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

NMFS Consultation Number: AKRO-2021-03483

Action Agencies: Office of Protected Resources, Permits and Conservation Division

Affected Species and Determinations:

ESA-Listed Species and Distinct Population Segments (DPS) or Evolutionarily Significant Units (ESU)	Status	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Bowhead whale (*Balaena mysticetus*)	Endangered	No	N/A	No	N/A
Fin whale (*Balaenoptera physalus*)	Endangered	No	N/A	No	N/A
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
Humpback whale, Western North Pacific DPS (*Megaptera novaeangliae*)	Endangered	No	No	No	No
Humpback whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	No	No	No	No
Steller sea lion, Western DPS (*Eumetopias jubatus*)	Endangered	No	No	No	No
Ringed seal, Arctic subspecies (*Phoca hispida hispida*)	Threatened	Yes	No	No	No
Bearded seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	Yes	No	No	No

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

Issued By:

Jonathan M. Kurland
Administrator, Alaska Region

Date: September 7, 2022

Accessibility of this Document

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Table of Contents

List of Tables

List of Figures

Terms and Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
AIS	Automatic Identification System
AKR	(NMFS) Alaska Region
ASAMM	Aerial Surveys of Arctic Marine Mammals
BA	Biological Assessment
BSAI	Bering Sea/Aleutian Islands
CFR	Code of Federal Regulations
CO_2	Carbon dioxide
CTD	Conductivity, temperature, density
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
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
NMIN	Minimum population estimate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OPR	Office of Protected Resources, Permits, and Conservation Division
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
SD	Standard deviation
SEL	Sound exposure level
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.

The action agency for this consultation is the NMFS Office of Protected Resources, Permits, and Conservation Division (OPR or Permits Division). OPR proposes to issue a scientific research permit (Permit No. 26254) pursuant to Section 104 of the Marine Mammal Protection Act of 1972 (MMPA), as amended (16 U.S.C. 1361 et seq.), and Section 10(a)(1)(A) of the ESA to the Alaska Department of Fish and Game (i.e., the researchers; ADFG). The permit would authorize scientific research on two seals listed as threatened under the ESA, the Beringia Distinct Population Segment (DPS) of bearded seals (*Erignathus barbatus*) and the Arctic subspecies of the ringed seal (*Phoca hispida hispida*). Permitted research activities could occur throughout the North Pacific Ocean (including the Bering Sea), Arctic Ocean (including the Chukchi and Beaufort seas), and all coastal and offshore regions of Alaska. However, it is anticipated that the majority of activities will occur nearshore. When issued the permit will be valid August 15, 2022 to August 14, 2027. The consulting agency for this proposal is NMFS's Alaska Region. This document 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.

This consultation, biological opinion, and incidental take statement were completed in accordance with section 7(b) of the statute (16 U.S.C. 1536 (b)), associated implementing regulations (50 C.F.R. part 402), and agency policy and guidance.

The opinion and ITS are in compliance with the Data Quality Act (44 U.S.C. §3504(d)(1) *et seq*.) and underwent pre-dissemination review.

1.1 Background

This opinion is based on information provided in the permit application (ADFG 2022), the biological assessment provided by OPR, the biological opinion for the prior Permit No. 20466 (FPR-2017-9197), and the biological opinion for a similar permit to NOAA's Marine Mammal Laboratory (OPR-2020-02318 for permit No. 23858). Other sources of information include emails, recent biological opinions completed in the Arctic, annual monitoring and incident reports submitted by ADFG, stock assessment reports, relevant peer reviewed literature, and Arctic marine mammal surveys. A complete record of the consultation is on file at NMFS's Anchorage, Alaska office.

The ice seal research activities that are the subject of this consultation are part of an on-going research program by ADFG begun in 2000. The purpose of the research is to monitor the behavior, health, and movements of four species of seals: ringed, bearded, spotted, and ribbon seals in the Bering, Chukchi, and Beaufort seas relative to changes in the environment and industrial activities in order to identify and evaluate potential conservation issues. Prior permits (numbers 20466, 15324, and 358-1787) and consultations have been issued for five-year periods for the same activities. These consultations resulted in biological opinions that concluded that the proposed action was not likely to jeopardize the continued existence of ringed seals and bearded seals; may affect but was not likely to adversely affect listed whales and Steller sea lions; and may affect but was not likely to adversely affect designated critical habitat for North Pacific right whales and Steller sea lions. Critical habitat was not designated for ringed or bearded seals when consultations were completed for the prior research activities.

Subsistence harvest is the legal hunting of seals by the indigenous peoples of Alaska for food, materials, and cultural practices. Upon issuance of the Permit, the researchers will continue to receive samples (e.g. whiskers, toenails, hair) from subsistence harvested seals opportunistically. Annually, ADFG will capture, sample, and track live seals as part of their biosampling and tagging activities from March until November, over the permit lifetime.

The Permits Division proposes to authorize the directed take of ringed seals and bearded seals to fulfill ADFG's scientific research objective. The proposed activities are explained in detail below. These actions have the potential to affect the endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered North Pacific right whale (*Eubalaena japonica*), endangered Western North Pacific distinct population segment (DPS) humpback whale (*Megaptera novaeangliae*), threatened Mexico DPS humpback whale (*Megaptera novaeangliae*), endangered Western North Pacific DPS gray whale (*Eschrichtius robustus*), endangered Western DPS Steller sea lion (*Eumetopias jubatus*), Arctic subspecies of ringed seal (*Phoca hispida hispida*), and threatened Beringia DPS bearded seal (*Erignathus barbatus nauticus*), and critical habitat for ringed and bearded seals. The proposed activities will have no effect on critical habitat for Steller sea lions, Western North Pacific or Mexico DPS humpback whales, or North Pacific right whales.

1.2 Consultation History

- January 25, 2022. Request for initiation of consultation and biological assessment received.
- January 28, 2022. Files from the Endangered Species Act Interagency Cooperation Division, who did the prior consultations, were sent to AKR.

- February 14, 2022. Notice of the application published in the Federal Register
- February 25, 2022. Teleconference with Permits Division to go over details of the permit.
- April 25, 2022. Revised permit application submitted.
- May 2, 2022. Consultation initiated
- May – July 2022. Email and phone communication and clarification of permit details with OPR.

On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019 regulations adopting changes to 50 CFR part 402 (84 FR 44976, August 27, 2019). This consultation was initiated when the 2019 regulations were still in effect. As reflected in this document, we are now applying the section 7 regulations that governed prior to adoption of the 2019 regulations (https://www.govinfo.gov/content/pkg/CFR-2018-title50-vol11/pdf/CFR-2018-title50-vol11-part402.pdf). For purposes of this consultation, we considered whether the substantive analysis and its conclusions regarding the effects of the proposed actions articulated in the biological opinion and incidental take statement would be any different under the 2019 regulations. We have determined that our analysis and conclusions would not be any different.

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 Permits Division proposes the issuance of a scientific research permit to ADFG, pursuant to the provisions of the MMPA, as amended (16 U.S.C. 1361 et seq.), and the regulations governing the taking and importing of marine mammals (50 CFR Part 216). Permit No. 20466 expires on August 15, 2022 and Permit No. 26254 (the subject of this consultation) would replace it and expire August 14, 2027.

As stated in the background, the objective of the research is to monitor the behavior, movement, and health of the populations of four species of ice seals (bearded, ringed, ribbon, and spotted) relative to changes in the environment and industrial disturbances in order to identify and evaluate potential conservation issues. Samples from animals killed during subsistence harvest will be collected. Upon issuance of the Permit, the researchers will receive samples from subsistence harvested seals opportunistically throughout the year and store them or send them to other researchers and labs for analysis.

The Permits Division proposes to authorize the directed take of ringed and bearded seals (Table 9) to fulfill ADFG’s scientific research objective. Although the proposed scientific research permit would be valid for five years through August 2027, the proposed ice seal research activities that are the subject of this consultation are part of an on-going research program ADFG has conducted since 2000. We expect that the ice seal research activities described in this opinion will continue into the reasonably foreseeable future.

The proposed activities are explained in detail below.

2.1 Proposed Activities

2.1.1.1 Import, Export, Receive Parts

The Permits Division proposes the authorization of the import/export and receipt of biological samples (or parts) to assess the health, condition, contaminant load, and diet of ice seals. The researchers will receive samples from the subsistence harvest by the indigenous people of Alaska with whom ADFG regularly interact (e.g. Point Hope, Shishmaref, Gambell, and Hooper Bay). Samples may also be received through the North Slope Borough from Utqiaġvik and Wainwright for coverage of the Bering, Chukchi, and Beaufort seas. Samples may also be imported from Russia, Canada, and Norway from legally taken seals (from subsistence harvest or research). Samples (non-hazardous tissues) will be shipped frozen and analyzed for genetics, isotopes, fatty acids, contaminants, and body condition. Any sample not destroyed in analyses will be archived. Standard laboratory safety protocols will be followed. No live animals will be imported or exported.

Samples may be exported to laboratories outside the U.S. for analysis. Samples provided to researchers will include:

- Tissues (skin and other organs)
- Stomach/stomach contents
- Blubber
- Muscle
- Female reproductive tracts
- Hair and toe nails
- Urine and fecal material
- Teeth

2.1.1.2 Surveys

We note that surveys occur if funding is available. No aerial or vessel-based surveys occurred in the last five years. Although these surveys could occur, they are not scheduled on a regular basis.

Manned aerial surveys will be conducted from a fixed wing aircraft flying at an altitude of 200 m or more. Surveys will be flown at the highest possible altitude while still allowing for accurate data collection. During surveys, the plane will circle within visual contact, but not directly over a group of seals, for up to 15 minutes in order to count and photograph all seals present. In addition, surveys will not be flown over whales and if one is spotted the course will be altered to avoid flying over it.

Unmanned aircraft systems (UAS or drones) may be used to fly over localized areas (sea ice or land haul outs) to assess seasonal distributions and abundance. Additionally, UAS may be used to survey the density of breathing holes and ringed seal lair entrance holes on the sea ice after snow melt. The UAS will never be out of sight of the pilot, the aircraft will have an auto return feature, and a max speed of 40 mph. The ground control station will be set up on boats, land, or the sea ice far enough from the seals to not cause disturbance. If the control station is on a boat, the boat will maintain a minimum distance of 50 yards from the seal to minimize disturbance. The ground control operator will monitor the seals through a live video feed. Altitude will depend on various factors including weather (e.g., fog and wind), sensor capabilities, FAA regulations, and purpose of the flight, however typical altitude would be 50–125 ft with a minimum altitude of 30 ft when taking photos. Only one UAS would be operated at a time. Pilots will be FAA licensed and authorized to operate UASs in Alaska and have at least 10 hours of flight time on the UAS in use.

Vessel-based surveys will be designed to monitor changes in local seal distribution or abundance with changing ice conditions. Surveys will be conducted from vessels ranging from small local boats to large commercial vessels. Transects will be designed to systematically cover the study area. When seals are present, the survey boat will follow the pre-determined transect slowly to minimize the wake, counting and observing seals within 200-500 m depending on visibility. Researchers will operate vessels at slow speeds (under 10 knots) with 100 percent observer coverage to look for ice seals. Seals hauled out will only be approached at a distance close enough to observe and record them, typically 100 m.

2.1.1.3 Remote instrument deployment

Wildlife-detection dogs may be used to locate ringed seal lairs and breathing holes in the sea ice February–May and to determine winter density of ringed seals in areas used for oil and gas production. They have been used for research purposes in Canada (e.g., Smith and Stirling 1975), Svalbard (e.g., Lydersen and Gjertz 1984), and Alaska (e.g., Kelly and Quakenbush 1990, Kelly et al. 2010a). Traditionally, subsistence hunters used dogs and dog teams to access breathing holes and lairs for hunting (Nelson 1969) and many now use snow machines. The dogs that may be used in this study will not come in physical contact with the seals and will be vaccinated for rabies, distemper, and parvovirus. Rabies and distemper can transfer from dogs to seals. These diseases are already present in the wild red and arctic fox populations and many dogs (often loose and free running) in coastal communities are not vaccinated.

One or two trained dogs, followed by a snow machine, will run on the sea ice along a course that quarters into the wind. When the dog catches the airborne scent of a seal structure (i.e., from a breathing hole or lair) it follows the scent to the structure (note that a seal does not need to be present for the structure to be detected by a dog). The dog stops and sniffs in the snow over the structure. The handler rewards the dog, and the dog is placed in a kennel, on a sled, to rest until it is needed to resume searching. If a seal is in the lair upon approach it is alerted by the sound of the snow machine and thus leaves the lair prior to the arrival of the dog. In many cases, the lair will be empty when the dog first scents the structure, and no seal is disturbed. No contact between dogs and seals is expected to occur.

Once located, ringed seal lairs will be instrumented with temperature sensors and cameras. These instruments require a small hole be made in the top of the lair, into which the instruments are placed. The lair structure is not compromised. The instruments will be covered with snow so that the lair is returned to its original condition and the instruments are not visible. The GPS location of the seal structure location will be recorded so that the lairs can be re-located without the dogs. The sensors are small and are not expected to impact ringed seal behavior while in place. The sensors will document ringed seal lair use and when the lairs collapse in spring and are no longer being used. The instruments may be checked up to four times during February–May.

Remote cameras that take photos or videos will also be placed at known land haulouts. Although ice seals typically haulout on sea ice, they will also haulout on barrier islands (Quakenbush 1988), up rivers (Huntington et al. 2016), and on land (Olnes et al. 2020). The cameras will document how often the land haulouts are used, season of use, and general age class of seals using them. Most cameras will be deployed during tagging activities, however, they may also be deployed independent of capture activities.

2.1.1.4 Capture

Seals may be captured in the water, on ice, or on land using various methods. ADFG proposes the capture of up to 100 seals per species per year, or 500 seals of each species over the 5-year permit. Scheduled capture events occur after pups are weaned. Females with dependent pups will not be targeted for capture under this permit nor will dependent young be captured.

Seals in the water will be captured using nets and traps. Nets are set using small boats and seals may be brought to shore, to ice, or processed in a boat. Seals are caught using specially designed "seal" nets. Research nets are not left unattended, and once a net is set it is monitored from a boat, from shore, or from sea ice. Monitoring includes, but is not limited to, watching the float line for movement, listening for splashing, and watching seals approach the net. Observers are never out of visual or audio range of the net. Nets set near lagoon entrances will be pulled immediately if belugas are seen or reported in the area to minimize the chance of capturing a beluga whale. Nets are checked by lifting them out of the water or in clear water by looking down through the water column. When captured, seals will be removed from the nets immediately by bringing the seal and/or net to the boat, shore, or ice. Small seals may be brought into the boat for processing or transporting. The nets are designed with light lead lines and are anchored to the float line so that once a seal is captured it can take the net to the surface to breathe as needed. Lead lines are not anchored.

Specialized nets may be set in ringed seal breathing holes (Figure 1). Seals enter through the bottom of the net and trigger a trip line which causes a lead weight to fall, pursing the bottom of the net together, preventing the seal from exiting the net. The captured seal is able to surface and breathe. Seals are removed from the net by the researcher grasping the pectoral or hind flippers and pulling them out onto the ice. The traps are set with an audio alarm which alerts researchers when a seal has been captured.

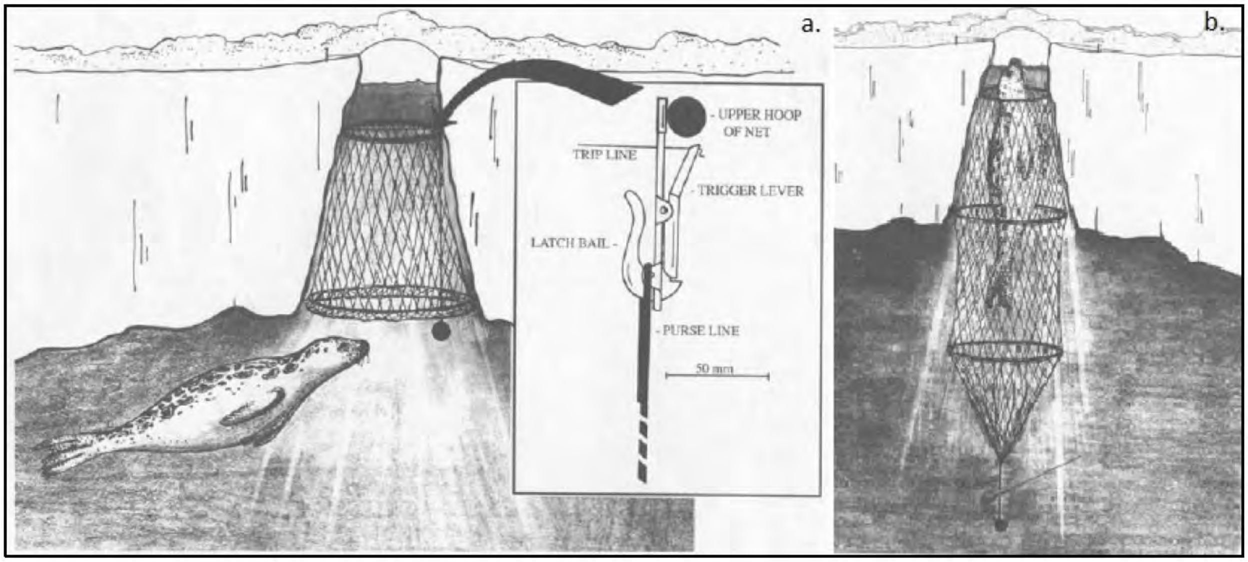

Figure 1. Net for live capturing ringed seals in their breathing holes shown with lower chambers attached to upper prior to seal's entrance with insert showing trigger mechanism (a) and shown fully extended and pursed (b) (from Kelly 1996).

A floating trap may be used for all four species of ice seals (Figure 2). The trap is made with hinged slatted doors and a net-framed box below in the water. When the seal attempts to haul out on the platform it drops through the doors into the net box. The net is held out by a metal frame at the bottom and does not entangle the seal but contains it until the trap is removed from the water. The doors have stops so that they will not open outward once the seal is inside the trap. The seal can surface and breathe (there is approximately 4" of space between the water surface and the slatted trap door; because the door is slatted a seal can breathe through it). The trap is designed to look like a floating piece of sea ice that a seal could haul out on. The presence of a boat nearby decreases the chances that a seal would haul out on these platforms. Therefore, the traps are observed from a distance using a spotting scope or binoculars and the seals are removed from the trap as soon as possible. This method has not been used in the U.S. but has been successful in Russia. The prior permit (Permit No. 20466) allowed the use of this kind of trap but it has not been used because deployment conditions have not been ideal and the other capture methods have been successful.

