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

Ice Exercise 2020

NMFS Consultation Number: AKRO-2019-02445

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

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Bowhead Whale (*Balaena mysticetus*)	Endangered	No	No	N/A
Gray Whale, Western North Pacific DPS (*Eschrichtius robustus*)	Endangered	No	No	N/A
Ringed Seal, Arctic Subspecies (*Phoca hispida hispida*)	Threatened	Yes	No	N/A
Bearded Seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	No	No	N/A

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By:

Robert D Mecum
for James W. Balsiger, Ph.D.
Regional Administrator

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TERMS AND ABBREVIATIONS

µPa	Micro Pascal
2D	Two-Dimensional
3D	Three-Dimensional
Ac	Acre
ACIA	Arctic Climate Impact Assessment
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
AGL	Above Ground Level
AKR	Alaska Region
ASAMM	Aerial Surveys of Arctic Marine Mammals
ASL	Above Sea Level
BA	Biological Assessment
Bbbl	Billion Barrels
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulations
CI	Confidence Interval
CSEL	Cumulative Sound Exposure Level
CV	Coefficient of Varience
CWA	Clean Water Act
dB re 1µPa	Decibel referenced 1 microPascal
DDT	Dichloro-Diphenyltrichloroethane
DPS	Distinct Population Segment
DWH	Deepwater Horizon
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ESA	Endangered Species Act
EZ	Exclusion Zone
°F	Fahrenheit
FAA	Federal Aviation Administration
Ft	Feet
FWS	U.S. Fish and Wildlife Service
Gal	Gallons
Hz	Hertz
ICEX	Ice Exercise
IHA	Incidental Harassment Authorization
IPCC	Intergovernmental Panel on Climate Change
ITS	Incidental Take Statement
IWC	International Whaling Commission
km	Kilometers
Kn	Knot
km^2	Square Kilometers

m	Meter
mi	Mile
Ms	Milliseconds
MMbbl	Million Barrels
MMPA	Marine Mammal Protection Act
NAEMO	Navy Acoustic Effects Model
Navy	United States Department of Navy
NEPA	National Environmental Policy Act
nm	Nautical mile
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
OC	Organochlorine
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
Opinion	Biological Opinion
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCE	Primary Constituent Element
Permits Division	NMFS Office of Protected Resources, Permits and Conservation Division
psi	Pound Per Square Inch
PSO	Protected Species Observers
PTS	Permanent Threshold Shift
R_{max}	Maximum Distance from Sound Source to the Contour
rms	Root Mean Square
RPA	Reasonable Prudent Alternative
SONAR	Sound Navigation and Ranging
SOP	Standard Operating Procedures
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
UAS	Unmanned Aircraft System
USDOI	United States Department of Interior
USFWS	United States Fish and Wildlife Service
VLOS	Very Large Oil Spill
VMS	Vessel Monitoring System
WNP	Western North Pacific

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) of the ESA 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.

For the actions described in this document, the action agencies are the United States Navy (Navy) which proposes to conduct military exercises in the Arctic and the NMFS Office of Protected Resources, Permits and Conservation Division (hereafter referred to as "the Permits Division"). The Permits Division plans to issue an incidental harassment authorization (IHA) pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA) (16 U.S.C. 1361 et seq.), to the Navy for harassment of marine mammals incidental to the proposed activities (83 FR 40234). When issued, the IHA will be valid from February 1, 2020 to January 31, 2021, and will authorize the incidental harassment of two ESA-listed pinniped species, the threatened Beringia DPS bearded seal and threatened Arctic ringed sea.

The consulting agency for this proposal is NMFS's Alaska Region (AKR). This document represents our biological opinion (opinion) on the proposed actions and their effects on endangered and threatened species.

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

1.1 Background

This opinion considers the effects of the Navy's Ice Exercise (ICEX20) in the winter/spring of 2020. These actions have the potential to affect the threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), and threatened Beringia DPS bearded seal (*Erignathus barbatus nauticus*).

This opinion is based on information provided in the November 2019 Biological Evaluation for the project, the November 2019 Request for an Incidental Harassment Authorization, the Environmental Assessment/Overseas Environmental Assessment; clarifying emails between NMFS and Navy staff; and other sources of information. A complete record of this consultation is on file at NMFS's Anchorage, Alaska office

1.2 Consultation History

July 2, 2019: IHA application package sent to Permits Division.

August 29, 2019: NMFS AKR received the Biological Evaluation and Section 7 initiation request from Navy.

October 7, 2019: Navy was emailed to clarify discrepancies between the IHA and BE, request details on the active acoustic devices, request a copy of the Overseas Environmental Assessment, request information about the emergency demobilization plan and ask about marine mammal monitoring.

October 15, 2019: AKR received an email with the training video that all ICEX personnel must watch.

October 16, 2019: AKR emailed additional questions to obtain more detail about the amount of flight time anticipated for the ICEX20 operation.

October 24, 2019: AKR had a teleconference with the Permits Division to discuss consultation.

October 25, 2019: AKR sent an email to Navy to see if there was progress on initial questions and to ask if they would like a list of Standard Operating Procedures and mitigation measures.

November 12, 2019: Navy sent out revised IHA and the Environmental Assessment to AKR and the Permits Division.

November 15, 2019: Permits Division sent out responses they received from the Navy to questions they had about acoustic effects on ringed and bearded seals. The Permits Division indicated they had all the necessary information to proceed.

November 19, 2019: Navy sent response to the SOP and mitigation measures. AKR sent a return email affirming the requested changes.

November 25, 2019: AKR received a revised BE and consultation was initiated.

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 (50 CFR § 402.02). The purpose of ICEX20 is to conduct military preparedness exercises under Arctic conditions. The primary purpose of the proposed action is to evaluate submarine operability in Arctic conditions. Secondarily, the proposed action will test emerging technologies and gather data on Arctic capabilities and environmental conditions. This includes testing of equipment and personnel and performing research activities. Once a suitable ice floe in the Beaufort Sea is located, a temporary camp will be constructed. Following ice camp construction, personnel will conduct submarine training and testing and other research activities as described below.

The entire proposed action, including ice camp construction and demobilization, will occur over a six-week period from February through early April 2020; the submarine training and testing and the research activities will occur over approximately four weeks within this timeframe.

2.2 Proposed Activities

2.2.1 Construction and demobilization of camp

All ice camp materials, fuel, and food will be transported from Prudhoe Bay and delivered by air-drop from military transport aircraft (e.g., C-17 and C-130), or by small twin-engine aircraft and military and commercial helicopters landing on the ice camp runway. At the completion of ICEX, the ice camp will be demobilized, and all personnel and construction material, solid waste, hazardous waste, and sanitary waste will be removed from the ice floe. All wastes will be disposed of in accordance with applicable laws and regulations.

During the proposed action, flights to and from Prudhoe Bay would use the public Deadhorse Airport, located next to Prudhoe Bay. Up to nine round trips could occur daily in addition to the usual flight traffic that occurs at the airport (average of 90 flights per day). All flights would leave from Deadhorse Airport and fly directly to the ice camp.

The ice camp consists of a command hut, dining tent, sleeping quarters, tents to house temporary visitors, a powerhouse, runway, and helipad (Figure 1). The number of shelters ranges from 10 to 20 and the shelters are typically 2 to 6 meters (m) by 6 to 10 m in size. The completed ice camp, including runway, is approximately 1.6 km in diameter. Support equipment for the ice camp includes snowmobiles, gas powered augers and saws (for boring holes through the ice), and diesel generators.

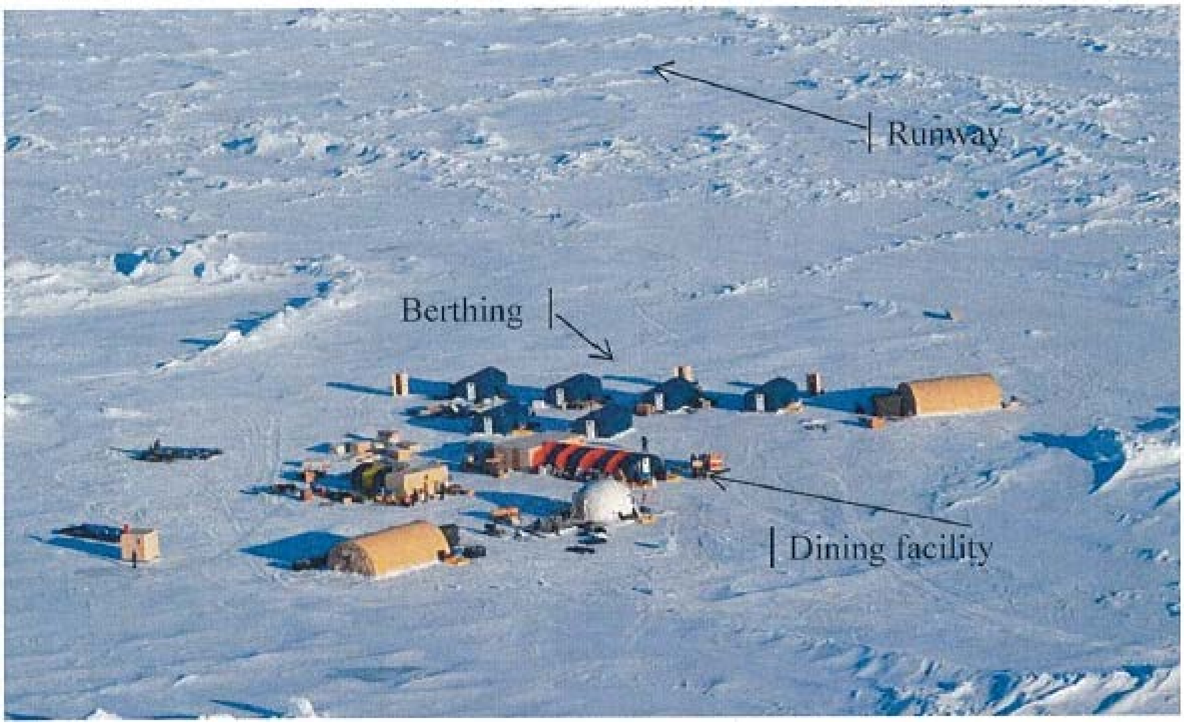

Figure 1. Typical layout of ice camp

2.2.2 Transportation

Typical platforms used for ice camp logistics and support include on-ice vehicles (e.g., snow machines), aircraft, unmanned vehicles (both aerial and underwater), and passive devices. The only platforms to be used in the vicinity of bearded seals are aircraft leaving from the Deadhorse Airport in Prudhoe Bay. All other platforms will be deployed far outside of the bearded seal range during the timeframe of the proposed action.

On-ice

Snowmobiles would be used to transport personnel and equipment on the ice. Additionally, snowmobiles would support research activities that require data collection from multiple locations, with some at a distance from the camp. Four to six snowmobiles would be used during ICEX20. Two types of snowmobiles are typically used at the ice camp. Heavyweight snowmobiles have a single steering track and a very large drive track; these machines are slow with limited maneuverability, and are used to pull sleds and sledges to move equipment around camp. Lightweight snowmobiles have dual steering tracks and a single drive track, are faster and maneuverable, and are used to transport personnel.

In addition to the typical snowmobiles, two types of all-terrain tracked vehicles, one equipped with four wheels and one equipped with six or eight wheels, that can be used in open water (referenced herein as all-terrain tracked vehicle) may be air-dropped to support runway construction and expeditionary forces. The all-terrain tracked vehicle has a low ground pressure of 1.6 pounds per square inch and is used in sensitive habitats. Expeditionary forces may use an all-terrain tracked vehicle. The all-terrain tracked vehicles have a load capacity of up to 1,200 pounds, depending on the model. They are capable of floating in open water if necessary. All-terrain tracked vehicles have two engine types typically gasoline engine or diesel. Both engines are approximately 30 horsepower (Ontario Drive and Gear Ltd. 2017). The all-terrain tracked vehicle would be used to transport expeditionary forces to and from the main camp.

In air

Fixed-wing aircraft will be used to move personnel and equipment. It is expected that there will be up to nine round trips during camp set up and demobilization. In addition one to three flights may occur during camp operations. Aircraft that may be used during ICEX20 include small, single or twin-engine fixed-wing aircraft and rotary-wing aircraft (helicopters) (Figure 2 *a*-*d*). These aircraft will transport shelters, personnel, and equipment to and from the ice camp and will also support many of the research activities. In addition to the typical commercial aircraft, military aircraft may be used, depending on their availability. Examples of military aircraft that may be used include C-130, V-22, and C-17 transport craft (as well as the LC-130, which is a modified C-130 suited to land on the ice) and CH-47 Chinook heavy-lift helicopters (Figure 2 *e*-*f*). These aircraft are much larger than the small, fixed-wing aircraft typically used and will allow for more efficient transport of supplies to and from the camp (i.e., fewer trips). Equipment and material may be dropped by parachute from these military aircraft. The LC-130 will conduct up to four round trip flights to the ice camp over the course of the exercise; these are included within the maximum number of daily flights to the ice camp.

Figure 2. Aircraft to be used during ICEX20. A-d: smaller aircraft; e: C-130, f: CH-47)

2.2.3 Research Activities

Details on submarine activities and specific systems associated with ICEX20 are classified, but generally entail safety maneuvers and use of active sonar (producing non-impulsive sounds).These maneuvers and sonar use are similar to submarine activities conducted in other undersea environments; they are being conducted in the Arctic to test their performance in a cold environment. Submarines and other in-water vessels (see below) may deploy in ocean waters 3,000 m (9,843 ft) to 4,000 m (13,123 ft) deep (Jakobsson *et al.* 2012), but will operate at a maximum depth of 800 m (244 ft).

In addition to submarine training and testing, personnel and equipment proficiency testing and multiple research and development activities will be conducted. Each type of activity scheduled for ICEX20 has been placed into one of seven general categories of actions (Table 1). Sonar transmission will be emitted only from the submarines. None of the other devices (e.g. buoys, acoustic array, unmanned underwater vehicles) will have active transmission.

Table 1. Summary of Training, Testing and Research Objectives

Activity Type	Category of Action	Project	Description
Submarine Training and Testing	Logistics	Ice Camp Operations	A camp is constructed and an associated underwater tracking range is deployed to support submarine training and testing.
	Submarine Training	Submarine Training and Testing	Submarines conduct various training events.
Research Objectives	Aerial Data Collection	Aircraft	Use of manned aircraft and sensors to collect ice and snow thickness data and to validate/calibrate satellite measurements.
		Balloon	Launch of balloons to collect atmospheric data, primarily for weather forecasting.
	In-water Device Data Collection	Buoy	Deployment of surface buoys through the ice to collect measurements of conductivity, temperature, and ocean/ice fluxes.
		Array	Use of acoustic arrays to collect data on ambient noise, as well as determine signal propagation through Arctic environments.
	Personnel/ Equipment Proficiency	Diving Evolutions	Diver personnel conduct cold water diving evolutions under the ice using various equipment.
		Personnel/ Equipment Air-Drop	Fixed-wing and rotary-wing aircraft deliver paratroopers and equipment to the ice camp. Equipment is dropped by parachute to support camp operations (e.g., food, fuel, building materials) as well as to verify search and rescue equipment delivery.
		Aircraft Landing Evaluation	Military aircraft are flown to the ice camp to evaluate the use of landing skis in the Arctic environment.
	Unmanned Aerial System Testing	Fixed-Wing	Fixed-wing unmanned aerial systems are launched by hand or pneumatic catapult. Fixed-wing systems may have up to a 10 ft (3 m) wingspan and fly at speeds up to 80 knots.
		Rotary-Wing	Rotary-wing unmanned aerial systems ("quadcopters") used individually or simultaneously. Rotary-wing systems are approximately 20 in (51 cm) square and fly at speeds up to 30 knots.
	Unmanned Underwater Vehicle Testing	Vehicle Testing	Autonomous and tethered unmanned underwater vehicles deployed to test navigation, control, and communications in the polar environment, as well as to gather data on existing oceanographic conditions.

Unmanned Vehicles and Systems

Unmanned underwater vehicles would either maneuver autonomously, or may be tethered to a command center. Unmanned underwater vehicles are typically slow moving (less than 5 knots), and range in size from approximately 52 cm in length and width to 493 cm in length and 53 cm in diameter. In addition, some unmanned underwater vehicles would have *de minimis* acoustic sources used and deployed throughout ICEX20, which are not discussed further in this document. *De minimis* sources have the following parameters: low source levels, narrow beams, downward directed transmission, short pulse lengths, frequencies above (outside) known marine mammal hearing ranges, or some combination of these factors (Navy 2019).

In addition to unmanned underwater vehicles, various unmanned aerial systems are proposed for testing. Systems used may be either fixed-wing or rotary-wing. Fixed-wing systems may have wingspans up to approximately 305 cm, and fly at speeds of about 80 knots. Rotary-wing systems are typically smaller, approximately 51 cm in length and width, and fly at speeds of about 30 knots (Figure 3).

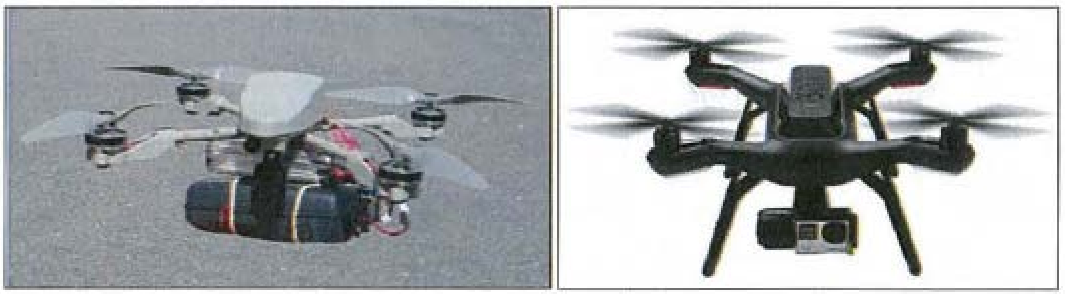

Figure 3. Examples of rotary-wing unmanned aerial systems for ICEX 20

Scientific Devices

Various passive acoustic devices will be used for data collection, including weather balloons, a vertical array, and buoys.

--*Weather Balloons*

Accurate weather forecasting is essential for a successful ICEX. To support weather observations, up to two Kevlar or latex balloons will be launched per day for 20 days at the ice camp (40 balloons total). These balloons and associated radiosondes (a sensor package that is suspended below the balloon) are similar to those that have been deployed by the National Weather Service since the late 1930s. When released, the balloon is approximately 1.5- 1.8 m in diameter and gradually expands as it rises owing to the decrease in atmospheric pressure. When the balloon reaches a diameter of 4-7 m, it bursts and a parachute is deployed to slow the descent of the associated radiosonde. Weather balloons are not recovered.

