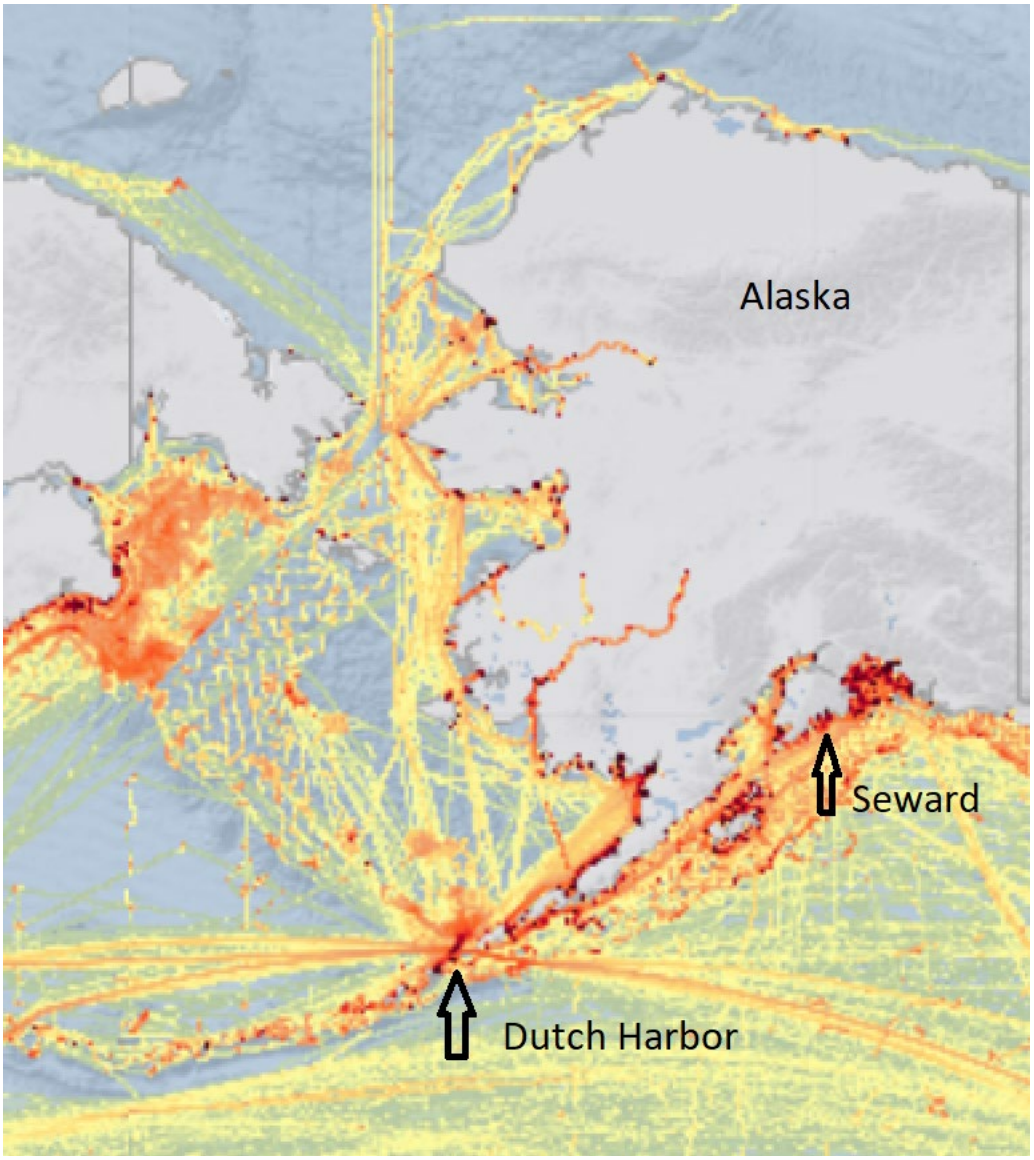

Figure 2. Vessel density monthly hours per km^2 (all vessel types) in July 2021. From Global Maritime Traffic viewed May 21, 2022 https://globalmaritimetraffic.org/index.html

Ships in transit typically travel in a consistent and predictable direction and speed, essentially providing warning of their arrival before reaching any given location. 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 low number of transits (2), a vessel speed of 10 to 12 kn, the implementation of mitigation measures, the transitory and short-term exposure, and the expected low level of response, NMFS concludes that any disturbance of 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. 2021). The CGC Healy is most likely to encounter Steller sea lions on the first leg of its transit from Seward to Unimak Pass and on its last leg as it nears Dutch Harbor. 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) and 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 and ringed 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 to 12 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 cruise will occur mid-summer, the probability that vessel noise would interfere with vocalizations related to breeding is greatly reduced.

As explained for 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 breathing, 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. 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 leg of the transit from Seward through Unimak Pass and on the last leg into Dutch Harbor. 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).

Unlike the other large cetaceans that migrate to winter feeding and breeding areas in the winter, and are only part time occupants of waters around Alaska, bowhead whales are a permanent Arctic inhabitant. Because of this and because the population has been steadily increasing and is currently about 16,000 whales, they potentially are the cetacean most likely to be encountered by the CGC Healy. However, in July, the high use area for bowhead whales is in the Amundsen Gulf and Canadian Beaufort Sea over continental shelf waters (Halliday et al. 2021). When bowheads begin their migration back towards the west, they remain over the shallower waters of the Alaskan Beaufort Sea. The bowhead seasonal migration pattern greatly reduces the likelihood that the CGC Healy will encounter a bowhead whale. Further, although there is annual overlap between ships using the Northern Sea Route and the Northwest Passage, scars associated with ship strike are only seen on about 2 percent of harvested whales (George et al. 2017). Some whales may be struck and never seen. However, the bowhead whale population has been growing at a steady rate of 3.2 to 3.7 percent per year (Muto et al. 2021) indicating that although bowhead whales may be struck, killed, and undetected, their loss is not impeding continued population growth.

Mitigation measures that apply to all cetaceans include: (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) 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 must use extreme caution and proceed at a safe speed (1-3 knots in ice; <10 knots in open ice-free waters). We expect that these mitigation measures will greatly reduce the probability of ship strike. In addition, because the cruise under consideration will be made in July, the long days should provide for better visibility than in other times of the year.

With the low number of transits (one north, one south), the implementation of the mitigation measures (person on watch at all times vessel is moving, speed 10 knots), 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 the CGC Healy striking a whale is very unlikely.

4.1.2.2. Pinnipeds

Bearded and ringed seals will likely be able to hear the CGC Healy from a distance and if disturbed, would likely move away from the vessel. 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 (Delean et al. 2020). Seals are extremely agile and capable of moving quickly in the water, greatly reducing the probability of being struck by a vessel traveling at 10 knots.

Funk et al. (2010) noted among vessels operating in the Chukchi Sea where received sound levels were <120 dB, 40% of observed seals showed no response to a vessel's presence, slightly more than 40% swam away from the vessel, 5% swam towards the vessel, and the movements of 13% of the seals were unidentifiable. More recently, Bisson et al. (2013) reported a total of 938 seals observed during vessel-based monitoring of exploratory drilling activities by Shell in the Chukchi Sea during the 2012 open-water season. This total includes animals sighted outside of the leased area during transits to and from the drill site. The majority of seals (42%) responded to moving vessels by looking at the vessel, while the second most noted behavior was no observable reaction (38%). Personnel will be watching for marine mammals whenever the ship is underway further reducing the possibility of ship strike. Therefore, we conclude that the probability of 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 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 unlikely to collide with a Steller sea lion.

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, Western DPS Steller sea lion, North Pacific right whale, bearded seal and ringed seal. 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 CGC Healy 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 bearded and 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 #6 and #7 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 over the water surface of critical habitat for Western North Pacific DPS humpback whale, Western DPS Steller sea lion, North Pacific right whale, bearded seal and ringed seal will have an immeasurably small effect on the features determined to be essential for these species.

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 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 3) (Thoman and Walsh 2019).

[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

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 4). 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; Meier et al. 2021). Based on data available since 1985, multiyear ice in 2021 reached its second lowest level by the end of summer and ice volume was at a record low (at least since 2010) in April 2021(Meier et al. 2021) (Figure 4). 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 5). The minimum Arctic sea ice extent in 2020 was the second lowest in the 42-year satellite record, second only to September 2012[5].

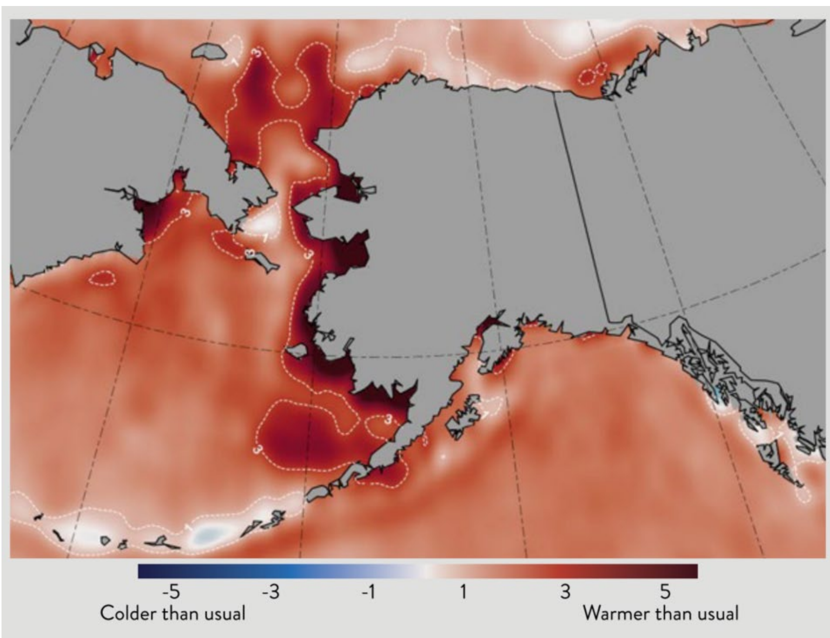

Figure 3. Arctic summer sea surface temperatures, 2019 (Thoman and Walsh 2019).