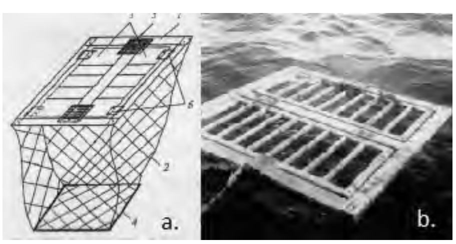

Figure 2. Floating trap for live capture of ice seals used in Russia that may be used in this study. The components of the trap are shown in (a) and an image of the trap in the water in (b) (from ADFG 2017).

Non-lethal deterrents (e.g., rubber bullets, bean bags, or paintballs) may be used to startle seals during capture activities. Non-lethal deterrents are shot in the direction of a seal without hitting it to minimize a seal's surface time causing it to tire. Firing of non-lethal deterrents (e.g. non-toxic paint balls, rubber bullets, bean bags) at a seal, which may be repeated several times, minimizes the time the seal is at the surface and causes it to tire so the boat can approach more closely in order to deploy a net. Non-lethal deterrents may also be used to startle a seal toward a net. The use of non-lethal deterrents is an adaptation of the method used by Native Alaskan seal hunters to get close to seals to harpoon them and prevent them from sinking once shot. Upon capture, seals will be held at the surface and allowed to breathe normally during the tagging and sampling process. No seal will be pursued for more than 30 minutes (approximately 3 – 5 approaches). If a seal is not captured within this 30-minute window, it will be left alone.

Long-handled dip nets can be used to catch smaller ringed and spotted seals upon approach by boat. A seal captured on land would be approached by running up to it and placing a small hoop net or long-handled dip net over it. In some conditions, seals on ice may also be captured by placing a hoop net or long-handled dip net over it similar to land capture techniques. Seals on the sea ice may be captured by blocking the hole with plywood, which can be moved across the hole from a blind, preventing the seal from entering the water. Once the access hole is blocked, a handler can take hold of the seal by the hind flippers and pull it away from the hole.

When a seal is caught in any net or trap, it is removed from the net or trap and placed in a hoop net (a soft mesh net with a rubber outer ring) in the boat for transfer to the beach or to ice. Seals are taken out of the boat and may be moved from the boat to a processing area out of the weather using an ATV with a trailer to hold the seal. The average distance to the processing area is 5 to 100 m and the average time to transport to the processing area is 0 to 5 minutes.

Playbacks of bearded seal vocalizations will be used to attract bearded seals to capture nets. Only bearded seal vocalizations will be used, background noise and calls from other animals will not be included in the recordings. Up to 30 vocalizations will be played within a two-hour period. Each vocalization will last about one minute and will be separated by at least 30 seconds. These vocalization playbacks will be emitted at an amplitude of ≤158 dB re 1 μPa at 1 m or less, this amplitude was used in similar seal playback experiments (Hayes et al. 2004; Charrier et al. 2013). Bearded seals are reported to produce vocalizations between 93 and 178 dB re 1 μPa at 1 m (Charrier et al. 2013), however, studies of their vocalizations do not provide information on source level and these values are estimates based on phocid hearing thresholds (Wartzok and Ketten 1999) and the distances at which bearded seal calls can be heard (Cleator et al. 1989). If the playbacks cause a fleeing response, the device will immediately be turned off.

2.1.1.5 Use and Administration of Drugs

Dart-delivered chemical immobilization may be used to capture bearded seals. To date, efforts to dart large bearded seals have been unsuccessful because they are wary of boats and people and leave ice flows before researchers are close enough to fire. A combination of three drugs (midazolam, butorphanol, and medetomidine) was used successfully to immobilize Steller and California sea lions and a two-drug combination (midazolam and medetomidine) has had mixed results for capturing grey seals. A drug combination will be developed for this research based on the combinations used for other species. All drug combinations and dosages will be coordinated with the ADFG veterinarian in consultation with other veterinarians based on experiments involving drug combinations for phocids in captivity. The seals will be approached following immobilization and a net will be deployed to hold tranquilized seals near the boat. After approach or physical restraint, an intramuscular (IM) dose of midazolam via pole syringe or hand injection or an intravenous (IV) dose of diazepam may be administered if necessary and an additional dose may be administered if the original dose starts to wear off.

Seals may be physically restrained on a stretcher with nylon straps or straddled with front flippers pinned to their sides (Figure 3). Some seals (large bearded or aggressive spotted and ringed seals) may need to be sedated as described above. Seals will be restrained only for the duration of the tag attachments, biopsy and blood draw. Non-sedated seals will be allowed to go directly into the water immediately after tagging and sampling. The total time from the onset of sampling and tagging will vary from 60 to 120 minutes.

Once the seal is physically restrained and blindfolded, components of the chemical restraint may be reversed at the end of the handling procedure using chemical reversal agents. During sampling and tagging (described below), some seals (all species) may need to be sedated with diazepam (IV) or midazolam (IM). If the original dose starts to wear off, seals may be administered an additional dose. If the seal becomes too deeply sedated and is hypoventilating or is otherwise in need of emergency intervention, in addition to the chemical reversal agents, doxapram will be administered by IV or sublingually. If intubated or if the animal can be intubated rapidly, doxapram in saline will be administered intratracheally followed by ventilation with oxygen. Epinephrine in saline can be administered intratracheally as an adjunct to the above emergency-only procedures. The expected duration of sedation will be approximately 40 minutes. After antagonist drugs are administered, the seal will be monitored visually until it is fully alert and reacts normally.

Seals that have been sedated and given a reversal agent will be held until they show signs of full recovery from the effects of the drugs (e.g., are alert at the approach of researchers and respond when gently touched).

2.1.1.6 Tagging and Sampling

All captured seals will have measurements taken, samples collected, and be given a numbered identification tag placed on a hind flipper (up to 100 animals per species per year). Scheduled capture events will take place after pups are weaned. No females with dependent young or dependent young themselves will be captured. All other seals will be sampled and tagged if the seal is deemed healthy.

Permanent tags: The webbing of one of the hind flippers will be cleaned with providone iodine, chlorhexidine scrub, Betadine or a similar disinfectant, wiped with 70 percent isopropyl alcohol and left to dry prior to the attachment of a tag. A hole is made in the flipper with special pliers in order to attach one or two numbered plastic tags (e.g., Jumbo Rototag). The skin plug that comes from the hole in the flipper created to place the tag will be frozen, placed in ethanol, or placed in dimethyl sulfoxide until sent for genetic analysis or archived.

Sampling: *Measurements:* Seals are weighed on stretchers or by bundling them in a tarp or hoop net and hanging them briefly from a spring scale on a bi- or tripod, or from a pole with two people holding the ends of it. With the seal on its belly, measurements taken include curvilinear length from the tip of the nose to the tip of the tail, straight length from the tip of the nose to the tip of the tail, girth behind the front flippers, and maximum girth around the belly. The sex of the animal is also recorded.

Blood Sampling: Regardless of capture method, seals will be physically restrained by people or a hoop net when drawing blood. The needle site will be cleaned with Betadine or similar solution before blood is drawn. Blood is drawn from the extradural intravertebral vein using a disposable sterile needle. No more than three attempts to draw blood will be made per individual. A maximum of 10 milliliters per kilogram (ml/kg) body weight of blood per seal will be collected (e.g., maximum volume of blood collected from a 20 kg seal would be 200 ml) based on the total blood volume of marine mammals and the amount that can be collected on a single occasion from healthy animals (ADFG 2017). Blood samples will be used to determine disease exposure, hormonal status, blood chemistry, and archived for other used. Blood may also be collected on filter paper from the flipper punch site when tagging animals.

Skin biopsy: Skin biopsies will be collected from seals that receive a hind flipper transmitter. Skin scrapings will be taken of skin lesions. Healthy skin samples will be used for genetic analysis and health studies. Between animals skin biopsy equipment will be washed with soap and water, then rinsed, then soaked in 10 percent bleach solution for at least 20 minutes, rinsed and sterilized using autoclave or gas sterilization with ethylene oxide and kept in individual sterile packages.

Hair Samples: A sample of hair from an area measuring approximately 5 cm by 5 cm may be shaved from the dorsal side of the body and collected in a whirlpak bag. Hair will be used for contaminant (e.g., mercury) and isotope (e.g., diet) analyses.

Urine, Fecal, and Swab Sample Collection: Urine and fecal material (free catch) may also be collected opportunistically and frozen for monitoring for the presence of toxic algae. Swabs (oral, nasal, urogenital, and rectal) may be taken to test for bacterial and other health screening factors. Skin lesions may also be swabbed.

Ultrasound: Blubber content may be measured non-invasively by measuring blubber depth at up to twenty sites along the body using a portable ultrasound unit. Readings are taken by placing the transducer upon the skin. This procedure can be performed in approximately 20 minutes.

2.1.1.7 Instrumentation

Up to 100 animals per species per year will be equipped with satellite location/depth transmitters. Captured seals may also be given up to four instruments at any one time (including one flipper-attached instrument and one temporarily attached glue-on instrument). If four instruments are attached, one would be located on the head, one on the flipper, and two on the back. The maximum combined mass of external instruments that could be deployed at the same time on an animal would not exceed 3 percent of a seal's body weight. Based on the information in the application, if four instruments were attached to one animal the combined in-air weight would be 1,825 grams. The weight would decrease as devices such as the Crittercams® are released or are fall off when the seal molts. Once the temporary instrument(s) were released, the overall weight that the seal would be carrying would be reduced. Following the threshold of 3 percent body weight, a seal would need to weigh about 61 kg to be equipped with all four instruments and 4–20 kg to be equipped with glued-on and flipper-attached satellite transmitters. Most seals will receive one glue-on transmitter and one flipper-mounted transmitter. Recapture of individual ice seals is not intended or anticipated during the duration of the project.

Figure 3. Head-mounted satellite location/depth transmitter on a ringed seal. The seal is being straddled by the handler to restrain it. The handler is not sitting on the seal; his weight is on his knees.

Glue-On Instruments: These include location/depth transmitters, location/CTD transmitters (also called a Sonde, this is an oceanographic instrument that measures the conductivity, temperature, and pressure of seawater), video camera recorders, and acoustic recorders with accelerometers. Transmitters send data to satellites while recorders store data and need to be retrieved. A glue-on satellite location/depth transmitter may be placed on top of the head or on the back (Figure 3, Figure 4). Adhesive (e.g., 5-minute epoxy or superglue) is mixed in two small batches. The first batch goes onto the bottom of the transmitter and on mesh or neoprene and on the hair of the seal. The glue is spread in a thin layer so that it does not generate too much heat during the curing process and irritate the seal's skin. When that layer dries, the second batch of glue is used to cover any places that were missed where the transmitter needs to be bonded to the seal's skin. A piece of mesh or neoprene may be used between the transmitter and the seal's hair. The neoprene is glued to the hair and transmitter in the same way in terms of applying glue to each surface and waiting until tacky before pressing together to ensure maximum adhesion.

An onboard video camera "Crittercam®" may be used to collect diet and habitat data. Crittercams® record video and the instrument can be remotely released from the animal when desired. Crittercams® are 30 by 8 by 8 cm and weigh approximately 1,000 grams (g) in air but are close to neutrally buoyant in water. A base plate is attached to the pelage on the back of the animal with quick setting epoxy and the camera is then attached to the base plate (Figure 4). The base plate will remain attached until the annual molt but the camera is released within 24 hours or remotely released sooner.

Acoustic data loggers record and store sound levels and can be attached to the animal in the same way as Crittercams®. Bioacoustic Probes (Greenridge Sciences) measure 19.3 by 3.2 cm and weigh approximately 230 g. Acoustic tags that transmit data to satellites are in development and may be used in areas where retrieving a logger is problematic. Acoustic satellite tags would be similar in size and mass to CTD tags.

Flipper-attached instruments: The hind flipper is cleaned with providone iodine or chlorhexidine and then wiped with 70 percent isopropyl alcohol and left to dry. Two disposable sterile 6 mm diameter biopsy punches will be used to make two holes in the webbing for the transmitter attachment. Seals are physically restrained by people or hoop nets as necessary while installing the transmitter. These transmitters are smaller than those that are glued on and only collect location data (e.g., Wildlife Computers SPOT tag measuring approximately 80 by 20 by 10 mm and weighing approximately 30 g). These tags are retained longer because they do not shed with the hair during the molt. Up to 100 seals of each species per year may receive both a glue-on and a flipper tag. In no case will the seal be intentionally recaptured to retrieve a tag. Hind flipper tags rarely transmit unless the seal is hauled out but are valuable in determining seasonal fidelity to areas where haulout behavior is common, such as for breeding and molting.

After instruments are securely attached and turned on, data sheets are checked to make sure the tag number is written down and all of the data are complete and the seal is then released into the water. The glue-on tags remain attached until the spring molt when they are shed with the old pelage.

2.1.1.8 Release

Captured seals that are not sedated will be allowed to go directly into the water immediately after sampling and tagging. The total time from the capture to the onset of sampling and tagging seals will vary from 60 to 120 minutes.

Figure 4. Back-mounted satellite location/depth transmitter on a ringed seal near restraining stretcher with straps. A green numbered tag is in right hind flipper.

2.1.2 Mitigation Measures

OPR's proposed permit will include a number of Terms and Conditions specifying the duration of the permit; the number and kind of protected species, location, and manner by which these species will be taken, and counting and reporting requirements for takes; and restrictions on research methods to be used including aerial and vessel surveys, darting, handling, and sampling of animals. The annual reports shall be sent to AKR (Table 1) as well as OPR.

In order to minimize or avoid exposure of ringed (Arctic DPS) and bearded (Beringia DPS) seals to the potential stressors, OPR will include the following conditions as permit requirements (see Appendix 1 for the complete permit text):

1. Manned aerial surveys must be flown at an altitude of 200 m. During surveys, the plane will circle within visual contact, but not directly over a group of seals for up to 15 minutes in order to accurately count and photograph all seals present.
2. Researchers must immediately stop permitted activities and the Permit Holder must contact the Chief, Permits Division, for written permission to resume if three pinnipeds of any species are darted and suffer unanticipated adverse effects, including entering the

water and either drowning or disappearing so that the fate of the animals cannot be determined.

3. Researchers must consult an experienced marine mammal veterinarian for proper dosages and protocols for use of anesthesia and sedatives, including administration via remote darting.
4. Researchers must capture and handle pinnipeds in groups small enough that handling and restraint time for each animal is minimized and all animals can be adequately monitored for signs of adverse reactions that could lead to serious injury or mortality.
5. When capturing or detaining animals in traps, researchers must adequately monitor the animals to prevent injury, mortality, and dehydration.
6. When deploying floating traps, researchers must monitor the traps from a distance using binoculars or spotting scope and extract seals from the trap as soon as possible.
7. The researcher will not set unmonitored nets across lagoons.
8. Lactating females, unweaned pups, and neonates will not be targeted for capture under this permit. If unintentionally captured, researchers must minimize the time lactating females are removed or otherwise separated from their dependent pups as a result of research activities.
9. Researchers must immediately cease attempts to approach, capture, sedate (including remote darting), restrain, sample, mark, or otherwise handle pinnipeds if the procedure does not appear to be working or there are indications such acts may be life threatening or otherwise endanger the health and welfare of the animal. To the extent that it would not further endanger the health or welfare of the animal, researchers may monitor or treat (e.g., administer reversal agents or attempt resuscitation) the animal as deemed appropriate in consultation with a veterinarian.
10. Researchers must use aseptic techniques for collection of external tissue samples (e.g., swabs), puncture procedures (e.g., venipuncture, flipper tagging), surgical procedures, and collection of internal tissue samples (e.g., blubber biopsy).
11. Researchers must use sterile disposable instruments (e.g., needles, biopsy punches) to the maximum extent practicable.
12. Researchers must limit the amount of blood collected to actual needs for sample analysis and not exceed three attempts (needle insertions) per site per animal, and not more than 1.0 ml of blood per kilogram body mass per capture event.
13. Sedated and anesthetized animals must be monitored closely and not be released until they recover normal locomotor capabilities. When sedated/anesthetized animals are too large or dangerous to be held until fully recovered from sedation/anesthesia they should be placed in secure sites where they will not be subjected to physical harm or extremes of temperature, and can be monitored from a safe distance.
14. Researchers must take appropriate actions (e.g., disinfection procedures) for minimizing the introduction of new disease agents, vectors capable of efficiently transmitting indigenous dormant diseases or those not currently being effectively transmitted, and species that can serve as amplification hosts for transmitting indigenous diseases to other

species.

15. To the maximum extent practicable without causing further disturbance of marine mammals, researchers shall monitor study sites following any disturbance (e.g., surveys or sampling activities) to determine if any marine mammals have been killed or injured or pups abandoned.
16. To the maximum extent practicable, researchers must continue to improve and refine their protocols including: minimizing capture risk by reducing net length and deployment duration; minimizing size of instruments or including release mechanisms; and minimizing duration of restraint.
17. In the event that a mortality occurs due to the use of floating traps, ADFG will contact NMFS to discuss mitigation measures for trap use. If two seals die due to the use of floating traps, use of the traps will be halted until ADFG confers with NMFS.

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
Reports & Data Submittal	AKR.section7@noaa.gov (please include NMFS consultation number AKRO-2021-03483)
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

2.2 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). For this reason, the action area is typically larger than the project area and extends out to a point where no measurable effects from the proposed action occur.

The proposed action would occur year-round in waters of the Bering, Chukchi, and Beaufort seas. The researchers will receive biological samples from seals harvested by residents of six villages (Point Hope, Shishmaref, Diomede, Gambell, Savoonga, and Hooper Bay) and from the North Slope Borough from Utqiaġvik, Wainwright, and Kaktovik (Figure 5). Researchers may also capture/restrain, tag, instrument, sample, and release seals in any village along the west and north coast of Alaska from Bristol Bay to Kaktovik. The trapping activities occur within 25 miles of the coast in water 50 m or less in depth and near communities where resources such as local vessels are available. The action area includes the local transit routes used by research vessels in order to reach locations where surveys and live capture of animals will take place.