--*Vertical Line Array*

A vertical line array will be deployed through the ice to measure ambient underwater noise and sound propagation through Arctic waters. This array would contain a series of acoustic recorders located at depths from 0 to 730 m. The array will be retrieved from the ice after approximately one week of data gathering. The vertical line array receives sound, it does not emit sound.

--*Scientific Buoys*

Various scientific buoys (typically less than 1m in diameter) will be deployed. An estimated five geographic positioning system buoys will be dropped from an aircraft on various ice floes in order for smaller aircraft capable of landing on the ice to re-locate the floes to determine suitability for the establishment of the ice camp; none of these buoys would be retrieved. Buoys will be deployed as part of the research activities to collect data on the under-ice topography and environmental conditions. These buoys have sensors that can extend as much as 800 m below the ice; sensor packages may either remain stationary below the ice or may move vertically to gather data at various depths within the water column. These buoys will be left in place for up to two years to gather data, after which time they are expected to eventually sink to the seafloor. These buoys receive sound, they do not emit sound. Finally, two radiofrequency identification tags will be deployed on the ice surface to determine their effectiveness in the Arctic environment for tracking ice movements. Radiofrequency tags will not be recovered.

2.3 Standard Operating Procedures and Mitigation Measures

Standard operating procedures and mitigation measures will be implemented during the proposed action. Standard operating procedures serve primarily to provide safety and mission success and are implemented regardless of their secondary benefits (e.g., to a resource). Mitigation measures are used to avoid or reduce potential impacts. The standard operating procedures and mitigation measures that are applicable to the proposed action are provided below.

2.3.1 Standard Operating Procedures

Camp operations

1. The Navy will comply with NPDES permit requirements for all authorized wastewater discharges from the camp.
2. Wastewater production will be minimized.
3. No shower facilities will be available at the camp.
4. Wastewater generated during food preparation and dishwashing will be discharged to the Beaufort Sea via a single drain in the camp’s dining facility. The drain will utilize a removable metal screen to capture solid debris (i.e., food particles) in the wastewater prior to discharge. The metal screen will have a mesh size of no greater than 0.16 centimeters (cm). Solids captured in the screen will be disposed of via the camp’s solid waste containers and brought back to Prudhoe Bay, Alaska, for disposal.
5. Dishwashing and a hygiene station will use biodegradable, chlorine-, and phosphate-free detergent that meets the Environmental Protection Agency’s Safer Choice standards (U.S. Environmental Protection Agency 2015).
6. Sanitary/human waste generated at the camp will be collected in zero-discharge sanitary facilities (e.g., barrels lined with a plastic bag), will be collected and containerized, then flown back to Prudhoe Bay, Alaska, for disposal at appropriate facilities.
7. All material (e.g., construction material, unused food, excess fuel) and wastes (e.g., solid waste, hazardous waste, human waste) will be removed from the ice floe upon completion of ICEX20; only scientific buoys and radiofrequency identification tags would be left behind.

8. Personnel are trained in the proper handling of fuels, containment procedures, and clean up procedures. Necessary equipment is provided and accessible.
9. In camp activities and personnel movement within the camp will only occur during daylight hours to the maximum extent possible.

Air Transportation

1. The shortest route from mainland to the camp that safety and weather conditions will allow will be used.
2. As aircraft approach the camp, aircraft crew will ensure that the landing zone is clear of any animals and will record and report the presence and behavior of any seals observed on the ice.
3. Pilots will make every attempt to avoid large flocks of birds (which are unlikely) in order to reduce the safety risk involved with a potential bird strike.
4. The location for any air-dropped equipment and material will be visually surveyed prior to release of the equipment/material to ensure the landing zone is clear. Equipment and materials will not be released if any animal is observed within the landing zone.
5. Spill response kits/material will be on-site prior to the air-drop of any hazardous material (e.g. fuel).
6. Air drop bundles will be packed within a plywood structure with honeycomb insulation to protect the material from damage.

On-ice Transportation

1. Passengers on all ice vehicles will observe for marine and terrestrial animals; any marine or terrestrial animal observed on the ice would be avoided by 100 m (330 ft).
2. On-ice vehicles will not be used to follow any animal (with the exception of actively deterring polar bears if the situation requires).
3. Personnel operating on-ice vehicles will avoid areas of snow drifts >0.5 m in depth (often near pressure ridges), which are preferred areas for ringed seal subnivean lairs.

In water Activities

1. For activities involving active acoustic transmission from submarines, passive acoustic sensors on the submarines will listen for vocalizing marine mammals. If a marine mammal is detected, the submarine will cease active transmissions, and not restart until after 15 minutes have passed with no marine mammal detections.
2. The general location and duration of vocalization of marine mammal detections will be recorded.

2.3.2 Mitigation Measures

The Navy has identified the following mitigation measures in the Biological Evaluation to minimize potential impacts from project activities to aid in the recovery or protection of ESA-listed species under NMFS jurisdiction.

At camp

1. A demobilization plan is in place in case emergency evacuation from the ice floe is required. After human safety, the plan prioritizes the removal of hazardous wastes from the camp site.
2. All personnel will be required to complete environmental compliance training including environmental health and safety procedures.

Air Transportation

1. Fixed wing aircraft will operate at highest altitudes practicable taking into account safety of personnel, meteorological conditions and need to support safe operations of a drifting ice camp. Aircraft will not reduce altitude if a seal is observed on the ice. In general, cruising elevation will be 305 m (1000 ft) or higher.
2. Unmanned Aircraft Systems (UASs) will maintain a minimum altitude of at least 10 m (35 ft) above the ice. They will not be used to track or follow marine mammals.
3. Helicopter flights will use prescribed transit corridors when traveling to/from Prudhoe Bay and the ice camp. Helicopters will not hover or circle above or within 457 m (1,500 ft) of groups of marine mammals.
4. Aircraft will maintain a minimum separation distance of 1.6 km (1 mi) from groups of 5 or more seals.
5. Aircraft will not land on ice within 800 m (0.5 mi) of hauled out pinnipeds;

On-ice Transportation

1. A dedicated observer (not the vehicle operator) will be on each snow machine or there will be at least one observer for each expeditionary team. Observers for ice trail activities need not be trained protected species observers, but they must be capable of observing and recording marine mammal presence and behaviors, and accurately and completely record data. When traveling, observers will have no other primary duty than to watch for and report observations related to marine mammals and human/seal interactions.
2. Observer will have sufficient equipment (binoculars/monocular, GPS, ability to record information) to aid in observing marine mammals, determining the location of observed marine mammals, and recording observations.
3. Observer will record the date, time, species, number, and geographic coordinate of all seals observed within 150 m (500 ft) of the main camp.
4. Observer will provide an account of interactions, or lack of apparent interaction, between humans (including human operated equipment) and seals or seal lairs that are within feet 150 m (500 ft) of camps or snow machine trails.
5. Observers or other designated personnel will submit to NMFS within 90 days of the cessation of ICEX20 a monitoring report in digital format that can be queried. The report will provide details about marine mammal observations and interactions that occurred during the exercise.
6. Observers will provide a record of all monitoring efforts, including date, time, duration of observation efforts, duration of time during which seals or seal lairs were known to be present within 150 m (500 ft) of human activities, and the behaviors exhibited by the seals during those observation periods.

7. Observers will record the minimum distance between human activities and seals or seal lairs.
8. If seal lairs are located within 150 m (500 ft) of camps or ice trails, observers will provide an account of the status of lairs through time.
9. If a seal lair or hauled-out seal is disrupted, the situation will be recorded and details reported to NMFS within 48 hrs.
10. Monitoring reports and all instances of seal and seal lair disturbance will be provided to NMFS Permits and Conservation Division, care of Amy Fowler (amy.fowler@noaa.gov) and Jolie Harrison (jolie.harrison@noaa.gov), and the Alaska Region, care of Marilyn Myers (marilyn.myers@noaa.gov).

Data Collection and Reporting Requirements

The results of the Navy marine mammal monitoring program, including estimates of “take by harassment” and “take by mortality,” will be presented in a technical report, with observer data submitted to NMFS in a digital spreadsheet format that can be queried. Reporting will address the requirements established by NMFS. The technical report(s) will include:

1. Summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the study period accounting for weather and other factors affecting visibility and detectability of marine mammals;
2. Species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories, group sizes, and ice cover;
3. Observed behaviors and types of movements versus exercise activity;
4. If applicable, estimates of “take by harassment” and “take by mortality;
5. If no seals are seen or detected, that information will also be reported.

2.4 Action Area

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

The action area for this biological opinion includes the travel corridor between Prudhoe Bay and the ice camp, the area surveyed by reconnaissance flights, the ice camp itself, which will have about a 2 km^2 diameter footprint, and a much larger area that will be used for submarine training and testing. The vast majority of training and research objectives will occur near the ice camp, although portions of the submarine training and testing may occur throughout the deep Arctic Ocean basin

The ice camp will be established in an area approximately 100 to 200 nautical miles (nmi) north of Prudhoe Bay, Alaska. The precise location for the ice camp cannot be predicted due to the uncertainty of spring ice conditions. The ice camp requires both multi-year and first-year ice. Prior to set-up, reconnaissance flights are conducted over an area of approximately 70,374 square kilometers (km^2) to locate suitable ice conditions for the location of the ice camp; the whole study area is 2,874,520 square kilometers, which also accounts for submarine maneuvers (Figure 4, purple area).

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, we consider 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).

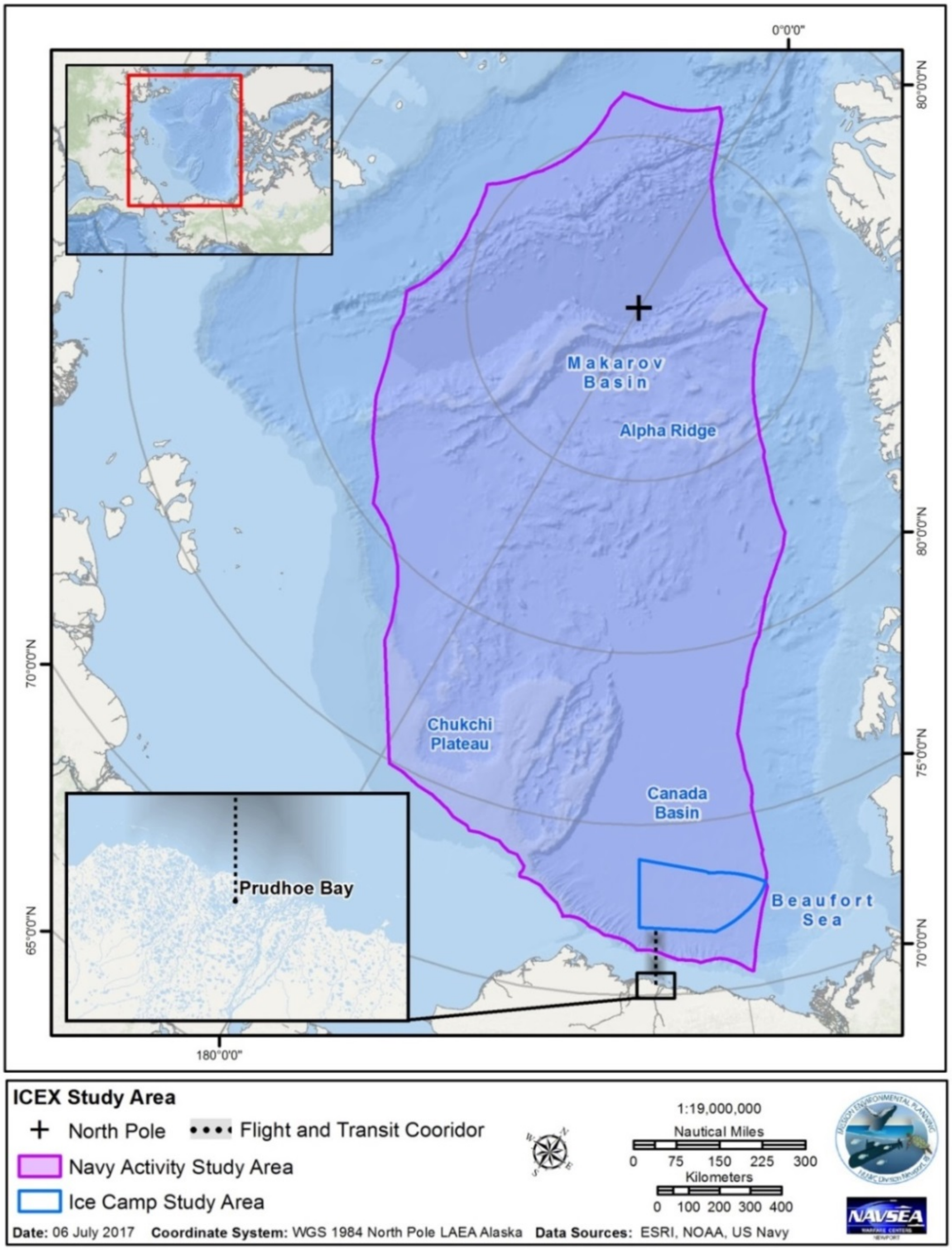

Figure 4. Action area for ICEX20

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).

While the ESA does not define "harass," NMFS issued guidance interpreting the term "harass" under the ESA as a means to: "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016).

We use the following approach to determine whether the proposed action described in Section 2.1 is likely to jeopardize listed species:

- Identify those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on listed species or critical habitat. As part of this step, we identify the action area – the spatial and temporal extent of these direct and indirect effects.
- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We determine the rangewide status of critical habitat by examining the condition of its PBFs - which were identified when the critical habitat was designated. Species are discussed in Section 4 of this opinion.
- Describe the environmental baseline including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or early Section 7 consultation, and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 5 of this opinion.
- Analyze the effects of the proposed actions. Identify the listed species that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our exposure analyses). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to stressors and the populations or subpopulations those individuals represent. NMFS also evaluates the proposed action's effects on critical habitat features. The effects of the action are described in Section 6 of this opinion with the exposure analysis described in Section 6.2 of this opinion.
- Once we identify which listed species are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed species are likely to respond given their exposure (these represent our response analyses). Response analysis is considered in Section 6.3 of this opinion.
- Describe any cumulative effects. Cumulative effects, as defined in NMFS's implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 7 of this opinion.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section

6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) 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 and critical habitat (Section 4). Integration and synthesis with risk analyses occurs in Section 8 of this opinion.

- Reach jeopardy and adverse modification conclusions. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 9. These conclusions flow from the logic and rationale presented in the Integration and Synthesis Section 8.
- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the action.

4 RANGEWIDE STATUS OF THE SPECIES AND CRITICAL HABITAT

Four species of marine mammals listed under the ESA under NMFS's jurisdiction may occur in the action area. Critical habitat has not been designated for these four species. This opinion considers the effects of the proposed action on these species (Table 2). At this time, there is no designated habitat for any species that is part of this consultation.

Table 2. Listed marine mammals considered in this opinion.

Species	Status	Listing	Critical Habitat
Bowhead Whale (*Balanea mysticetus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Gray Whale, Western North Pacific DPS (*Eschrichtius robustus*)	Endangered	NMFS 1970, 35 FR 18319	Not designated
Ringed Seal, Arctic Subspecies (*Phoca hispida hispida*)	Threatened	NMFS 2012, 77 FR 76706	Not designated
Bearded Seal, Beringia DPS (*Erignathus barbatus nauticus*)	Threatened	NMFS 2012, 77 FR 76740	Not designated

4.1 Species Not Likely to be Adversely Affected by the Action

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

As described in the *Approach to the Assessment* section of this opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are likely to be adversely affected. The first criterion is *exposure* or some reasonable expectation of a co-occurrence between one or more potential stressors associated with Navy's activities and a listed species or designated critical habitat. The second criterion is the probability of a *response* given exposure. For endangered or threatened species, we consider the *susceptibility* of the species that may be exposed; for example, species that are exposed to sound fields produced by sonar activities, but are not likely to exhibit physical, physiological, or behavioral responses given that exposure (at the combination of sound pressure levels and distances associated with an exposure), are not likely to be adversely affected by the sonar activity. For designated critical habitat, we consider the *susceptibility* of the constituent elements or the physical, chemical, or biotic resources whose quantity, quality, or availability make the designated critical habitat valuable for an endangered or threatened species.

We applied these criteria to the species listed above and determined that the following species are not likely to be adversely affected by the proposed action: Western DPS gray whale, bowhead whale, and bearded seal.

4.1.1 Gray whale

Gray whales migrate from Baja California and southern California to Alaska to feed during the summer. In Alaska they are seen feeding in greatest numbers along the northwest coast along the continental shelf waters of the Chukchi Sea (ASAMM 2019). There have been a few, far rarer, sightings of gray whales in the Alaskan and Canadian Beaufort Sea (ASAMM 2019). The earliest recorded sighting was in 1933 near Cross Island north of Deadhorse. From 1933 to 2014 there have been fewer than 20 sightings of gray whales in the Alaskan and Canadian Beaufort Sea from vessels and aerial surveys in the summer and fall (ASAMM 2019). Through acoustic recordings it has been documented that a few gray whales may occasionally overwinter in the Beaufort Sea (Stafford et al. 2007). Stafford et al. (2007) deployed two hydrophones northeast of Barrow in October 2003 and recovered the recordings in September 2004. One hydrophone at a depth of 316 m (1036 ft), was on the continental shelf and the other, at 1258 m (4127 ft), was at the base of the continental slope. Gray whale vocalizations were recorded through the winter. The calling rate at the shallower depth was higher than at the deeper recorder but the deeper instrument detected calls throughout the winter, though the calling rate diminished as winter progressed (Stafford et al. 2007).

The extent to which gray whales may overwinter in the Beaufort Sea is unknown. We note that other studies in which hydrophones recorded through the winter in the Beaufort Sea did not report that gray whales were recorded even though their equipment covered the bandwidth of gray whale vocalizations (MacIntyre et al. 2013, Jones et al. 2014; MacIntyre et al. 2015). It is clear that the majority of the gray whale population migrates south because the migration is well documented and highly visible along the coast (Rugh 1984, Rugh et al. 2001, Swartz et al. 2006). Gray whales begin their southward migration in October, mate in shallow coastal waters and continue to Baja California and coastal southern California where they calve and overwinter (Rugh 1984, Rugh et al. 2001). Typically, northward migrating gray whales do not reach the Bering Sea before May or June (Frost and Karpovich 2008), after the proposed action will occur, and several hundred kilometers south of the action area. Gray whales are primarily bottom feeders (Swartz et al. 2006) in water less than 60 m deep (Pike 1962). We would expect any overwintering individuals would remain in shallow water over the continental shelf where they could feed.