[5] http://nsidc.org/arcticseaicenews/2020/10/ viewed May 14. 2022

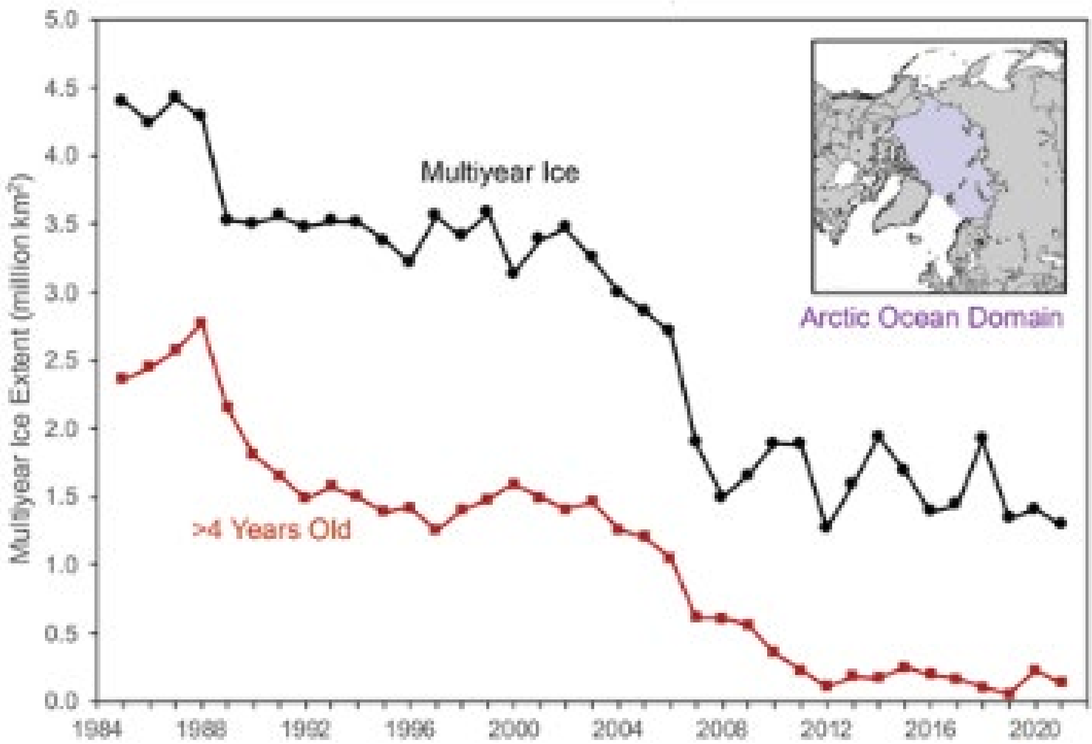

Figure 4. Extent of multiyear ice (black) and ice greater than 4 years old (within the Arctic Ocean for the week of the minimum total extent (Figure from Meier et al. (2021)).

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).

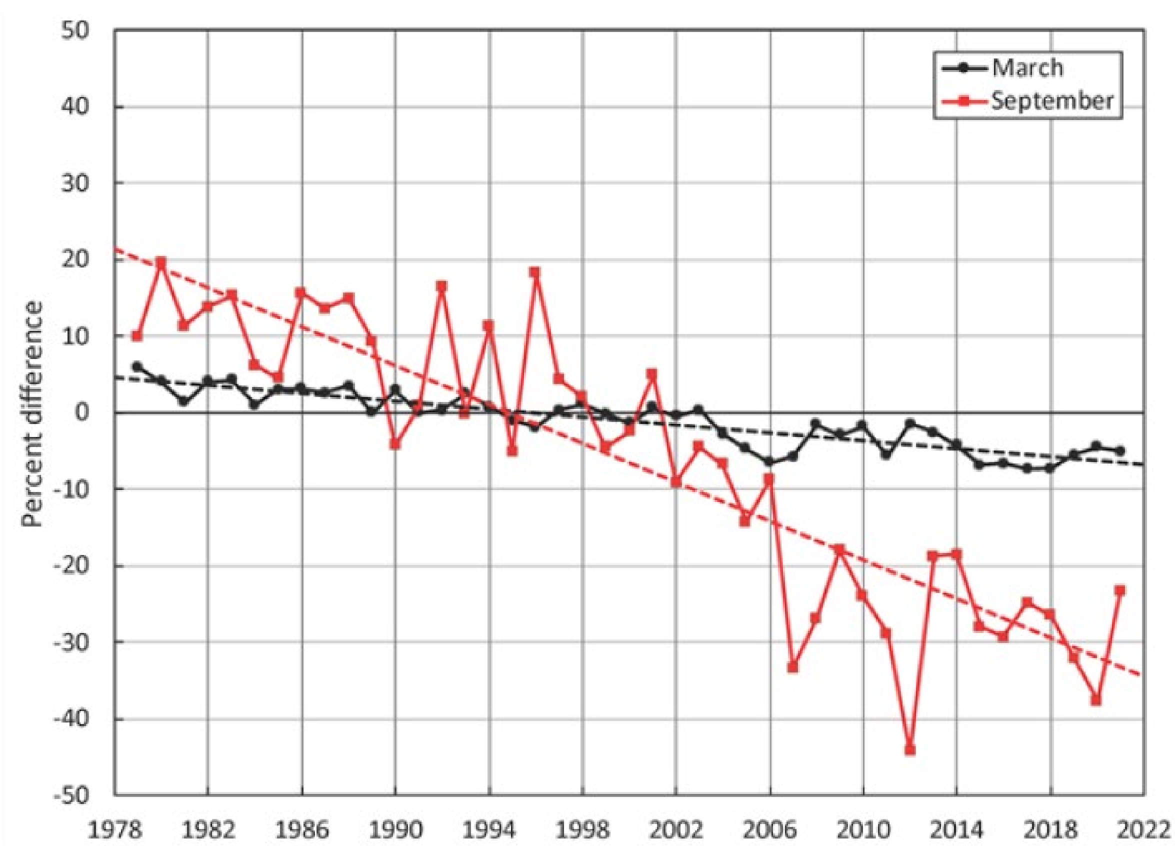

Figure 5. Arctic ice extent declines in September (red) and in March (black). The value for each year is the difference in percent in ice extent relative to the mean values for 1981-2010. Both trends are significant at the 99% confidence level. The slopes of the lines indicate losses of -2.7 for the maximum ice extent and -13.0 percent for the minimum ice extent, per decade (Meier et al. 2021).

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 6). 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).

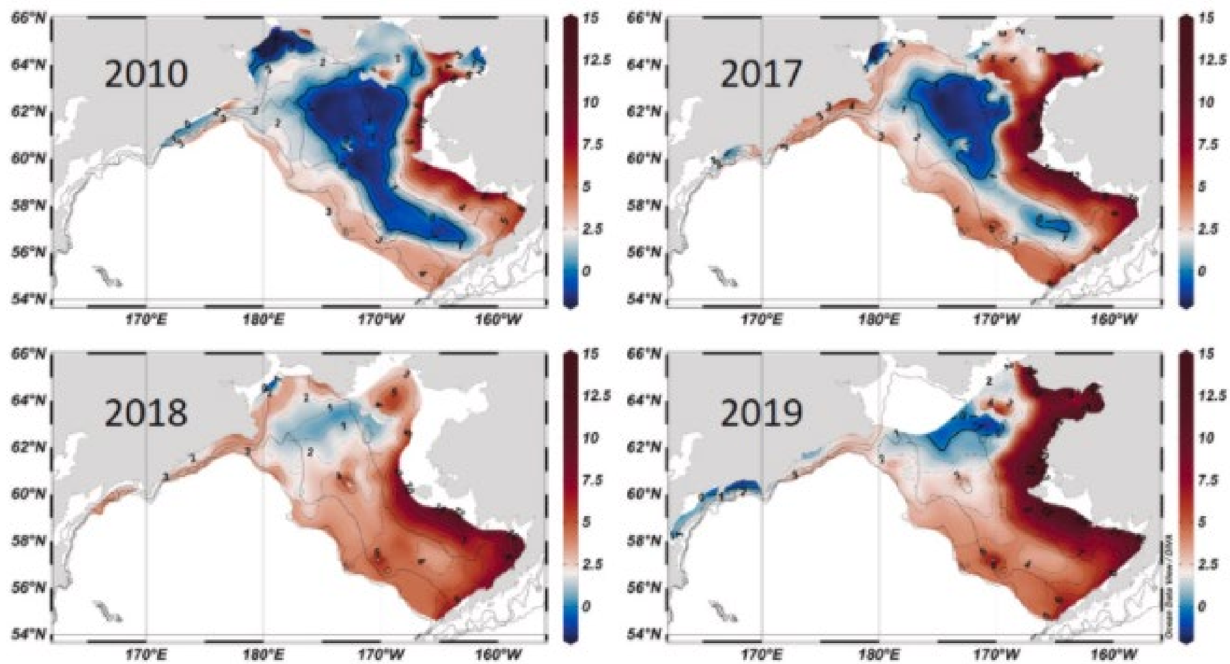

Figure 6. Bottom temperatures from summer oceanographic surveys. Graphic display of the shrinkage of the cold pool over time. From Eisner et al. (2020).

The 2018 Pacific cod stock assessment[6] 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.