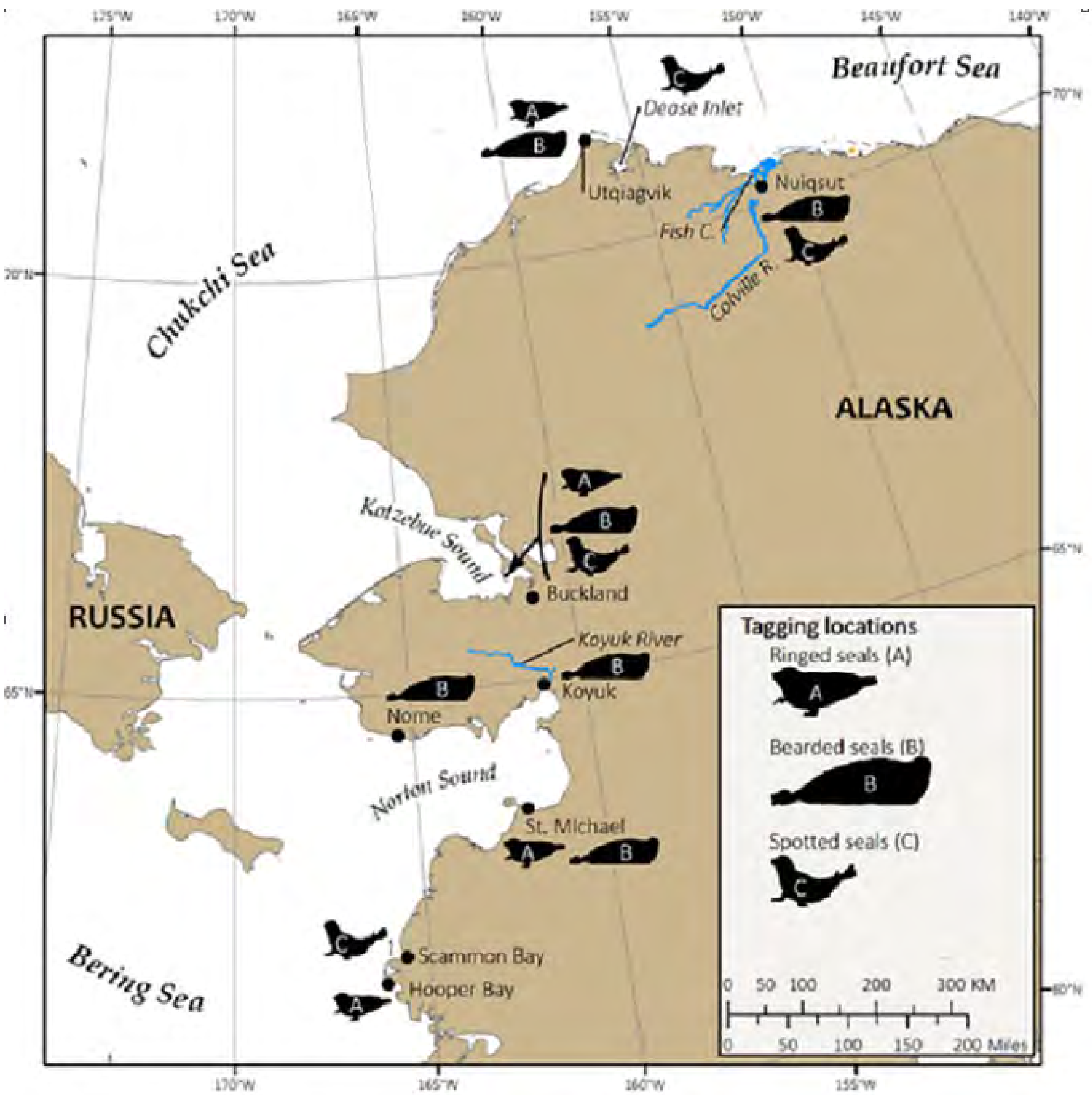

Figure 5. Generalized map of action area. Research activities will be concentrated in narrow band along the coast in water depths of 50 m or less. Seal symbols indicate the most likely locations for surveys, and seal capture.

3 Approach to the Assessment

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

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

Under NMFS's regulations, the destruction or adverse modification of critical habitat means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species (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.

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.

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

- The ADFG permit application
- Past annual reports and incident reports from the applicant
- Stock Assessment Reports
- Published 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

This opinion considers the effects of the proposed action on the species and designated critical habitats specified in (Table 2). Research activities may include vessel and aerial surveys of ice seals (spotted, ringed, bearded, and ribbon) and capture of ice seals that requires the use of vessels, as well as deployment of nets and traps. These activities are targeted at the research subjects but could overlap with other animals that happen to be in the vicinity of the research operations. The ESA listed species and designated critical habitat in Table 2 are under NMFS jurisdiction and may occur within the action area.

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
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
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
Steller sea lion (*Eumetopias jubatus*)	Endangered	55 FR 49204	NMFS 1993, 58 FR 45269
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

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

As described in the Approach to the Assessment section, 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 ADFG's research activities and a listed species or designated critical habitat. The second criterion is the probability of a response, given exposure. ESA-listed species and critical habitat that overlaps with a potential stressor but is not likely to respond to the stressor is also not likely to be adversely affected by the proposed action. The research activities have the potential to overlap with the following cetaceans whose ranges include the action area: bowhead, North Pacific right, North Pacific DPS gray, fin, and Western

North Pacific, and Mexico DPS humpback whales. Of these, bowhead whales are more likely to be found within the action area compared to the subarctic baleen whales because they are an Arctic species and have greater potential to overlap with the research activities. However, researchers have not previously observed bowheads (or other baleen whales) while doing their work, and as with previous permits the research activities proposed here will have a limited spatial scope. No take was requested by ADFG for these species and none is being authorized by OPR.

Capture and Trapping: Several factors reduce the likelihood of overlap of the research activities with large baleen whales. All of the ESA-listed whales, with the exception of the bowhead, are subarctic species greatly reducing the number that may be present in the action area which is concentrated in northern latitudes (Figure 5). The research activities will largely occur from the shoreline out to a depth of about 50 m. When conducting tagging and trapping operations, the researchers will use small boats with all eyes on the water looking for seals and obstacles. Noise from these small vessels (e.g. 22 ft skiff) would be intermittent because after a seal is found and captured, the boats are not in use while the animal is being processed and tagged. The infrequent and intermittent vessel use is not expected to rise to the level of harassment to any large whale. Large whales are conspicuous, the researchers have years of experience identifying marine mammals, and there will be multiple observers on the vessels ensuring that it is highly unlikely that a large whale in the vicinity of research operations would go unnoticed. If a whale were seen, every effort would be made to not disturb it. The researchers report that they have not seen cetaceans other than beluga whales near their target species when conducting their work (ADFG 2022).

Vessel Based Surveys: Surveys conducted from boats are proposed to monitor ice seal distribution and population trends. Surveys could be conducted from vessels ranging in size from small boats to large commercial vessels. However, no vessel-based surveys were conducted in the five prior years, indicating a low level of disturbance frequency from this activity. If done, the researchers will operate vessels at slow speeds (under 10 knots) with 100 percent observer coverage to look for ice seals. The observers will also be responsible for reporting sightings of non-target species in order to avoid a collision with any marine mammal. The slow speeds at which vessels will operate coupled with the number of observers who will be onboard make it extremely unlikely that a vessel would collide with an ESA-listed whale species during surveys. ADFG has been conducting similar research activities since 2000, with previous authorization from OPR with no reports of sightings or vessel strikes. Any noise or visual disturbance from vessel operations to cetaceans associated with surveys is expected to be fleeting and immeasurably small.

Aerial Surveys: Aerial surveys using a fixed-wing aircraft are proposed to monitor ice seal distribution and population trends. In the prior 5-year period of the permit (No. 20466), no aerial surveys were conducted, indicating a low potential level of disturbance frequency as these surveys are rarely conducted. Aerial surveys could take place at any time of year, but are most likely to occur from April to October over the 5-year permit lifetime. Thus, aerial surveys will take place when whales are more likely to be in the action area. Planes will fly at altitudes of 200 m or greater and will avoid flying over non-target species, such as whales. If an ESA-listed cetacean is observed, flight altitude will be increased or the course will be altered to avoid harassing the whale. Therefore, any noise or visual disturbance associated with the surveys would be of very short duration (the time needed to spot the whale and alter course or increase the altitude of the airplane) and would be so small as to be immeasurable.

Nets and Traps: Nets and traps will be used to capture ice seals. The nets and traps are too small to capture cetaceans but have the potential for entanglement. Nets used across lagoon entrances are larger and have the potential to capture smaller cetaceans like beluga whales. However, these nets are monitored continuously and it would be very unlikely that a large baleen whale would swim in such shallow water. The constant monitoring will protect ESA-listed whale species from becoming entangled. Traps and nets are monitored continuously. No nets or traps will be deployed if ESA-listed whales are observed in a deployment area and gear will be retrieved from the water if ESA-listed whales enter the area while nets and traps are in the water. ADFG retrieves all gear at the end of each capture attempt, removing the potential for entanglement. There has been only one whale entanglement incident (in 2012), when beluga whales (non-listed) became entangled in a net at a lagoon entrance. However, this led to a change in procedure in which nets set at lagoons are monitored constantly. Consequently, there has not been a subsequent incident involving whales. Therefore, the effects to ESA-listed whales associated with entanglement in nets and traps used to capture ice seals is very unlikely to occur.

Ringed and Bearded Seal Critical Habitat: The Primary Biological Features essential to both ringed and bearded seal are based on specific sea ice habitat characteristics and availability, and prey resources. Sea ice provides a platform for basking, molting, whelping, nursing, resting, and the substrate for ringed seal subnivean birth lairs. Although some research activities may occur when sea ice is present, the research activities would not affect the quality or quantity of sea ice habitat. In the specific areas where ice seals are captured and handled, bearded and ringed seals may avoid the immediate area for a short period of time while the researchers are present. However, we would expect that the habitat would be vacated only for the period of time that research activities were occurring, which would be a matter of a few hours, and that the sea ice habitat would be reoccupied once the researchers left the area.

Up to 60 ringed seal lairs may be disturbed by being found by dogs, investigated by researchers, and outfitted with instruments in the ceiling of the lair (ADFG 2022). Previous studies (e.g., Kelly and Quakenbush 1990, Kelly et al. 2010a) document that breathing holes and lairs visited by dogs and researchers continue to be used, indicating the essential features of the lair remained intact. The instruments may be checked up to four times from February–May. However, the GPS location of the lairs will be documented so they will only be visited by the dogs one time. We expect that checking the instruments should have minimal impact on the lair structure. The availability of only 2 trained dogs, the limited window of opportunity provided by the overlap of suitable weather and lair presence, the very large area of designated critical habitat, and the large population size of ringed seals (see section 4.3.1) indicates that even if 60 ringed seal lairs were found it would represent a very small fraction of the total lairs available.

Both males and females create and use subnivean lairs, and Kelly et al. (1986) found that in the southern Beaufort Sea and Kotzebue Sound, radio-tagged seals used from one to four subnivean lairs. Using the very conservative population estimate of 171,418 (Muto et al. 2021) we would expect there could be at least that many lairs present and likely two to three times more, indicating that the number of subnivean lairs disturbed could conservatively range from 0.03 to 0.01 percent of the lairs present. Given that we expect the subnivean lairs to be minimally disturbed, and a very small fraction will be found and instrumented, we conclude that effects to this aspect of ringed seal critical habitat would be too small to measurably detect. In addition, we conclude that the value of the sea ice as a platform for bearded and ringed seal life history functions will be very minimally, if at all, affected.

North Pacific Right Whale, Humpback Whale, and Steller Sea Lion Critical Habitat: Research will not be conducted within the area designated as North Pacific right whale critical habitat, which lies outside of Alaska State waters. High densities of copepods and euphausiids comprise the Primary Biological Feature within designated critical habitat and no aspect of the proposed research activities will affect the abundance or distribution of the prey species in the designated critical habitat. Therefore, the proposed action will have no effect on North Pacific right whale critical habitat.

Critical habitat for the Western North Pacific and Mexico DPSs of humpback whales and Steller sea lion does not fall within the proposed action area. No effect to critical habitat for these species is expected.

In summary, we conclude that OPR's issuance of Permit No. 26254 may affect, but is not likely to adversely affect ESA-listed bowhead, North Pacific right, North Pacific gray, fin, Western North Pacific humpback, and Mexico DPS humpback whales, and critical habitat for ringed and bearded seals. The proposed research will have no effect on North Pacific right whale, Western North Pacific DPS humpback whale, Mexico DPSs humpback whale, and Steller sea lion designated critical habitat.

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 percent 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 2,000 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.

[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

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 6) (Thoman and Walsh 2019).

Warmer ocean water affects sea ice formation and melt. In the first decade of the 21st century, Arctic sea ice thickness and annual minimum sea ice extent (i.e., September sea ice extent) declined at a considerably accelerated rate and continues to decline (Stroeve et al. 2007; Stroeve and Notz 2018) (Figure 7). 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 percent of the ice pack in 1985, but by March 2019, it represented only 1.2 percent 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 7). 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 8). The minimum Arctic sea ice extent in 2020 was the second lowest in the 42-year satellite record, second only to September 2012[5].

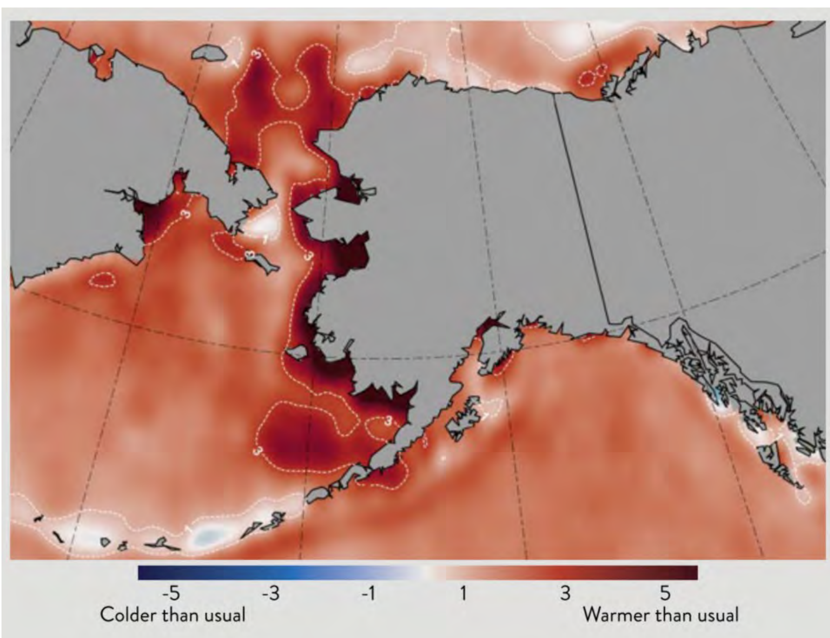

Figure 6. Arctic summer sea surface temperatures, 2019 (Thoman and Walsh 2019).

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

Figure 7. 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).

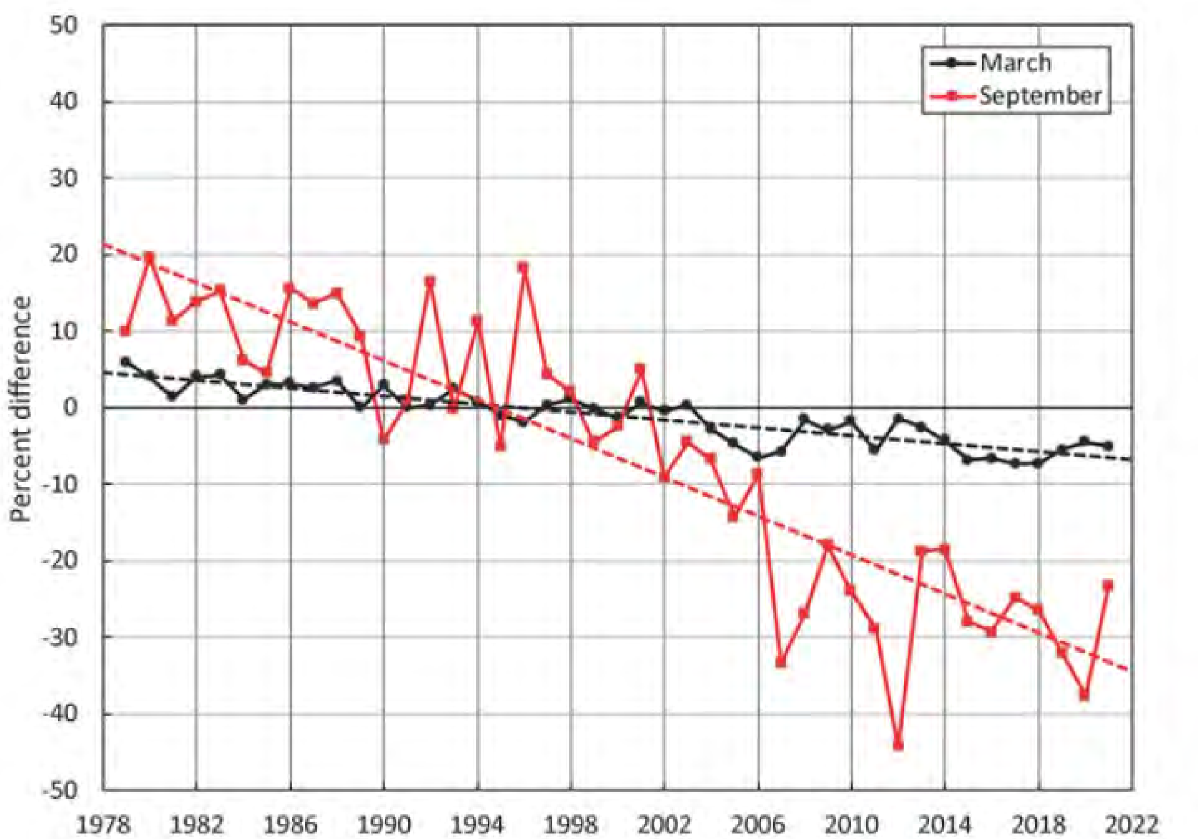

Figure 8. Arctic ice extent declines in September (red) and in March (black). The value for each year is the difference in percent in ice extent relative to the mean values for 1981-2010. Both trends are significant at the 99 percent confidence level. The slopes of the lines indicate losses of -2.7 for 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 9). 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).