Because the proposed action will occur from February through early April (late winter) the occurrence of gray whales in the action area is highly unlikely based on the very few gray whales documented in the area during annual surveys in the summer and fall, and because of their strong migratory behavior. If a few individuals do remain in the area, we would expect them to concentrate on areas of shallower water where they could continue to feed. When a location for the ICEX camp is being scouted, the Navy is searching for an area of multiyear ice without leads or deformations (Navy 2019). Gray whales would need to be in a location where leads and open water are present so that they could breathe. This requirement for open water and the fact that the camp will be located in water 800 m or more in depth, far deeper than locations where they feed, indicates that it is extremely unlikely that any gray whales that stay in the Beaufort Sea would be near the ice camp. For these reasons, we determine that gray whales will not likely be adversely affected by the activities associated with ICEX20.

4.1.2 Bowhead whale

The bowhead whale may occur in or near the action area during the summer, but winter in the Bering Sea. Based on years of traditional knowledge, aerial surveys, and confirmed by satellite telemetry results bowhead whales migrate south in the fall into the Bering Sea, sometimes as far south as the Pribilof Islands, and remain there during the winter (Braham et al. 1980, Moore and Reeves 1993, Mate et al. 2000, Quakenbush et al. 2013, ASAMM 2019). On their spring migration, the earliest that bowheads reach Point Hope, well south of Point Barrow, is late March to mid-April (Braham et al. 1980). Although the ice camp location is not known with certainty, it is approximately 350 km from the general location of the ice camp to Point Barrow and an additional 525 km from Point Barrow to Point Hope (straight line distance). At the time of ICEX20 bowhead whales will be far south of the proposed action area. In addition, any sound produced by the action would be blocked by the protrusion of Point Barrow into the Chukchi Sea. The proposed action will occur from February through early April, approximately two months before the bowhead whales are expected to migrate around Point Barrow. Consequently, it is extremely unlikely that any individual bowheads would be exposed to any of the activities related to the proposed action. For this reason, we conclude that the bowhead would not likely be adversely affected by the activities of ICEX20.

4.1.3 Bearded seal

Within the U.S. range of the Beringia DPS, the extent of favorable ice conditions in the Beaufort Sea for bearded seals is limited to where there is a relatively narrow ice-shelf with suitable water depths. The most probable area in which bearded seal might be found within the action area during winter months is along the continental shelf of the Chukchi and Beaufort Seas. Bearded seals feed extensively on benthic invertebrates (e.g. clams, gastropods, crabs, shrimp, bottom-dwelling fish) (Quakenbush et al. 2011; Cameron et al. 2010) and are typically found in water depths of 200 m (656 ft) or less (Burns 1970). The Bureau of Ocean Energy Management (BOEM) conducted an aerial survey from June through October that covered the shallow Beaufort and Chukchi Sea shelf waters, and observed bearded seals from Point Barrow to the border of Canada (Clarke et al. 2015). The farthest from shore that bearded seals were observed was the waters of the continental slope.

Although acoustic data indicate that some bearded seals remain in the Beaufort Sea year round (MacIntyre et al. 2013, Jones et al. 2014; MacIntyre et al. 2015), satellite tagging data (Boveng and Cameron 2013; ADF&G 2017) show that large numbers of bearded seals move south in fall/winter with the advancing ice edge to spend the winter in the Bering Sea, confirming previous visual observations (Burns and Frost 1979; Frost et al. 2008; Cameron and Boveng 2009). The southward movement of bearded seals in the fall means that very few individuals are expected to occur along the Beaufort Sea continental shelf in February through early April, the timeframe of the proposed activities. The northward spring migration through Bering Strait, occurs from mid-April through June and is more marked and noticeable than the southward movements in late fall through winter (Burns and Frost 1979).

It is anticipated that the ice camp will be established 100-200 nm (185-370 km) north of Prudhoe Bay in water depths of 800 m or more. The continental shelf near Prudhoe Bay is approximately 55 nm (100 km) wide. Therefore, even if the ice camp were established at the closest estimated distance (100 nm from Prudhoe Bay), it would still be approximately 45 nm (83 km) distant from habitat potentially occupied by bearded seals. The sound created by the sonar is not expected to have any impact on marine mammals beyond 10 km (5.4 nm) (Navy 2019). Although bearded seals are found 20 to 100 nm (37 to 185 km) offshore during spring (Simpkins et al. 2003, Bengtson et al. 2005), winter is a time we expect bearded seals to select habitats where food is abundant and easily accessible to minimize the energy required to forage and maximize energy reserves in preparation for whelping, lactation, mating, and molting. Bearded seals are not known to dive to 800 m to forage and it is highly unlikely that they would be in the vicinity of the camp or where the research activities will be conducted. Because very few bearded seals are expected to be in the action area, there will be at least 80 km between the ice camp and where bearded seals are likely to occur, and because sonar effects are not expected to extend beyond 10 km, we conclude that the chance of a bearded seal being exposed to sonar sound created by ICEX20 activities is extremely unlikely. We do not anticipate adverse effects to bearded seals from sonar use.

Noise will also be created by snow machines at the camp, by airplanes flying overhead, and occasionally by helicopters that will transport supplies and personnel from Prudhoe Bay to the ice camp. Similar to sonar, it is extremely unlikely that bearded seals will be exposed to sound from snow machines because the distance between the ice camp and where any bearded seals may occur at that time of year (along the continental shelf) is a minimum of 45 nm (83 km) away. Any noise created by snow machines or aircraft will be greatly attenuated at that distance.

Because bearded seals will not be near the ice camp location, they will only be exposed to aircraft noise from the overflights after takeoff or before landing from the Deadhorse Airport. Aircraft noise will not be novel to any bearded seals that remain in the area because approximately 90 flights per day occur from the Deadhorse Airport (Navy 2019). ICEX20 would increase air traffic from the airport by approximately 10 percent (maximum of 9 trips per day during camp build-up and demobilization, and one to three trips during ice camp operations). It is approximately 15 km between Deadhorse Airport and the coastline. The loudest aircraft noise (from takeoff and landing) will be attenuated by this distance from shore. In addition, all aircraft should easily be able to reach cruising altitude by the time they reach the coast, diminishing the magnitude of sound reaching the ice below.

Potential effects on pinnipeds from aircraft activity could involve both acoustic and non-acoustic (visual) effects. It is uncertain if an animal reacts to the sound of the aircraft or to its physical presence flying overhead, or both. It has been noted that pinniped hearing sensitivity is reduced at frequencies below 2 kHz, and generally pinnipeds are less sensitive than humans to airborne sounds less than 10 kHz (Richardson et al. 1995). The noise created by the aircraft in flight proposed for use in ICEX20 will be 1.7 kHz or less (Navy 2019). Reactions of hauled out pinnipeds to aircraft flying overhead have been noted, such as looking up at the aircraft, moving on the ice or land, entering a breathing hole or crack in the ice, or entering the water (Blackwell et al. 2004; Born et al. 2004). Reactions depend on several factors including the animal's behavioral state, activity, group size, habitat, and the flight pattern of the aircraft (Richardson et al. 1995).

Overall, there has been no indication that aircraft flying above pinnipeds in water cause long term displacement of these animals (Richardson et al. 1995). In the extremely unlikely event that a bearded seal is hauled out and disturbed by the aircraft, it is highly unlikely this brief disturbance would interfere with any essential life function, such as breeding or feeding. We do not expect temporal overlap between breeding behaviors and aircraft activity associated with this project. Therefore, aircraft sound passing through the air-ice/water interface is extremely unlikely to impact breeding behaviors, including vocalizations. Taking all of these factors into account, we conclude that a few individuals may be exposed to overflight noise but the exposure would be brief and transitory, it would be noise they are accustomed to, and it is not likely to disrupt normal behavioral patterns, so harassment is not expected (Wieting 2016).

Other activities associated with ICEX 20 including construction of a camp, deployment of hydrophones, discharge of gray water and saline water, use of unmanned underwater vehicles, and use of Unmanned Aircraft Systems will all occur at least 45 nm (83 km) from suitable bearded seal habitat. Therefore, we conclude that it is highly unlikely that any of these activities will adversely affect the bearded seal because they will not be exposed to the activities.

Up to two Kevlar or latex balloons would be launched per day for 20 days at the ice camp (40 balloons total) to support weather observations. These balloons and associated radiosondes (a sensor package that is suspended below the balloon) are similar to those that have been deployed by the National Weather Service since the late 1930s. When released, the balloon gradually expands as it rises owing to the decrease in atmospheric pressure. When the balloon reaches a diameter of 4-7 m, it bursts and a parachute is deployed to slow the descent of the associated radiosonde. Weather balloons are not recovered. Individual balloons could travel over 200 km before they burst and come to rest on land, sea ice, or in the water column. Weather balloons, and their associated components, introduce the potential for entanglement following their descent if they enter the water.

Although there is a potential for entanglement from an expended material, the amount of material will be low. Additionally, bearded seals are very mobile within the water column and are capable of avoiding debris. Although Northern fur seals (*Callorbinus ursinus*) have become entangled with discarded fishing gear and plastic strapping in the Bering Sea (Laist, 1997, Savage 2019), we have no reports of bearded seals becoming entangled in any type of material. Therefore, based on the lack of evidence of previous pinniped entanglements in this region and the very low amount of project material capable of resulting in entanglement, the probability of bearded seals becoming entangled in weather balloon-related material is extremely small, and thus adverse effects to the seals are extremely unlikely to occur.

For all these reasons we conclude that the proposed activities from ICEX20 may affect, but are not likely to adversely affect, bearded seals.

4.2 Climate Change

There is widespread consensus within the scientific community that atmospheric temperatures are increasing and that this will continue for at least the next several decades (Watson and Albritton 2001, Oreskes 2004). The Intergovernmental Panel on Climate Change (IPCC) estimated that since the mid-1800s, average global land and sea surface temperature has increased by 0.6°C (±0.2°C), with most of the change occurring since 1976 (IPCC 2013). 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). In 2016, the global average atmospheric CO2 concentration exceeded 400 parts per million, a level Earth's atmosphere has not experienced for at least the past 800,000 years and possibly much longer (Lüthi et al. 2008, Fischer et al. 2018).

It is predicted that continued emission of greenhouse gases will 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 2014). The year 2019 was the second warmest year in the 140-year record. Global land and ocean surface temperature departures from average were +0.95°C (+1.71°F) (NCDC 2020).The five warmest years in the 1880–2019 record have all occurred since 2015, while nine of the 10 warmest years have occurred since 2005 (NCDC 2020). The upper ocean heat content, which measures the amount of heat stored in the upper 2000 m (6561 ft) of the ocean, was the highest on record by a wide margin (NCEI 2020).

Since 2000, the Arctic (latitudes between 60ºN and 90ºN) has been warming at more than three 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, black carbon, and many other factors (Serreze and Barry 2011, Overland et al. 2017, NASA 2020). 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. Approximately three-quarters of summer Arctic sea ice volume has been lost since the

1980s (IPCC 2013) and since 1979, the areal proportion of thick ice at least 5 years old has declined by approximately 90% (IPCC 2019). From 1981 through 2012, the annual minimum extent of perennial and multi-year ice declined by 12 percent and 15 percent, respectively (Comiso 2012). The minimum Arctic sea ice extent in 2019, was effectively tied with 2007 and 2016 for second lowest, only behind 2012, which is the record minimum (NSIDC 2019). Wang and Overland (2009) estimated that the Arctic will be nearly ice-free (i.e., sea ice extent will be less than 1 million square kilometers[km^2]) during the summer between the years 2021 to 2043.

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Houghton 2001, McCarthy 2001, Parry 2007, Burek 2008). Effects of climate change on physical aspects of the marine environment include, among others, increases in atmospheric temperatures; decreases in sea ice; and changes in sea surface temperatures, oceanic pH, patterns of precipitation, and sea level. Such changes have impacted, are impacting, and will continue to impact marine species in a variety of ways, such as (IPCC 2014):

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

Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2009). Therefore, we expect the extinction risk of at least some ESA-listed species to rise with global warming. The depth and duration of snow cover are projected 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). 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 (Cameron et al. 2010, Kelly et al. 2010). It is likely that, within the foreseeable future, the number of ringed seals will decline substantially, and they will no longer persist in substantial portions of their range (Cameron et al. 2010, Kelly et al. 2010).

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

The Arctic ringed seal is the only listed species that is likely to be adversely affected by the proposed action. The status of Arctic ringed seals is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as 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.

In the following narrative, we present a summary of information on the population structure and distribution of Arctic ringed seals to provide a foundation for the exposure analyses that appears 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 determination we make later in this opinion. That is, we rely on the species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

More detailed background information on the status of the species can be found in a number of published documents, including stock assessment reports for Alaska marine mammals (Muto et al. 2017) and the comprehensive status review report completed in 2010 for ringed seals (Kelly et al. 2010).

4.3.1 Arctic Ringed Seal

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 and snow cover stemming from climate change within the foreseeable future (77 FR 76706).

Ringed seal population surveys in Alaska have used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current and comprehensive abundance estimates or trends for the Alaska stock are not available. 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. (2002b) 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. (2010) 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.

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. 2010, Harwood et al. 2015). Harwood and Stirling (1992) reported that in late summer and early fall, aggregations of ringed seals in open-water in some parts of their study area in the southeastern Canadian Beaufort Sea where primary productivity was thought to be high. Harwood et al. (2015) also found that in the fall, several satellite-tagged ringed seals showed localized movements offshore east of Point Barrow in an area where bowhead whales are known to concentrate in the fall to feed on zooplankton. With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack, with many seals dispersing throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Frost and Lowry 1984, Crawford et al. 2012, Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010).

Occurrence in the Action Area

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

The study area in the Beaufort Sea has not been surveyed in a manner that supports quantifiable density estimation of marine mammals. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and the likelihood of the presence of specific species has been used to predict densities using model-based approaches. A density estimate was derived from habitat-based modeling by (Kaschner 2004) and (Kaschner et al. 2006), resulting in 0.3957 animals per km^2 in the cold season (defined as December through May). The density numbers are assumed static throughout the ice camp proposed action area for this species. These habitat suitability models include relative environmental suitability (RES) models. Habitat suitability models can be used to understand the possible extent and relative expected concentration of a marine species distribution. These models are derived from an assessment of the species occurrence in association with evaluated environmental explanatory variables that results in defining the RES suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated for each RES value based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed.

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. 2010). 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 5 summarizes the approximate annual timing of Arctic ringed seal reproduction and molting (Kelly et al. 2010).

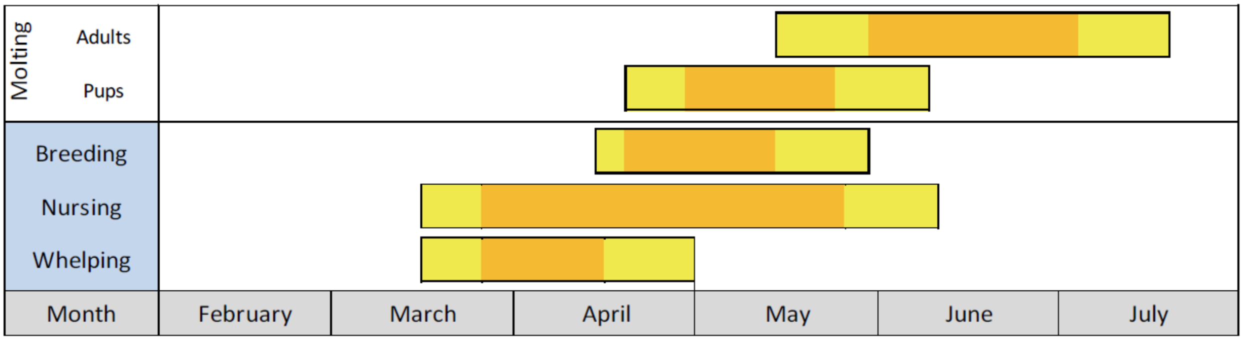

Figure 5. Approximate annual timing of Arctic ringed seal reproduction and molting. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicate the "peak" timing of each event (Kelly et al. 2010).

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. 2010).

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. 2010). Many studies of the diet of Arctic ringed seal have been conducted and although there is considerable variation in the diet regionally, several patterns emerge. Most ringed seal prey is small, and preferred prey tends to be schooling species that form dense aggregations. Fish of the cod family tend to dominate the diet from late autumn through early spring in many areas (Kovacs 2007). Arctic cod (*Boreogadus saida*) is often reported to be the most important prey species for ringed seals, especially during the ice-covered periods of the year (Lowry et al. 1980, Smith 1987, Holst et al. 2001, Labansen et al. 2007). Quakenbush et al. (2011) reported evidence that in general, the diet of Alaska ringed seals sampled consisted of cod, amphipods, and shrimp. Fish are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by 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).

Hearing, Vocalizations, and Other Sensory Capabilities

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

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

Hyvärinen (1989) suggested that ringed seals in Lake Saimaa may use a simple form of echolocation along with a highly developed vibrissal sense for orientation and feeding in dark, murky waters. The vibrissae likely are important in detecting prey by sensing their turbulent wakes as demonstrated experimentally for harbor seals (Dehnhardt et al. 1998).

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

5 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the listed species or its critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action areas that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR §402.02).

Existing Stressors within the Action Area

The following discussion summarizes the principal natural and anthropogenic stressors that affect Arctic ringed seals:

- Climate change
- Biotoxins, disease and predation
- Targeted hunts
- Ambient and anthropogenic noise
- Oil and gas development
- Other Arctic Projects
- Pollutants and contaminants
- Vessel Traffic
- Commercial Fisheries
- Research

For more information on all stressors affecting the ESA-listed species considered in depth in this opinion, please refer to the following documents:

- "Alaska Marine Mammal Stock Assessments, 2016" (Muto et al. 2017), available online at https://www.fisheries.noaa.gov/resource/%7Bpath_utils%7D/alaska-marine-mammal-stock-assessments-2016

- "Status Review of the Ringed Seal (*Phoca hispida*)" (Kelly et al. 2010), available online at http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/Ringed%20seal%202012_.pdf"

5.1 Climate Change

Climate change is the driver behind many changes that have already been observed in the Arctic or are anticipated. It is difficult to overstate the magnitude and rate of change that is occurring in the Arctic (Thoman and Walsh 2019). Observed and projected annual average warming of the Arctic is more than three times the global mean and annually averaged Arctic air temperatures for the past six years (2014-19) all exceed previous records since 1900 (Richter-Menge et al. 2019, NASA 2020). The average October temperature in Utqiaġvik (Barrow, AK), which is near the action area, has increased continuously over the last 10 years (Figure 6). In addition, the average summer high temperature in Utqiaġvik (June-August) of 2019 was 61.1°F, 4.2°F (2.3° C) above average and ranked as the second warmest such period on record (99 years) (NOAA 2019a). "The Arctic marine environment has shown changes over the past several decades, and these changes are part of a broader global warming that exceeds the range of natural variability over the past 1,000 years" (Walsh 2008). In 2018-2019, the April sea ice in the Bering Sea was a small fraction of its historical extent. A NOAA cruise in 2018 found no ribbon or spotted seals in their historically preferred breeding areas (NOAA 2019b). This is just one of many indicators of how quickly conditions are changing in the Arctic.