[6]NOAA Fisheries, Alaska Fisheries Science Center website. Available at https://apps-afsc.fisheries.noaa.gov/REFM/stocks/Historic_Assess.htm, accessed December 2, 2020.

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[7].

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 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

[7] NOAA Global Monitoring Laboratory website. Trends in Atmospheric Carbon Dioxide. Available at https://www.esrl.noaa.gov/gmd/ccgg/trends/, accessed November 10, 2020.

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 3.

Table 3. 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	
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	Increased likelihood of ship strikes, fisheries

Effect	Result
related to longer open water period	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.

Only one species, the threatened Arctic ringed seal, is likely to be adversely affected by the proposed action. 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.

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 subspecies of ringed seal.

Ringed seal population surveys in Alaska have used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current and comprehensive abundance estimates or trends for the Alaska stock are 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). Conn et al. (2014), using a sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of 171,418 ringed seals (95% CI: 141,588-201,090) (Muto et al. 2021). This estimate did not account for availability bias due to seals in the water at the time of the surveys and did not include ringed seals in the shorefast ice zone, which were surveyed using a different trackline design that will require a separate analysis. Thus, the actual number of ringed seals in the U.S. portion of the Bering Sea is likely much higher, perhaps by a factor of two or more. Due to the lack of precise population estimates, the population trends for the Arctic subspecies and Alaska stock are unknown.

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).

4.3.1.3. Occurrence in the Action Area

Although the distribution of sea ice is highly variable and unpredictable, if the CGC Healy encounters thick ice that needs to be broken it will most likely be over the deeper waters of the

Beaufort Sea as the sea ice typically retreats away from the shore. There is not a reliable density estimate of ringed seals in this remote area but based on the water depth and generally low productivity we expect that the density of ringed seals is low. However, tagging studies have shown that ringed seals will make trips across the open water to the ice edge.

Seals tagged in Utqiaġvik, Alaska showed the movement patterns in Figure 7 from July to November (Von Duyke et al. 2020). Most of the tagged seals made brief (about a week long) mid-summer movements into the deepwater of the Beaufort Sea to reach the retreating edge of the sea ice where they spent more time hauled out than foraging (Von Duyke et al. 2020). Thus ringed seals may occur in the Beaufort Sea when the CGC Healy arrives in July and where icebreaking may occur.

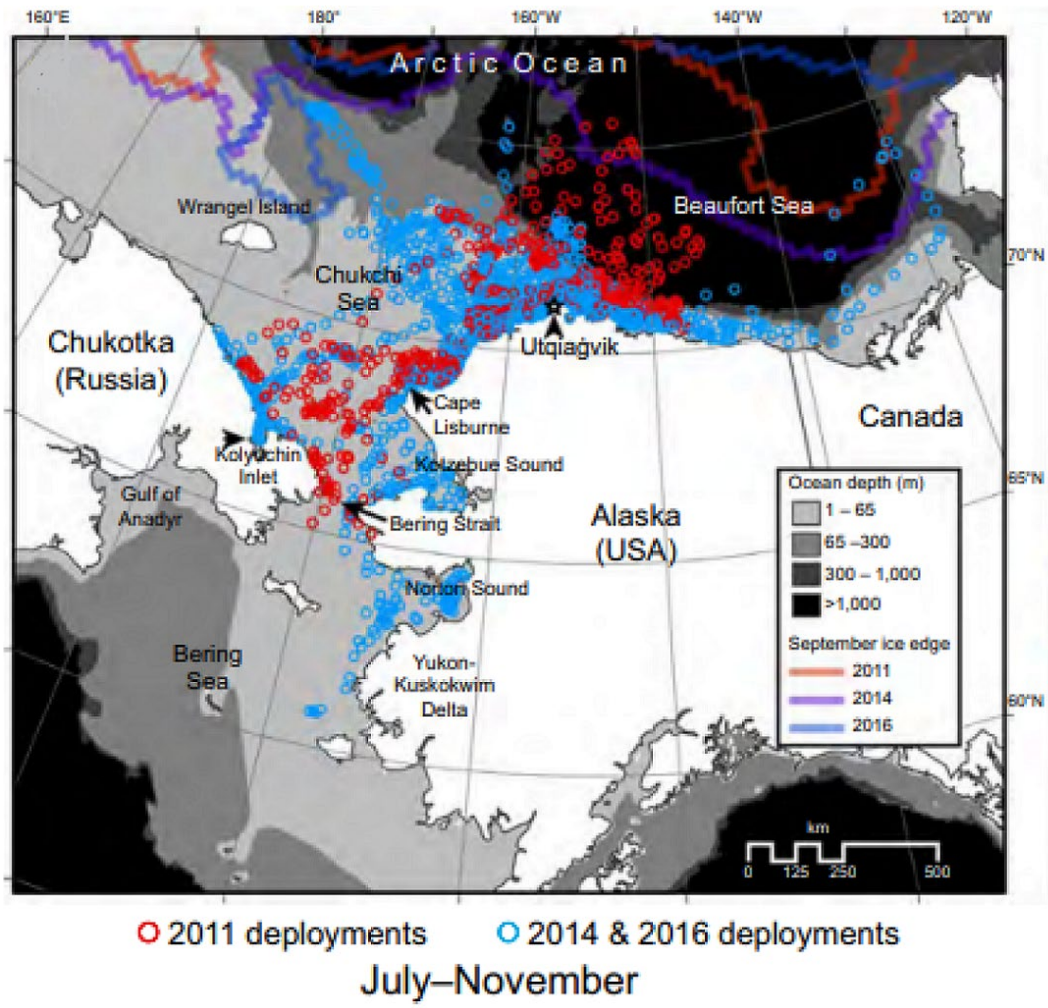

Figure 7. Locations of tagged ringed seals from July to November (Von Duyke et al. 2020).

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. Life History

Ringed seal pups are born and nursed in the spring (March through May). 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).

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). It is thought that the relatively long periods of time that ringed seals spend out of the water during the molt are needed to maintain elevated skin temperatures during new hair growth (Feltz and Fay 1966). Figure 8 summarizes the approximate annual timing of Arctic ringed seal reproduction and molting (Kelly et al. 2010a).

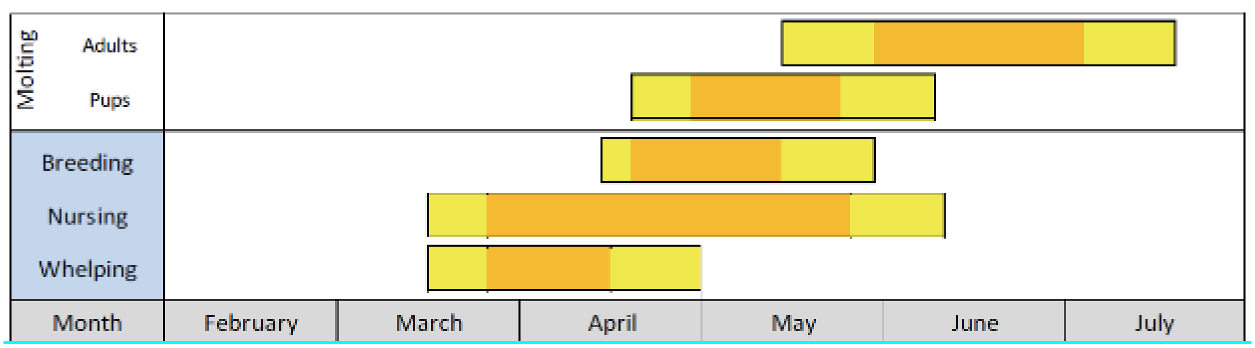

Figure 8. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicate the "peak" timing of each event (Kelly et al. 2010a).

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). 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).

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; Sills et al. 2015). NMFS defines the functional hearing range for phocids as 50 Hz to 86 kHz (NMFS 2018). Jones et al. (2014) describe ringed seal vocalizations as barks, yelps, and growls which were recorded only between mid-December and late May over three years. Recordings were taken along the continental slope break of the Chukchi Sea 120 km north-northwest of Utqiaġvik, Alaska. Recordings were made only from September to June, so ringed seal presence in the area during the summer was not documented (Jones et al. 2014).

Unlike cetaceans, phocids do not have the acute, high frequency sound production or reception systems needed for underwater echolocation (Schusterman et al. 2000). 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. 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” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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 areas that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency’s discretion to modify are part of the environmental baseline (50 CFR § 402.02). This section discusses the environmental baseline, focusing on existing anthropogenic and natural activities within the action area and their influences on listed species and their critical habitat that may be adversely affected by the proposed action.

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 changes in the climate in the past, 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 9). 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).