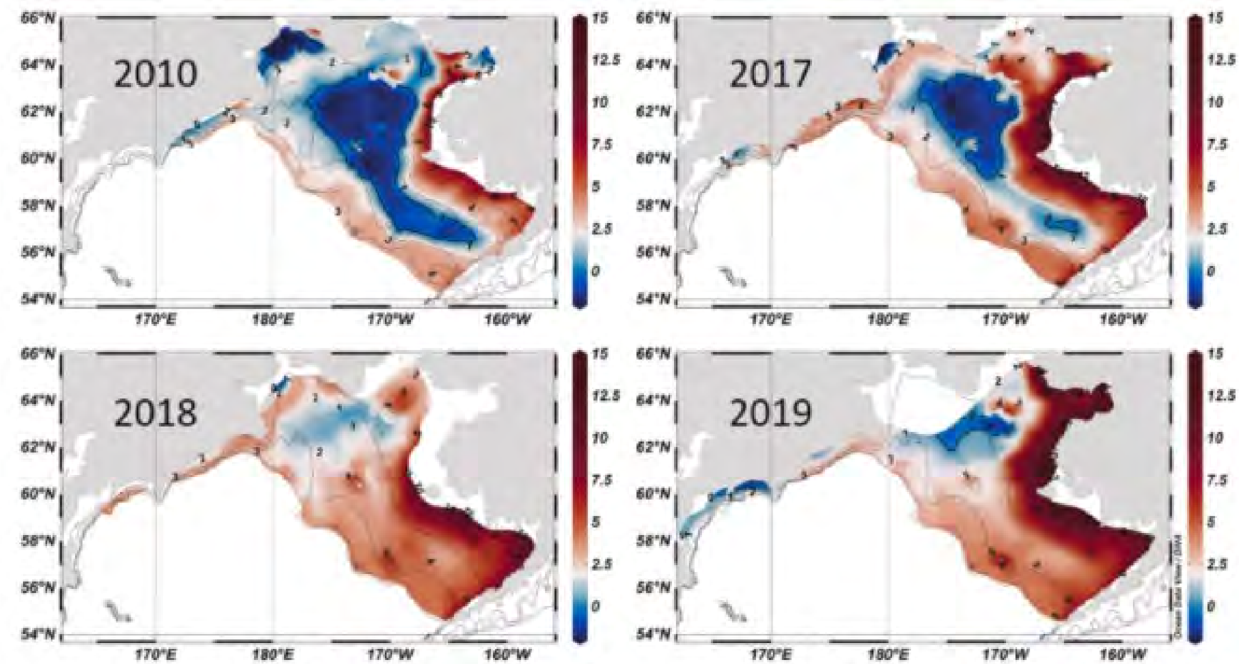

Figure 9. Bottom temperatures from summer oceanographic surveys. Graphic display of the shrinkage of the cold pool over time. From Eisner et al. (2020).

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

[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.

in the foreseeable future (Hinzman et al. 2005; Burek et al. 2008; Doney et al. 2012; Huntington et al. 2020). The physical effects on the environment described above have impacted, are impacting, and will continue to impact marine species in a variety of ways (IPCC 2014), such as:

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

Some of the biological consequences of the changing Arctic conditions are shown in Table 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 related to longer open water period	Increased likelihood of ship strikes, fisheries interactions, acoustic injury. Chemical and pathogen pollution due to shipping or aquaculture practices. Introduction of nonnative species

Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2009). For species that rely primarily on sea ice for major parts of their life history, such as ringed and bearded seals, 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.

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

More detailed background information on the status of ringed and bearded seals can be found in a number of published documents including stock assessment reports on Alaska marine mammals by Muto et al. (2021) and Cameron et al. (2010) that provide status reviews of ringed and bearded seals, respectively.

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. Critical habitat for the Arctic ringed seal was designated on April 1, 2022 (87 FR 19232).

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

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

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, in late summer and early fall, aggregations of ringed seals in open-water in some parts of their study area in the southeastern Canadian Beaufort Sea where primary productivity was thought to be high. Harwood et al. (2015) also found that in the fall, several satellite-tagged ringed seals showed localized movements offshore east of Point Barrow in an area where bowhead whales are known to concentrate in the fall to feed on zooplankton. With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack, with many seals dispersing throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Frost and Lowry 1984; Crawford et al. 2012; Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010). In analyzing data from ringed seals tagged from 2011-2017, Von Duyke et al. (2020) found that continental shelf waters were occupied for greater than 96 percent of tracking days, during which repetitive diving (suggestive of foraging), primarily to the seafloor, was the most frequent activity.

4.3.1.3 Occurrence in the Action Area

In Alaskan waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort seas (Frost 1985; Kelly 1988b), and therefore are in the study area. Passive acoustic monitoring (PAM) of ringed seals from a high frequency recording package deployed at a depth of 787 ft. (240 m) in the Chukchi Sea (65 nm) 120 km north-northwest of Barrow, Alaska detected ringed seals in the area between mid-December and late May over the four year study (Jones et al. 2014). At the onset of the fall freeze, ringed seal movements become increasingly restricted and seals will either move west and south with the advancing ice pack into the Chukchi and Bering Seas, with some remaining in the Beaufort Sea (Frost and Lowry 1984; Crawford et al. 2012; Harwood et al. 2012; Von Duyke et al. 2020).

Crawford et. al (2012) found that during their migrations ringed seals remained within 100 km (38.9 km average) from shore over the continental slope, and that all age classes made short, shallow foraging dives (4-40 m). Tag data from Von Duyke et. al (2020) showed that continental shelf waters were occupied for greater than 96 percent of tracking days, during which the predominate activity was repetitive diving indicative of foraging. In February and March, ringed seals were feeding within high concentrations of pack ice over the continental shelf. Ringed seals tagged in Utqiaġvik, Alaska showed the movement patterns in Figure 10 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 deep water 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).

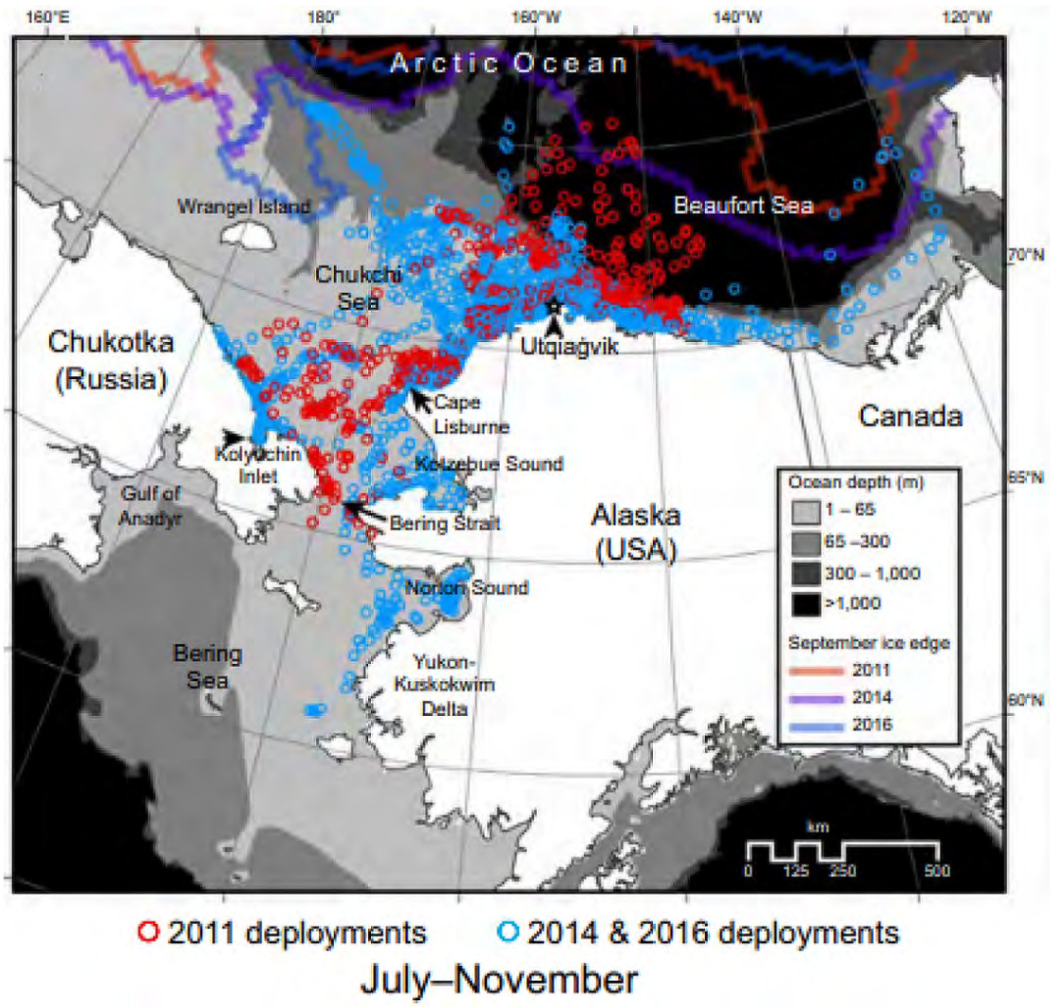

Figure 10. Locations of tagged ringed seals from July to November (Von Duyke et al. 2020).

4.3.1.4 Feeding, Diving, Hauling out and Social Behavior

Ringed seal pups are born and nursed in the spring (March through May), normally in subnivean birth lairs, with the peak of pupping occurring in early April (Frost and Lowry 1981). Subnivean lairs provide thermal protection from cold temperatures, including wind chill effects, and some protection from predators (Smith and Stirling 1975; Smith 1976). These lairs are especially important for protecting pups. Arctic ringed seals appear to favor shore-fast ice for whelping habitat. Ringed seal whelping has also been observed on both nearshore and offshore drifting pack ice (e.g., Lentfer 1972). Seal mothers continue to forage throughout lactation, and move young pups between lairs within their network of lairs. The pups spend time learning diving skills, using multiple breathing holes, and nursing and resting in lairs (Smith and Lydersen 1991; Lydersen and Hammill 1993). After a 5 to 8 week lactation period, pups are weaned (Lydersen and Hammill 1993; Lydersen and Kovacs 1999).

Mating is thought to take place under the ice in the vicinity of birth lairs while mature females are still lactating (Kelly et al. 2010a). The sex ratio is even to slightly male dominated (Smith 1970; Quakenbush et al. 2011b). Ringed seals undergo an annual molt (shedding and regrowth of hair and skin) that occurs between mid-May to mid-July, during which time they spend many hours hauled out on the ice (Reeves 1998). The relatively long periods of time that ringed seals spend out of the water during the molt have been ascribed to the need to maintain elevated skin temperatures during new hair growth (Feltz and Fay 1966). Figure 11 summarizes the approximate annual timing of Arctic ringed seal reproduction and molting (Kelly et al. 2010a).

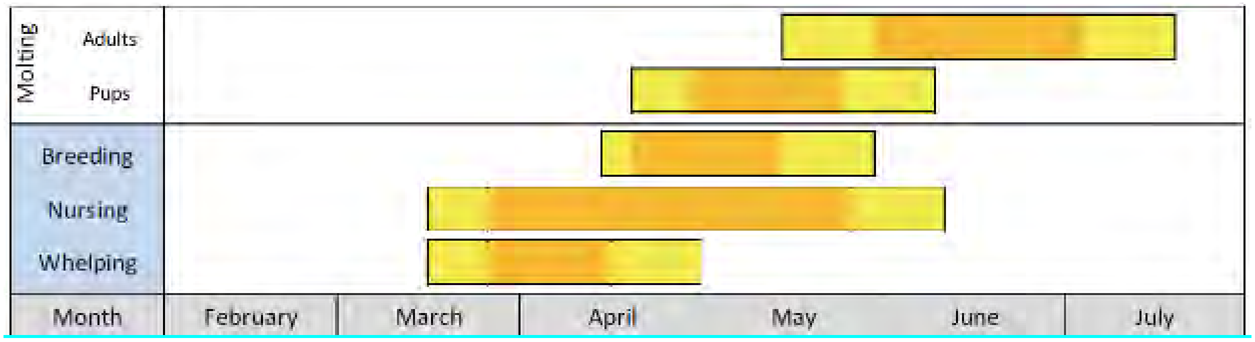

Figure 11. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the “normal” range over which each event is reported to occur and orange bars indicate the “peak” timing of each event (Kelly et al. 2010a).

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). Diel activity patterns suggested greater allocation of foraging efforts to midday hours (Von Duyke et al. 2020). Haul-out patterns were complementary, occurring mostly at night until April-May when midday hours were preferred (Von Duyke et al. 2020).

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 seals have been conducted and although there is considerable variation in the diet regionally, several patterns emerge. Most ringed seal prey is small, and preferred prey tends to be schooling species that form dense aggregations. Fish of the cod family tend to dominate the diet from late autumn through early spring in many areas (Kovacs 2007). Arctic cod (*Boreogadus saida*) is often reported to be the most important prey species for ringed seals, especially during the ice-covered periods of the year (Lowry et al. 1980; Smith 1987; Holst et al. 2001; Labansen et al. 2007). Quakenbush et al. (2011b) reported evidence that in general, the diet of Arctic ringed seals sampled from Alaska waters consisted of cod, amphipods, and shrimp. Fish are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by availability of various types of prey during particular seasons as well as preference, which in part is guided by energy content of various available prey (Reeves 1998; Wathne et al. 2000). Invertebrate prey seem to become more important in the diet of Arctic ringed seals in the open-water season and often dominate the diet of young animals (e.g., Lowry et al. 1980; Holst et al. 2001).

4.3.1.5 Hearing, Vocalizations, and Other Sensory Capabilities

Ringed seals vocalize underwater in association with territorial and mating behaviors.

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

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

4.3.2 Bearded Seals

4.3.2.1 Status and Population Structure

There are two recognized subspecies of the bearded seal: *E. b. barbatus*, often described as inhabiting the Atlantic sector (Laptev, Kara, and Barents seas, North Atlantic Ocean, and Hudson Bay; (Rice 1998)); and *E. b. nauticus*, which inhabits the Pacific sector (remaining portions of the Arctic Ocean and the Bering and Okhotsk seas; (Ognev 1935; Scheffer 1958; Manning 1974; Heptner et al. 1976). Based on evidence for discreteness and ecological uniqueness, NMFS concluded that the *E. b. nauticus* subspecies consists of two DPSs—the Okhotsk DPS in the Sea of Okhotsk, and the Beringia DPS, encompassing the remainder of the range of this subspecies (75 FR 77496; December 10, 2010). Only the Beringia DPS is found in U.S. waters (and the action area). NMFS listed the Beringia DPS of bearded seals as threatened under the ESA on December 28, 2012 (77 FR 76740). On April 1, 2022, designation of critical habitat for the bearded seal was finalized and published (87 FR 19180). NMFS has not prepared a Recovery Plan for the Beringia subspecies of bearded seal.

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

4.3.2.2 Distribution

The Beringia DPS of the bearded seal includes all bearded seals from breeding populations in the Arctic Ocean and adjacent seas in the Pacific Ocean between 145°E longitude in the East

Siberian Sea and 130°W longitude in the Canadian Beaufort Sea, except west of 157°W longitude in the Bering Sea and west of the Kamchatka Peninsula (where the Okhotsk DPS is found). The bearded seal's effective range is generally restricted to areas where seasonal sea ice occurs over relatively shallow waters. Cameron et al. (2010) defined the core distribution of bearded seals as those areas of known extent that are in waters less than 500 m (1,640 ft) deep.

Bearded seals are closely associated with sea ice, particularly during the critical life history periods related to reproduction and molting, and can be found in a broad range of ice types. They generally prefer moving ice that produces natural openings and areas of open-water (Heptner et al. 1976; Fedoseev 1984; Nelson et al. 1984). They usually avoid areas of continuous, thick, shorefast ice and are rarely seen in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Fedoseev 1965; Burns and Harbo 1972; Burns and Frost 1979; Burns 1981; Smith 1981; Fedoseev 1984; Nelson et al. 1984). Within the U.S. range of the Beringia DPS, the extent of favorable ice conditions for bearded seals is most restricted in the Beaufort Sea, where there is a relatively narrow shelf with suitable water depths. In comparison, suitable ice conditions and water depths occur in limited areas of the Chukchi Sea, and over much broader areas in the Bering Sea (Burns 1981). During winter, the central and northern parts of the Bering Sea shelf, where heavier pack ice occurs, have the highest densities of adult bearded seals (Heptner et al. 1976, Burns and Frost 1979, Burns 1981, Nelson et al. 1984, Cameron et al. 2018), possibly reflecting the favorable ice conditions there. In contrast, Cameron et al. (2018) found that young bearded seals were closely associated with the ice edge farther south in the Bering Sea.

Spring surveys conducted in 1999 through 2000 along the Alaska coast of the Chukchi Sea, and in 2001 near St. Lawrence Island, indicated that bearded seals tended to prefer areas of between 70 and 90 percent ice coverage, and were typically more abundant in offshore pack ice 37 to 185 km (20 to 100 nautical miles [nm]) from shore than within 37 km (20 nm) from shore, except for high concentrations nearshore to the south of Kivalina (Simpkins et al. 2003; Bengtson et al. 2005). Juvenile bearded seals that were tagged from 2014-2018 primarily occupied shallow coastal waters and areas with intermediate-concentration pack ice or were near the ice edge. Seals spent half their time near the sea floor. Hauling out occurred less in the winter and increased during spring and summer, coinciding with the annual molting period.

It is thought that in the fall and winter most bearded seals move south with the advancing ice edge through Bering Strait into the Bering Sea where they spend the winter, and in the spring and early summer, as the sea ice melts, many of these seals move north through the Bering Strait into the Chukchi and Beaufort Seas (Burns 1967; Burns and Frost 1979; Burns 1981; Cameron and Boveng 2007; Cameron and Boveng 2009; Cameron et al. 2018). The overall summer distribution is quite broad, with seals rarely hauled out on land (Burns 1967, Heptner et al. 1976, Burns 1981, Nelson et al. 1984). However some seals, mostly juveniles, have been observed hauled out on land along lagoons and rivers in some areas of Alaska, such as in Norton Bay (Huntington 2000), near Wainwright (Nelson 1981), and on sandy islands near Barrow (Cameron et al. 2010).

4.3.2.3 Occurrence in the Action Area

Bearded seals are expected to be widely but patchily present throughout the action area based on presence of suitable sea ice habitat and availability of prey. Bearded seals are primarily benthic feeders and are typically found in relatively shallow water (< 200 m) of the shelf areas of the Bering, Chukchi, and Beaufort seas, presumably because their prey is more accessible to them in the shallower water. Bearded seal vocalizations (produced by adult males) have been recorded nearly year-round in the Beaufort Sea (MacIntyre et al. 2013; MacIntyre et al. 2015) from recorders that were on the shelf area in water depths ranging from 46 to 131 m and less than 100 km from shore. Many bearded seals spend the winter months in the Bering Sea and then move north through the Bering Strait between late April and June. They then continue into the Chukchi Sea where they spend the summer months along the fragmented and drifting ice pack. Bearded seals have been observed in the Chukchi Sea year-round when sea ice coverage was greater than 50 percent. Juveniles may not migrate north to follow the ice, as most adults do, and may remain along the coasts of the Bering and Chukchi Seas. Apart from these juveniles, seasonal distribution appears to be correlated with the ice pack (Muto et al. 2019).