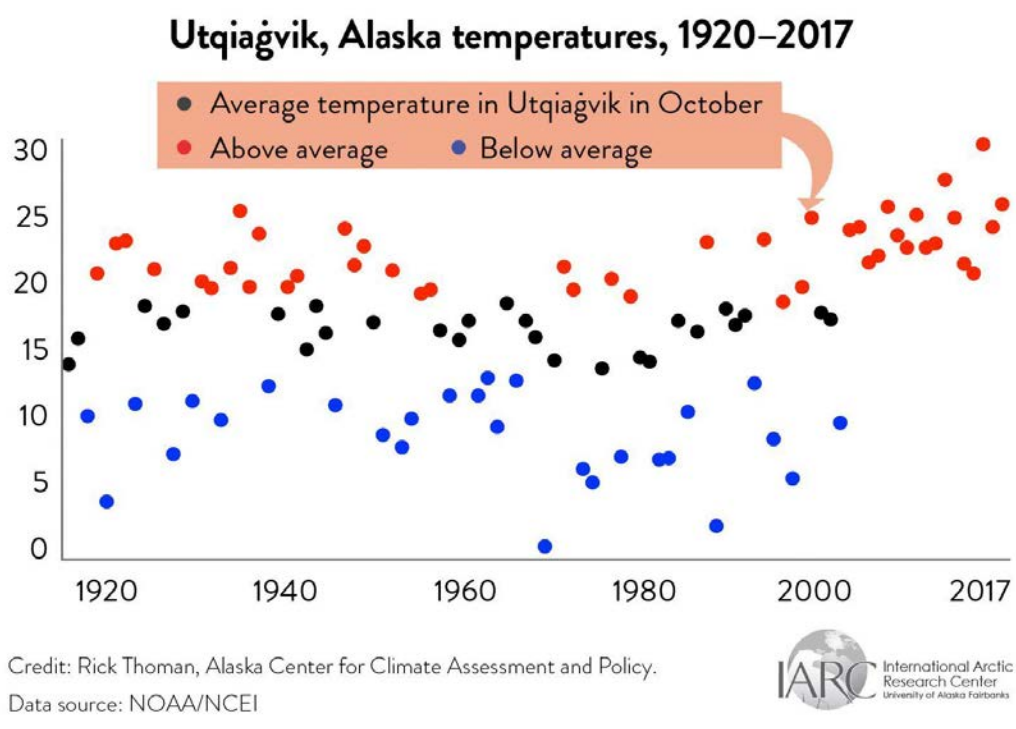

Figure 6. Air temperatures for Utqiagvik (Barrow) over time.

The proximate effects of climate change in the Arctic are being manifested as increased average winter and spring temperatures and changes in precipitation amount, timing, and type (Overland et al. 2019). There are changes in sea-ice extent, thickness, distribution, age, and melt duration (Perovich et al. 2018). The sea-ice extent and thickness are decreasing in the Arctic summer and winter. The September monthly average ice extent trend for the entire Arctic Ocean is now minus 12.8% per decade relative to the 1981-2010 average (Perovich et al. 2018). The distribution of ice is changing, and its age is decreasing. In 1985, the oldest ice comprised 16% of the ice pack whereas in March of 2018, old ice only constituted 0.9% of the ice pack (Perovich et al. 2018). Sea ice extents in four successive winters 2015–2018 (January through March) were at record low levels (Overland et al. 2019). Because thin sea ice grows quickly, the winter extent of sea ice use to rapidly return to historical extents; however, this was not the case for winters 2015–2018 (Overland et al. 2019).

It is generally thought that the Arctic will become ice free in summer, but at this time there is considerable uncertainty about when that will happen. By taking the mean of several climate models, Parry (2007) predicted that the Arctic will be ice free during summer in the latter part of the 21st century. Holland et al. (2006) estimates that 40 to 60 percent summer ice loss will occur by the middle of the 21st century. Using a suite of models, Overland and Wang (2007) predicted a 40 percent or more ice loss for the Beaufort and Chukchi Seas by 2050. While the annual minimum sea ice extent is often taken as an index of the state of Arctic sea ice, the recent reductions of multi-year sea ice and sea ice thickness are of greater physical importance. It would take many years to restore the ice thickness through annual growth, and the loss of multi-year sea ice makes it unlikely that the Arctic will return to previous climatological conditions in the foreseeable future.

Increasing ocean acidification is predicted to cause changes in ecosystem processes and presents additional stressors to organisms in the Arctic (Bates et al. 2009). Ocean acidification occurs as carbon dioxide increases in the atmosphere and is absorbed into ocean waters. The increase in carbon dioxide lowers ocean pH over time and reduces the concentration of calcium carbonate (Bates et al. 2009). Mathis and Questel (2013) studied the carbonate chemistry in the northeast Chukchi Sea during August, September, and October 2010 and found low saturation rates of calcite and aragonite (two forms of calcium carbonate) as summer progressed. Undersaturated waters are potentially highly corrosive to any calcifying organism, such as corals, bivalves, crustaceans, echinoderms and many forms of zooplankton, and consequently may affect Arctic food webs (Bates et al. 2009). Qi et al. (2017) found that the percentage of aragonite undersaturated area from 0 to 250 m in depth, in the Arctic increased from 5% in 1994 to 31% in 2010. They also suggest, based on modelling, that within approximately the next two decades, Arctic Ocean surface water will be entirely undersaturated with respect to aragonite (Qi et al. 2017).

Changes in sea ice and ocean acidification are expected to result in changes to the biological environment, causing shifts, expansion, or retraction of species' home ranges, changes in behavior, and changes in population parameters of species. Research in recent years has focused on the effects of naturally occurring or human-induced global climate regime shifts and the potential for these shifts to cause changes in habitat structure over large areas. Although many of the forces driving global climate regime shifts may originate outside the Arctic, the impacts of global climate change are exacerbated in the Arctic (ACIA 2005). These threats will be most pronounced for ice-obligate species such as the polar bear, walrus, ringed seal, and bearded seal.

The main concern about the conservation status of ringed seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projects accelerated warming within the foreseeable future. According to climate model projections, snow cover is forecasted to be inadequate for the formation and occupation of birth lairs for ringed seals within this century over the Alaska stock's entire range (Kelly et al. 2010). A decrease in the availability of suitable sea ice conditions may not only lead to high mortality of ringed seal pups but may also produce behavioral changes in seal populations (Loeng et al. 2005). Changes in snowfall over the 21st century were projected to reduce areas with suitable snow depths for ringed seal lairs by 70 percent (Hezel et al. 2012). In addition, with a progressively earlier spring breakup, the molt may be interrupted due to a lack of access to a stable ice surface and can result in compromised body condition and disease (Ferguson et al. 2017).

The ringed seal's broad distribution, ability to undertake long movements, diverse diet, and association with widely varying ice conditions suggest they may be somewhat resilient in the face of environmental variability. Although no scientific studies have directly addressed the impacts of ocean acidification on ringed seals, the effects would likely be through changes in their prey base (Bates et al. 2009). The decreased availability or loss of prey species from the ecosystem may have cascading trophic effects on these species (Kelly et al. 2010). Some of the anticipated biological consequences of the changing Arctic conditions are shown in Table 3.

Table 3. A summary of possible direct and indirect effects for Arctic marine mammals (focus on seals) related to climate change (adapted from Burek et al. 2008).

Effect	Result
Direct Loss of sea ice platform	1. Reduction of suitable habitat for feeding, resting, molting, breeding. 2. Movement and distribution will be affected
Changes in weather	Reduction in snow, loss of suitable lair habitat
Ocean acidification	Alterations of prey base
Indirect Changes in infectious disease transmission (changes in host–pathogen associations due to altered pathogen transmission or host resistance)	1. Increased host density due to reduced habitat, increasing density-dependent diseases. 2. Epidemic disease due to host or vector range expansion. 3. Increased survival of pathogens in the environment. 4. Interactions between diseases, loss of body condition, and increased immunosuppressive contaminants, resulting in increased susceptibility to endemic or epidemic disease.

Effect	Result
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, use of the Arctic)	1. Mortality events from biotoxins 2. Toxic effects of contaminants on immune function, reproduction, skin, endocrine systems, etc.
Other negative anthropogenic impacts related to longer open water period	1. Increased likelihood of ship strikes, fisheries interactions, acoustic injury 2. Chemical and pathogen pollution due to shipping or agricultural practices. 3. Introduction of nonnative species

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 Gulf of Alaska as well as the Bering, Chukchi, and Beaufort Seas (Figure 7). The years 2015–2016 coincided with the occurrence of the “blob” of exceptionally warm water in the North Pacific Ocean. This warmth became more extreme in the 2017–2019 period in association with the unprecedented loss of sea ice. The past two winters (2017–18 and 2018–19) have seen “marine heat waves” in the Bering Sea (Thoman and Walsh 2019). The heat content of the entire water column was greater in 2018 than ever recorded. The “cold pool” of water usually near the bottom of the Bering Sea disappeared during this time. This disappearance has major implications for the region, as the cold pool served as a barrier to northward migration of various aquatic species (Thoman and Walsh 2019). There have been increases of subarctic species seasonally found in the Chukchi Sea. With increasing sea-surface temperatures in the Arctic, and the loss of the cold water pool, the potential northward movement of sub-Arctic and non-native species increases (Nordon

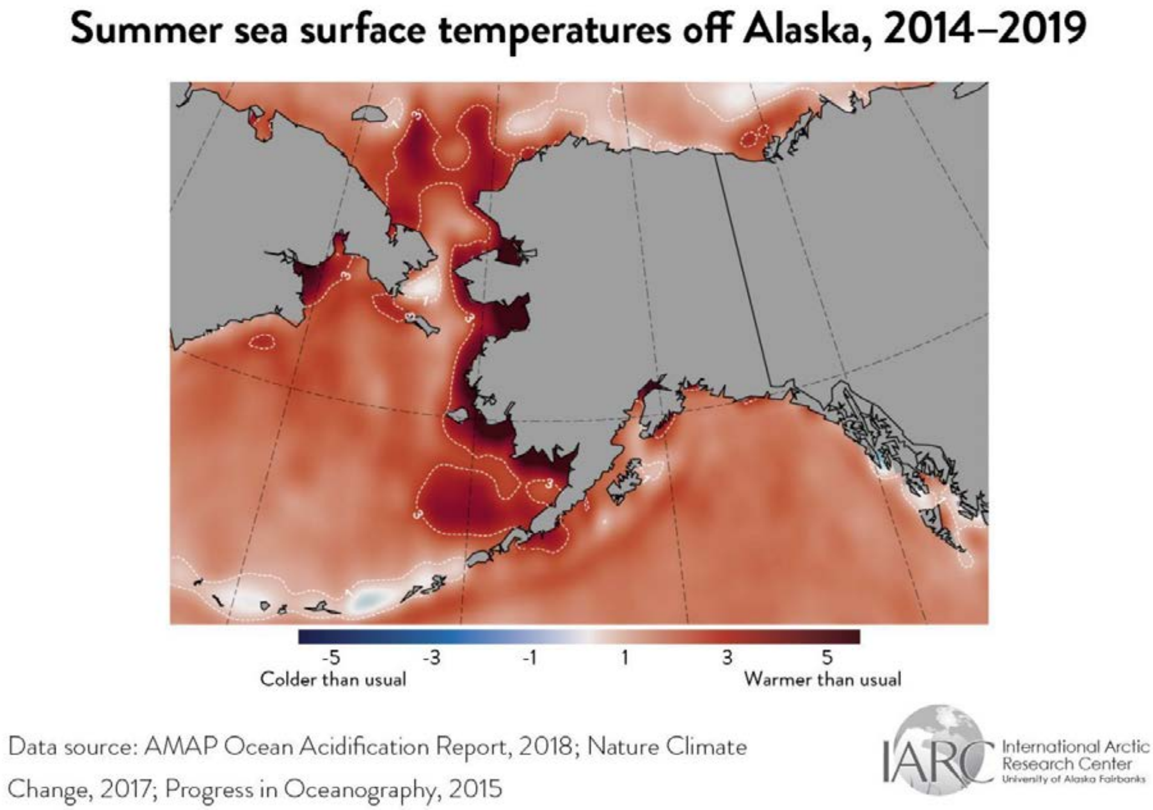

Figure 7. Arctic summer sea surface temperatures over the last 5 years.

5.2 Biotoxins, Disease, and Predation

5.2.1 Biotoxins

As temperatures in the Arctic waters warm and sea ice diminishes, marine mammal health may be compromised through nutritional and physiological stress, toxins from harmful algal blooms, and exposure to new pathogens. Fey et al. (2015) found that across all animal taxa mass mortality events were most often associated with disease, human disturbance (primarily point source contamination), and biotoxicity from harmful algal blooms. 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). In 2015, 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 8) Domoic acid was detected in all 13 species examined and had the greatest prevalence in bowhead whales (68%) and harbor seals (67%). Saxitoxin was detected in 10 of the 13 species, with the highest prevalence in humpback whales (50%) and bowhead whales (32%) and 5% of the animals tested had both toxins present (Lefebvre et al. 2016). It is not known if exposure to multiple toxins result in additive or synergistic effects or perhaps suppress immunity to make animals more vulnerable to secondary stressors (Broadwater et al. 2018). Three harmful algal blooms were documented in open water of the Chukchi Shelf in 2019 (NOAA 2019b).

Figure 8. Algal toxins detected in 13 species of marine mammals from southeast Alaska to the Arctic from 2004 to 2013 (Lefebvre et al. 2016).

5.2.2 Disease

In addition to influencing animal nutrition and physiological stress, environmental shifts may foster exposure to new pathogens in Arctic marine mammals. Through altered animal behavior and absence of physical barriers, loss of sea ice may create new pathways for animal movement and introduction of infectious diseases into the Arctic. The health impacts of this new normal in the Arctic are unknown, but new open water routes through the Arctic suggest that opportunities for Phocine distemper virus (PDV) and other pathogens to cross between North Atlantic and North Pacific marine mammal populations may become more common (Van Wormer 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 (Van Wormer 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 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 (Mahoney 2019). Since June 1, 2018, NOAA Fisheries has confirmed at least 291 strandings (NMFS 2019a). 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 sampled in the last 2 years do not have the hair loss or skin lesions which were prominent in the prior UME. Subsistence hunters noted that some of the seals taken had less fat than normal, but if they otherwise appeared healthy, they were taken.

Studies of ringed seals in the western Canadian Arctic, Beaufort Sea, and Hudson Bay (Harwood et al. 2012, Harwood et al. 2015, Ferguson et al. 2017) have found that their condition has declined over time. For the western Canadian Arctic, the relationships between body condition, reproduction (ovulation rate, percent pups in harvest), and sea ice were examined over a 20 year time series from 1992 to 2011. The results revealed a statistically significant trend of decreasing mean annual body condition for adults and subadults over the past two decades (Harwood et al. 2012). The fact that the changes in body condition were well matched among years and sex/age groupings suggests that the trend may be linked to ecosystem changes in the seal's diet, possibly from shifts in fish species composition or availability (Harwood et al. 2012)

Hudson Bay represents one of the most southerly distributions of ringed seals and therefore, as climate and ice conditions change, it is predicted that their range will be compressed northward (Kovacs and Lydersen 2008). Ferguson et al. (2017) provide evidence for decreasing body condition and increasing stress in ringed seals over 2003–2013. They suggest that the gradual reduction in body condition could be associated with the recent changes in Hudson Bay prey resource abundance and availability. The prevalence of capelin (*Mallotus villosus*) and sand lance (*Ammodytes spp*.) and decrease in Arctic cod (*Boreogadus saida*) abundance in Hudson Bay since 2000 has caused dietary shifts from endemic Arctic cod to sub-Arctic capelin and sand lance in several species.

In contrast to these studies from the eastern Arctic, Crawford et al. (2015) found that ringed and bearded seal condition in the Bering and Chukchi Seas has not declined. They compared data from 1975-1984 to data collected from 2003-2012. They suggest that since ringed and bearded seals are generalist feeders, changes in prey availability is less likely to be detrimental and the changes noted in prey availability have not caused declines in indices of seal health.

5.2.3 Predation

Polar bears are the main predator of ringed seals (Kelly et al. 2010). Other predators 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 snow owls successfully prey on pups when they are not concealed in lairs (Smith 1976, Kelly et al. 1986, Lydersen and Smith 1989, Lydersen and Ryg 1990, Lydersen 1998). The threat currently posed to ringed seals by predation is considered moderate, but predation risk is expected to increase as snow and sea ice conditions change with a warming climate (Kelly et al. 2010).

5.3 Targeted hunts

Local population depletions of ringed seals occurred during the 20th century as a result of commercial harvests (Kelly et al. 2010). Although the United States does not allow commercial harvest of marine mammals, including of ringed seals, such harvests are permitted in other portions of the species' ranges. However, commercial harvest is not considered to currently pose a significant threat to ringed seals (Kelly et al. 2010).

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 ice-associated seals for subsistence purposes (Ice Seal Committee 2016). Estimates of subsistence harvest of ringed seals are available for 17 of these communities based on annual household surveys conducted from 2009 through 2014 (Table 4), but more than 50 other communities that harvest these species for subsistence were not surveyed within this time period or have never been surveyed. Household surveys are designed to estimate harvest for the specific community surveyed; extrapolation of harvest estimates beyond a specific community is not appropriate because of local differences in seal availability, cultural hunting practices, and environmental conditions (Ice Seal Committee 2017). From 2010 to 2014, the total annual ringed and bearded seal harvest estimates across surveyed communities ranged from 695 to 1,286 and 217 to 1,176, respectively (Table 4). However, it should be noted that the geographic distribution of communities surveyed varied among years such that these totals may be geographically or otherwise biased. Nelson et al. (2019) in an analysis of subsistence harvest data from 1992-2014, from 41 of 55 ice seal hunting communities determined that the subsistence harvest is sustainable.