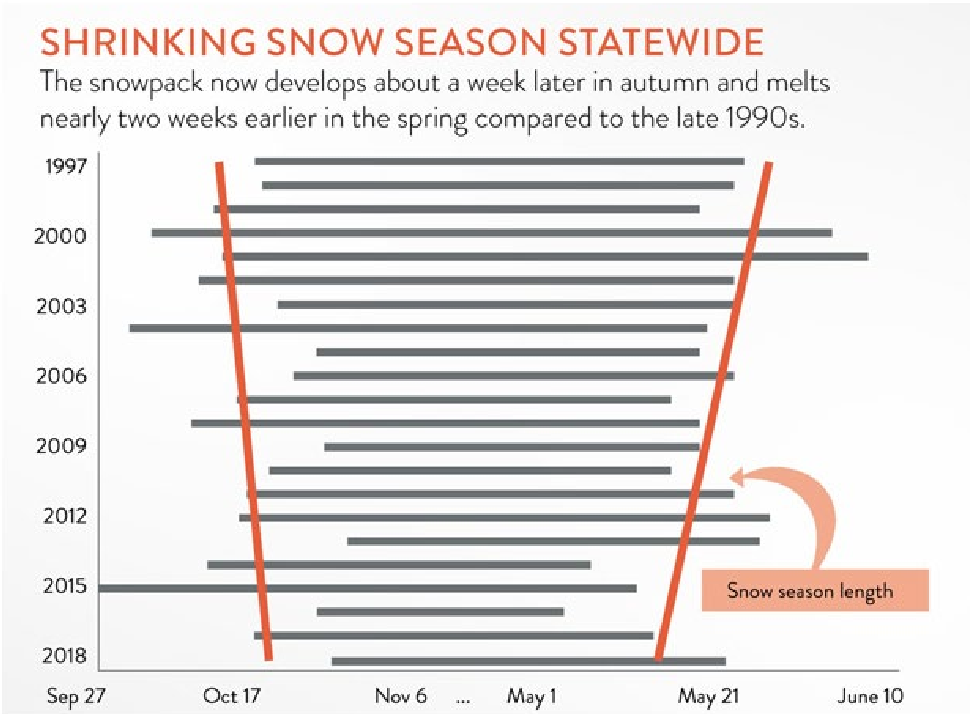

Figure 9. Length of the snow season (gray bars) in Alaska each year from 1997-2018. Orange slanting bars show the trends of the date when the state becomes 50 percent snow covered in fall and when half the winter snow has melted in spring. Image by Rick Thoman, Alaska Center for Climate and Policy.

Because the sea ice extent and thickness have been decreasing consistently, vessel traffic, and more importantly for seals, ice breaker traffic, is 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 an increase in icebreakers, we would expect that ice dependent seals could be affected.

With an earlier retreat of sea ice in the spring and warmer ocean temperatures (Section 4.2.1.2), there have been changes in the distribution of whales. Aerial surveys to study the distribution, relative abundance, and behavior of marine mammals have been conducted in the eastern Chukchi Sea, primarily during July through October, 1982–1991 and 2008–2016, for the Aerial

Surveys of Arctic Marine Mammals (ASAMM) project and its precursors (Brower et al. 2018). Although historical records from commercial whaling and scientific research document humpback, fin, and minke whales from June through October in the western Chukchi Sea and near the Chukotka coast, few records of these subarctic species exist in the eastern Chukchi Sea (Clarke et al. 2013) and these species were entirely absent from this area in the 1982–1991 surveys (Brower et al. 2018). In contrast, there were 159 sightings of 250 individuals of these species in 2008–2016 in the eastern Chukchi Sea (Brower et al. 2018).

In addition to these observations, passive acoustic monitors (PAM) have been recording the presence of subarctic species in various parts of the Chukchi Sea (Delarue et al. 2013; Hannay et al. 2013; Crance et al. 2015; Tsujii et al. 2016; Stafford et al. 2022).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) and the extended use of the area by killer whales (Stafford et al. 2022). We would expect as sea ice continues to decline, presence of these subarctic species in more northerly latitudes will increase.

Shipping in the Arctic is expected to increase as sea ice decreases. Both major shipping routes, the Northern Sea Route along the northern Russian coast and the Northwest Passage through the Canadian Archipelago, pass through Bering Strait. The entire population of bowhead whales passes through Bering Strait each spring and fall between wintering and summering areas (Quakenbush et al. 2012). There are about 33 km (20 mi) between the west side of the Diomedes Islands and the Chukotka coast. Ships traveling along the coast between October and December could encounter a high proportion of the bowhead population (Quakenbush et al. 2012). Ship strikes are the greatest source of mortality for North Atlantic right whales (*Eubalaena glacialis*) and bowhead and North Pacific right whales may be as vulnerable to ship strikes as North Atlantic right whales due to their swimming speed and feeding behavior (Reeves et al. 2012). Two percent of subsistence-harvested bowheads bear scars from vessel encounters (George et al. 2017). In addition, with the expansion of habitat by the subarctic species to the north, interactions with ship traffic in the Bering Strait is an area of concern for all species (Reeves et al. 2012).

Some Arctic species may benefit from some aspects of climate change. Conceptual models suggested that overall reductions in sea ice cover should increase the Western Arctic stock of bowhead whale prey availability (Moore and Laidre 2006). This theory may be substantiated by the steady increase in the Western Arctic bowhead population during the nearly 20 years of sea ice reductions (Walsh 2008). (George et al. 2006), showed that harvested bowheads had better body condition during years of light ice cover. Similarly, George et al. (2015) found an overall improvement in bowhead whale body condition and a positive correlation between body condition and summer sea ice loss over the last 2.5 decades in the Pacific Arctic. George et al. (2015) speculated that sea ice loss has positive effects on secondary trophic production within the Western Arctic bowhead whale's summer feeding region. Moore and Huntington (2008) anticipated that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change.

5.1.1.1. 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 10). 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[8].

[8] 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 10. 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.

5.1.1.2. 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[9]. Since June 1, 2018, NMFS confirmed 311 strandings[10] (Table 4). The cause of the UME has not been determined but many of the seals had low fat thickness. 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. As strandings and mortalities have returned to baseline levels, the UME will soon be closed. The causes of the event are still being investigated.

Table 4. 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	27	111
2019	50	35	26	53	164
2020	10	9	8	11	38
2021	11	22	8	14	55
2022 (as of January 7))	0	0	0	0	0
Total*	**108**	**87**	**55**	**130**	**380**

*June 1, 2018 - 27 August 2021. 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.

---

[9] Barbara Mahoney, 2019, unpublished document. Ice Seal UME Update in the Alaska Region Marine Mammal Stranding Network Fall/Winter 2019 newsletter.
[10] 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.

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 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 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 can cause serious injury depending on whether the gear works its way into the gastrointestinal tract, whether the gear penetrates the gastrointestinal tract lining, is 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 moves or shifts freely with the marine mammal's movement and does not indent the skin can result in disfigurement.
- Gear that encircles any body part and has sufficient tension to either indent the skin or to not shift with marine mammal's movement can cause lacerations, partial or complete fin amputation, organ damage, or muscle damage and interfere with mobility, feeding, and breathing. Lines from weighed gear (e.g., crab pots) that becomes entangled with whales can cause drowning or exhaustion. In July 2010, a dead bowhead whale was found in Kotzebue Sound, entangled in crab pot gear similar to that used in the Bering Sea (Suydam et al. 2011). In 2015, a dead female bowhead whale was found near St. Lawrence Island in the Bering Strait, entangled in fishing gear. The gear was identified as originating in the 2012/2013 winter commercial king crab fishery from the northern Bering Sea, near St. Matthew Island (Suydam et al. 2016; Muto et al. 2018).
- Chronic tissue damage from line under pressure can compromise a whale's physiology. Fecal samples from entangled whales had extremely high levels of cortisols (Rolland et al. 2005), an immune system hormone. Extended periods of pituitary release of cortisols can exhaust the immune system, making a whale susceptible to disease and infection.

From 2013 to 2017, the minimum estimated mean annual mortality and serious injury rate for bearded seals in U.S. commercial fisheries between 2014 and 2018 is 1.8 from two federally-managed US commercial fisheries in the Bering Sea and Aleutian Islands (Bering Sea/Aleutian Islands (BSAI) pollock trawl, BSAI flatfish trawl) (Muto et al. 2021). During the same timeframe, the minimum estimated mean annual mortality and serious injury rate for ringed seals by the U.S. commercial fisheries was 4.6 for BSAI flatfish trawl (Muto et al. 2021). Entanglement and entrapment in trawl fishery gear was the leading cause of serious injury and mortality for all phocids analyzed in Helker et al. (2019).

Because no commercial fisheries currently 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

BSAI management area.

5.3. Oil & Gas

Offshore petroleum exploration activities have been conducted in the action area both within State of Alaska waters and the Outer Continental Shelf (OCS) of the Beaufort and Chukchi seas, and nearby in Canada's eastern Beaufort Sea off the Mackenzie River Delta, in Canada's Arctic Islands, in the Russian Arctic, and around Sakhalin Island in the Sea of Okhotsk (NMFS 2016a). In the central Beaufort Sea in Alaska, oil and gas exploration, development, and production activities include seismic surveys; exploratory, delineation, and production drilling operations; construction of artificial islands, causeways, ice roads, shore-based facilities, and pipelines; and vessel and aircraft operations. Stressors associated with these activities that are of primary concern for marine mammals include noise, physical disturbance, and pollution, particularly in the event of a large oil spill.

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.

Endicott Satellite Drilling Island, built in 1987, was constructed to support the first continuous production of oil from an offshore field in the Arctic. Subsequently, the Northstar offshore island was constructed in 1999 and 2000 to support oil production. Northstar, as well as the Nikaitchuq and Oooguruk developments, currently operates in nearshore areas of the Beaufort Sea, and is expected to continue operating in the future. Other oil and gas related activities that have occurred in the Beaufort Sea and Chukchi Sea OCS to date include exploratory drilling, exploration seismic surveys, geohazard surveys, geotechnical sampling programs, and baseline biological studies and surveys. There are also several exploration and development projects occurring on the North Slope including Greater Moose's Tooth 1 and 2, Smith Bay, Nuna, and Nanushuk.

The Alaska Gasoline Development Corporation has 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. Construction infrastructure would include shipping traffic through the Bering, Chukchi, and Beaufort seas.

Since 1975, 84 exploration wells, 14 continental offshore stratigraphic test wells (i.e., COST), and six development wells have been drilled on the Arctic OCS (BOEM 2012). Historical data on offshore oil spills for the Alaska Arctic OCS region consists of all small spills (i.e., less than 1,000 barrels [31,500 gallons]) (NMFS 2013a).