4.3.2.4 Feeding, Diving, Hauling out and Social Behavior

Bearded seal diets vary with age, location, season, and changes in prey availability (Kelly 1988a). They are mostly benthic feeders (Burns 1981), consuming a variety of invertebrates (e.g., crabs, shrimp, clams, worms, and snails; Quakenbush et al. 2011a), fish (including arctic and saffron cod, flounders, and sculpins), and octopuses (Burns 1981; Kelly 1988a; Reeves et al. 1992; Hjelset et al. 1999; Cameron et al. 2010). Bearded seals “scan” the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall et al. 2006; Marshall et al. 2008).

Studies using data recorders and telemetry on lactating females and their dependent pups showed that bearded seals are highly aquatic during a nursing period of about 3 weeks (Lydersen and Kovacs 1999). At Svalbard Archipelago, nursing mothers spent more than 90 percent of their time in the water, split equally between near-surface activity and diving/foraging (Holsvik 1998; Krafft et al. 2000), while dependent pups spent about 50 percent of their time in the water.

The diving behavior of adult bearded seals is closely related to their benthic foraging habits and in the few studies conducted so far, dive depths have largely reflected local bathymetry (Gjertz et al. 2000; Krafft et al. 2000). Studies using depth recording devices have until recently focused on lactating mothers and their pups. These studies showed that mothers in the Svalbard Archipelago make relatively shallow dives, generally <100 m in depth, and for short periods, generally less than 10 min in duration. Adult females spent most of their dive time (47-92 percent) performing U-shaped dives, believed to represent bottom feeding (Krafft et al. 2000); U-shaped dives are also common in nursing pups (Lydersen et al. 1994b).

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

2007). Scars on the males suggest fighting may be involved in defending territories as well.

4.3.2.5 Hearing and Vocalizations

Bearded seals vocalize underwater in association with territorial and mating behaviors. The predominant calls produced by males during breeding, termed trills, are described as frequency modulated vocalizations. Trills show marked individual and geographical variation, are uniquely identifiable over long periods, can propagate up to 30 km (19 mi), are up to 60 seconds in duration, and are usually associated with stereotyped dive displays (Cleator et al. 1989; Van Parijs et al. 2001; Van Parijs 2003; Van Parijs et al. 2003; Van Parijs et al. 2004; Van Parijs and Clark 2006). NMFS defines the functional hearing range for phocids (including bearded seals) as 50 Hz to 86 kHz (NMFS 2018b).

Hearing thresholds for two captive bearded seals were measured for underwater tonal sounds at frequencies between 0.1 and 61 kHz, under quiet controlled conditions and in the presence of octave-band masking noise (Sills et al. 2020). The bearded seals displayed sensitive underwater hearing with peak sensitivity near 50 dB re 1 μPa and a broad frequency range of best hearing extending from approximately 0.3 to 45 kHz, while the full range of hearing extended from at least 0.1 to 60 kHz. Such a wide range of sensitive hearing is exceptional among mammals (Sills et al. 2020). Additionally, the two seals performed particularly well compared to other mammals when detecting target signals embedded within background noise.

5 Environmental Baseline

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

5.1 Climate Change

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

As discussed in Section 4.2, the Arctic is warming at two or more times the global average. One consequence of the warming is a reduction in the length of the snow season (Figure 12). 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 12. 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.

5.2 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 13). Domoic acid was detected in all 13 species examined and had the greatest prevalence in bowhead whales (68 percent) and harbor seals (67 percent). Saxitoxin was detected in 10 of the 13 species, with the highest prevalence in humpback whales (50 percent) and bowhead whales (32 percent) and 5 percent 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].

Hendrix et al. (2021) examined 998 seals harvested for subsistence purposes in western and northern Alaska during 2005–2019 for domoic acid and saxitoxin. Both toxins were detected in bearded, ringed, and spotted seals, though no clinical signs of acute neurotoxicity were reported in harvested seals. Bearded seals had the highest prevalence of each toxin, followed by ringed seals. Bearded seal stomach content samples from the Bering Sea showed a significant increase in domoic acid prevalence with time (logistic regression, p = .004). These findings are consistent with predicted northward expansion of domoic acid-producing algae. A comparison of paired samples taken from the stomachs and colons of 15 seals found that colon content consistently had higher concentrations of both toxins (Hendrix et al. 2021).

Figure 13. 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.

5.3 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

[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.

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. Strandings and mortalities have returned to baseline levels; 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

[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.

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					

5.4 Fisheries

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

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

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 fishery management area.

5.5 Oil & Gas

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

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

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

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

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

5.5.1 Pollution and Discharges (Excluding Spills)

Previous development and discharges in portions of the action area are the source of multiple pollutants that may be bioavailable (i.e., may be taken up and absorbed by animals) to ringed and bearded seals or their prey items (NMFS 2013). Drill cuttings and fluids contain contaminants that have high potential for bioaccumulation, such as dibenzofuran and polycyclic aromatic hydrocarbons. Historically, drill cuttings and fluids have been discharged from oil and gas developments in the Beaufort Sea near the action area, and residues from historical discharges may be present in the affected environment (Brown et al. 2010). Polycyclic aromatic hydrocarbons are also emitted to the atmosphere by flaring waste gases at production platforms or gas treatment facilities. For example, approximately 162,000 million standard cubic feet of waste gas was flared at Northstar in 2004 (Neff 2010).

The Clean Water Act of 1972 (CWA) has several sections or programs applicable to activities in offshore waters. Section 402 of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges into waters of the United States. Section 403 of the CWA requires that EPA conduct an ocean discharge criteria evaluation for discharges of pollutants from point sources into the territorial seas, contiguous zones, and the oceans. The Ocean Discharge Criteria (40 CFR part 125, subpart M) sets forth specific determinations of unreasonable degradation that must be made before permits may be issued.

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

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

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

The principal regulatory mechanism for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic outer continental shelf (OCS) is also the CWA. Discharges are covered under the Vessel Incidental Discharge Act, which is in the new CWA Section 312(p)[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.

5.5.2 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)

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

was 0.23 pipeline spills per Bbbl of oil produced (BOEM 2016).

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

Marine mammals can ingest spilled compounds while feeding, inhale the volatile components, or be affected by direct contact. Effects of oil ingestion on marine mammals can range from progressive organ damage to death, depending on the quantity and composition of the ingested oil (Geraci and St. Aubin 1990). The effects of an oil spill on ringed or bearded seals would depend largely on the size, season, and location of the spill. Surface contact with oil spills can damage mucous membranes and eyes of seals, or disrupt thermoregulation in seal pups (Geraci and St. Aubin 1990). If a spill were to occur during the ice free, open water season, seals may be exposed to oil through direct contact, or perhaps through contaminated food items. However, St. Aubin (1990) notes that with their keen sense of olfaction and good sense of vision ringed and bearded seals may be able to detect and avoid oil spills in the open water season (St. Aubin 1990).

Immersion studies by Geraci and Smith (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.

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

5.5.3 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).

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).

5.6 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 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 14). 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).

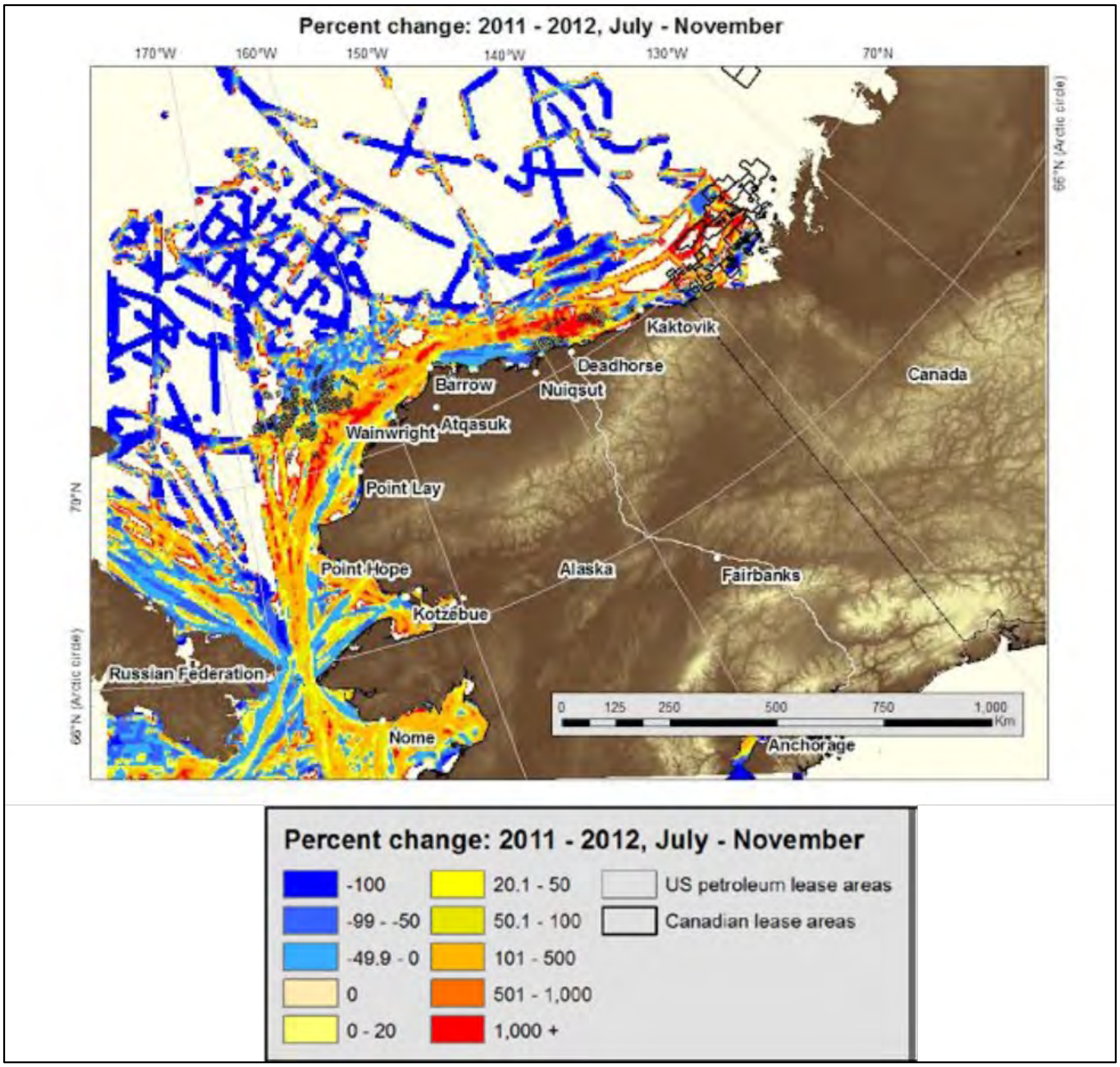

Figure 14. Percent difference in vessel activity between 2011 and 2012 using 5-km grid cells.

(Azzara et al. 2015)

Marine vessel traffic may pose a threat to ringed and bearded seals 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 increased 128 percent 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 percent 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 a 2.5 months longer navigation season over what was seen in 2019 (U.S. Committee on the Marine Transportation System 2019).

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

5.6.1 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.

5.6.2 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.

5.7 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).

5.7.1 Oil and Gas Exploration, Drilling, and Production Noise

As introduced in section 5.5, oil and gas exploration activities began on the North Slope in the early 1900s, and oil production started at Prudhoe Bay in 1977. NMFS reviewed the potential effects of oil and gas development in a Final Environmental Impact Statement for the effects of oil and gas activities in the Arctic Ocean (NMFS 2013) and has conducted numerous Section 7 consultations on oil and gas activities in the Chukchi and Beaufort Seas. Here we present a summary of the most recent and relevant consultations regarding oil and gas drilling, exploration, and production noise.

In 2018, NMFS Alaska Region completed a consultation with BOEM, BSEE, EPA, and USACE for oil and gas exploration activities for the Liberty Project taking place from December 2020 to November 2045 (NMFS 2018). In 2019, the NMFS Alaska Region reinitiated consultation with BOEM, BSEE, EPA, and USACE for the Liberty Project and conducted a consultation with the NMFS Permits Division on the issuance of a letter of authorization (LOA) to take marine mammals incidental to oil and gas exploration activities for the Liberty Oil and Gas Development and Production Activities (NMFS 2019a). The biological opinion estimates take of ringed seals: 831 by harassment due to noise and physical presence, 8 by injury due to noise, and 10 by mortality, and for bearded seals, 130 by harassment due to noise and physical presence and 4 by injury. This project has not yet begun.

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

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

In 2019, the Alaska Gasoline Development Corporation proposed a liquid natural gas pipeline that would extend from Prudhoe Bay, generally following the existing Trans Alaska Pipeline

System through interior Alaska, to end at the Liquefaction Facilities in Nikiski in Southcentral Alaska (84 FR 30991). The project would increase shipping traffic through the Bering, Chukchi, and Beaufort seas and could incidentally harass 1765 ringed seals and 300 bearded seals (AKRO-2018-01319). Project activities were permitted from 2021-2025. Construction on this project has not begun.

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

5.7.2 Seismic Exploration

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. Authorized takes by harassment included 907 bearded seals and 10,269 ringed seals. Monitoring from the project reported that actual takes included 6 sightings of bearded seals and 9 sightings of ringed seals. Sightings of two of the ringed seals resulted in a shutdown of seismic activity for 20 minutes.

5.7.3 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).

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).

5.8 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.

5.8.1 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 5. 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)	
	Ringed Seals	Bearded Seals
North Slope Borough	1,146	1,031
Maniilaq	493	1.038
Kawerak	2,287	3,248
Association of Village Council Presidents	2,484	1,360
Bristol Bay Native Association	44	30
Statewide total	6,454	6,707

5.8.2 Stranding

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

5.8.3 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).

5.9 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).

5.10 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 ringed seals during submarine training and testing activities associated with Ice Exercise 2020 north of Prudhoe Bay, Alaska from February 2020 through January 2021. Monitoring reports from the projects indicate that no ringed seals were observed.

In 2016, NMFS Alaska Region conducted internal consultations with NMFS Permits Division on the issuance of an Incidental Harassment Authorizations (IHA) to take marine mammals incidental to anchor retrieval in the Chukchi, and Beaufort seas during the 2016 open water season. The biological opinion estimated takes (by harassment) of 231 bearded seals and 6,895 ringed seals as a result of exposure to continuous or impulsive sounds at received levels at or above 120 dB or 160 dB re 1 μPa rms, respectively. Based on the number of actual hours that noise was produced it was estimated that 316 ringed seals and 104 bearded seals may have been harassed by the sounds produced by the project. However, protected species observers saw no ringed or bearded seals during the anchor retrieval process.

In 2016 and 2017, NMFS Alaska Region conducted internal consultations with NMFS Permits

Division on the issuance of an IHA associated with the continuation of fiber optic cable laying. Quintillion was permitted to install 1,904 km (1,183 mi) of subsea fiber optic cable during the open-water season, including a main trunk line and six branch lines to onshore facilities in Nome, Kotzebue, Point Hope, Wainwright, Barrow, and Oliktok Point. The biological opinion estimated takes (by harassment) of 475 bearded seals and 922 ringed seals as a result of exposure to sounds of received levels at or above 120 dB re 1 μPa_{rms} from sea plows, anchor handling, and operation and maintenance activities (NMFS 2016). Monitoring reports from the project indicated that 41 bearded and 50 ringed seals were taken by harassment.

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

5.11 Scientific Research

Research provides essential information on the life history, distribution, health, and abundance of threatened and endangered species. However, research activities can also harass and harm the animals. Research on marine mammals often requires boats, adding incrementally to the vessel traffic, noise, and pollution in the action area. NMFS issues scientific research permits that are valid for five years for ESA-listed species. When permits expire, researchers often apply for a new permit to continue their research. Additionally, applications for new permits are issued on an on-going basis; therefore, the number of active research permits is subject to change in the period during which this biological opinion is valid.

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

Pinnipeds

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

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

Table 6. Current NMFS scientific research and enhancement permits authorizing take of Beringia DPS beard seals and Arctic ringed seals.

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

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

5.12 Summary of Environmental Baseline

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

6 Effects of the Action

Effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

This biological opinion relies on the best scientific and commercial information available. We try to note areas of uncertainty, or situations where data is not available. In analyzing the effects of the action, NMFS gives the benefit of the doubt to the listed species by minimizing the likelihood of false negative conclusions (concluding that adverse effects are not likely when such effects are, in fact, likely to occur).

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

We conclude this section with an *Integration and Synthesis of Effects* that integrates information presented in the *Status of the Species* and *Environmental Baseline* sections of this opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

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

6.1 Project Stressors

Stressors are any physical, chemical, or biological phenomena that can induce an adverse response. Based on our review of the data available, the following proposed activities may cause stress, injury, or a behavioral response in bearded and/or ringed seals:

1. aerial and vessel based surveys
2. disturbance of non-target animals
3. acoustic playbacks
4. remote instrument deployment,
5. capture,
6. drug administration,
7. tagging and sampling
8. instrument attachment and/or burden
9. release

Although the proposed scientific research permit would be valid for five years through August 2027, the proposed ice seal research activities that are the subject of this consultation are part of an on-going research program ADFG has conducted since 2000. As part of our effects analysis, we assume that the ice seal research activities conducted by ADFG during the five-year permit will continue into the reasonably foreseeable future at levels similar to those described in this opinion.

6.1.1 Minor Stressors on ESA-Listed Species and Critical Habitat

The effects of the following minor stressors on ringed and bearded seals are expected to be too small to detect or measure and are not likely to significantly disrupt their normal behavioral patterns. The number of exposures to these minor stressors are shown in Table 9.

6.1.1.1 Surveys

Aerial and vessel-based surveys would be authorized under the proposed permit in order to assess the abundance and distribution of ringed and bearded seals. The use of fixed-wing aircraft and vessels could lead to disturbance of ice seals due to their reaction to either the noise or visual disturbance created by the planes or boats. We note that ADFG did not conduct any surveys during the last five year permit period. Consequently, the frequency of disturbance from aerial and vessel-based surveys is expected to be very low.

Aerial Surveys: OPR proposes the authorization of aerial surveys by ADFG to assess the abundance and distribution of bearded and ringed seals and to survey the density of breathing holes and ringed seal lair entrance holes on the sea ice. Flights in fixed-wing planes over seals at 200 m could cause seals that are hauled out to enter the water. Seals that remain on the ice may also display behaviors such as raising their head, extending their fore flippers, or movement across the ice indicating a response to the aircraft. In a comparison of seal reactions to the use of fixed-wing aircraft and helicopters, Born et al. (1999) found that 6 percent of seals escaped into the water in response to the presence of a low flying (150 m) fixed-wing aircraft as opposed to 49 percent when helicopters were used. Born et al. (1999) concluded that small fixed-wing aircraft needed to be at least 500 m from seals in order to reduce the risk of scaring the animals into the water and should not be flown directly overhead of the animals. Reactions depend on several factors including the animal's behavioral state, activity, group size, habitat, wind chill, wind direction, time of day and the flight pattern of the aircraft (Richardson et al. 1995; Born et al. 1999). Perry et al. (2002) found sex and age compositions of haul-out groups (for gray and harbor seals) are important factors in determining the degree of the reaction to aircraft, with mothers and pups more likely to react.