Table 4. Alaska ringed and bearded seal harvest estimates based on household surveys, 2010–2014 (Ice Seal Committee 2017)

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

5.4 Ambient and Anthropogenic Noise

5.4.1 Ambient Noise

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

The presence of ice can contribute substantially to ambient sound levels and affects sound propagation. While sea ice can produce substantial amounts of ambient sounds, it also can function to dampen or heighten ambient sound. Smooth annual ice can enhance sound propagation compared to open water conditions (Richardson et al. 1995). However, with increased cracking, ridging, and other forms of sub-surface deformation, transmission losses generally become higher compared to open water (Richardson et al. 1995, Blackwell and Greene 2001). Urick (1983) discussed variability of ambient noise in water, including under Arctic ice; he stated that “the ambient background depends upon the nature of ice, whether continuous, broken, moving or shore-fast, the temperature of air, and the speed of the wind.” Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. The spectrum of cracking ice sounds typically displays a broad range from 100 Hz to 1 kHz, and the spectrum level has been observed to vary as much as 15 dB re 1 μPa at 1 m within 24 hours due to diurnal variability in air temperatures (BOEM 2011). Data are limited, but in at least one instance it has been shown that ice-deformation sounds produced frequencies of 4 to 200 Hz (Greene 1981).

During the open-water season in the Arctic, wind and waves are important sources of ambient sound with levels tending to increase with increased wind and sea state, all other factors being equal (Richardson et al. 1995). Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz.

There are many marine mammals in the Arctic marine environment whose vocalizations contribute to ambient sound including bowhead whales, gray whales, beluga whales, walrus, ringed seals, and spotted seals. Walrus, seals, and seabirds all produce sound that can be heard in air as well. Ringed seal calls have a source level of 95 to 130 dB re 1 μPa at 1 m, with the dominant frequency under 5 kHz (Cummings et al., 1986 as cited in Thomson and Richardson 1995).

5.4.2 Anthropogenic Noise

Anthropogenic sources (human-caused) of noise in the action area include vessels, shipping, oil and gas activities, geophysical surveys (including seismic activities), drilling, construction, dredging, pile-driving, icebreaking, sonars, and aircraft. The combination of anthropogenic and natural noises contributes to the total noise at any one place and time. Levels of anthropogenic sound can vary dramatically depending on the season, type of activity, and environmental conditions. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994, Richardson et al. 1995, NRC 1996, NRC 2000, NRC 2003, Jasny et al. 2005, NRC 2005). Because responses to anthropogenic noise vary among species and individuals within species, it is difficult to determine long-term effects. Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Clark et al. (2009b) identified increasing levels of anthropogenic noise as a habitat concern for whales because of its potential effect on their ability to communicate (i.e. masking). Some research (Parks 2003, McDonald et al. 2006a, Parks 2009) suggests marine mammals compensate for masking by changing the frequency, source level, redundancy, and timing of their calls. However, the long-term implications of these adjustments, if any, are currently unknown. Additional information on anthropogenic noise sources can also be found in Section 5.4.1 (*Noise Related to Oil and Gas Activities*) and Section 5.7.1 (*Vessel Noise*).

5.5 Oil and Gas Development

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

5.5.1 Noise Related to Oil and Gas Activities

Anthropogenic noise levels in the Beaufort Sea are higher than in the Chukchi Sea due to nearshore and onshore oil and gas development on the Alaskan North Slope, particularly in the vicinity of Prudhoe Bay. In the central Beaufort Sea in Alaska, oil and gas exploration, development, and production activities include: seismic surveys; exploratory, delineation, and production drilling operations; construction of artificial islands, causeways, ice roads, shore-based facilities, and pipelines; and vessel and aircraft operations. Stressors associated with these activities that are of primary concern for marine mammals include noise, physical disturbance, and pollution, particularly in the event of a large oil spill.

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

In 1977, the Trans-Alaska Pipeline System began to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska. Today, it continues to transport the North Slope's entire onshore and offshore oil production, and it is projected to do so for years into the future. Endicott SDI, built in 1987, was constructed to support the first continuous production of oil from an offshore field in the Arctic. Subsequently, the Northstar offshore island was constructed in 1999 and 2000 to support oil production. Northstar, as well as the Nikaitchuq and Oooguruk developments, currently operates in nearshore areas of the Beaufort Sea, and is expected to continue operating in the future. Other oil and gas related activities that have occurred in the Beaufort Sea and Chukchi Sea OCS to date include exploratory drilling, exploration seismic surveys, geohazard surveys, geotechnical sampling programs, and baseline biological studies and surveys. There are also several exploration and development projects occurring on the North Slope including Greater Moose's Tooth 1 and 2, Smith Bay, Nuna, and Nanushuk. In addition, the Alaska Gasoline Development Corporation is developing the Alaska Stand-Alone Gas Pipeline that would extend from the North Slope to Southcentral Alaska. The project would include barging to the North Slope and modifications to West Dock.

Seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea since the late 1960s and early 1970s, resulting in extensive coverage over the area. Seismic surveys vary, but a typical 2D/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, 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).

NMFS has conducted numerous ESA section 7 consultations related to oil and gas activities in the Beaufort Sea. Many of the consultations have authorized the take (by harassment) of bowhead whales and ringed and bearded seals (as well as non ESA-listed marine mammals) from sounds produced during geophysical (including seismic) surveys and other exploration and development activities.

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

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

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

In 2015, NMFS Alaska Region conducted two internal consultations with NMFS Permits Division on the issuance of IHAs to take marine mammals incidental to shallow geohazard and 3D ocean bottom node seismic surveys in the Beaufort Sea, Alaska, during the 2015 open-water season. These consultations were also either directly or indirectly linked to the Arctic regional biological opinion. The incidental take statements in the three biological opinions estimated 461 bowhead whales, 202 bearded seals, and 1,472 ringed seals, total, would be taken (by harassment) as a result of exposure to impulsive sounds at received levels at or above 160 dB re 1 μPa_{rms} and one bowhead whale, 10 bearded seals, and 20 ringed seals as a result of exposure to impulsive sounds at received levels at or above 180 dB re 1 μPa_{rms}.

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

The first stepwise (i.e., tiered) consultation under the lease sale 193 incremental step consultation was conducted in 2015. NMFS Alaska Region consulted with the NMFS Permits Division on the issuance of an IHA to take marine mammals incidental to exploration drilling activities in the Chukchi Sea, Alaska, in 2015 (NMFS 2015b). The incidental take statement issued with the biological opinion allowed for takes (by harassment) of 1,083 bowhead whales, 14 fin whales, 14 humpback whales, 1,722 bearded seals, and 25,217 ringed seals as a result of exposure to continuous and impulsive sounds at received levels at or above 120 dB re 1 μPa_{rms} and 160 dB re 1 μPa_{rms}, respectively.

There were no consultations for oil and gas activities completed with the NMFS Permits Division in 2016 and 2017. In 2018, a consultation for the Liberty Project in Foggy Island Bay in the Beaufort Sea, for the purpose of oil and gas extratction was completed. This project has a 25-year life. Incidental take for bowhead whales (34), bearded seals (134) and ringed seals (870) through Level A and B harassment was authorized as well as 10 ringed seals deaths.

Anticipated impacts by harassment from noise associated with oil and gas activities generally include changes in ringed seals' behavioral state from low energy states (i.e., foraging, resting, and milling) to high energy states (i.e., traveling and avoidance).

5.6 Other Arctic Projects

NMFS conducted informal consultations with the Navy on prior military exercises in the Arctic that were very similar to the proposed project. In 2016 and 2018, the Navy also 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. Economic Zone, 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). The Navy obtained a NPDES permit from EPA for discharges from camp operations for discharge greywater and reject water from desalinization.

In 2016, NMFS Alaska Region conducted internal consultations with NMFS Permits Division on the issuance of three IHAs to take marine mammals incidental to dock construction, fiber optic cable laying, and anchor retrieval in the Bering, Chukchi, and Beaufort Seas, during the 2016 open water season. The incidental take statements issued with the three biological opinions allowed for takes (by harassment) of 788 bowhead whales, 19 fin whales, 13 humpback whales, 706 bearded seals, 7,887 ringed seals, and 2,185 western DPS Steller sea lion total, 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.

Fiber optic cable laying continued in 2017, and NMFS Alaska Region conducted a consultation with NMFS Permits Divison on the issuance of an IHA for this project. Quintillion was permitted to install 1,904 km (1,183 mi) of subsea fiber optic cable during the open-water season, including a main trunk line and six branch lines to onshore facilities in Nome, Kotzebue, Point Hope, Wainwright, Barrow, and Oliktok Point. The incidental take statement issued with the biological opinion allowed for takes (by harassment) of 314 bowhead whales, 15 fin whales, 3 Western North Pacific DPS humpback whales, 7 Mexico DPS humpback whales, 62 bearded seals, 855 ringed seals, and 8 Western DPS Steller sea lions, total, 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 2017).

5.7 Pollutants and Contaminants

5.7.1 Authorized Discharge

Discharges authorized from development activities occurring in portions of the action area are the source of multiple pollutants that may be bioavailable (i.e., may be taken up and absorbed by animals) to ESA-listed species and their prey items (NMFS 2016). Drill cuttings and fluids contain contaminants such as dibenzofuran and polycyclic aromatic hydrocarbons that have high potential for bioaccumulation. Historically, drill cuttings and fluids have been discharged from oil and gas developments in the Beaufort Sea near the action area, and residues from these historical discharges may be present in the environment (Brown et al. 2010). Polycyclic aromatic hydrocarbons are also emitted to the atmosphere by flaring water 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 GP). The general permit authorizes 13 types of discharges from exploration drilling operations and establishes effluent limitations and monitoring requirements for each waste stream.

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

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

The principal regulatory mechanism for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic Region OCS is also the Clean Water Act of 1972. The EPA issued a NPDES vessel general permit effective from December 19, 2013, to December 18, 2018, that applies to pollutant discharges from non-recreational vessels that are at least 24 m (79 ft) in length, as well as ballast water discharged from commercial vessels less than 24 m. This general permit restricts the seasons and areas of operation, as well as discharge depths, and includes monitoring requirements and other conditions.

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

5.7.2 Accidental Discharges - Oil Spills and Gas Releases

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 2017a).

Small Oil Spills

Offshore petroleum exploration activities have been conducted in State of Alaska waters adjacent to 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 2017a).

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

Large Oil Spills and Very Large Oil Spills

Because no large spills (≥ 1,000 bbl) have occurred on the Alaska or Atlantic OCS from oil and gas activities (BOEM 2017b), the large OCS spill-size assumption BOEM uses for large spill analysis are based on reported spills in the Gulf of Mexico and Pacific OCS.

The loss of well control (LOWC) occurrence frequencies, per well, are on the order of 10^{-3}-10^{-6}. The occurrence frequencies depend upon the operation or activity, whether the LOWC was a blowout or well release, and whether there was oil spilled (BOEM 2017b).

In general, historical data show that LOWC events escalating into blowouts and resulting in oil spills are infrequent and that those resulting in large accidental oil spills are even rarer events (BOEM 2017b). From 1964 to 2010 there were 283 well control incidents, 61 of which resulted in crude or condensate spills (BOEM 2012a, 2017b). From 1971 to 2010, fewer than 50 well control incidents occurred. Excluding the volume from the DWH spill, the total spilled volume was less than 2,000 bbl of crude or condensate, with the largest of the 1971-2010 spills—other than the DWH event—being 350 bbl. The DWH event was the only VLOS to occur between 1971 and 2010 (BOEM 2012a, 2017b). During that same time period, more than 41,800 wells were drilled on the OCS and almost 16 Bbbl of oil were produced.

From 1971-2010, industry drilled 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. During this period, there were 77 well control incidents associated with exploration drilling. Of those 77 well control incidents, 14 (18 percent) resulted in oil spills ranging from 0.5 bbl to 200 bbl, for a total 354 bbl, excluding the estimated volume from the DWH spill. These statistics show that, while approximately 15,000 exploration wells were drilled, there were a total of 15 loss-of-well-control events that resulted in a spill of any size: 14 were small spills and one was a large spill (≥1,000 bbl) that resulted in a blowout. That one large/very large spill was the DWH (BOEM 2017b).

The risk of an unlikely or rare event, such as a loss of well control incident, is determined using the best available historical data. The 2012-2017 Five-Year Program Final PEIS (BOEM 2012a) provides a detailed discussion of the OCS well control incidents and risk factors that could contribute to a long duration LOWC event. Risk factors include geologic formation and hazards; water depth and hazards; geographic location (including water depth); well design and integrity; loss of well control prevention and intervention; scale and expansion; human error; containment capability; response capability; oil types and weathering/fate; and specific regional geographic considerations, including oceanography and meteorology (BOEM 2017b).

Quantifying the frequency of very large oil spills (VLOSs) from a loss of well control event is challenging as relatively few large oil spills that can serve as benchmarks have occurred on the OCS (Scarlett et al. 2011). Based on an analysis of this historic data from both the 1971-2010 (the modern regulatory era) and the 1964-1971 time frames, the frequency of a loss of well control occurring and resulting in a VLOS of different volumes was determined (BOEM 2016b). This analysis, which is set forth in the 2017-2022 Five-Year Program Final PEIS, was used to calculate the frequency (per well) of a spill exceeding 4,610,000 bbl, which was the VLOS volume assumed in the Liberty analysis (BOEM 2017b).

Increased oil and gas development in the U.S. Arctic has led to an increased risk of various forms of pollution to whale and seal habitat, including oil spills, other pollutants, and nontoxic waste (Muto et al. 2017).

5.7.3 Heavy metals

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). Mercury levels in Arctic marine predators, such as belugas, ringed seals and polar bears, have increased ten-fold over the past century (Dietz et al. 2006, Outridge et al. 2009), and in some populations, are above multiple thresholds for neurological effects (Dietz et al. 2013).

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 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. Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals, which might reflect localized natural arsenic sources.

5.7.4 Plastics

An additional 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, strapping are problems for marine sea birds, turtles, and mammals because of ingestion and entanglement (Laist 1997, Law 2017, Peeken et al. 2018). We have no documented reports of strandings of ringed 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, increased number of observers (tourists, scientists, employees), and longer periods of open water which can promote delivery of plastics to the Arctic, it is anticipated that ingestion and entanglement of ringed and bearded seals will be documented in coming years.

Of equal concern in the Arctic is the presence of microplastics. 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 (Bergmann et al. 2017, Lusher et al. 2015) and water (Kanhai et al. 2018).

Marine plastic debris is associated with a 'cocktail of chemicals', including chemicals added or produced during manufacturing (Lithner et al. 2011) and those present in the marine environment that accumulate onto the debris from surrounding seawater (Mato et al. 2001, Ogata et al. 2009). 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 whales (Besseling et al. 2012, Besseling et al. 2014, Besseling et al. 2015, Fang et al. 2018) 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 2009, Rochman 2015). What remains less understood, is whether these plastic-associated contaminants biomagnify in higher trophic level animals 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 (Rochman 2015).

5.8 Vessel Traffic

The general seasonal pattrn 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. Unaided navigation is limited to an even narrower time frame. Decreasing ice levels will facilitate an increase in vessel traffic associated with oil and gas exploration, tourism, and open historically closed trade routes. The Northern Sea Route reduces the distance between Northwest Europe and Northeast Asia by 40% compared to the passage throught the Suez Canal. The Northwest Passage reduces the sailing distance between Northeast Asia and the U.S. Atlantic coast by 23% compared to the route via the Panama Canal (Bekkers et al., 2016). The two Arctic routes allow shipping companies to avoid increased tolls in the Suez and Panama Canals and provide routes for super ships that are larger and able to carry greater volumes of cargo (Nong et al. 2018). In an effort to predict the increase of vessel traffic through the Northwest Passage and the Northern Sea Route, Melia et al. (2016) used global climate models to project how sea ice loss might increase Arctic shipping. For a high-emission scenario, by late century, trans-Arctic shipping may be commonplace, with a season ranging from 4 to 8 months. For a low-emissions scenario, with global mean temperature stabilization of less than 2º C above preindustrial, the frequency of open water vessel transits still has the potential to double by midcentury with a season ranging from 2 to 4 months (Melia et al. 2016).

Degradation of Arctic marine ecosystems may accompany expanding vessel operations through increased air-borne emissions levels (CO2 and black carbon) increased underwater noise, potential for large oil spills, introduction of nonnative species, and probability of ship strike. These factors may compound stressors already effecting marine mammal populations due to climate change (Silber and Adams 2019).

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, an increase of 108 percent (ICCT 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 Prudhoe Bay from oil and gas exploration activity is particularly pronounced (ICCT 2015). However, the number of vessels identified in this region in 2012 likely also reflects traffic associated with the offshore exploratory drilling program that was conducted by Shell on the OCS of the Chukchi Sea that year. 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 (ICCT 2015).

5.8.1 Nonnative species

Many studies have demonstrated a close relationship between trade and nonnative species, with shipping being identified as the main vector of nonnatives in aquatic ecosystems (Nong 2018, Chan et al. 2019). Olson (2006) reviewed numerous studies of biological invasions and highlighted that international trade is an important vector that links to the existence and spread of invasive species internationally. Globally, shipping has been found to be responsible for 69% of marine invasive species (Molnar et al. 2008). Chan et al. found that vessels transferred the greatest number of aquatic nonnatives (39%) to the Arctic, followed by natural spread (30%) and aquaculture activities (25%).

Risks associated with oceanic shipping come primarily from hitchhiking species on ship hulls (hull fouling) and in ballast water (Drake and Lodge, 2007; Keller et al. 2011). Until recently, the Arctic has had very low exposure to nonnatives because of the extensive ice cover, remoteness, and harshness of the environment. The Arctic is about to undergo extensive and unprecedented biotic introductions (Miller and Ruiz 2014). In general, the introduction of nonnative species is one of the primary causes decreased biodiversity in an ecosystem (Trombulak et al. 2004). The impact of nonnatives in marine systems ranges from extirpation of native species through competition or predation, shifts in ecosystem food webs, to changes to the physical structure of the habitat (Norse and Crowder 2005). Although it is not possible to predict which nonnatives will arrive and thrive in the Arctic, it is reasonably certain that they will be yet another facet of change and potential stress to native biota which may affect either the health or prey base of native fauna.

5.8.2 Vessel Noise

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the oceans (Simmonds and Hutchinson 1996, Nation Research Council 2003). The types of vessels operating in the Bering, Chukchi, and Beaufort Seas typically include fishing vessels, 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 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). 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).

5.8.3 Ship Strike

Ship strike of seals in open water unlikely to occur because they are small and maneuverable. However, icebreakers could be lethal to nursing pups through collisions or crushing by displaced ice (Wilson et al. 2017). 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 trips 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, to 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. Studies like this have not been conducted in Alaska but it is likely the effects would be similar. The two best ways to reduce ship strike are to have ship routes that avoid areas with high levels of marine mammal use and to reduce ship speed (Wilson et al. 2017, Pirotta et al. 2019).