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, and risk of ship strike. 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 2013a) 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). Increased oil and gas development in the U.S. Arctic has led to an increased risk of various forms of pollution to whale and seal habitat, including oil spills, other pollutants, and nontoxic waste (Allen and Angliss 2015). Spills can occur from produced fluids, diesel, sales oil, bulk storage tanks, and more (Table 5).

Table 5. Relative rate of occurrence for spills from main sources (BLM 2019).

Source	Spill Size				
	Very Small	Small	Medium	Large	Very Large
Produced fluids	H	H	M	L	VL
Saltwater	H	H	M	L	VL
Diesel	H	M	L	VL	0
Sales oil	M	M	M	L	VL
Bulk storage tanks and containers on pads	L	L	L	VL	0
Tank vehicles	H	M	L	VL	0
Vehicle and equipment operation and maintenance	VH	VH	M	VL	0
Other routine operations	VH	VH	H	L	VL
Drilling blowout	VL	VL	VL	VL	VL
Production uncontrolled release	VL	VL	VL	VL	VL
Notes:					
VL = Very low rate of occurrence VH = Very high rate of occurrence L = Low rate of occurrence M = Medium rate of occurrence H = High rate of occurrence 0 = Would not occur	Very small: <0.24 barrels (10 gallon) Small: 0.24-2.37 barrels (10-99.5 gallons) Medium: 2.38-23.8 barrels (100-999.5 gallons) Large: 23.8-2,380 barrels (1,000-100,000 gallons) Very Large: >2,380 barrels (>100,000 gallons)				

Many of the consultations have authorized the take (by harassment) of bowhead whales and 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 surveying has acoustic impacts on the marine environment. The noise generated from seismic surveys has been linked to behavioral disturbance of wildlife, masking of cetacean communication, 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 and across the ranges of many of the species considered in this Biological Opinion.

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 ESA-listed species or their prey items (NMFS 2013a). 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).

Marine mammals can ingest spilled compounds while feeding, inhale the volatile components, or be affected by direct contact. For example, whales can experience baleen fouling upon encountering petroleum products. Effects of oil ingestion on marine mammals can range from progressive organ damage to death, depending on the quantity and composition of the ingested oil (Geraci and St. Aubin 1990). Surface contact with oil spills can damage mucous membranes and eyes of seals, or disrupt thermoregulation in seal pups (Geraci and St. Aubin 1990).

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 OCS is also the CWA. Discharges are covered under the Vessel Incidental Discharge Act, which is in the new CWA Section 312(p)[11]. 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, only 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% 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

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

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.

With respect to the ringed and bearded seals, small spills could result in irritation of the eyes, mouth, lungs, and anal and urogenetical surfaces (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. 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 (1976) 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 (1976) 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.

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.

Bratton et al. (1993) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowhead whales harvested from 1983 to 1990. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time. The metal levels observed in all tissues of the bowhead are similar to levels reported in the literature in other baleen whales. The bowhead whale has little metal contamination as compared to other arctic marine mammals, except for cadmium. Mossner and Ballschmiter (1997) reported that total levels of polychlorinated biphenyls and chlorinated pesticides in bowhead blubber from the North Pacific and Arctic Oceans were many times lower than those in beluga whales or northern fur seals. However, while total levels were low, the combined level of three isomers of the hexachlorocyclohexanes (chlorinated pesticides) was higher in the blubber tested from bowhead whales than from three marine mammal species sampled in the North Atlantic (pilot whale, common dolphin, and harbor seal). These results were believed to be due to the lower trophic level of the bowhead as compared to the other marine mammals tested.

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.

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

Lee et al. (1996) compared persistent organochlorine pesticides and PCBs in Steller sea lions in the Gulf of Alaska to Steller sea lions in the Russian waters of the Bering Sea. PCBs were the predominant organochlorine in Steller sea lion blubber, followed by DDT. The level of PCBs in male Steller sea lions were higher than those in ringed seals in Arctic waters. Steller sea lions in the Bering Sea had significantly lower DDTs and PCBs than those from the Gulf of Alaska (Lee et al. 1996). Ferdinando (2019) assessed heavy metals in marine mammals including Steller sea lions. In the southwest Alaska area consisting of the Aleutian Islands, mercury was the highest concentration of heavy metal found in Steller sea lions, followed by lead, nickel, and copper and were concentrated in the fur, tendon, and muscle tissues (Ferdinando 2019).

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 automatic identification system (AIS) in U.S. waters north of the Pribilof Islands increased from 120 in 2008 to 250 in 2012, and is expected to continue to increase (Azzara et al. 2015). This includes only the northern Bering Sea, the Bering Strait, Chukchi Sea and Beaufort Sea to the Canadian border. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the near-shore waters off Prudhoe Bay from oil and gas exploration activity is particularly pronounced (ICCT 2015). The number of vessels identified in this region in 2012 includes a spike in vessel traffic associated with the offshore exploratory drilling program that was conducted by Shell on the outer continental shelf (OCS) of the Chukchi Sea that year. A comparison of the geographic distribution of vessel track lines between 2011 and 2012 provides some insight into the changes in vessel traffic patterns that may occur as a result of such activities (Figure 11). Overall, in 2012 there was a shift toward more offshore traffic, and there were also noticeable localized changes in vessel traffic concentration near Prudhoe Bay and in the vicinity of the drilling project in the Chukchi Sea (Azzara et al. 2015).

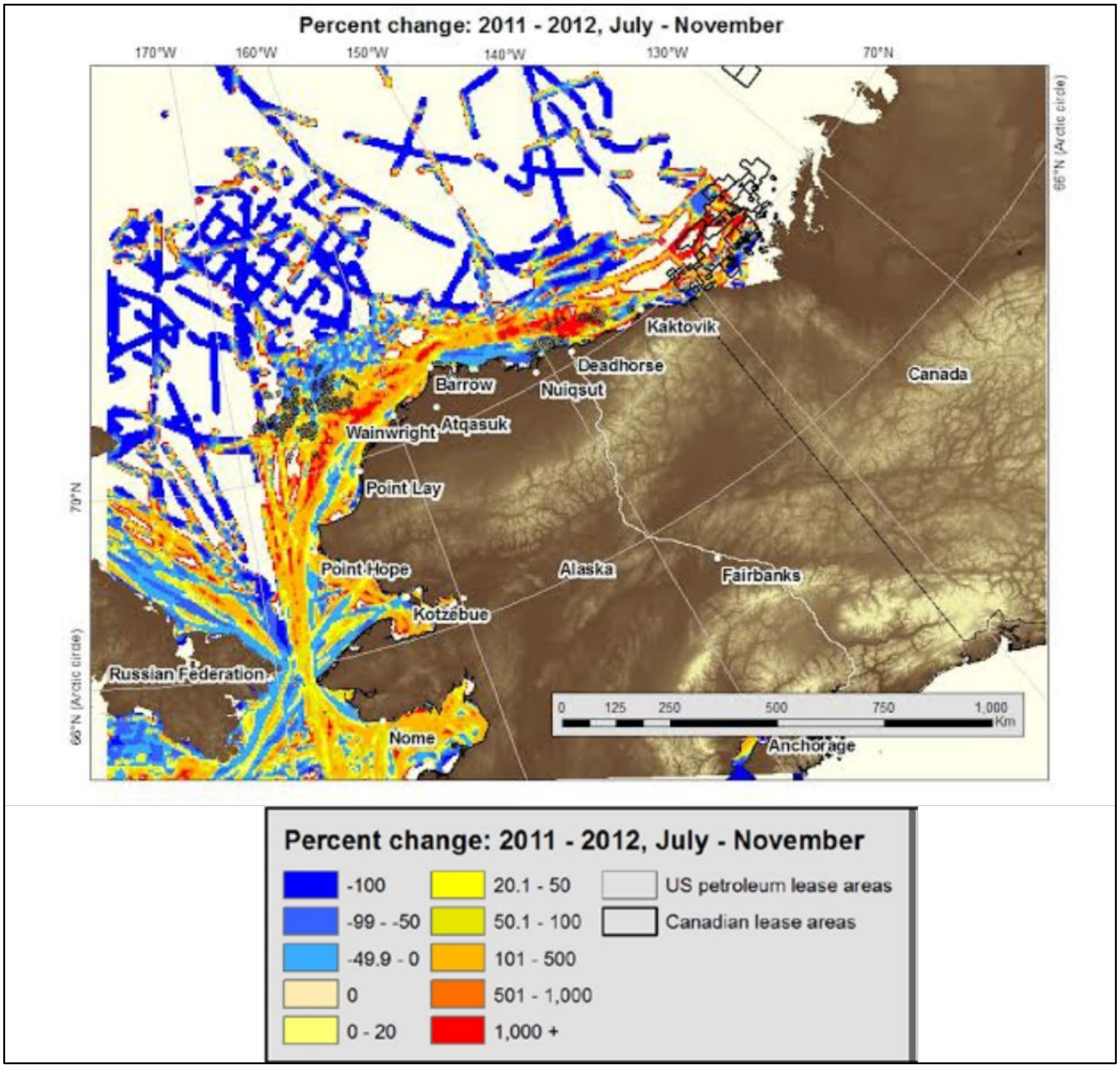

Figure 11. Percent difference in vessel activity between 2011 and 2012 using 5-km grid cells. (Azzara et al. 2015)

Marine vessel traffic may pose a threat to pinnipeds and cetaceans in the action area, because of ship strikes and vessel noise. The U.S. Committee on the Marine Transportation System (CMTS) reported that about 255 vessels transited through the US Arctic and surrounding region from 2015-2017, as determined by automatic identification system (AIS) data.

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. 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 currently 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 anticipated 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. However, Sternfeld (2004) documented a single spotted seal stranding in Bristol Bay, Alaska, that may have resulted from a propeller strike.

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 (human-caused) 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).

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).