Juveniles and non-nursing adults spend at least 80 percent of their time in the water (Kelly et al. 1986) and so would be less likely to be affected by the aircraft. Similarly, bearded seal pups enter the water within hours after birth (Kovacs et al. 1996) and pups aged 4 to7 days spend over half their time in the water (Lydersen et al. 1994). Pups rest close to ice holes so they can escape into the water when disturbed. An animal may be harassed up to 3 times each year during survey activities for a maximum of 15 minutes each time.

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

The permit will require that aerial surveys be limited to no more than 15 minutes in the area of a group of seals, be flown at a minimum altitude of 200 m, not be conducted directly over seals, and if seals are seen escaping in response to the presence of the aircraft, the plane will leave the area.

Aerial surveys using unmanned aircraft systems provide a low cost alternative when compared to traditional manned aerial survey options. The low cost and ability to launch the platform from a research vessel or land provide can increase the potential area surveyed, reduce disturbance (Moreland et al. 2015), and can provide a means to understand habitat use and partitioning (Larsen et al. 2022). Moreland et al. (2015) found that 58 percent of spotted and ribbon seals had no response to their drone while only 12 percent of the seals had no response to a helicopter. Use of UASs for surveys is becoming more widespread and the altitude at which effects are minimal depends on many factors including species, individuals age, weather, size and type of drone, and altitude (Raoult et al. 2020). For this research the UAS will operate at or above 50 ft but may descend to no lower than 30 ft for photo identification of the seals. The clearest, most useful pictures are those in which the subject is not moving. We expect that every effort will be made to disturb the seals to the least extent possible.

Based on past reporting we expect that aerial surveys will be infrequently flown. If they are used, we expect that the use of a fixed-wing plane, the altitude restrictions, and the desire to disturb the seals as little as possible to get the best counts or the best pictures possible will result in minimal disturbance to the seals. If the seals react by raising their head, extending their foreflippers, or by entering the water, these actions are within the range of normal behavioral reactions and any impacts on individual ringed and bearded seals are expected to be too small to detect or measure.

Vessel-based surveys: OPR proposes the authorization of vessel surveys by ADFG to assess the abundance and distribution of bearded and ringed seals. According to information from ADFG, vessels used in the surveys will range from small boats to large commercial vessels. The use of vessels could lead to visual and auditory disturbance, and potentially, ship strikes

Vessel surveys will be conducted at speeds of 10 knots or less and there will be 100 percent observer coverage to look for seals during surveys. If seals enter the water or change their swimming patterns in response to the presence of a survey vessel, the permit requires that the survey vessel leave the area in order to minimize effects to ringed and bearded seals.

Seals that react to vessel disturbance may swim away if they are in the water. Ringed and bearded seals are commonly observed close to vessels (Harris et al. 2001; Blees et al. 2010). Survey vessels will not alter their course to approach seals. Researchers will count and photograph seals as the vessel passes by. If researchers notice seals swimming away in response to survey vessels, the permit will require that vessels leave the area. Given the slow vessel speed, all eyes on the water, and the maneuverability of the seals, vessel strike is highly unlikely.

Ringed seals on ice exhibited short-term escape reactions (temporarily entering the water) when a ship came within 0.25 to 0.5 km (Brueggeman et al. 1992). Less drastic responses to disturbances would be head lifting, extension of flippers, and movement of body. Juveniles and non-nursing adults spend at least 80 percent of their time in the water (Kelly et al. 1986), bearded seal pups enter the water within hours after birth (Kovacs et al. 1996), and pups aged 4 to7 days spend over half their time in the water (Lydersen et al. 1994). Alerting or entering the water is consistent with normal seal behavior, and effects on both bearded and ringed seals are expected to be too small to detect or measure.

6.1.1.2 Disturbance of non-targeted seals

During capture activities, seals in the vicinity of the capture event may be disturbed by the activities that are focused on a single individual. If on ice, these seals may enter the water, and if in the water, they may swim to a location farther away to observe. Although the permit indicates up to 500 bearded seals and 1,000 ringed seals could potentially be exposed to this activity each year (Table 9), the highest number of non-target seals that have been disturbed in one year associated with the capture activities is 45 ringed seals in 2015. Unlike other pinnipeds such as walrus, fur seals, and Steller sea lions that congregate in large numbers, ringed and bearded seals tend to be solitary or be in groups of just a few individuals. Consequently, we expect that the number of non-target seals that will be affected incidentally during any capture event will continue to be very low. Non-targeted seals are expected to be curious or vigilant but effects to them are expected to be very minimal and too small to detect.

6.1.1.3 Acoustic Playback

Playbacks of bearded seal vocalizations may be used to attract bearded seals so that they can be captured. These sounds are sounds normally heard by bearded seals, ringed seals, and other marine mammals in the environment and it is unlikely that any exposed marine mammals will be able to distinguish playbacks from actual bearded seal calls. Consequently, we do not expect any response beyond that which they would normally have. If such sound source levels were to disturb non-target marine mammals, we expect them to leave the area. Playbacks will be emitted at an amplitude of ≤158 dB re 1 μPa at 1 m or less, this amplitude was used in similar seal playback experiments (Hayes et al. 2004; Charrier et al. 2013). The maximum received levels of active acoustics will be below that which is expected to cause injury in all marine mammal species. The playbacks permitted for research will be played for two hours or less at a time. Although the purpose of the playbacks is to attract bearded seals, if the playbacks cause any animals to flee the device will be turned off immediately.

Because the playback sounds are consistent with sounds that are normally heard by bearded seals and other listed marine mammals in the Arctic, we expect that any response they create would be within the range of normal behavioral responses and would not have a measurable effect on bearded seals or other marine mammals that may hear the playback sounds.

Table 7. Potential exposures of bearded and ringed seals to minor stressors from the research activities.

Species	Exposures	Project Activity	Possible Impacts	Details
Seal, bearded	500	Photograph/Video; Remote video monitoring, acoustic playback	Potential behavioral response	Minor disturbance of non-target animals during deployment/retrieval of instruments cameras, or capture of target individuals
Seal, bearded	Unlimited	Tissues will be collected from an unlimited number of subsistence harvested animals. Import/Export activities may occur on tissues collected from both subsistence harvest and live capture activities.	None	Tissues will be collected from an unlimited number of subsistence harvested animals. Import/Export activities may occur on tissues collected from both subsistence harvest and live capture activities.
Seal, bearded	2500	Aerial (including UAS) and vessel surveys	Potential behavioral response	Minor disturbance of non-target animals during surveys
Seal, ringed	1000	Photograph/Video; Remote video monitoring, acoustic playback	Potential behavioral response	Minor disturbance of non-target animals during deployment/retrieval of instruments or cameras; capture of target individuals, or when locating seal lairs using trained wildlife-detection dogs and snow machines
Seal, ringed	Unlimited	Tissues will be collected from an unlimited number of subsistence harvested animals. Import/Export activities may occur on tissues collected from both subsistence harvest and live capture activities.	None	Tissues will be collected from an unlimited number of subsistence harvested animals. Import/Export activities may occur on tissues collected from both subsistence harvest and live capture activities.
Seal, ringed	2500	Aerial (including UAS) and vessel surveys	Potential behavioral response	Minor disturbance of non-target animals during surveys

6.1.1.4 Remote instrument deployment

Wildlife-detection dogs may be used to locate ringed seal lairs and breathing holes in the sea ice February–May and to determine winter density of ringed seals in areas used for oil and gas production. The dogs would be fully vaccinated so that transmission of disease to ringed seals is not a concern. The approach of snow machines and dogs to an occupied lair would likely cause a ringed seal to enter the water. If a ringed seal had a pup, the pup would also enter the water and both would likely go to an alternate lair. In a study of lairs at Kotzebue Sound and Ledyard Bay conducted in 1983 and 1984, which also used dogs to locate lairs, Hauser et al. (2021) found that 29 percent were pup lairs. This indicates that potentially about a third of the lairs that are discovered could be pup lairs if reproduction rates have remained the same. The reaction of the seals would be consistent with behavior escape from a predator (e.g. polar bear or fox). We expect that stress hormones would increase in all individuals for a short time as they fled the lair and moved to another but long term survival and fitness would not be affected.

The ADFG deployed eight game cameras (2 per study site) and four acoustic recorders in July of 2021, at three known spotted seal haul-outs (Oarlock Island in Dease Inlet, the Pisuq River Delta in Smith Bay, and Eluksingiak Point in Peard Bay) and a new potential site. No seals were present during gear deployment or when it was removed in late October of 2021, eliminating the potential for harassment. Although as noted, spotted seals haul out on land, it is very rare for ringed and bearded seals to haul out on terrestrial sites. For this reason we conclude that adverse effects to ringed and bearded seals from camera deployment are improbable.

6.1.2 Major Stressors on ESA-Listed Species and Critical Habitat

Several research activities could create stressors likely to adversely affect bearded and ringed seals including capture, use of non-lethal deterrents, administration of drugs, tagging and sampling, instrumentation, and animal release. As described below, we anticipate that exposures of ringed and bearded seals to these activities may result in increased stress hormones, increased energetic demand, inadvertent injury, or death.

6.2 Exposure Analysis

OPR developed the proposed take authorization of Arctic ringed seals and Beringia DPS bearded seals based on the permit application materials provided by the ADFG (ADFG 2022) (Table 10) and from information gathered from the prior permits issued to ADFG for similar work (No. 20466, 15324 and 358-1787). For this research both males and females from all life stages except unweaned pups and lactating females could be captured, handled, sampled, tagged, and released. Up to 100 bearded and ringed seals could be captured each year and up to five mortalities for each species may occur for a total take of 105 animals for each species each year of the permit. The exposures and resulting effects are discussed below.

Table 8. Annual take of bearded and ringed seals to ADFG research activities in Alaska.

Species	Authorized Take	Take Action	Procedures	Details
Seal, bearded	5	Unintentional mortality	Intentional (directed) mortality; Unintentional mortality	Unintentional mortalities during capture activities, NTE 25 seals in 5 years. Includes euthanasia, if warranted.
Seal, bearded	50	Capture; Sedate; Handle; Tag; Release	Administer drug, IM; Administer drug, IV; Administer drug, subcutaneous; Administer drug, topical; Anesthesia, injectable sedative; Collect, scat; Collect, urine; Instrument, external (e.g., VHF, SLTDR); Mark, flipper tag; Measure (standard morphometrics); Restrain, board; Restrain, hand; Restrain, net; Sample, blood; Sample, clip hair; Sample, skin biopsy; Sample, swab all mucus membranes; Ultrasound; Weigh	Remote dart-delivery of sedatives and/or non-lethal deterrents may be used. Unweaned pups and lactating females will not be captured, sampled, or tagged.
Seal, bearded	50	Capture/Handle / Release	Collect, scat; Collect, urine; Mark, flipper tag; Measure (standard morphometrics); Restrain, board; Restrain, hand; Restrain, net; Sample, blood; Sample, clip hair; Sample, skin biopsy; Sample, swab all mucus membranes; Ultrasound; Weigh	Non-lethal deterrents may be used. Unweaned pups and lactating females will not be captured. Up to two of these seals may be captured during beluga captures (Permit 24334).
Seal, ringed	5	Unintentional mortality	Intentional (directed) mortality; Unintentional mortality	Unintentional mortalities during capture activities, NTE 25 seals in 5 years. Includes euthanasia, if warranted.
Seal, ringed	50	Capture/Handle / Release	Administer drug, IM; Administer drug, IV; Administer drug, subcutaneous; Administer drug, topical; Collect, scat; Collect, urine; Instrument, external (e.g., VHF, SLTDR); Mark, flipper tag; Measure (standard morphometrics); Restrain, board; Restrain, hand; Restrain, net; Sample, blood; Sample, clip hair; Sample, skin biopsy; Sample, swab all mucus membranes; Ultrasound; Weigh	Non-lethal deterrents may be used. Lactating females and unweaned pups will not be captured.
Seal, ringed	50	Capture/Handle / Release	Collect, scat; Collect, urine; Mark, flipper tag; Measure (standard morphometrics); Restrain, board; Restrain, hand; Restrain, net; Sample, blood; Sample, clip hair; Sample, skin biopsy; Sample, swab all mucus membranes; Ultrasound; Weigh	Non-lethal deterrents may be used. Lactating females and unweaned pups will not be captured. Up to two of these seals may be captured during beluga captures (Permit 24334)

ADFG proposes the capture of up to 100 seals per species per year, or 500 seals of each species over the 5-year permit (Table 10). In addition, up to five unintentional mortalities for each species may occur. Although the permit allows capture of 100 seals per species per year, past reports from ADFG indicate that far fewer are typically captured. Since 2012, 10 or fewer bearded or ringed seals were captured in a year (Table 11). During the last two permit periods (ten years), two ringed seal mortalities have occurred, indicating that mortality during capture is a rare occurrence.

Table 9. Reported number of ringed and bearded seals captured under prior ADFG Permits (No. 15234 and 20466). Data not available for 2016.

Year	2012	2013	2014	2015	2017	2018	2019	2020
Ringed	2	3	7	2	2	5	0	1
Bearded	1	0	4	10	1	3	1	0

6.3 Response Analysis

Based on reports from prior years we expect few mortalities or long-term adverse effects as a result of the proposed activities on ringed and bearded seals. Short-term behavioral responses from disturbance, would be from sampling and tagging. In addition, the energetic costs (from tag attachments) that may result from research activities would not likely lead to disruption of essential behaviors such as feeding, mating, or nursing, to a degree that the individual's likelihood of successful reproduction or survival would be substantially reduced. Rarely, capture of pinnipeds and associated activities can result in serious injury and mortality. Thus far all mortalities have been associated with entanglement in nets. The sections below review the proposed activities and the corresponding effects on ringed and bearded seals.

6.3.1 Capture

As discussed in section 2.1.1.4, several possible capture methods may be used depending on location, species, and conditions encountered. Overall, capture and handling of the seals by any of the methods is expected to elicit an escape-avoidance response and a temporary increase in blood cortisol concentrations. Capture may lead to unintentional mortality, injury, and a stress response ranging from mild to severe. The most likely source of mortality is drowning in a net; however, the mitigation measures and research protocols are designed to minimize the probability of a seal drowning. Seals will suffer stress as a result of capture activities, including the use of non-lethal deterrents. Stress response results in the release of stress hormones, including epinephrine and cortisol. Acute stress, as might be experienced by capture, may result in hyperthermia where body temperatures rise to a level that can lead to muscle rigidity, brain damage, and even death. No studies of the capture stress response of ringed and bearded seals were found but the response to capture of other seal species has been reported. Harcourt et al. (2010) reported a prolonged elevation in cortisol in response to capture in Weddell seals that could be ameliorated by a small dose of diazepam. Handling does not affect the blood chemistry of southern elephant seal mothers and pups (Engelhard et al. 2002) or the survival of pups to one year (McMahon et al. 2005). In a more recent study on juvenile elephant seals that were being translocated, Cooley et al. (2022) found that although the animals exhibited mild physiological stress responses to handling activities in the short term, they recovered rapidly and showed no long-term deleterious effects. In grey seal pups, handling did not affect cortisol levels, thyroid hormone levels, or body mass (Bennett et al. 2012). Baker and Johanos (2002) did not find indicators that handling affected the survival, migration, or condition of 549 Hawaiian monk seals.

Escape attempts during capture could lead to injuries to seals including contusions, lacerations, abrasions, hematomas, concussions, and fractures. Such injuries would reduce seal fitness if not noticed and treated. Injuries of this type would be noticed by researchers and would lead to injured seals being held for treatment rather than released. ADFG did not report any of these types of injuries as a result of capture activities from 2012 through 2021 under permits to do the same work as proposed here. Such injuries would be covered by the number of takes associated with capture activities.

6.3.2 Use and Administration of Drugs

The researchers propose the use of darts carrying drugs to capture bearded seals on the ice. This activity was proposed under the previous permit but no attempts to use this capture technique were successful. A qualified veterinarian would perform any dart-injections of sedatives used to capture large bearded seals. The drug combination proposed for this (midazolam and butorphanol) does not override the dive reflex that prevents marine mammals from inhaling while submerged. Thus, if a seal were to enter the water after being darted, it would not inhale underwater, which would minimize chances of a darted animal drowning. If a darted seal enters the water, researchers would deploy a net to capture the seal or administer a reversal agent again using a dart if they could not reach the animal. Potential complications from the proposed drugs include apnea, bradycardia, hyperthermia, and hypothermia (Baylis et al. 2015). If complications arise, a veterinarian would administer naltrexone, doxapram, and/or epinephrine. While this procedure has not been used on bearded seals and the sedatives proposed for darting are different than those used on captured animals, the drug combination has been used successfully on other seal species. Similarly, the drugs proposed to counter any adverse reaction to the sedatives have been used successfully on other pinnipeds.

The use of drugs is also proposed to sedate ringed and bearded seals during capture and restraint if the animal is aggressive or agitated. However, ADFG indicated that drugs are typically not used during capture and handling (ADFG 2022). The use of drugs is proposed in up to 50 individuals of each species. Seals that are sedated are given reversal agents and their reactions are tested prior to any release of the animal to minimize the potential for drowning or other effects of sedation. ADFG has not reported any mortalities as a consequence of sedating ringed and bearded seals.

6.3.3 Tagging and Sampling

OPR proposes the authorization of biological sampling including the collection of tissue, blood, whiskers, blubber, muscle, hair, and oral, nasal, and urogenital samples from each seal captured by researchers. As noted previously, no females with dependent pups, pups, or neonates will be captured and sampled as part of the proposed research activities. Potential stressors from this sampling include discomfort, pain, infection, and injury. Researchers will also measure, weigh, and ultrasound captured seals in order to track health parameters, which may cause discomfort and stress response in seals. Finally, captured seals will receive tags to enable researchers to assess the abundance and distribution of ringed and bearded seals based on future capture in research surveys or during legal harvest. Potential stressors from the placement of plastic tags on the rear flippers of captured seals include pain and infection. In order to reduce stressors, the researchers will minimize restraint during weighing, measuring, and sample collection and retain captured seals for no more than 120 minutes.

Potential responses to sampling and tagging include no response, behavioral reactions to pain (in the case of invasive sampling and tagging), an immune response at the sample collection or tagging site, and tissue damage if tagging tears the flipper. No reports of infection as a result of sampling and tagging were found and ADFG researchers reported that hunters who captured sampled and tagged seals informed them that the seals were healthy.