Current shipping activities in the Arctic pose varying levels of threats to ringed seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with their habitats. The presence and movements of ships in the vicinity of seals can affect their normal behavior (Jansen et al. 2010) and may cause them to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne 1979, Mansfield 1983). To date, no ringed seal carcasses have been found with propeller marks. However, Sternfeld (2004) documented a singled spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike. Icebreakers pose greater risks to ringed and bearded seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (e.g., tankers and bulk carriers) through ice-covered areas. Reeves (1998) noted that some ringed seals have been killed by icebreakers moving through fast-ice breeding areas.

5.9 Commercial fishing

While no commercial fishing is currently authorized in the Beaufort Sea, ringed seals may be impacted by commercial fishing interactions as they migrate through the Bering Sea to the Chukchi Sea. Commercial fisheries may impact ringed seals through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations. Estimates of ringed seal bycatch could only be found for commercial fisheries that operate in Alaska waters. From 2010 through 2014, incidental mortality and serious injury of ringed seals was reported in 4 of the 22 federally-regulated commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Muto et al. 2017). An additional ringed seal mortality due to U.S. commercial fisheries was reported to the NMFS Alaska Region stranding network in 2011; however, because the seal was discovered during the offloading process, the resulting mean annual mortality and serious injury rate of 0.2 could not be assigned to a specific fishery (Helker et al. 2016). Based on data from 2010 through 2014, the average annual rate of mortality and serious injury incidental to U.S. commercial fishing operations is 3.9 ringed seals (3.7 from observer data + 0.2 from stranding data).

5.10 Research

The NMFS Permits Division issues scientific research permits for activities that adversely affect bowhead whales, ringed seals, and bearded seals in the Bering, Chukchi, and Beaufort Seas. The following summarizes current research permits issued, and more information can be found on the NMFS Authorizations and Permits for Protected Species website.

Permit No. 19309, which expired March 25, 2012, authorized the capture of up to 150 ringed seals and 150 bearded seals; takes by harassment of up to 3,000 of each species during capture operations and certain sampling activities; and takes by harassment of up to 3,200 bearded seals and 6,700 ringed seals during aerial surveys. Permit No. 20466, which expired March 31, 2012, authorized the capture of up to 200 bearded seals and 200 ringed seals; takes by harassment of up to 3,000 of each species during capture activities; and takes by harassment of up to 15,000 of each species during aerial and vessel surveys. Permit No. 18890, which expires June 15, 2021, authorizes the annual capture of 2 bearded seals and 2 ringed seals; and take by harassment of up to 8 of each species during vessel surveys. Permit No. 14856, which expires December 31, 2018, authorizes take by harassment of up to 100 ringed and 100 bearded seals during vessel surveys. Finally, Permit No. 20465, which expires May 31, 2022, authorizes take by harassment of up to 200 bearded seals and 200 ringed seals during aerial surveys.

Occasionally, mortalities may occur incidental to marine mammal research activities authorized under MMPA research permits. In 2010 through 2014, one mortality was reported incidental to research on the Alaska stock of ringed seals, resulting in an average of 0.2 ringed seal mortalities per year from this stock (Muto et al. 2017).

6 EFFECTS OF THE ACTION

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

This biological opinion relies on the best scientific and commercial information available. We try to note areas of uncertainty, or situations where data are 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.

6.1 Project Stressors

During the course of this consultation, we identified the following potential stressors from the proposed ICEX20 project:

- *Acoustic effects* from active transmissions from submarines;
- *Incidental noise* from aircraft transporting supplies and personnel between the camp and Prudhoe Bay, ice augering, and on-ice vehicle operation; and
- *Physical effects* from vessel or vehicle strike, entanglement in or ingestion of expended materials, waste and reject water discharge, and fuel spills.

All potential stressors from the proposed action were considered, individually and cumulatively, in developing the analysis and conclusions in this opinion regarding the effects of the proposed action on Arctic ringed seals.

6.2 Exposure and Response Analyses

As discussed in the *Approach to the Assessment* section of this opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

As discussed in Section 2.3.1 and 2.3.2 above, the Navy proposed mitigation measures that should avoid or minimize exposure of ringed seals to underwater and airborne noise. Mitigation measures for on-ice travel and air travel will minimize the exposure of seals to sounds propagated in the air. In addition, ringed seals that are out of the water are expected to be in lairs covered by snow during the timeframe of ICEX20. The combination of ice below, and snow above, would attenuate any sounds created near them. Underwater, passive acoustic sensors on the submarines will listen for vocalizing marine mammals. If a marine mammal is detected, the submarine will cease active transmissions, and not restart until after 15 minutes have passed with no marine mammal detections. We anticipate that this measure will limit the exposure of any ringed seals to sonar transmission under water. Because the proposed activity will occur before whelping, only adult ringed seals will potentially be exposed to any air borne or underwater sounds. Both males and females could be present. As explained below (6.3.1), we anticipate that the potential numbers of ringed seals that could be present in the action area, will be very low.

For our exposure analyses, NMFS generally relies on an action agency's estimates of the number of marine mammals that might be "taken." A quantitative exposure analysis was provided in the Biological Evaluation (Navy 2019) and IHA (Permits Division 2019). Based on these initial qualitative and quantitative analyses, NMFS AKR calculated the exposure and "take" estimates for the project.

Briefly, the Navy's quantitative underwater acoustic exposure analysis is based on the Navy Acoustic Effects Model (NAEMO) and estimates the number of marine mammals that could be harassed by the underwater non-impulsive acoustic sources during the proposed action (Navy 2019). Inputs to the quantitative analysis included marine mammal density estimates obtained from the Navy Marine Species Density Database, marine mammal depth occurrence distributions, oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential animal exposures. The model calculates sound energy propagation from the proposed non-impulsive acoustic sources, the sound received by animat (virtual animal) dosimeters representing marine mammals distributed in the area around the modeled activity, and whether the sound received by a marine mammal exceeds the thresholds for effects.

The National Defense Authorization Act of Fiscal Year 2004 (PL 108-136) amended the definition of "harassment" as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 3(18)(B) of the MMPA [16 U.S.C. §1362 (18)(B)]. The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (PL 107-314). Military training activities within the study area composed of military readiness activities, as that term is defined in PL 107-314, because training activities constitute "training and operations of the Armed Forces that relate to combat" and "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." For military readiness activities, the relevant definition of harassment is any act that:

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

While the ESA does not define "harass," NMFS issued guidance interpreting the term "harass" under the ESA as to: "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016).

Following the exposure analysis is the response analysis. The response analyses determine how listed species are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. Our assessments try to detect the probability of lethal responses, physical damage, physiological responses (particularly stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

Possible responses by Arctic ringed seals to project activities in this analysis are:

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

6.2.1 Sound Measurements Used in this Document

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

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

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

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

6.2.2 Threshold Shifts

Exposure of marine mammals to very loud noise can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Temporary threshold shift (TTS) is a temporary hearing change, and its severity is dependent upon the duration, frequency, sound pressure, and rise time of a sound (Finneran and Schlundt 2013). TTS could occur to adult ringed seals from exposure to sonar. However, because of the standard operating procedures and the because sonar effects are not expected to exceed 10 km (6.2 mi) (Navy 2019), we expect that only a small number of ringed seals may be affected. TTSs can last minutes to days. Full recovery is expected, and this condition is not considered a physical injury. At higher received levels, or in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur. When PTS occurs, auditory sensitivity is unrecoverable (i.e., permanent hearing loss). The effect of noise exposure generally depends on a number of factors relating to the physical and spectral characteristics of the sound (e.g., the intensity, peak pressure, frequency, duration, duty cycle), and relating to the animal under consideration (e.g., hearing sensitivity, age, gender, behavioral status, prior exposures). Both TTS and PTS can result from a single pulse or from accumulated effects of multiple pulses from an impulsive sound source (e.g., impact pile or pipe driving) or from accumulated effects of non-pulsed sound from a continuous sound source (i.e., vessel noise). In the case of exposure to multiple pulses, each pulse need not be as loud as a single pulse to have the same accumulated effect.

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

Both duration and pressure level of a sound are factors in inducement of threshold shift. Exposure to non-pulsed sound (i.e., thruster noise from dynamic positioning) may induce more threshold shift than exposure to a pulsed sound with the same energy; however, this is dependent on the duty cycle of the pulsed source because some recovery may occur between exposures (Kryter et al. 1966, Ward 2007). For example, exposure to one pulse of a sound with a higher sound pressure level than a continuous sound may induce the same impairment as that continuous sound; however, exposure to the continuous sound may cause more impairment than exposure to a series of several intermittent softer sounds with the same total energy (Ward 2007).

Temporary threshold shift was reported in toothed whales after exposure to relatively short, continuous sounds (ranging from 1 to 64 sec) at relatively high sound pressure levels (ranging from 185 to 201 dB re 1 μPa_{rms}) (Ridgway et al. 1997, Schlundt et al. 2000, Finneran et al. 2005, Finneran et al. 2007); however, toothed whales experienced TTS at lower sound pressure levels (160 to 179 dB re 1 μPa_{rms}) when exposed to continuous sounds of relatively long duration (ranging from 30 to 54 min) (Nachtigall et al. 2003, Nachtigall et al. 2004).

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

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

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

Since 1997, NMFS has used generic sound exposure thresholds to determine whether an activity produces underwater and in-air sounds that might result in impacts to marine mammals (70 FR 1871). NMFS developed comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary thresholds shifts (PTS and TTS; Level A harassment) (81 FR 51694). NMFS is in the process of developing guidance for behavioral disruption (Level B harassment). However, until such guidance is available, NMFS uses the following conservative thresholds of underwater sound pressure levels[2], expressed in root mean square[3] (rms), from broadband sounds that cause behavioral disturbance, and referred to as Level B harassment under section 3(18)(A)(ii) of the Marine Mammal Protection Act (MMPA):

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

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

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

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

Under the PTS/TTS Technical Guidance, NMFS uses the following thresholds (Table 5) for underwater sounds that cause injury, referred to as Level A harassment under section 3(18)(A)(i) of the MMPA (NMFS 2016d). These acoustic thresholds are presented using dual metrics of cumulative sound exposure level (L_E) and peak sound level (PK) for impulsive sounds and L_E for non-impulsive sounds.

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

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

Table 5. PTS Onset Acoustic Thresholds for Level A Harassment for Phocids (NMFS 2016b).

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

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

6.2.3 Auditory Interference (masking)

Auditory interference, or masking, occurs when an interfering noise is similar in frequency and loudness to (or louder than) the auditory signal received by an animal while it is processing echolocation signals or listening for acoustic information from other animals (Francis and Barber 2013). Although studies of the responses of phocids (including ringed seals) to the effects of masking are limited (Terhune 1999), other marine mammals exhibit changes to vocal behavior and call structure when the animals are compensating for an increase in background noise. Masking can interfere with an animal's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Francis and Barber 2013). Vocalizations may also change in response to variation in the natural acoustic environment (e.g., from variation in sea surface motion) (Dunlop et al. 2014), including vocalizations of conspecifics (Terhune 1999).

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

The ringed seal may experience short-term masking as a result of the proposed action, but the effects will most likely be brief.

6.2.4 Behavior Response

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

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

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

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

For non-impulsive sounds (similar to the sources used during the proposed action), data suggest that exposures of pinnipeds to sources between 90 and 140 dB re 1 μPa do not elicit strong behavioral responses. Kvadsheim et al. (2010) exposed hooded seals in an experimental setting to non-impulsive sources with a received sound pressure level which may be similar to the levels in the proposed action; they mimicked military sonar signals in the 1 to 7 kHz band in order to assess potential adverse effects. The hooded seals were fitted with dataloggers capable of recording diving behavior, swimming activity, and heart rate. The animals responded to the initial (10% duty cycle) exposure with avoidance to signals above 160 to 170 dB rms (re 1 µPa) received levels. They reduced diving activity, began rapid exploratory swimming at surface, and lifted their heads out of the water. Upon repeated exposure, and regardless of signal frequency (from 1.3 to 7 kHz), the seals adapted to the exposure with disappearance of the initial exploratory surface swimming and directly transitioned from diving to passive floating with their heads out of the water in an area furthest from the sound source. The seals had the option of hauling out on a platform, but none did. Their heart rate increased at the surface indicating emotional activation during sonar exposure, but lack of effect of sonar exposure on heart rate during diving indicates that physiological responses during diving remained normal (Kvadsheim et al. 2010). During ICEX20 we expect that there will be a solid layer of ice in the action area. Consequently, any ringed seals that are exposed to sound could not avoid it by raising their head above the water surface unless they were close to a breathing hole. However, they would be free to swim away from the source unlike the experimental animals which were held in an enclosure (Kvadsheim et al. 2010).

Experimentally, Götz and Janik (2011) tested underwater responses in wild-captured gray seals to a startling sound (sound with a rapid rise time and a 93 dB sensation level) and a non-startling sound (sound with the same level, but with a slower rise time). The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the non-startling treatment either did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal's habituation. Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Götz and Janik 2011; Ellison et al. 2012). In cases where marine mammal response is brief (i.e., changing from one behavior to another, relocating a short distance, or ceasing vocalization), the effect(s) are not likely to be measurable at the population level, but could rise to the level of take of individuals.

Individual ringed seals could react to the Navy's ICEX20 active transmissions over the two-week operation period by alerting or temporarily avoiding the area close to the source; however, feeding or reproduction is unlikely to be compromised because the behavioral response is expected to be very short in duration. The expected response of swimming away from the sonar source or swimming to a breathing hole and raising the head above the water surface is not likely to increase energy expenditure to the point of significantly disrupting normal behavioral patterns. If the sonar happened to occur within a ringed seal's home range, because they construct multiple breathing holes and lairs within their home ranges (Smith and Stirling 1975) individuals would have several options for avoiding the noise. Based on the reactions of hooded seals (Kvadsheim et al. 2010) and gray seals (Götz and Janik 2010) we expect that seals that stay near sonar transmissions would habituate to the sound and would have very little reaction after the initial pulses are heard. In cases where marine mammal response is brief (i.e., changing from one behavior to another, relocating a short distance, or ceasing vocalization), the effect(s) are not likely to be measurable at the population level, but could rise to the level of take of individuals.

6.2.5 Physical or Physiological Effects

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

Mammalian stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996, Gardiner and Hall 1997, Hunt et al. 2006, Romero et al. 2008). The stress response can be behavioral (e.g., startle, sudden change in behavior) and/or physiological (e.g., release of stress hormones, increase in heart rate, etc.). Different types of sounds have been shown to produce variable stress responses in marine mammals. As explained in the prior section Kvadsheim et al. (2010) exposed hooded seals to typical sonar transmissions. They found that sonar exposure led to a significant 28% increase in heart rate when the animals were at the surface but an insignificant change when the animals were diving (Kvadsheim et al. (2010). The increased heart rate at the surface during sonar exposure might therefore indicate emotional activation or discomfort, but the rapid behavioural adaptation with passive floating at the surface during sonar exposure indicates that there was no panic. The lack of effect of sonar exposure on heart rate during diving also indicates that despite any emotional activation, normal physiological responses to diving were still intact (Kvadsheim et al. (2010).

Marine mammals use hearing as a primary way to gather information about their environment and for communication; therefore, we assume that limiting these abilities is stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NRC 2003, NMFS 2006). We expect individual ringed seals may experience Level B acoustic harassment and acoustic masking and may exhibit behavioral responses from project activities. Therefore, we expect they may experience stress responses. If seals are not displaced and remain in a stressful environment, we expect the stress response will dissipate shortly after the individual leaves the area or after the cessation of the acoustic stressor.

6.3 Acoustic Stressors

6.3.1 Active Sonar Transmissions

The submarine training and research activities have acoustic transmissions with potential effects to ringed seals. Some acoustic sources are either above the known hearing range of marine species or have narrow beam widths and short pulse lengths that affect a very small area of water for a very short amount of time, and are therefore extremely unlikely to affect marine mammals that are present at low densities in the action area. Submarine training and testing, which are proposed to occur over a two-week period, are the only portions of the proposed action with active acoustics that require quantitative analysis. All other equipment and devices to be used will have *de minimis* effects which means they have low source levels, narrow beams, downward directed transmission, short pulse lengths, frequencies outside known marine mammal hearing ranges, or some combination of these factors (Navy 2019). Effects to seals swimming underwater are the primary concern regarding this active transmission, because the sound levels received by hauled out seals will be much lower, due to transmission loss through the ice and air.

Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience the loss of hearing sensitivity at certain frequency ranges (Finneran 2015). This hearing "threshold shift" (TS) can be permanent (PTS) and not fully recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall et al. 2007). Repeated sound exposure that leads to TTS could cause PTS. In severe cases of PTS, there can be total or partial deafness, while in most cases the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter et al. 1985).

The Navy Acoustic Effects Model (NAEMO) was used to produce a quantitative estimate of the total sound exposure level and maximum sound pressure level that a ringed seal may receive underwater from acoustic transmissions. In NAEMO, "animats" (modeled animal unit) are distributed randomly based on species-specific density, depth distribution, and group size information, and animats record projected energy received at their location in the water column. A fully three-dimensional environment is used for calculating sound propagation and animat exposure in NAEMO. A full description of NAEMO can be found in the Naval Undersea Warfare Center Newport Technical Report available online at: http://hstteis.com/Portals/0/hstteis/SupportingTechnicalDocs/TR_12084A_HSTT_Final.pdf.

The Navy uses behavioral response functions (BRFs) to estimate the probability that marine mammals will display behavioral effects to received sound (Finneran and Jenkins 2012). Although the BRFs were originally derived from few studies, primarily on captive dolphins and belugas (Navy 2003, Finneran and Schlundt 2004, Nowacek et al. 2004, Navy 2008, Navy 2012), they have been updated to include data on captive hooded and gray seals and California sea lions (Gotz et al. 2010; Houser et al. 2013; Kvadsheim et al. 2010); they constitute the best science available at this time for assessing such effects.

For the ICEX20 acoustic transmissions, NAEMO calculated that no ringed seals or bearded seals were likely to experience received sound exposure levels that may result in permanent threshold shifts (PTS). NAEMO further calculated that 11 ringed seals and 1 bearded seal could experience TTS and an additional 1,395 ringed seals and 3 bearded seals could respond behaviorally to acoustic transmissions associated with ICEX20 (Navy 2019) (Table 6). Although Navy requested coverage in their IHA for take of 4 bearded seals, as explained above in 4.1. NMFS concludes that the proposed action may affect, but is not likely to adversely affect, bearded seals, and thus we anticipate no take of bearded seals.