5.5.2. Oil and Gas Exploration, Drilling, and Production Noise

NMFS has conducted numerous ESA section 7 consultations related to oil and gas activities in the Beaufort Sea. Many of the consultations have authorized the take (by harassment) of bowhead whales and estimated take of ringed and bearded seals from sounds produced during geophysical (including seismic) surveys and other exploration and development activities. Below are some key consultations completed in the action area, but this is not an exhaustive list.

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 or Beringia DPS bearded seals; therefore, ESA section 9 take prohibitions do not apply to these species. In our biological opinions, we estimate take of these threatened species, we determine whether the action may jeopardize the continued existence of these species, and we work with the action agency to minimize take. We do not, however, authorize take of threatened species for which take is not prohibited under the ESA.

For each consultation, the process to estimate take of listed species is very specific to that action, relying on assumptions specific to the proposed action, and the best available information at that time for species density, and the best available science at that time to understand the scope and intensity of a stressor (e.g., acoustics, sound source verification, transmission loss, etc.). The estimates of take are conservative and thus are, most likely, overestimates. We also make assumptions about the ability of an action agency to accurately recognize that take has occurred during the course of an action—that whales and pinnipeds are not always available to be observed, or they can be affected in ways that are not observable. It is possible that the actual take numbers reported by an action agency may underestimate the instances of take of listed species. We present these caveats to provide context for the authorized take estimates below.

In 2013, NMFS completed an incremental step consultation with BOEM and Bureau of Safety and Environmental Enforcement (BSEE) on the effects of the authorization of oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi seas over a 14-year period, from March 2013 to March 2027 (i.e., the Arctic Regional Biological Opinion (NMFS 2013b)). The incidental take statement issued with the biological opinion for the 14-year period allows for takes (by harassment) from sounds associated with high-resolution, deep penetration, and in-ice deep penetration seismic surveys of 87,878 bowhead whales, 896 fin whales, 1,400 humpback whales, and estimated take of 91,616 bearded seals, and 506,898 ringed seals. Take will be more accurately evaluated and authorized for project-specific consultations that fall under this over-arching consultation (i.e., stepwise consultations), and the cumulative take for all subsequent consultations will be tracked and tiered to these consultations.

In 2014, NMFS Alaska Region conducted three internal consultations with NMFS Permits Division on the issuance of IHAs to take marine mammals incidental to 3D ocean bottom sensor seismic and shallow geohazard surveys in Prudhoe Bay, Foggy Island Bay, and the Colville River Delta, in the Beaufort Sea, Alaska, during the 2014 open-water season (NMFS 2014a; NMFS 2014b; NMFS 2014c). These project-specific consultations were either directly or indirectly linked to the Arctic regional biological opinion. The incidental take statements issued with the three biological opinions allowed for take (by harassment) of 138 bowhead whales, and estimates take of 744 bearded seals and 427 ringed seals, as a result of exposure to impulsive sounds at received levels at or above 160 dB re 1 μParms.

NMFS completed an incremental step consultation with BOEM and BSEE in 2015 on the effects of oil and gas exploration activities for lease sale 193 in the Chukchi Sea, Alaska, over a nine-year period, from June 2015 to June 2024 (AKR-2015-9422) (NMFS 2015a) (Table 6).The incidental take statement issued with the biological opinion allows for takes (by harassment) from sounds associated with seismic, geohazard, and geotechnical surveys, and exploratory drilling of 8,434 bowhead whales, 133 fin whales, 133 humpback whales, while also estimating take of 1,045,985 ringed seals, and 832,013 bearded seals.

Subsequently in 2015, NMFS Alaska Region consulted with the NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to Shell's exploration drilling activities in the Chukchi Sea, Alaska (AKR-2015-9449) (NMFS 2015b). The incidental take statement issued with the biological opinion allowed for takes (by harassment) of 1,038 bowhead whales, 14 fin whales, 14 humpback whales, while estimating take of 1,722 bearded seals, and 25,217 ringed seals as a result of exposure to continuous and impulsive sounds at received levels at or above 120 dB re 1 μParms and 160 dB re 1 μParms, respectively.

Table 6. 2015 consultations and exposure numbers in the Chukchi Sea and Beaufort Sea related to oil and gas production.

Consultation Number	Topic	Project proponent	Bowhead whales	Fin whales	Humpback whales	Ringed seals	Bearded seals
AKR-2015-9422	Lease sale 193	BLM	8,434	133	133	1,045,985	832,013
AKR-2015-9449	Drilling activities	Shell	1,038	14	14	1,722	25,217
AKR-2015-9448	Aviation activities	Shell	-	-	-	793	11
AKR-2015-9454	Shallow geohazard survey	Hilcorp	12	-	-	350	100
AKR-2015-9451	3-D seismic survey	SAE	9	-	-	443	22

In 2015, NMFS Alaska Region conducted an internal consultation with NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to ice overflight and ice survey activities conducted by Shell Gulf of Mexico and Shell Offshore Inc., from May, 2015, to April, 2016, (AKR-2015-9448) (NMFS 2015c). The biological opinion estimated take (by harassment) of 793 ringed seals and 11 bearded seals as a result of exposure to visual and acoustic stimuli from aircraft. An IHA was issued for Hilcorp's proposed shallow geohazard survey in the Beaufort Sea[12] (AKR-2015-9454) that authorized harassment of 12 bowhead whales, 100 bearded seals, and 350 ringed seals (80 FR 27901). Lastly, NMFS Alaska Region developed a biological opinion[13] (AKR-2015-9451) in response to the issuance of an MMPA IHA authorizing take of 9 bowhead whales, and estimating take of 443 ringed seals, and 22 bearded seals for SAExploration's 3-D seismic survey (80 FR 20084).

There were no consultations for oil and gas activities completed with the NMFS Permits Division in 2016 and 2017.

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

[12] https://www.fisheries.noaa.gov/resource/document/biological-opinion-proposed-issuance-incidental-harassment-authorization-hilcorp
[13] https://www.fisheries.noaa.gov/resource/document/biological-opinion-issuance-incidental-harassment-authorization-saexploration-0

Development and Production Activities (NMFS 2019a). 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, and for bearded seals, 130 by Level B harassment due to noise and physical presence and 4 by Level A harassment The biological opinion also authorized the following take for bowhead whales: 120 by Level B harassment and 4 by Level A harassment.

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.

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 used a towed 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.

Several of the section 7 consultations discussed in the previous subsection on oil and gas exploration (5.5.2) include estimates of take (by harassment) of marine mammals from noise produced through seismic activity.

5.5.4. Aircraft Noise

The sound and visual presence of aircraft can result in behavioral changes in whales 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)).

Region	Average harvest (including struck and lost)
North Slope Borough	1,146
Maniilaq	493
Kawerak	2,287

Region	Average harvest (including struck and lost)
Association of Village Council Presidents	2,484
Bristol Bay Native Association	44
Statewide total	6,454

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, 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 from 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 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, and 2020 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). 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 Ice Exercise 2020 north of Prudhoe Bay, Alaska from February 2020 through January 2021.

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

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

An IHA was issued to the Alaska Gasline Development Corporation to harass marine mammals during pile driving associated with the Alaska LNG project in Prudhoe Bay from July 2022 through June 2023. Estimates of Level A takes of ESA-listed animals associated with this project include 32 ringed seals and 5 spotted seals. Estimates of Level B takes of ESA-listed animals associated with this project include 110 bowhead whales, 1,765 ringed seals, and 300 bearded seals. This project has not been initiated.

5.9. Scientific Research

Research is a necessary endeavor to assist in the recovery of threatened and endangered species; however, research activities can also disturb these 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 Opinion is valid.

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

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. 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.

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.

6. Effects of the Action

"Effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR § 402.02).

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 research vessels transiting to and from the project area, the deployment of 4 moored acoustic sources, and ice breaking. Effects of the moored acoustic sources were analyzed in AKRO-2021-01926 and the effects of the vessel transit through open water were discussed in section 4.1. Consequently, in this section we only consider the effects of ice breaking on ringed seals. Icebreaking will create the following stressors:

- Sound fields created by the vessel (engine noise, propeller noise, and ice cracking)
- Physical destruction of ice habitat

6.1.1. Minor Stressor on ESA-Listed Species

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 in July, we have no information that indicates the passage of an ice breaker through the ice would decrease the value or function of the ice chunks during the summer activity. If an icebreaker is needed, ice is available for the seals to haul out. Because the icebreaker will be operating in July, pups will be weaned and independent. Consequently, issues with moms and pups being separated by icebreaker passage 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 at being in the water and on ice.

The CGC Healy travels at 3 knots or less when icebreaking, greatly reducing the likelihood of vessel strike. We expect any seals near the path of the ship will leave the area if disturbed and would easily evade the ship once they are in the water. It is possible the ship could destroy breathing holes created by the ringed seals. However, the breaking of ice 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 decline in health or fitness.

As previously mentioned, critical habitat was excluded from the deep waters of the Beaufort Sea where the icebreaking is most likely to occur. Therefore, there will be no effect of the project on critical habitat.

6.1.2. Major Stressor on ESA-Listed Species

The following sections analyze the stressors likely to adversely affect the ringed seal due to underwater noise created by the icebreaker. First we provide a brief explanation of the sound measurements and acoustic thresholds used in the discussions of acoustic effects in this opinion.

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[14], expressed in rms[15] from broadband sounds that cause 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 each hearing group is in Table 8

Table 8. Underwater marine mammal hearing groups (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 9, 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[16] associated with NMFS Technical Guidance, or through modeling.

[14] 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.
[15] Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.
[16] The Optional User Spreadsheet can be downloaded from the following website: http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm

Table 9. PTS Onset Acoustic Thresholds (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)):

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

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 Level A or Level B disturbance sound thresholds described below, which must be authorized by the ITS (Section 10 of this opinion) (except that take is not prohibited for threatened species that do not have ESA section 4(d) regulations).