In terms of whisker collection, the loss of a single whisker for sampling purposes will be not be distinguishable from normal whisker loss. Measurement, weighing, and ultrasound are commonly used to assess the condition of captured seals. These activities are not expected to result in adverse effects beyond discomfort from being restrained by a researcher or in a net.

6.3.4 Instrumentation

OPR proposes the authorization of the use of on-board instruments on bearded and ringed seals. No animal will be fitted with more than two glue-on transmitters, one temporary recording instrument, and one flipper transmitter for a total of four instruments. Most seals will receive one glue-on transmitter and one flipper-mounted transmitter. Seals may experience skin irritation due to the use of epoxy to secure some of the instruments. McCafferty et al. (2007) found localized heat increases around instruments placed on grey seals as the animals dried out apparently due to heat leakage around the sides of the instruments and mounting straps. McCafferty et al. (2007) concluded that these localized heat increases did not significantly change the total heat exchange of grey seals on land and no temperature effects were observed when seals were wet.

Flipper instruments are placed on a flipper using two biopsy plugs to create holes through which fasteners are placed. Thus, the placement of flipper instruments is similar to tagging with similar potential effects to seals. Potential responses to the placement of flipper instruments include no response, behavioral reactions to pain, an immune response at the installation site, and tissue damage if the flipper is torn (for instance if the instrument becomes entangled in something and the animals struggles to free itself). Regions of elevated temperature at sites of needle injection and biopsies were observed by McCafferty et al. (2007) associated with an immune response, but these hot spots around the sample site were temporary. Paterson et al. (2011) used infrared thermography to monitor the healing process after attachment of flipper tags to grey seals and reported small increases in surface temperatures and swelling that lasted less than 24 days. There was little evidence of tagging-related infections or tag loss irrespective of age at tagging.

Instrumentation could lead to entanglement of animals potentially resulting in drowning and complications due to drag caused by instruments that could affect foraging time and success and ability to escape predators. In a controlled setting, using two captive fur seals (*Callorhinus ursinus*), Rosen et al. (2018) found that using tags that were less than 1 percent of the seal’s body mass, diving metabolic rate increased an average of 8.1 to12.3 percent (depending on tag type) and swim speed decreased an average of 3.0 to 6.0 percent when wearing the tags. These results were consistent with those found by Boyd et al. (1997) examining the energetic cost of a tag to lactating Antarctic fur seals (*Arctocephalus gazella*) in the wild. However, Boyd et al. (1997) concluded that although the time taken to return to the pup was significantly longer in the treatment group, there was no difference in the rate of delivery of energy (measured from pup growth rate) to the pups in each group. Because the mothers in the treatment group did not use significantly more body reserves, they concluded that behavioral adjustments at the scale of individual dives allowed mothers in the treatment group to compensate for the additional foraging costs (Boyd et al. 1997).

Crittercams® are much larger than the flipper or glue on satellite tags. They are approximately 30 by 8 by 8 cm and 1,000 grams (g) in air but, are close to neutrally buoyant in water. For this research the cameras would only remain on the animals for up to 24 hours before being released and recovered. Researchers using earlier, larger models (2,000 g) on Hawaiian monk seals and male harbor seals concluded that the cameras did not appear to significantly affect seal behavior (Parrish et al. 2000; Bowen et al. 2002; Littnan et al. 2004). The similar depths and durations of dives seen in both the satellite tag and Crittercams® studies supported the conclusion that the camera equipment did not substantially affect the foraging behavior of the seals (Parrish et al. 2000). The limited Crittercam deployment time proposed for this research would minimize any energetic costs or changes in behavior in the seals.

6.3.5 Release

As discussed previously, ADFG researchers propose the capture of up to 100 ringed and bearded seals annually over the five-year permit period. Attempts to escape during release could inadvertently result in injuries to seals including contusions, lacerations, abrasions, hematomas, concussions, and fractures. However, injuries to ringed and bearded seals during tagging and upon release have not been recorded. In all cases thus far, the seals have been tagged without unexpected injury, re-entered the ocean, and swam away.

7 Cumulative Effects

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

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

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 increased 128 percent 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 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.

Although the proposed scientific research permit would be valid for five years through August 2027, the proposed ice seal research activities that are the subject of this consultation are part of an on-going research program ADFG has conducted since 2000. As part of our analysis, we assume that the ice seal research activities conducted by ADFG during the five-year permit will continue into the reasonably foreseeable future at levels similar to those described in this opinion.

We assume that existing regulations or similar regulatory requirements will apply over the life of the ADFG's permit from August 15, 2022 to August 14, 2027. Regulatory changes may require reinitiation of consultation per 50 CFR 402.16. In addition, we assume that all required mitigation measures will be implemented, and any failure to implement mitigation measures would represent a change to the action which may require reinitiation per 50 CFR 402.16.

The Arctic ringed seal and Beringia DPS bearded seal were listed as threatened under the ESA because the species are at risk of becoming endangered in the future due to change in sea ice resulting from climate change. Both species have large population sizes, although reliable abundance estimates and population trends are not available. The species both appear to be resilient to perturbations including oil and gas exploration, shipping and transportation, subsistence hunting, fisheries interactions, pollution, and scientific research, as well as to unexplained events such as the UME.

The collection of samples from subsistence-harvested seals will not adversely affect any seal because the animals sampled will have been killed by hunters. Other activities that will be conducted under the proposed permit, including sampling and tagging, on-board instrumentation, and release, are likely to have adverse effects on individual animals and may have a short term energetic cost. Aerial and vessel surveys may cause a behavioral response to the noise or visual disturbance generated by fixed-wing aircraft, UAS, or vessels, but the overall effects of survey work to ringed and bearded seals are expected to be too small to measure or detect.

As discussed in sections 6.3.1 through 6.3.5 seals will suffer stress as a result of capture activities. Chronic stress can impair the functionality of the immune and reproductive systems. Acute stress may result in hyperthermia, but this has not been observed by the researchers. No studies of the capture stress response of ringed and bearded seals are available. However, based on studies of the response to capture of other seal species, it does not appear that capture of seals results in long-term health risks. Transmission of data from tagged ringed and bearded seals for a mean time of 492 days and up to 694 days (ADFG 2022) indicates that although seals may be stressed at the time of capture they can resume normal activities. Although up to 100 individuals of each species could be stressed by capture activities each year, based on reports from the last 10 years it is highly unlikely that that many animals will be captured. We do not have evidence from the reports that have been submitted for this research or from similar research activities on ringed and bearded seals in Arctic that there are long term negative effects on individuals.

The capture of seals and use of drugs is likely to adversely affect seals and may result in the death of up to five individuals of each species per year over the 5-year permit as a result of drowning during capture activities (in nets, traps, or due to remote administration of a sedative using darts) or due to an adverse reaction to the administration of drugs. The mortality of up to 5 individuals of each species will result in a reduction in numbers of each species. As discussed previously, females with dependent pups and pups will not be targeted for capture. Animals that will be targeted for capture include males and females of each species that may be sexually mature. The loss of up to five individuals of each species that may be sexually mature would represent a loss of reproduction at an individual level.

With the exceptions of capture, including the use of darts to deliver a sedative to try and capture bearded seals on the ice, and the use of drugs, the proposed activities are not likely to reduce the fitness of any seals. Capture and the use of drugs could result in the annual mortality of up to five seals of each species as a result of drowning in a net or trap, drowning due to escape to the water following dart-delivered sedation, or complications from the use of drugs. Despite these potential mortalities, the activities proposed under this permit are not expected to have population of species-level effects. Only capture and the use of drugs are considered further in this risk analysis.

Unintentional mortality is not common. Under the previous permit (No. 20466, 2017 to present) there was one mortality of a spotted seal that got caught in a net. From 2012-2015 (No. 15324), there was also one mortality as a result of a ringed seal drowning in a net. Prior to 2012, a permit (No. 358-1787) to capture ice seals using the same methods, did not result in any mortalities of ringed or bearded seals in 2006 or 2008 (data were not available for 2007 or 2009-2011). Because the OPR proposes the authorization of five unintentional mortalities annually for each species as a result of the proposed activities, we consider the effects of these deaths on the species. We use the 2021 Stock Assessment Report ((Muto et al. 2021) for each species to evaluate the effects of five mortalities annually over the five-year permit period on Arctic ringed and Beringia DPS bearded seals.

Due to insufficient data, population trends for the Arctic subspecies of ringed seal cannot be calculated. Normally, the abundance estimate along with other parameters would be used to calculate potential biological removal levels. However, a minimum population estimate (NMIN) for the entire stock of ringed seals cannot be determined because current reliable estimates of abundance are not available for the Chukchi and Beaufort seas (Muto et al. 2021). For 2012, Conn et al. (2014) provided an abundance estimate of 171,418 that can be considered an NMIN for only the U.S. sector of the Bering Sea ringed seal population. Muto et al. (2021) used the NMIN for ringed seals in the U.S. sector of the Bering Sea to calculate a potential biological removal rate of 4,755 animals, although a similar calculation cannot be made for the entire stock because an estimate of NMIN is not available.

In terms of the potential impact of five unintentional mortalities of ringed seals as a result of the proposed research activities on population viability, we consider the population effects in the context of total annual anthropogenic mortality. The minimum estimated mean annual level of human-caused mortality and serious injury for the portion of the Arctic ringed seal stock in U.S. waters between 2014 and 2018 was 6,459 seals: 5 in U.S. commercial fisheries, 6,454 in the Alaska Native subsistence harvest (average statewide harvest, including struck and lost animals), 0.2 in marine debris, and 0.2 incidental to MMPA authorized research. Five unintentional mortalities per year will not result in a significant increase in total annual mortality. This level of take associated with ongoing research activities that are reasonably foreseeable beyond the five year permit also will not result in a significant increase in total annual mortality Therefore, we conclude that the loss of up to five individuals annually would not have any appreciable effect on the population and is not likely to reduce the population viability of the Arctic ringed seal.

In the status review for bearded seals, Cameron et al. (2010) estimated that the population of the Beringia DPS was 155,000 animals. Thus, five mortalities per year over a 5-year period represents an annual loss of approximately 0.003 percent of the Beringia DPS bearded seal population. Because of the challenges in surveying, the population estimate for bearded seals is considered to be an underestimate (Allen and Angliss 2013), which means the annual loss would be an even smaller percentage of the total population and overall population viability. A minimum population estimate (NMIN) for the entire stock of bearded seals cannot be determined but research programs have recently developed new survey methods and partial abundance estimates (Muto et al. 2021). 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 301,836 bearded seals of the Bering Sea bearded seal population. Muto et al. (2021) used the 2012 Bering Sea abundance estimate to calculate an NMIN of 273,676 bearded seals in the U.S. sector of the Bering Sea. Using this NMIN, a potential biological removal rate of 8,210 animals was calculated, although a similar calculation cannot be made for the entire stock because an estimate of NMIN is not available (Muto et al. 2021).

In terms of the potential impact of five unintentional mortalities of bearded seals as a result of the proposed research activities on population viability, we consider the population effects in the context of total annual anthropogenic mortality. The minimum estimated mean annual level of human-caused mortality and serious injury for the portion of the Beringia bearded seal stock in U.S. waters between 2014 and 2018 was 6,709 seals: 1.8 in U.S. commercial fisheries, 6,707 in the Alaska Native subsistence harvest (average statewide harvest, including struck and lost animals, in 2015), and 0.4 due to MMPA authorized research-related permanent removals from the population. Adding up to five unintentional mortalities per year will not result in a significant increase in total annual mortality. Therefore, we conclude that the loss of up to five individuals annually would not have any appreciable effect on the population and is not likely to reduce the population viability of the bearded seal (Beringia DPS).

The proposed action will not affect the species' current geographic range or the geographic range of their DPSs. Despite the lack of adequate population estimates for each species, the loss of up to five individuals annually is not expected to exceed 0.0005 and 0.003 percent of the total abundance of ringed and bearded seals, respectively.

Future state or private actions are likely to continue and some potentially to increase in the action area, especially those related to increased shipping as sea ice continues to decline.

Considering the status of Arctic ringed and the Beringia DPS bearded seals, the environmental baseline, the effects of the action, and cumulative effects, we do not expect the proposed research activities to result in a significant reduction in numbers or reproduction of ringed and bearded seals or a change in the distribution of either species. Any reductions would not 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). Therefore, we expect that the proposed action will not appreciably reduce the likelihood of both survival and recovery of these species in the wild. We have determined that the anticipated level of authorized mortality (up to five individuals of each species annually) of ringed and bearded seals is not likely to jeopardize the continued existence of the Arctic ringed seal or the Beringia DPS bearded seal.

As discussed in Section 4.1, we concluded that the proposed activities may affect but is not likely to adversely affect Western North Pacific DPS humpback whale, Mexico DPS humpback whale, fin whales, Western DPS gray whales, North Pacific right whales, and bowhead whales. We came to this conclusion because it is unlikely that they will present in the proposed action area, the implementation of protective mitigation measures, and the limited spatial and temporal extent of the research.

In conclusion, because the proposed action is not likely to have an appreciable effect on population size of either species and likewise is not likely to reduce the population viability of Arctic ringed seals or Beringia DPS bearded seals, we conclude that the proposed action is not likely to reduce the viability of these species.

9 Conclusion

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of Arctic ringed seals or Beringia DPS bearded seals.

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).

All research activities associated with the issuance of Permit No. 26254 involve directed take for the purposes of scientific research. We do not expect the proposed action will incidentally take other threatened or endangered species.

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).

- Researchers should thoroughly document the time spent surveying ice seals using fixed-wing aircraft and UASs and the responses of all animals during these survey activities in order to assess stress responses and develop measures to further minimize them in coordination with the Permits Division. Details such as model numbers, type of craft, and altitude flown should be included.
- Researchers should thoroughly document the time spent surveying ice seals using vessels and document the responses of animals during the survey. Vessel type, number of observers in the vessel, vessel size used should be included.
- Researchers should thoroughly document the time spent in all attempted capture and release activities and the responses of target and non-target animals to these activities in order to assess stress responses on the part of these animals and develop measures to further minimize the stress responses of captured animals and animals that are incidentally harassed as a result of capture and release activities.
- Researchers should thoroughly document the behavioral reactions to all sampling and tagging activities in order to determine whether additional measures to further minimize stress and potential physical and biological impacts such as injury and immune responses to sampling and tagging.
- Researchers should submit this information to the Permits Division and AKR as part of their required annual reporting.
- The Permits Division should post this information on their Authorizations and Permits for Protected Species online database (https://apps.nmfs.noaa.gov/) including all attachments detailing the results.

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, ADFG and OPR should notify NMFS of any conservation recommendations implemented.

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 ADFG, 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.

ADFG. 2022. Population Status, Health, Movements, and Habitat Use of Ringed, Bearded, Spotted, and Ribbon Seals in the Bering, Chukchi, and Beaufort Seas, Alaska.

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.

Baker, J. D., and T. C. Johanos. 2002. Effects of research handling on the endangered Hawaiian monk seal. Marine Mammal Science 18(2):500-512.

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.

Baylis, A. M., B. Page, I. Staniland, J. P. Arnould, and J. McKenzie. 2015. Taking the sting out of darting: Risks, restraint drugs and procedures for the chemical restraint of Southern Hemisphere otariids. Marine Mammal Science 31(1):322-344.

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

Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biology 28(11):833-845.

Bennett, K. A., S. E. Moss, P. Pomeroy, J. R. Speakman, and M. A. Fedak. 2012. Effects of handling regime and sex on changes in cortisol, thyroid hormones and body mass in fasting grey seal pups. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 161(1):69-76.

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.

Blees, M., K. Hartin, D. Ireland, and D. Hannay. 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2010: 90-day report. LGL Rep. P 1119:102.

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

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

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

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

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

Born, E. W., F. F. Riget, R. Dietz, and D. Andriashek. 1999. Escape responses of hauled out ringed seals (Phoca hispida) to aircraft disturbance. Polar Biology 21(3):171-178.

Boveng, P. L., M. Cameron, P. B. Conn, and E. Moreland. 2017. Abundance Estimates of Ice-Associated Seals: Bering Sea Populations that Inhabit the Chukchi Sea During the Open-Water Period, Final Report. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Anchorage, AK. Report prepared by NMFS Marine Mammal Laboratory for BOEM, BOEM Report 2016-077, 119 p. plus appendices.

Bowen, W., D. Tully, D. J. Boness, B. Bulheier, and G. Marshall. 2002. Prey-dependent foraging tactics and prey profitability in a marine mammal. Marine Ecology Progress Series 244:235-245.

Boyd, I., D. McCafferty, and T. Walker. 1997. Variation in foraging effort by lactating Antarctic fur seals: response to simulated increased foraging costs. Behavioral Ecology and Sociobiology 40(3):135-144.

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

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. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Pittman-Robertson Project Report W-6-R and W-14-R, Juneau, AK, 66 p.

Burns, J. J. 1981. Bearded seal *Erignatus barbatus* Erxleben, 1777. Handbook of Marine Mammals Volume 2: Seals:145-170.

Burns, J. J., and T. J. J. Eley. 1976. The natural history and ecology of the bearded seal (*Erignathus barbatus*) and the ringed seal (*Phoca (Pusa) hispida*). Pages 263-294 *in* Environmental Assessment of the Alaskan Continental Shelf. Principal Investigators' Reports for the Year Ending March 1976, volume 1-Marine Mammals, U.S. Department of Commerce, NOAA, Boulder, CO.

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

Burns, J. J., and S. J. Harbo. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4):279-290.

Burns, J. J., B. P. Kelly, L. D. Aumiller, K. J. Frost, and S. Hills. 1982. Studies of ringed seals in the Alaskan Beaufort Sea during winter: impacts of seismic exploration, Fairbanks, AK, 31 December 1982. Annual Report for Contract No: NA 81 RAC 00045, NOAA Project No. RU #232, 57 p.

Calvert, W., and I. Stirling. 1985. Winter distribution of ringed seals (Phoca hispida) in the Barrow Strait area, Northwest Territories, determined by underwater vocalizations. Canadian Journal of Fisheries and Aquatic Sciences 42(7):1238-1243.

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

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

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

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

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.

Charrier, I., N. Mathevon, and T. Aubin. 2013. Bearded seal males perceive geographic variation in their trills. Behavioral Ecology and Sociobiology 67(10):1679-1689.

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., 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.

Cleator, H. J., and I. Stirling. 1990. Winter distribution of bearded seals (*Erignathus barbatus*) in the Penny Strait area, Northwest Territories, as determined by underwater vocalizations. Canadian Journal of Fisheries and Aquatic Sciences 47(6):1071-1076.