Table 6. Quantitative Modeling Results of Potential Exposures for ICEX Activities.

Common Name	Level B Harassment		Level A Harassment	Percentage of Stock Taken (%)
	Behavioral	TTS		
Bearded seal	3	1	0	0.001
Ringed seal	1,395	11	0	0.468

The number of ringed seals that will be disturbed to a degree that would be considered take under the ESA is likely to be considerably lower than the modeled results, for several reasons:

1. The estimated ringed seal density is likely lower than the value used in the NAEMO model. Although ringed seals may be present in the action area, Frost et al. (2004) found that their density was highest at water depths between 25-35 m (82-115 ft). Although their surveys extended only a short distance beyond the continental shelf, ringed seal density was significantly less at depths greater than 35-45 m (82-150 ft) (Frost et al. 2004). Frost et al. (2002) found the same significant relation, with seal density decreasing with depth up to 55 m (180 ft) (the maximum surveyed). Crawford et al. (2012) caught and tagged 25 seals from Kotzebue Sound in 2007 and 2008 and tracked their movements. Average water depth in which they stayed over time was 36.5 m (120 ft). Likewise, Bengtson et al. (2005) found ringed seals were four to ten times more abundant in nearshore fast and pack ice environments than in offshore pack ice, consistent with the pattern reported by other authors such as Smith (1973), who reported that densities of ringed seals were much lower beyond 29 km (18 mi) from shore. Bengtson et al. (2005) concluded that the higher density of ringed seals in the coastal areas was not surprising, given the importance of shore fast ice for ringed seal lairs and breeding habitat. These results lead us to believe that far fewer ringed seals will be present at the ICEX20 activity area because it will be well off the continental shelf in water 800 m (2,625 ft) or more in depth.

   Early winter, prior to the occupation of breeding sites, is an important time in which female ringed seals accumulate enough fat stores to support estrus and lactation (McLaren 1958; Kelly et al. 2010). We expect that ringed seals select habitats at this time where food is abundant and easily accessible to minimize the energy required to forage. Arctic cod, an important part of ringed seal diet, is abundant near shore from November to April when the fish concentrate to spawn (Logerwell et al. 2015). Foraging over the continental shelf where productivity is high and food more accessible (both fish and invertebrates available, and at shallower depths) is likely, in part, responsible for the distribution of seals that has been documented (e.g. Frost et al. 2002, Frost et al. 2004).

   Because ringed seals have a diet that includes both benthic invertebrates and fish, at 800 m (location of ICEX20 activities) benthic invertebrates would be eliminated as a food option and ringed seals would have to depend exclusively on fish. We have no information on fish densities in the deep waters of the Arctic Ocean in the winter but reducing the food options available would likely make the area less favorable for ringed seals.

Crawford et al. (2019) and Hamilton et al. (2018) found that there is a 5 to 15 percent probability that ringed seals will be hauled out during winter. Hamilton et al. (2018) found that average haulout time was 3.3 hours. Because the level of sound received is greatly reduced through transmission loss to ice and air, any animal that is hauled out would not be harassed or harmed by the underwater noise. Seals that are hauled out and not harmed by sonar transmission would have the effect of reducing the density of animals in the project area.

However, we also cannot assume that density at the camp location would be 0. Jones et al. (2014) deployed a High-Frequency Acoustic Recording Package over the shelf break, at a depth of 240 m, 120 km northwest of Barrow from September to June 2006-09. They recorded vocalizations of ringed seals at that location, although the direction from which the sounds were generated (onshore or father offshore), and the distance from the vocalizing animals are unknown. Consequently, although it is reasonable to assume that ringed seal density is lower than the 0.39 seals/km^2 that the Navy used in their model, we do not have data to calculate a lower density.

2. Because of the way the NAEMO model is constructed, it overestimates the number of seals that may be affected by sonar for the following reasons. The model uses animated surrogates (animats) to mimic seal movement in the water. The animats record the energy received from the sonar. However, animats are stationary horizontally and therefore do not avoid the sound source, unlike wild animals which would be expected to avoid exposures at higher sound levels, especially those exposures that may result in PTS.

   Animats are modeled as being underwater, stationary, and facing the source and therefore always receive the maximum sound level. Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model. Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures. These characteristics of the animats lead to an overestimation of the number of animals likely to be affected by sonar transmission.
3. The Navy will implement a mitigation measure specifically to minimize acoustic effects to ringed seals swimming underwater. Submarines will use passive acoustic sensors to listen for vocalizing marine mammals and will halt active transmissions in the event vocalizing marine mammals are detected. The NAEMO model does not incorporate this mitigation measure.
4. The length of time that the submarines will be testing and using sonar will be limited to about 12 days within the four weeks of exercises. Potential exposure will be limited both by the short length of activity time and because the sonar will be a transient, temporary source of disturbance.
5. In a study conducted in the Beaufort Sea, ringed seals showed relatively minor responses to impulsive sounds from airgun arrays. Some, but not all ringed seals encountering airgun arrays with impulse output up to ~222 dB source level avoided the zone within 492 ft (150 m) of the source [received level of 189 dB], not moving much beyond 820 ft

(250 m) from the source [received level of 186 dB]. The airgun operations did not cause seals to abandon the general area of the activity (Harris et al. 2001).

6. Studies of ringed seal response in winter to underwater sounds from Northstar offshore oil production in the Beaufort Sea (with levels of sound in the strongest 1/3rd octave band often exceeding background levels beyond 5 km underwater) indicated that winter industrial activity (including ice roads and Vibroseis) did not affect ringed seal density in the spring (Moulton *et al*. 2002, 2003, 2008; Williams *et al*. 2008). Thus, it appears that underwater sounds from the Northstar activity did not result in ringed seals abandoning the area.

Although the Navy's estimate of take is likely high, because we do not have reliable estimates of density of ringed seals in the action area, nor do we know the sound source level or frequency that will be transmitted (because this information is classified), it is not possible to accurately estimate by what amount the NAEMO-predicted take of ringed seals should be reduced. The Permits Division‘s IHA has authorized the take of 1,395 ringed seals through behavioral harassment and 11 for TTS.

6.3.2 Noise from Aircraft Activity

Ringed seals may react to the sound of an aircraft or to its physical presence flying overhead, or both. During February – April, when the fixed-wing and helicopter flights associated with the proposed action will occur, ringed seals may be on the ice, in the water, or within their subnivean lairs. Ringed seals that are hauled out may react to the noise or visual stimulus by looking up at the aircraft, moving on the ice, entering a breathing hole or crack in the ice, or entering the water (Blackwell et al. 2004, Born et al. 2004). Reactions depend on several factors including the animal's behavioral state, activity, group size, habitat, and the flight pattern of the aircraft (Richardson et al. 1995). Additionally, a study conducted by Born et al. (1999) found that wind chill was also a factor in level of response of ringed seals hauled out on ice (higher wind chill increases probability of leaving the ice), as well as time of day and wind direction. Ringed seal reactions to helicopter disturbance are difficult to predict, though helicopters have been recorded to elicit a stronger behavioral response than a fixed-wing aircraft (Burns and Frost 1979, Born et al. 1999).

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.

During the proposed action, small, fixed-wing aircraft (the most frequently used aircraft) could operate at altitudes up to 3,500 m. At this altitude, the footprint of airborne noise at the ice surface would be an approximately 2 km^2 area which would move along the flight path of the aircraft. Due to the relatively small area over which aircraft noise would radiate outward, the noise would be transient (about 15 sec, assuming a flight speed of 120 kts). As received sound levels would be reduced by the time the sound reaches the ice from an overhead flight (attenuating in the air column) and would still have to attenuate through the ice, underwater noise would be brief in duration, of reduced intensity, and would transfer to water along a narrow swath of ice.

Helicopter flights associated with the proposed action are used for logistical purposes (transport of personnel and equipment) and logistical training purposes (military pilots gaining proficiency in transporting equipment) and are not conducting typical training or testing and therefore would not be hovering or flying a route pattern for an extended period. Helicopters produce low frequency sound (Pepper et al. 2003; Richardson et al. 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Noise generated from helicopters is transient in nature and variable in intensity. Helicopters often radiate more sound forward than aft. The underwater noise produced is generally brief when compared with the duration of audibility in the air. Rotary-wing aircraft tend to be noisier than similar-sized fixed wing aircraft. Noise generated from helicopters is transient in nature and variable in intensity. The underwater noise produced is generally brief when compared with the duration of audibility in the air.

Based on the intermittent use of fixed-wing aircraft and helicopters, and the short-term impacts of any behavioral reactions from aircraft activities, we conclude that the impact of aircraft sound is very minor, and thus adverse effects to ringed seals will be brief and of very low intensity, with any reactions by the seals expected to be imperceptible or very brief. Therefore, we conclude that adverse effects from aircraft traffic will be minimal or undetectable.

Two unmanned aerial systems (UAS) would be utilized during ICEX20. The rotary-wing unmanned aerial system operates in a similar manner as helicopters, but on a smaller scale. Based on a study by Christiansen et al. (2016), an initial analysis of underwater recordings at 1 m below the water surface of noise produced by a rotary-wing UAS was only detectable above ambient noise when the system was flown at altitudes lower than 10 m. Though the study found that in-air recordings showed that the noise levels produced by the UAS were within noise-level ranges known to cause disturbance in some marine mammals, the in-water received noise levels at 1 m depth were orders of magnitude below those shown to cause any direct damage on auditory systems or compromise physiology in marine mammals (Christiansen et al. 2016; Southall et al. 2007). The UAS that will be used are small and will not hover over marine mammals, and will fly at an altitude of at least 10 m. The impact of these devices will be very minor, and adverse effects to ringed seals will be immeasurably small, if they occur at all. Therefore, we conclude that adverse effects from UAS on these seals will be minimal or undetectable.

6.3.3 On-Ice Vehicle Noise

The use of on-ice vehicles is integral to ice camp logistics (e.g., personnel and equipment transport) and to the completion of many research objectives. Small snow machines create sounds at higher frequencies than larger, slower machinery. The sound level associated with snow machines is dependent upon the model, engine size, and speed driven. In addition, noise levels are affected by the ice condition, amount of snow on the ice, wind, and other similar factors (Richardson et al. 1991), making precise predictions of the noise transmitted, difficult.

Snowmobiles produce sound at source levels of 104 dBA on average (Richardson et al. 1995). Generally, two- and four-stroke snowmobiles traveling at approximately 32 kilometers per hour (km/hr) had a resultant average sound level of 66–71 dBA re 20 µPa at 15 m. At higher speeds of approximately 64 km/hr, the average sound level increased to 73–75 dBA re 20 µPa at 15 m. During acceleration, the highest sound level was recorded as 80.2 dBA re 20 µPa at 15 m. As reported in Malme et al. (1989), the under-ice sound pressure level for a snowmobile driving 16 km/hr is 124 dB re 1 µPa at a frequency of 1.6 kHz. While this is well within the hearing range phocids underwater, Kvadsheim et al. (2010) noted that hooded seals did not react to sounds at this frequency and decibel sound level. In addition, at 100 m (mitigation distance) the received sound levels would be well below the 100 dB re 20 micro Pa rms for non-harbor seal pinnipeds that cause Level B behavioral disturbance under section 3(18)(A)(ii) of the MMPA.

To the extent possible, the location for the ice camp will be selected to avoid pressure ridges and snow drifts to facilitate ease in camp construction, logistics, and aircraft landing safety. Any seals with lairs in the vicinity of the ice camp would likely move to a new lair during the gradual establishment of the camp prior to being subject to higher levels of activity once the camp is fully operational. If, after the ice camp is established, a new pressure ridge forms nearby, it is unlikely that a ringed seal would construct a lair in the area near the ice camp. During excursions away from the ice camp (e.g., to deploy research equipment), on-ice vehicles would use the same routes once routes are established. Use of the same route would minimize the number of subnivean lairs potentially exposed to on-ice vehicle noise as the routes would be established avoiding any pressure ridges, and it is not expected that a ringed seal would create a lair in the vicinity of a snowmobile route once the route is established. Seal pups are not anticipated to be in the vicinity of the ice camp during operations, because any highly sensitive females would not likely whelp within the camp's disturbance zone and whelping is not expected prior to mid-March.

Because of the selection of the camp location to avoid pressure ridges and potential ringed seal habitat, the use of established snow machine routes, the high likelihood that ringed seal presence in the area is extremely low, the low likelihood that noise from the snow machines will disturb seals either on the ice or under the ice, we conclude that ringed seal responses to noise associated with on-ice vehicles is not likely to result in significant disruption of feeding, breeding or other natural behavioral patterns. If such disturbance occurs, it would likely affect only a small number of ringed seals for a short period of time.

6.4 Physical Stressors

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

6.4.1 On-Ice Vehicle Strike

Four to six snow machines would be used for personnel and equipment transport, as well as supporting research activities away from the ice camp. Dependent on the type of equipment and supplies to be transported, the snowmobiles may tow a sled to accommodate the items. Additionally, small unit support vehicles may be used to establish the runway for fixed-wing aircraft landings. An all-terrain tracked vehicle may be used by expeditionary forces to transport forces to and from the ice camp. Snowmobile excursions away from the ice camp would support various research activities during the height of the proposed action (for a period of approximately four weeks). Some excursions away from the ice camp may last up to six hours, while shorter trips would only last one to two hours. Snow machines would not be in constant use during these trips; they would transport personnel and equipment to an offsite location (generally up to 5 km from camp) and then stand by until the experiment is complete before returning the personnel to the camp. Additionally, personnel movement on snowmobiles, small unit support vehicles, and all-terrain tracked vehicles both away from and around camp would only occur during daylight hours, which would reduce the potential for striking a ringed seal.

During the timeframe of the proposed activities it is highly unlikely that ringed seals would be basking on the surface of the ice as the molting period does not begin until mid-April (Figure 6). Kelly et al. (1986) tagged ringed seals from Reindeer Island and Kotzebue Sound off the coast of Alaska, in the Beaufort and Chukchi Sea, respectively. The tagged ringed seals spent between 3.5 and 30.8 percent of the time out of the water during the pre-basking period. Time spent out of the water during this period was only spent in lairs and not on the open sea ice.

Snow machine routes will be selected to avoid pressure ridges, and once established, snow machine routes will be re-used. Under the proposed action's mitigation measures, all snow machine expeditions will have a dedicated observer looking for marine mammals and any ringed seal observed would be avoided by 100 m. Additionally, snowmobiles and all-terrain vehicles are highly mobile and would move easily to avoid any ringed seal spotted nearby, and the risk of collision is further reduced by a ringed seal's avoidance of any vehicle making noise nearby. The likelihood of an on-ice vehicle strike would be exceedingly remote.

6.4.2 Ice Augering

Ten holes will be augered in the ice for the deployment of hydrophones in the vicinity of the ice camp. In addition, one hole will be augered to drain gray water from the dining hall and one hole will be drilled for the desalinization equipment. Greene et al. (2008) recorded underwater noise from an ice auger during ice road construction at the Northstar Development (Beaufort Sea) and found noise levels at the source were below 100 dB re 1μPa. These levels are below the behavioral threshold for underwater noise harassment for seals. Ringed seals that are out of the water in February through April are expected to be in lairs. Airborne sounds would be greatly attenuated by the ice and snow. The total size of the ice camp will be approximately 1.6 km in diameter. Compared to the over 178,000 km^2 of the Beaufort Sea, the area disturbed by drilling holes in the ice is extremely small. Background noise from wind and movements of the ice are expected to be louder and more consistent than the short duration noise created by ice augering. For these reasons the effects of ice augering on ringed seals is expected to be extremely unlikely.

6.4.2 In-Water Vessel and Vehicle Strike

Submarines and underwater vehicles that would be utilized during ICEX20 have the potential to result in strike to ringed seals. Unmanned underwater vehicles and associated towed arrays similarly could result in strike to ringed seals, but are slow moving, typically less than 8 knots. In-water vessels and vehicles would operate at a maximum depth of 800 m during the proposed action. Research on animal reactions to submerged submarines and unmanned underwater vehicles has not been conducted; the discussion below is based on potential reactions to boats, which is used as a surrogate for this analysis.

Vessels have the potential to affect ringed seals by eliciting a behavioral response or causing mortality or serious injury from collisions. It is difficult to differentiate between behavioral responses to vessel sound and visual cues associated with the presence of a vessel (Richardson et al. 1995); thus, it is assumed that both play a role in prompting reactions from animals. Reactions to vessels often include changes in general activity (e.g. from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement. Past experiences of the animals with vessels are important in determining the degree and type of response elicited from an animal-vessel encounter. Some species have been noted to tolerate slow-moving vessels within several hundred meters, especially when the vessel is not directed toward the animal and when there are no sudden changes in direction or engine speed (Heide-Jørgensen et al. 2003; Richardson et al. 1995).

Ringed seals react to vessels in a variety of ways. Some respond by retreating or engaging in antagonistic responses, while other animals ignore the stimulus altogether (Terhune and Verboom 1999; Watkins 1986). The size of a vessel and speed of travel affect the likelihood of a collision. Reviews of stranding and collision records indicate that larger surface ships (80 m or larger) and ships traveling at or above 14 knots have a much higher instance of collisions with marine mammals that result in mortality or serious injury (Laist et al. 2001). The depths at which the submarines and unmanned underwater vehicles operate would overlap with known dive depths of ringed seals, which have been recorded to 300 m in depth (Gjertz et al. 2000; Lydersen 1991). For most of the training and testing activities during the proposed action, vessel and vehicle speeds would not exceed 10 knots during the time spent within the study area, which would lessen the likelihood of collisions with ringed seals. Additionally, as part of the Navy's standard operating procedures, personnel will be passively listening for marine mammals during marine training and testing activities, thereby further reducing the possibility of ship strike.

Submarines and unmanned underwater vehicles are not expected to elicit an anti-predator response in a ringed seal. The primary predator to the ringed seal is the polar bear. Submarines are much larger than the natural predators to the ringed seal, and it would not be likely a submarine would cause a ringed seal to have an antipredator response. Although unmanned underwater vehicles are much smaller than a submarine, the movement patterns of these vehicles would not resemble the swimming pattern of a polar bear, and therefore would not likely result in an anti-predator reaction. Although Sternfield (2004) documented a single spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike, there have been no incidents of ship strike with ringed seals documented in Alaska (BOEM 2015a) despite the fact that protected species observers routinely observe bearded and ringed seals during oil and gas exploration activities.

Considering the very low density of animals that may be present in the action area, the fact that the vessels will typically be traveling less than 10 knots, ringed seals are highly maneuverable, and none of the vessels will resemble a predator, we conclude that vessel strike is extremely unlikely and that the normal activities of ringed seals will not be disrupted by vessel activity.