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.

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 (2022 is year 4). The take presented in this biological opinion uses the results from new modeling of the icebreaking that employs changes in the length of time of expected icebreaking and a new density estimate for ringed seals.

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 icebreaking. Inputs to the quantitative analysis included ringed seal density estimate obtained from the Navy Marine Species Density Database, marine mammal depth occurrence distributions, oceanographic and environmental data, ringed seal 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.

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 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.

As discussed above, within NAEMO, animats do not move horizontally or react in any way to avoid sound. Therefore, the current model overestimates non-impulsive acoustic impacts, such as icebreaking, especially physiological impacts near the sound source.

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 on habitat-based modeling by Kaschner et al. (2006) and Kaschner (2004). Table 10 shows the exposures expected for the ringed seal based on NAEMO modeled results. When modeling the takes caused by ice breaking, the Navy assumed there would be one hour of icebreaking and three hours off for a total of six hours of icebreaking per day to represent a typical icebreaking event. Icebreaking could last up to eight days.

Table 10. Quantitative Modeling Results of Potential Exposures

Species	Density Estimate within Study Area (animals per square km)[1]	Level B Harassment (behavioral)	Level B Harassment (TTS)
Ringed Seal	0.3958	538	1
[1] Kaschner (2004); Kaschner et al. (2006)			

Icebreaking takes were modeled using information provided by Roth et al. (2013a), which is specific to the CGC Healy. (Roth et al. 2013a) depicts the source spectrum level versus frequency for 8/10 (heavy ice) and 3/10 (light cover) ice cover, respectively. The sound signature of each of the ice coverage levels was broken into 1-octave bins. In the model, each bin was included as a separate source on the modeled vessel. When these independent sources go active concurrently, they simulate the sound signature of CGC Healy. The modeled source level summed across these bins was 196.2 dB for the 8/10 signature and 189.3 dB for the 3/10 ice signature. These source levels are a good approximation of the icebreaker's observed source level. Each frequency and source level was modeled as an independent source, and applied simultaneously to all of the animats within NAEMO. Each second was summed across frequency to estimate sound pressure level (root mean square). This value was incorporated into the behavioral risk function to estimate behavioral exposures. For PTS and TTS determinations, sound exposure levels were summed over the duration of the test and the transit to the areas with moored sources.

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. 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).

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.

Icebreaking, should it be needed would occur in mid- July. Most ringed seals will likely have completed their annual molt at that time. 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. It is not known if these animals were still molting. If ringed seals are basking on the ice, we expect that if the icebreaker came near, 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 approaches them, so a startle response is not expected. If they dive into the water they would be exposed temporarily to the underwater noise of icebreaking. We expect most seals will 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 seal vocalizations will be occurring much less often than at other times of the year (MacIntyre et al. 2013; Jones et al. 2014; Stafford et al. 2022).

Data on how close seals allow icebreakers to approach are limited, but ringed and bearded seals on pack ice typically dove into the water within 0.93 km (0.58 mi) of the vessel (Brueggeman et al. 1992) and remained on the ice when the icebreaker was 1-2 km away (Kanik et al. 1987).

Behavioral reactions are expected to be short term, as icebreaking would occur in small isolated areas and would be transient in nature, limiting any potential exposure. Behavioral reactions could include swimming away, hauling out, diving underwater or avoidance behavior. These short-term reactions are not expected to significantly disrupt behavioral patterns such as migration, breathing, nursing, breeding, feeding and sheltering to a point where the behavior pattern is abandoned or significantly altered.

Seals that are underwater during icebreaking activities may alter their behavior (e.g., use a different breathing hole, alter vocalizations, cease foraging, move away from the icebreaking), but this is likely to be temporary, and not cause significant disruption. Icebreaking noise may also temporarily disturb or mask hearing and communication of seals. However we expect most pinnipeds will transit through or around the area where vessels are in transit and/or icebreaking is occurring, rather than remaining in the area and possibly experiencing TTS, and that any masking during this time will be brief. Individuals may remain in the area if they are highly motivated to stay due to the presence of a food source. However, it is unlikely that ringed seal prey resources are concentrated in the deep waters of the Beaufort Sea.

Ringed seals are anticipated to occur in the action area and are anticipated to overlap with noise associated with icebreaking. We assume that some individuals are likely to be exposed and respond to these continuous noise sources. 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 (away from favored ringed seal habitat), and its timing (occurring outside of the main molting and breeding periods when bearded and ringed seals are most likely to be hauled out on the ice and/or inside subnivean lairs), adverse effects from icebreaking to seals hauled out on ice habitat will be minimized. 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). Both ringed and bearded 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, 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 occur in July, 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. 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

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) 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.

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

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 habituate 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, were shown to change 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 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 icebreaking 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 TTS are expected to be accompanied by physiological stress responses (NRC 2003, NMFS 2006).

We expect that project activities from the proposed action may result in ringed seals temporarily exhibiting behavioral responses from project activities. 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 expect bans on commercial sealing will remain in place. We also expect that with commercial and private vessels operating in the Bering, Chukchi, and Beaufort Seas, the risk of non-permitted oil and pollutant discharges remains.

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 anticipated 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). 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 as a whole 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 the existing regulations apply over the life of the ONR's Arctic Research Activities from October 2021 to October 2022. 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 the required mitigation measures and 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 whale, fin whale, blue whale, sei whale, North Pacific right whale, Western North Pacific DPS gray whales, sperm whale, Western North Pacific DPS humpback whale, Mexico DPS humpback whale, Beringia DPS bearded seal, Steller sea lion and would not adversely affect critical habitat for North Pacific right whale, Western North Pacific DPS and Mexico DPS of humpback whale, ringed seal, bearded seal and Steller sea lion. 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 current vessel strike over the majority of 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 will be exposed to icebreaking noise. Exposure to noise from icebreaking may result in Level B harassment (and therefore takes) due to project sounds (Table 11).

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). The icebreaking will occur in July when ringed seal adults are toward the end of their annual molt and spend their time foraging and basking. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to significantly impact 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 an approach by an icebreaking vessel is not likely to reduce its fitness or current or expected future reproductive success or reduce the rates at which it will 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 icebreaking will happen ringed seals will not be breeding or pupping, reducing potential effects. While individual ringed seals may be impacted by behavioral responses to the vessel, 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. All of the exposures are expected to constitute Level B takes in the form of acoustic harassment. Table 11 shows the number of takes based on the exposure analysis associated with icebreaking.

Table 11. Exposures of Ringed Seals from Icebreaking

Species	**Density Estimate within Study Area (animals per square km)[1]**	**Level B Harassment (behavioral)**	**Level B Harassment (TTS)**
Ringed Seal	0.3958	538	1
[1] Kaschner (2004); Kaschner et al. (2006)			

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.

No restriction in the distribution of Arctic subspecies of ringed seals from the Arctic Ocean is expected because of icebreaking needed to carry out ONR's Arctic Research Activities. As mentioned in the Background section (section 1.1), NMFS Permits and Conservation Division decided that issuance of a new IHA for this activity was not needed, therefore this consultation is not related to any action on their part.

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 number of ringed seals taken in 2015 was estimated to be 6,454 (Table 7)but is likely highly variable from year to year. This level of harvest was found to be sustainable (Nelson et al. 2019). 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.

Due to insufficient data, population trends for the Arctic subspecies of ringed seal cannot be calculated. It is unknown if the population is stable or fluctuating. However, the Arctic subspecies of ringed seal has an apparently large population, making it resilient to immediate perturbations. The primary threat they face is climate change and the changes it is expected to have on sea ice, snow cover, and prey resources in the future. In the long-term, the species may become endangered.

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 538 ringed seals will be harassed, and one may have a TTS from the proposed research activities. Because we do not anticipate a reduction in numbers or reproduction of Arctic subspecies of ringed seals as a result of the proposed research activities 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 actions, we do not anticipate the proposed icebreaking needed to carry out the Arctic Research Activities 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 the icebreaking needed to carry out ONR's proposed Arctic Research Activities in the Beaufort Sea is not likely to jeopardize the continued existence of the Arctic ringed seal.

In addition, the proposed action is not likely to adversely affect 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, and 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, 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. In this particular instance the MMPA authorization has been issued (86 FR 54931).

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. 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 anticipates the proposed ONR project in the Beaufort Sea, Alaska, scheduled to occur during July 2022, is likely to result in the incidental take of ringed seals by harassment. ONR estimated take by considering: 1) acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; 2) the range to which behavioral effects were anticipated to reach; and 3) the density or occurrence of marine mammals within these ensonified areas. NMFS 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, one Arctic ringed seal by causing TTS and 538 Arctic ringed seals through behavioral harassment.

Harassment of these individuals will occur by exposure to sound created by icebreaking.

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 must reinitiate consultation. Likewise, if the action deviates from what is described in Section 2 of this biological opinion, ONR 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 all authorized and unauthorized take, 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 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 will submit AIS data for the cruise.

1.2 To verify compliance with marine mammal avoidance when the vessel is in transit, a complete and accurate log must be kept which includes:

- 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 i.-vi, above.

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, the monitoring log will contain all behavioral reactions that marine mammals have to vessel passage, icebreaking, and device deployment. The monitoring log will be submitted 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 authorized and unauthorized take), the following must occur:

3.1 To monitor and report all authorized and unauthorized take (e.g. vessel strike), ONR must report the taking of any marine mammal in a manner other than that authorized in this ITS within 48 hours to NMFS AKR, Protected Resources Division 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).