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

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

Cooley, L. A., D. P. Costa, S. M. Hannah, A. G. Hindle, R. R. Holser, M. Horning, H. Klinck, P. J. Ponganis, C. L. Williams, and B. I. McDonald. 2022. Research Handling Effects on Stress Hormones, Blood Parameters, and Heart Rate in Juvenile Northern Elephant Seals (Mirounga angustirostris). FASEB Journal: Official Publication of the Federation of American Societies for Experimental Biology 36.

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.

DeGrandpre, M., W. Evans, M.-L. Timmermans, R. Krishfield, B. Williams, and M. Steele.

2020. Changes in the Arctic Ocean Carbon Cycle With Diminishing Ice Cover. Geophysical Research Letters 47(12):e2020GL088051.

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

Dehnhardt, G., B. Mauck, and H. Bleckmann. 1998. Seal whiskers detect water movements. Nature 394(6690):235-236.

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

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

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

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

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

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

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

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

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

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.

Engelhard, G., S. Brasseur, A. Hall, H. Burton, and P. Reijnders. 2002. Adrenocortical responsiveness in southern elephant seal mothers and pups during lactation and the effect of scientific handling. Journal of Comparative Physiology B 172(4):315-328.

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.
Fabry, V. J., J. B. McClintock, J. T. Mathis, and J. M. Grebmeier. 2009. Ocean acidification at high latitudes: the Bellweather. Oceanography 22(4):160-171.
Fabry, V. J., B. A. Seibel, R. A. Feely, and J. C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science 65:414-432.
Fang, C., R. Zheng, F. Hong, Y. Jiang, J. Chen, H. Lin, L. Lin, R. Lei, C. Bailey, and J. Bo. 2021. Microplastics in three typical benthic species from the Arctic: Occurrence, characteristics, sources, and environmental implications. Environmental Research 192:110326.
Fang, C., R. Zheng, Y. Zhang, F. Hong, J. Mu, M. Chen, P. Song, L. Lin, H. Lin, and F. Le. 2018. Microplastic contamination in benthic organisms from the Arctic and sub-Arctic regions. Chemosphere 209:298-306.
Fay, F. H., J. L. Sease, and R. L. Merrick. 1990. Predation on a ringed seal, *Phoca hispida*, and a black guillemot, *Cepphus grylle*, by a Pacific walrus, *Odobenus rosmarus divergens*. Marine Mammal Science 6(4):348-350.
Fedewa, E. J., T. M. Jackson, J. I. Richar, J. L. Gardner, and M. A. Litzow. 2020. Recent shifts in northern Bering Sea snow crab (Chionoecetes opilio) size structure and the potential role of climate-mediated range contraction. Deep Sea Research Part II: Topical Studies in Oceanography:104878.
Fedoseev, G. A. 1965. The ecology of the reproduction of seals on the northern part of the Sea of Okhotsk. Izvestiya TINRO 65:212-216.
Fedoseev, G. A. 1984. Population structure, current status, and perspective for utilization of the ice-inhabiting forms of pinnipeds in the northern part of the Pacific Ocean. Pages 130-146 *in* A. V. Yablokov, editor. Marine mammals. Nauka, Moscow.
Feely, R. A., S. C. Doney, and S. R. Cooley. 2009. Ocean acidification: present conditions and future changes in a high-CO_2 world. Oceanography 22(4):37-47.
Feely, R. A., C. L. Sabine, K. Lee, W. Berelson, J. Kleypas, V. J. Fabry, and F. J. Millero. 2004. Impact of anthropogenic CO2 on the CaCO3 system in the oceans. Science 305(5682):362-366.
Feltz, E. T., and F. H. Fay. 1966. Thermal requirements in vitro of epidermal cells from seals. Cryobiology 3(3):261-264.
Fey, S. B., A. M. Siepielski, S. Nusslé, K. Cervantes-Yoshida, J. L. Hwan, E. R. Huber, M. J. Fey, A. Catenazzi, and S. M. Carlson. 2015. Recent shifts in the occurrence, cause, and magnitude of animal mass mortality events. Proceedings of the National Academy of Sciences 112(4):1083-1088.
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.
Freitas, C., K. M. Kovacs, R. A. Ims, M. A. Fedak, and C. Lydersen. 2008. Ringed seal post-moulting movement tactics and habitat selection. Oecologia 155(1):193-204.
Frölicher, T. L., E. M. Fischer, and N. Gruber. 2018. Marine heatwaves under global warming. Nature 560(7718):360-364.
Frost, K. J. 1985. The ringed seal (Phoca hispida). Pages 79-87 *in* J. J. Burns, K. J. Frost, and L. F. Lowry, editors. Marine Mammal Species Accounts. Alaska Department of Fish and Game, Juneau, AK.
Frost, K. J., and L. F. Lowry. 1981. Ringed, Baikal and Caspian seals. Handbook of marine

mammals 2:29-54.
Frost, K. J., and L. F. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea. P. W. Barnes, D. M. Schell, and E. Reimnitz, editors. The Alaskan Beaufort Sea: Ecosystems and Environments. Academic Press, Inc., New York, NY.
Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. Arctic 57(2):115-128.
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.
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.
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.
Gjertz, I., K. Kovacs, C. Lydersen, and Ø. Wiig. 2000. Movements and diving of bearded seal (*Erignathus barbatus*) mothers and pups during lactation and post-weaning. Polar Biology 23(8):559-566.
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., 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.

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.

Harcourt, R. G., E. Turner, A. Hall, J. R. Waas, and M. Hindell. 2010. Effects of capture stress on free-ranging, reproductively active male Weddell seals. Journal of Comparative Physiology A 196(2):147-154.

Harris, R. E., G. W. Miller, and W. J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4):795-812.

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.

Hauser, D. D., K. J. Frost, and J. J. Burns. 2021. Ringed seal (Pusa hispida) breeding habitat on the landfast ice in northwest Alaska during spring 1983 and 1984. PloS one 16(11):e0260644.

Hayes, S. A., D. P. Costa, J. T. Harvey, and B. J. le Boeuf. 2004. Aquatic mating strategies of the male Pacific harbor seal (Phoca vitulina richardii): Are males defending the hotspot? Marine Mammal Science 20(3):639-656.

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.

Hendrix, A. M., K. A. Lefebvre, L. Quakenbush, A. Bryan, R. Stimmelmayr, G. Sheffield, G. Wisswaesser, M. L. Willis, E. K. Bowers, and P. Kendrick. 2021. Ice seals as sentinels for algal toxin presence in the Pacific Arctic and subarctic marine ecosystems. Marine Mammal Science 37(4):1292-1308.

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.

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.

Hjelset, A., M. Andersen, I. Gjertz, C. Lydersen, and B. Gulliksen. 1999. Feeding habits of bearded seals (*Erignathus barbatus*) from the Svalbard area, Norway. Polar Biology 21(3):186-193.

Holst, M., I. Stirling, and K. A. Hobson. 2001. Diet of ringed seals (Phoca hispida) on the east and west sides of the North Water Polynya, northern Baffin Bay. Marine Mammal Science 17(4):888-908.

Holsvik, R. 1998. Maternal behaviour and early behavioural ontogeny of bearded seals (*Erignathus barbatus*) from Svalbard, Norway. Masters Thesis. Norwegian University of Science and Technology, Trondheim, Norway, 36.

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

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

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

ICCT. 2015. A 10-year projection of maritime activtiy in the U.S. Arctic Region. Contracted and coordinated under the U.S. Committee of the Marine Transportation System. Prepared by the International Council on Clean Transportation (ICCT), Washington, DC., January 1, 2015. Contract No. DTMA91P140125, 73 p.

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

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

IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 151 p.

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

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

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

Jansen, J. K., P. L. Boveng, S. P. Dahle, and J. L. Bengtson. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74(6):1186-1194.

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.

Kelly, B. P. 1988a. Bearded seal, *Erignathus barbatus*. Pages 77-94 *in* J. W. Lentfer, editor. Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, D.C.

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

Kelly, B. P., O. H. Badajos, M. Kunnasranta, J. R. Moran, M. Martinez-Bakker, D. Wartzok, and P. Boveng. 2010a. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology 33(8):1095-1109.

Kelly, B. P., J. L. Bengtson, P. L. Boveng, M. F. Cameron, S. P. Dahle, J. K. Jansen, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010b. Status review of the ringed seal (*Phoca hispida*). U.S. Dept. of Commerce, NOAA, NMFS, Alaska Fisheries Science Center, December 2010. NOAA Tech. Memo. NMFS-AFSC-212, 250 p.

Kelly, B. P., 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.

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.

Kovacs, K. M., C. Lydersen, and I. Gjertz. 1996. Birth-site characteristics and prenatal molting in bearded seals (Erignathus barbatus). Journal of Mammalogy 77(4):1085-1091.

Krafft, B. A., C. Lydersen, K. M. Kovacs, I. Gjertz, and T. Haug. 2000. Diving behaviour of lactating bearded seals (Erignathus barbatus) in the Svalbard area. Canadian Journal of Zoology 78(8):1408-1418.

La Daana, K. K., K. Gardfeldt, T. Krumpen, R. C. Thompson, and I. O'Connor. 2020. Microplastics in sea ice and seawater beneath ice floes from the Arctic Ocean. Scientific Reports 10(1):1-11.

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

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

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

Larsen, G. D., A. C. Seymour, E. L. Richmond, L. M. Divine, E. E. Moreland, E. Newton, J. M. London, and D. W. Johnston. 2022. Drones reveal spatial patterning of sympatric Alaskan pinniped species and drivers of their local distributions. Drone Systems and Applications 10(1):235-255.

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

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

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

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

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.

Littnan, C. L., J. D. Baker, F. A. Parrish, and G. J. Marshall. 2004. Effects of video camera attachment on the foraging behavior of immature Hawaiian monk seals. Marine Mammal Science 20(2):345-352.

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

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

Lowry, L. F., K. J. Frost, and J. J. Burns. 1980. Variability in the diet of ringed seals, Phoca hispida, in Alaska. Canadian Journal of Fisheries and Aquatic Sciences 37(12):2254-2261.

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., M. O. Hammill, and K. M. Kovacs. 1994. Diving activity in nursing bearded seal (Erignathus barbatus) pups. Canadian Journal of Zoology 72(1):96-103.

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

Lydersen, C., and K. M. Kovacs. 1999. Behaviour and energetics of ice-breeding, North Atlantic phocid seals during the lactation period. Marine Ecology Progress Series 187:265-281.

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

Lydersen, C., and T. G. Smith. 1989. Avian predation on ringed seal *Phoca hispida* pups. Polar Biology 9(8):489-490.

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

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

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

Macleod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. Endangered Species Research 7(2):125-136.

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

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

Marshall, C. D., H. Amin, K. M. Kovacs, and C. Lydersen. 2006. Microstructure and innervation of the mystacial vibrissal follicle-sinus complex in bearded seals, *Erignathus barbatus* (Pinnipedia: Phocidae). The Anatomical Record Part A: Discoveries in Molecular, Cellular, and Evolutionary Biology 288(1):13-25.

Marshall, C. D., K. M. Kovacs, and C. Lydersen. 2008. Feeding kinematics, suction and hydraulic jetting capabilities in bearded seals (*Erignathus barbatus*). Journal of Experimental Biology 211(5):699-708.

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.

McCafferty, D. J., J. Currie, and C. E. Sparling. 2007. The effect of instrument attachment on the surface temperature of juvenile grey seals (Halichoerus grypus) as measured by infrared thermography. Deep Sea Research Part II: Topical Studies in Oceanography 54(3-4):424-436.

McMahon, C. R., M. N. Bester, H. R. Burton, M. A. Hindell, and C. J. Bradshaw. 2005. Population status, trends and a re-examination of the hypotheses explaining the recent declines of the southern elephant seal Mirounga leonina. Mammal Review 35(1):82-100.

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.

Moreland, E. E., M. F. Cameron, R. P. Angliss, and P. L. Boveng. 2015. Evaluation of a ship-based unoccupied aircraft system (UAS) for surveys of spotted and ribbon seals in the Bering Sea pack ice. Journal of Unmanned Vehicle Systems 3(3):114-122.

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

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

Muto, M. M., V. T. Helker, B. J. Delean, 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.

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

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

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

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

NMFS. 2016. Endangered Species Act Section 7(a)(2) Biological Opinion Quintillion Subsea Operations, LLC, Proposed Subsea Fiber Optic Cable-laying Activities and Associated Proposed Issuance of an Incidental Harassment Authorization in the Bering, Chukchi, and Beaufort Seas, Alaska. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, NMFS Alaska Region, Juneau, Alaska, October 4, 2016. NMFS Consultation Number AKR-2016-9590, 99 p.

NMFS. 2018. 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. 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.

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

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

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

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

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

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.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier. 2000. Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. Marine Mammal Science 16(2):392-412.

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.

Paterson, W., P. Pomeroy, C. Sparling, S. Moss, D. Thompson, J. Currie, and D. McCafferty. 2011. Assessment of flipper tag site healing in gray seal pups using thermography. Marine Mammal Science 27(2):295-305.

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.

Perry, E. A., D. J. Boness, and S. J. Insley. 2002. Effects of sonic booms on breeding gray seals and harbor seals on Sable Island, Canada. The Journal of the Acoustical Society of America 111(1):599-609.

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

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

Quakenbush, L., J. Citta, and J. Crawford. 2011a. Biology of the bearded seal (*Erignathus barbatus*) in Alaska, 1961–2009. Final report from Alaska Dept. of Fish and Game Arctic Marine Mammal Program to the National Marine Fisheries Service, Fairbanks, AK.

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

Quakenbush, L., J. Citta, J. C. George, 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.

Raoult, V., A. P. Colefax, B. M. Allan, D. Cagnazzi, N. Castelblanco-Martínez, D. Ierodiaconou, D. W. Johnston, S. Landeo-Yauri, M. Lyons, and V. Pirotta. 2020. Operational protocols for the use of drones in marine animal research. Drones 4(4):64.

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

Reeves, R. R. 1998. Distribution, abundance and biology of ringed seals (*Phoca hispida*): an overview. 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.

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

Richardson, W. J. 1998. Marine mammal and acoustical monitoring of BP Exploration (Alaska)'s open-water seismic program in the Alaskan Beaufort Sea, 1997. LGL Rep. TA2150-3. Rep. from LGL Ltd., King City, Ontario, and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska) Inc., Anchorage, AK, and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD, November 1998, 318 p.

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

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

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

Risch, D., C. W. Clark, P. J. Corkeron, A. Elepfandt, K. M. Kovacs, C. Lydersen, I. Stirling, and S. M. Van Parijs. 2007. Vocalizations of male bearded seals, *Erignathus barbatus*: classification and geographical variation. Animal Behaviour 73(5):747-762.

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.
Rosen, D. A., C. G. Gerlinsky, and A. W. Trites. 2018. Telemetry tags increase the costs of swimming in northern fur seals, Callorhinus ursinus. Marine Mammal Science 34(2):385-402.
Savage, K. 2019. 2018 Alaska Region Marine Mammal Stranding Summary. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK, January 28, 2019.
Scheffer, V. B. 1958. Seals, sea lions and walruses: a review of the Pinnipedia. Stanford University Press, Palo Alto, CA.
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.
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.
SIMIP Community. 2020. Arctic Sea Ice in CMIP6. Geophysical Research Letters 47(10):e2019GL086749.
Simmonds, M. P., and W. J. Eliott. 2009. Climate change and cetaceans: concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom 89(1):203-210.
Simmonds, M. P., and J. D. Hutchinson. 1996. The Conservation of Whales and Dolphins - Science and Practice. John Wiley & Sons.
Simpkins, M. A., L. M. Hiruki-Raring, G. Sheffield, J. M. Grebmeier, and J. L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. Polar Biology 26(9):577-586.
Smiley, B. D., and A. R. Milne. 1979. LNG transport in Parry Channel: possible environmental hazards. Institute of Ocean Sciences, Sydney, Canada, 47 p.
Smith, M. A., M. S. Goldman, E. J. Knight, and J. J. Warrenchuk. 2017. Ecological Atlas of the Bering, Chukchi, and Beaufort Seas, 2nd Ed. Audubon Alaska, Anchorage, AK.
Smith, T. G. 1970. Population dynamics of the ringed seal in the Canadian Eastern Arctic.
Smith, T. G. 1976. Predation of ringed seal pups (*Phoca hispida*) by the Arctic fox (*Alopex agopus*). Canadian Journal of Zoology 54(10):1610-1616.
Smith, T. G. 1981. Notes on the bearded seal, *Erignathus barbatus*, in the Canadian Arctic. Canadian Technical Report of Fisheries and Aquatic Sciences 1042:49 p.
Smith, T. G. 1987. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. Bulletin Fisheries Research Board of Canada, 0660124637, Ottawa, Canada, 81.
Smith, T. G., and C. Lydersen. 1991. Availability of suitable land-fast ice and predation as factors limiting ringed seal populations, *Phoca hispida*, in Svalbard. Polar Research 10(2):585-594.
Smith, T. G., and I. Stirling. 1975. The breeding habitat of the ringed seal (Phoca hispida). The birth lair and associated structures. Canadian Journal of Zoology 53(9):1297-1305.
Snyder-Conn, E., J. R. Garbarino, G. L. Hoffman, and A. Oelkers. 1997. Soluble trace elements and total mercury in Arctic Alaskan snow. Arctic:201-215.
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.

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

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

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

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

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

Teilmann, J., E. W. Born, and M. Acquarone. 1999. Behaviour of ringed seals tagged with satellite transmitters in the North Water polynya during fast-ice formation. Canadian Journal of Zoology 77(12):1934-1946.

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.

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.
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.
Van Parijs, S. M. 2003. Aquatic mating in pinnipeds: A review. Aquatic Mammals 29(2):214-226.
Van Parijs, S. M., and C. W. Clark. 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, Erignathus barbatus. Animal Behaviour 72(6):1269-1277.
Van Parijs, S. M., K. M. Kovacs, and C. Lydersen. 2001. Spatial and temporal distribution of vocalising male bearded seals: Implications for male mating strategies. Behaviour 138(7):905-922.
Van Parijs, S. M., C. Lydersen, and K. M. Kovacs. 2003. Vocalizations and movements suggest alternative mating tactics in male bearded seals. Animal Behaviour 65(2):273-283.
Van Parijs, S. M., C. Lydersen, and K. M. Kovacs. 2004. Effects of ice cover on the behavioural patterns of aquatic-mating male bearded seals. Animal Behaviour 68(1):89-96.
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.
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., and D. R. Ketten. 1999. Marine mammal sensory systems. Biology of marine mammals 1:117.
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.

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.

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.