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 2022-00873). 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. NMFS encourages ONR to add passive acoustic monitors to their existing equipment when possible or to deploy passive acoustic monitors in the Beaufort Sea as part of their mission so that we can get a better understanding of the marine mammal presence in the area.
3. We suggest that ONR utilize standardized monitoring forms to record the pertinent information for marine mammal observations.
4. 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.

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.

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, B. M., and R. P. Angliss. 2015. Alaska marine mammal stock assessments, 2014. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, June 2015. NOAA Technical Memorandum NMFS-AFSC-301, 304 p.

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.

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.

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. 2012. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017. Final Programmatic Environmental Impact Statement. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS EIS/EA BOEM 2012-030, 2,057 p.

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.

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.

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., J. T. Clarke, and M. C. Ferguson. 2018. Increased sightings of subArctic cetaceans in the eastern Chukchi Sea, 2008–2016: population recovery, response to climate change, or increased survey effort? Polar Biology 41(5):1033-1039.

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.

Brueggeman, J., R. Grotefendt, M. Smultea, G. Green, R. Rowlett, C. Swanson, D. Volsen, C. Bowlby, C. Malme, and R. Mlawski. 1992. Final Report, Chukchi Sea 1991, Marine Mammal Monitoring Program (Walrus and Polar Bear) Crackerjack and Diamond Prospects. Anchorage, AK: Shell Western E&P Inc. and Chevron USA. Inc.

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., 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.

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.

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.

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., K. Stafford, S. E. Moore, B. Rone, L. Aerts, and J. Crance. 2013. Subarctic cetaceans in the southern Chukchi Sea: Evidence of recovery or response to a changing ecosystem. Oceanography 26(4):136-149.

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.
Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. E. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U. S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, Seattle, WA, January 2020. NOAA Tech. Memo. NMFS-AFSC-401, 86 p.
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.
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.

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.

Ferdinando, P. M. 2019. Assessment of heavy metals in subsistence-harvested Alaskan marine mammal body tissues and vibrissae. Master's thesis. Nova Southeastern University, Fort Lauderdale, FL, 144 p.

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

Finneran, J. J., 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.

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.

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., 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.

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., M. L. Druckenmiller, K. L. Laidre, R. Suydam, and B. Person. 2015. Bowhead whale body condition and links to summer sea ice and upwelling in the Beaufort Sea. Progress in Oceanogprahy 136:250-262.

George, J. C., C. Nicolson, S. Drobot, J. Maslanik, and R. Suydam. 2006. Sea ice density and bowhead whale body condition preliminary findings [Poster] Society for Marine Mammalogy, San Diego, CA.

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.

Geraci, J. R., and T. Smith. 1976. 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 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.

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.

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., 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.

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. 2021. 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.

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.

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., 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.

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.

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.

Kanik, B., R. W. Tanasichuk, and M. Winsby. 1987. Observations of Marine Mammal and Sea Bird Interaction with Icebreaking Activities in the High Arctic, July 2-12, 1980. Pallister Resource Management Limited.

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.

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.

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.

Lee, J. S., S. Tanabe, H. Umino, R. Tatsukawa, T. R. Loughlin, and D. C. Calkins. 1996. Persistent organochlorines in Steller sea lion (*Eumetopias jubatusi*) from the bulk of Alaska and the Bering Sea, 1976-1981. Marine Pollution Bulletin 32(7):535-544.

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.

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.

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).

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.

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.

Meier, W. N., D. Perovich, S. Farrell, C. Haas, S. Hendricks, A. A. Petty, M. Webster, D. Divine, S. Gerland, and e. al. 2021. Sea Ice *In* Arctic Report Card 2021, T.A. Moon, M.L Druckenmiller, and R.L. Thoman, eds., 32-40.

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

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 H. P. Huntington. 2008. Arctic marine mammals and climate change: impacts and resilience. Ecological Applications 18(sp2).

Moore, S. E., and K. L. Laidre. 2006. Trends in sea ice cover within habitats used by bowhead whales in the western Arctic. Ecological Applications 16(3):932-944.

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.

Mossner, S., and K. Ballschmiter. 1997. Marine mammals as global pollution indicators for organochlorines. Chemosphere 34(5-7):1285-1296.

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, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2018. Alaska marine mammal stock assessments, 2017. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, June 2018. NOAA Technical Memorandum NMFS-AFSC-378, 382 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.

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.

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. 2013a. 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. 2013b. Endangered Species Act Section 7(a)(2) Biological Opinion on Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, Alaska, April 2, 2013. Consultation Number F/AKR/2011/0647.

NMFS. 2014a. Endangered Species Act section 7 consultation biological opinion for the issuance of Incidental Harassment Authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to SAExploration, Inc. (SAE) for marine 3D ocean bottom node seismic activities in the U.S. Beaufort Sea, Colville River Delta, Alaska, during the 2014 open water season. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Alaska Region, Juneau, Alaska, August 8, 2014. NMFS consultation number: AKR-2014-9383.

NMFS. 2014b. Endangered Species Act section 7(a)(2) biological opinion on the issuance of an incidental harassment authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to BP Exploration (Alaska), Inc. (BPXA) for shallow geohazard survey in the U.S. Beaufort Sea, Foggy Island Bay, Alaska, during the 2014 open water season. U. S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Alaska Region, Juneau, AK, June 19, 2014. NMFS consultation number: AKR-2014-9370.

NMFS. 2014c. ESA Sect 7 Biological Opinion on the Issuance of Incidental Harassment Authorization under Section 101(a)(5)(D) of the Marine Mammal Protection Act to BP Exploration (Alaska), Inc. (BPXA) for Marine 3D Ocean Bottom Sensor Seismic Activities in the U.S. Beaufort Sea, Prudhoe Bay, Alaska, during the 2014 Open Water Season. National Marine Fisheries Service, Alaska Regional Office, Juneau, AK, June 10, 2014.

NMFS. 2015a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Section 7(a)(4) Conference Report on Lease Sale 193 Oil and Gas Exploration Activities in the U.S. Chukchi Sea, Alaska. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Juneau, AK, June 4, 2015. NMFS Consultation Number AKR-2015-9422, 342 p.

NMFS. 2015b. Endangered Species Act section 7(a)(2) biological opinion on the issuance of incidental harassment authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell for the non-lethal taking of whales and seals in conjuction with planned exploration drilling activities during 2015 Chukchi Sea, Alaska. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Alaska Region, Juneau, Alaska, June 5, 2015. Consultation Number AKR-2015-9449.

NMFS. 2015c. Endangered Species Act section 7(a)(2) consultation biological opinion and section 7(a)(4) conference opinion on the issuance of incidental harassment authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell Gulf of Mexico and Shell Offshore Inc. (Shell) for aviation operations associated with ice condition monitoring over the Beaufort and Chukchi Seas from May 2015 through April 2016. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, May 20, 2015. NMFS consultation number: AKR-2015-9448.

NMFS. 2016a. Effects of oil and gas activities in the Arctic Ocean: Final Environmental Impact Statement. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, October 2016.

NMFS. 2016b. Endangered Species Act Section 7(a)(2) Biological Opinion Quintillion Subsea Operations, LLC, Proposed Subsea Fiber Optic Cable-laying Activities and Associated Proposed Issuance of an Incidental Harassment Authorization in the Bering, Chukchi, and Beaufort Seas, Alaska. 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. 2019a. 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. 2019b. Endangered Species Act (ESA) Section 7(a)(2) programmatic biological opinion for the Arctic National Wildlife Refuge Coastal Plain Lease Sale. U.S. Dept. of Commerce, NOAA, NMFS, Alaska Regional Office, Juneau, AK, February 6, 2019. NMFS Consultation Number AKRO:2019-00141, 141 p.

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.

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.

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.

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.

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, J. C. George, M. P. Heide-Jørgensen, R. Small, H. Brower, L. Harwood, B. Adams, L. Brower, and G. Tagarook. 2012. Seasonal movements of the Bering-Chukchi-Beaufort stock of bowhead whales: 2006–2011 satellite telemetry results. Report to the International Whaling Commission Scientific Committee SC/64/BRG1.

Reeves, R., C. Rosa, J. C. George, G. Sheffield, and M. Moore. 2012. Implications of Arctic industrial growth and strategies to mitigate future vessel and fishing gear impacts on bowhead whales. Marine Policy 36(2):454-462.

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.

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.

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., K. E. Hunt, S. D. Kraus, and S. K. Wasser. 2005. Assessing reproductive status of right whales (*Eubalaena glacialis*) using fecal hormone metabolites. Gen Comp Endocrinol 142(3):308-17.

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. 2013a. 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.

Roth, E. H., V. Schmidt, J. A. Hildebrand, and S. M. Wiggins. 2013b. Underwater radiated noise levels of a research icebreaker in the central Arctic Ocean. The Journal of the Acoustical Society of America 133(4):1971-1980.

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.

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.

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.

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.

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., 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.

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., 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.

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. 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.

Sternfeld, M. 2004. Ice Seals in the National Marine Fisheries Service Alaska Region (NMFS AKR) Stranding Records: 1982-2004. USDOC, NOAA, NMFS Alaska Region, Juneau, Alaska, December 13, 2004, 3 p.

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.

Suydam, R., J. C. George, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. International Whaling Commission, SC/63/BRG02.

Suydam, R., J. C. George, B. Person, D. Ramey, R. Stimmelmayr, T. Sformo, L. Pierce, and G. Sheffield. 2016. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2015 and other aspects of bowhead biology and science. International Whaling Commission, SC/66b/BRG03.

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.

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.

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. 2011. Marine Protected Species Program for the GOA, Bering Sea/Aleutian Islands, and Arctic, Junea, Alaska, 95.

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

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.

Walsh, J. E. 2008. Climate of the Arctic marine environment. Ecological Applications 18(2 Supplement):S3-S22.

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.

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.