6.4.3 Human Presence

The construction of the ice camp and associated human presence could potentially cause ringed seals to leave an established lair or breathing hole. However, ringed seals typically build several lairs and breathing holes, and are assumed to be readily able to move to another lair or breathing hole (Kelly 1988b) within their home range. The ice camp location would be selected, in part, to avoid areas near pressure ridges where ringed seals may build their subnivean lairs. If the ice camp were near a subnivean lair or breathing hole, it could cause ringed seals to evacuate the lair or leave their breathing hole. Although ringed seals may abandon their subnivean lair or breathing hole, the population effect would most likely be minor since ringed seals are assumed to be readily able to move to different areas under the ice (Kelly 1988b). It is anticipated that construction of the camp would be completed prior to whelping. As such, pups are not anticipated to be in the vicinity of the camp at the commencement of the exercises, and therefore mothers would not need to move newborn pups due to construction noise from camp.

Human presence could potentially affect ringed seals within the water column during diving evolutions as part of the research objectives to measure personnel and equipment proficiency. Few divers would be in the water at any given time; diving activities would occur over a couple of weeks, with various personnel and equipment tested during this time. Data are not available on ringed seal reactions to humans in water; however, they would likely exhibit an avoidance response to the perceived predatory threat. This could result in a very short-term and localized behavioral response by the ringed seals in the immediate area of the diving activity.

Because of the low density of ringed seals in the action area, the very limited time period over which human presence will potentially intersect with ringed seals, and because of standard operating procedures and mitigation measures which are designed to minimize the impact of human activities on marine mammals, human presence is unlikely to adversely impact ringed seals.

6.4.4 Entanglement

We expect entanglement of ringed seals in the hydrophone lines will be highly unlikely as the lines will be kept taut from their anchor attachments, reducing the risk of entanglement. In addition, when the camp is active, the likelihood of entanglement will be further reduced because personnel will be monitoring for the presence of marine mammals under the proposed mitigation measures and should be aware of their presence in the area. Buoys that will be left at the conclusion of the exercises to collect oceanographic data, have weights at the end of wire ropes. The wire will rust in the corrosive salt water and disintegrate over time. Consequently, entanglement from these devices in both the short and long term is unlikely.

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

Although there is a potential for entanglement from an expended material, the amount of material will be low. Additionally, pinnipeds are very mobile within the water column and are capable of avoiding debris. Although Northern fur seals have become entangled with discarded fishing gear and plastic strapping in the Bering Sea (Laist, 1997, Savage 2019), we have no reports of ringed seals becoming entangled in any type of material. Therefore, based on the lack of evidence of previous pinniped entanglements in this region and the very low amount of project materials capable of causing entanglement, the probability of ringed seals becoming entangled in project-related materials is extremely small, and thus adverse effects to the seals are extremely unlikely.

6.4.5 Pollution

The air-drop of equipment and material poses some potential risk, particularly from the drop of fuel drums. Fuel may be dropped in bundles of five 55-gallon drums from a military cargo aircraft (e.g., C-130 or C-17). Military aircrews are highly trained in this activity and routinely drop equipment and supplies, including fuel, in expeditionary environments across the globe (including environments similar to the Arctic such as Greenland and Antarctica) without incident. The air drop bundles are made of several layers of a plywood structure with honeycomb insulation protecting the drums. Air-drop of material would occur only after initial construction of the camp has begun and personnel are available to respond to any potential rupture with proper spill containment procedures.

Under the Navy's standard operating procedures, all air-drop of materials would include the use of a parachute meant to stabilize the fall and slow the load so that it impacts the ice with minimal force. Equipment and material that may be air-dropped to the camp includes construction material, food, vehicles, and fuel. A worst case scenario would be that a parachute fails to open for a single load of fuel (five 55-gallon drums), in which case 275 gallons of fuel could be released to the ice. The likelihood of this worst case scenario occurring is extremely remote because, although ruptures have occurred, they are very infrequent (Navy 2019). Even in the case of a parachute failure, typically only one or two barrels would be dented or possibly ruptured. In the event of a fuel drum rupture, personnel would be standing by with applicable spill control measures and spill kits (e.g., absorbent materials) to remove any spilled fuel from the ice floe. All snow and ice cover that become contaminated would be collected and removed from the ice floe to the greatest extent possible. All personnel would have oil spill response training, and oil spill response and reporting procedures would be followed.

In addition to a rupture from air-dropped fuel, refueling activities at the camp (e.g., for snowmobiles and generators) could result in small spills. Camp activities such as snowmobile refueling and generator refueling will temporarily increase the risk of accidental fuel and lubricant spills. Accidental spills may occur from a spilled container, vessel leak, or air dropped container. However, the standard operating procedures which includes training of personnel, hazardous waste clean-up supplies, and measures to contain spills that may occur (i.e. containment trays), and protective packing, will minimize probability and extent of any spills. In addition, only small volumes of fuel would be present on the ice flow. Adverse impacts to the seals are therefore extremely unlikely.

Because all human waste will be removed from the ice floe, and flown back to land and properly disposed, no pollution is expected from human waste. In addition, environmentally appropriate soap will be used in the galley, there will be no shower facilities, food waste will be minimized through the use of prepared meals, and gray water will be screened so that only small particles less than 16 mm will pass through. Saline water approximately three times more saline than the receiving water will be discharged from the camp as the result of desalinization. It is estimated that just over 8,000 gallons (about 140 gallons per day) of saline water will be discharged over the time frame of ICEX20. This water will be diluted and mixed in the receiving water. The amount of water to be discharged is insignificant compared to the volume of water in the Beaufort Sea and is not anticipated to have any impact on ringed seals. Through these standard operating procedures, adverse impacts to seals are extremely unlikely to occur.

The plastics from the weather balloons and equipment left behind will add to the growing amount of plastic debris in the Arctic. Most likely, over time, these plastics will degrade into microplastics that will act as collectors of contaminants and become available to filter feeds at the base of the food web. The amount of plastic contributed by ICEX20 is tiny compared to the tons of plastic being delivered to the Arctic annually through ocean currents. Currently, the effect of microplastics (and the contaminants they carry) on marine biota is still in the early stages of investigation. For these reasons, we conclude adverse impacts to ringed seals from microplastics, if any, are expected to be too small to detect.

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 pursuant to 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 regarding non-Federal actions other than what has already been described in the Environmental Baseline (see Section 5 of this opinion). We expect fisheries, subsistence harvest, noise, oil and gas activities, pollutants and discharges, scientific research, and ship strike will continue into the future. We expect moratoria on commercial whaling and bans on commercial sealing will remain in place, aiding in the recovery of ESA-listed whales and pinnipeds.

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

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 both the survival or recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) result in the adverse modification or destruction of critical habitat as measured through appreciable reductions in the value of designated critical habitat for the conservation of the listed species. These assessments are made in full consideration of the status of the species (Section 4).

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

Ringed Seal Risk Analysis

Based on the results of the exposure analysis, we expect ringed seals may be exposed to underwater noise from submarine sonar that may result in Level B harassment takes. Exposure to aircraft noise, noise from snow machines, authorized discharge, and small oil or lubricant spills may occur but would not rise to the level of take. Because of the Standard Operating Procedures and mitigation measures which are proposed as part of this action, stressors associated with on-ice activities (camp construction and decommissioning, camp operation, excursions) are expected to occur very infrequently, it at all. Finally, exposure to vessel strike, entanglement, and marine debris is extremely unlikely to occur.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Early winter period, prior to the occupation of breeding sites, is important in allowing female ringed seals to accumulate enough fat stores to support estrus and lactation (Kelly et al. 2010). This early winter period overlaps camp construction and the first weeks of the exercises. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of ringed seals. As a result, the ringed seal's probable responses (i.e., tolerance, avoidance, short-term masking, and short-term vigilance behavior) are not likely to reduce the fitness or current or expected future reproductive success or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent. For physical disturbance, if an active ringed seal lair is not detected and is incidentally impacted by a snow machine, the adult female could likely escape into the water but the pup could be killed by crushing or premature exposure to the water or frigid air. If snow machine excursions occur after March 1st, a mortality or physical harassment may occur. While individuals may be impacted, these impacts are not likely to reduce the abundance, reproductive rates, or growth rates of the populations those individuals represent.

Exposure to vessel noise, aircraft noise (fixed-wing aircraft, helicopters, and UAS), noise from geohazard surveys, habitat alteration, and small oil spill discharge may occur as part of the proposed action, but are considered insignificant and would not rise to the level of take. The occurrence of vessel strikes are considered extremely unlikely due to the agility of seals in the water, implementation of mitigation measures and low number of vessels associated with the action. Exposure to harmful marine debris is extremely unlikely. Large and very large oil spills are considered low probability, high-impact events (see Sections 6.2.1 through 6.2.6).

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the ringed seal. As a result, the proposed Arctic military exercises are not likely to appreciably reduce the ringed seals' likelihood of surviving or recovering in the wild.

9 CONCLUSION

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of Arctic ringed seals. The proposed action also is not likely to adversely affect Beringia bearded seals, bowhead whales, or western North Pacific DPS gray whales. No critical habitat has been designated for these species, therefore, none will be affected.

10 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species unless there is a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. "Incidental take" is defined as take that results from, but is not the purpose of, carrying out an otherwise lawful activity (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).

As described in Section 6.2, for military readiness activities, the relevant definition of harassment is any act that:

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

For this consultation, we anticipate only Level B harassment to ringed seals associated with sonar noise exposure.

Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement (ITS).

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must be authorized by Section 101(a)(5) of the MMPA before being authorized in an ITS. However, the only ESA-listed species for which we expect take to occur is the threatened Arctic ringed seal. Under the ESA, Section 9 prohibits take only of endangered species. NMFS may, in its discretion, promulgate a rule under ESA Section 4(d) to extend the take prohibition to a threatened species. Since NMFS has not promulgated a 4(d) rule to extend the take prohibition under Section 4(d) of the ESA for the threatened Arctic ringed seals, the

ESA Section 9 take prohibition does not apply to the ringed seal.

Although take of Arctic ringed seals is not prohibited, we provide this ITS to guide the Navy and the NMFS Permits Division in monitoring and minimizing take to assess whether reinitiation of consultation may be needed in the event levels of take are likely to be higher than anticipated. If the amount or extent of incidental take exceeds the levels estimated and analyzed here, or if the project-specific effects on the listed species or designated critical habitat will occur in a manner or to an extent not considered in this opinion, reinitiation of consultation will be required (50 CFR 402.16).

10.1 Amount or Extent of Take

Section 7 regulations require NMFS to estimate the number of individuals that may be taken by a proposed action or utilize a surrogate (e.g., other species, habitat, or ecological conditions) if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (50 CFR § 402.14(i)(1); see also 80 FR 26832 (May 11, 2015)).

NMFS anticipates the proposed ICEX20 is likely to result in the incidental take of Arctic ringed seals by Level B harassment. The proposed IHA would permit the take of 1,406 ringed seals by harassment. Through our analysis we conclude that the take will be far less than the permitted amount (section 6.3.1); however, because we do not have information about the sonar transmission levels nor do we have reliable density estimates for the action area, we do not have the information necessary to arrive at a lower take estimate. Therefore, this opinion considers the full amount of authorized take requested by the Navy and proposed by the Permits Division.

The Navy and Permits Division also requested consultation on Level B harassment of 4 bearded seals. However, in our analysis (section 4.1.2) we came to the conclusion that the proposed action is not likely to adversely affect bearded seals. We came to this conclusion based on low numbers of bearded seals that may be present in the action area in suitable habitat during the winter and the fact that sonar transmissions will occur at water depths of 800 m or more where it is extremely unlikely that bearded seals will be present.

10.2 Effect of the Take

In Section 9 of this opinion, we determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of Arctic ringed seals. The majority of anticipated takes from the proposed action are associated with behavioral harassment from acoustic noise. Although the biological significance of behavioral responses remains unknown, this consultation has assumed that exposure to major noise sources might disrupt one or more behavioral patterns that are essential to an individual animal's life history. However, any behavioral responses of these pinnipeds to major noise sources and any associated disruptions are not expected to affect the reproduction, survival, or recovery of the species.

10.3 Reasonable and Prudent Measures (RPMs)

“Reasonable and prudent measures” are actions determined necessary or appropriate to minimize the amount or extent of incidental take (50 CFR 402.02). These measures are nondiscretionary.

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

1. Navy will document and report on the implementation of the mitigation measures, including monitoring, SOPs, and compliance with permits.
2. The take of listed marine mammals by serious injury or mortality, whether authorized or unauthorized will be reported to NMFS AKR.
3. Observations of dead, injured, contaminated, or entangled marine mammals will be reported to NMFS AKR.

10.4 Terms and Conditions

“Terms and conditions” implement the reasonable and prudent measures (50 CFR 402.14).

The Navy must comply with the following terms and conditions, which implement the RPMs described above, as well as the standard operating procedures and mitigation measures set forth in Section 2.3 of this opinion. The Navy and Permits Division have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14).

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

To carry out RPM #1, the Navy must undertake the following:

A. Navy must provide NMFS AKR with documentation of Navy’s implementation of the SOPs, mitigation measures, and compliance with permits. The documentation should include the effectiveness of the measures, any problems with implementation, lessons learned, and any suggestions for improvement that can be incorporated into future Navy ice exercises.

To carry out RPM #2, Navy must undertake the following:

A. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury (Level A harassment), serious injury, or mortality, the Navy shall immediately cease operations and immediately report the incident to NMFS AKR, Protected Resources Division at 907-271-3023 and/or by email to Greg Balogh greg.balogh@noaa.gov, the Marine Mammal Stranding Hotline at 877-925-7773, and NMFS Permits Division (Amy Fowler at 301-

427-8461) for any MMPA authorization issues. The report must include the following information:

1. Number of listed animals taken
2. Date and time of each take
3. Cause of the take
4. Mitigation measures implemented prior to animal being taken
5. NMFS Contacts: Reports of unauthorized take must be submitted to:NMFS Alaska Region, Protected Resources Division Greg Balogh Greg.balogh@noaa.gov 907-271-3023 or 907-271-5006

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

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

11 CONSERVATION RECOMMENDATIONS

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

1) NMFS encourages the Navy's research efforts in the Arctic, especially those efforts which increase our understanding of marine mammal densities and distribution in seasons and localities that are infrequently visited or surveyed. We encourage Navy to use and share the information it gathers on marine mammals during ICEX20 so that marine mammal density and other data in NAEMO are updated with the most current available information.

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

12 REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed Navy's ICEX20 in the Beaufort Sea, Alaska and the associated Permits Division issuance of an IHA. 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.

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.

Utility

This document records the results of an interagency consultation. The information presented in this document is useful to NMFS, BOEM, BSEE, USACE, EPA, 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.

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.

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

ACIA. 2005. Arctic Climate Impact Assessment. Page 1042. Cambridge University Press, Cambridge, UK.

Alaska Department of Fish and Game [ADF&G] 2017. Ice Seal Research: Movements and Habitat Use Studies. Most recent update: July 2017. http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.icesealmovements

Allen, B. M., and R. P. Angliss. 2014. Alaska marine mammal stock assessments, 2013. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-277.

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

Arthur C, Baker J, Bamford H, eds. 2009. Proceedings of the International Research Workshop on the Occurrence,Effects, and Fate of Microplastic Marine Debris. Tech. Memo. NOS-OR&R-30. Washington, DC: Natl.Ocean. Atmos. Adm.

ASAMM 2019. Aerial Surveys of Arctic Marine Mammals. Post #5, September 10, 2019. https://www.fisheries.noaa.gov/science-blog/2019-aerial-surveys-arctic-marine-mammals-post-5

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. JASCO Document #01003. Technical report by JASCO Applied Sciences for NMFS..

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, J. Geophys. Res., 114, C11007, doi:10.1029/2008JC004862.

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. USDOC, NOAA, NMFS, and USDOC, National Institute of Standards and Technology, Silver Spring, MD.

Bekkers, E., Francois, J. F., and Rojas-Romagosa, H. 2016. Melting ice caps and the economic impact of opening the northern sea route. The Economic Journal. https://doi.org/10.1111/ecoj.12460

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

Bergmann, 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. 51:11000-11010.

Besseling, E., Wegner, A., Foekema, E.M., Van den Heuvel-Greve, M.J., Koelmans, A.A., 2013. Effects of microplastic on fitness and PCB bioaccumulation by the lugworm Arenicola marina (L.). Environ. Sci. Technol. 47, 593–600. http:// dx.doi.org/10.1021/es302763x.

Besseling, E., Wang, B., Lürling, M., Koelmans, A.A., 2014. Nanoplastic affects growth of S. obliquus and reproduction of D. magna. Environ. Sci. Technol. 48, 12336– 12343. http://dx.doi.org/10.1021/es503001d.

Besseling, E., E.M. Foekemab, J.A. Van Franekerb, M.F. Leopoldb, S. Kühnb, E.L. Bravo Rebolledob, E. Heßeb, L. Mielkeb, J. IJzerc, P. Kammingad, A.A. Koelmansa.2015. Microplastic in a macro filter feeder: Humpback whale Megaptera novaeangliae. Marine Pollution Bull. http://dx.doi.org/10.1016/j.marpolbul.2015.04.007

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

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

Boeker, and Schulz. 2010. Examination of the low frequency limit for helicopter noise data in the FAA's Environmental Design Tool and Integrated Noise Model.

BOEM. 2011. Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas. OCS EIS/EA BOEMRE 2011. Alaska Outer Continental Shelf.

BOEM. 2012. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017. Final Programmatic Environmental Impact Statement, OCS EIS/EA BOEM 2012-030. USDOI, BOEM, Headquarters, Herndon, VA.

BOEM. 2015. Biological Assessment for Oil and Gas Activities Associated with Lease Sale 193. Page 312, Anchorage, AK.

BOEM. 2016a. Outer Continental Shelf Oil and Gas Leasing Program. Final Programmatic Environmental Impact Statement: 2017-2022. OCS EIS/EA BOEM 2016-060. November 2016. http://boemoceaninfo.com/review/.

BOEM. 2016b. Outer Continental Shelf, Oil and Gas Leasing Program: 2017-2022, Final Programmatic Environmental Impact Statement.

BOEM. 2017a. Liberty Development and Production Plan Biological Assessment. Page 235, Anchorage, AK.

BOEM. 2017b. Liberty Development Project Draft Environmental Impact Statement. Page 784, Anchorage, AK.

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

Born, E.W., J. Teilmann, M. Acquarone and F. Riget. 2004. Habitat use of ringed seals (Phoca hispida) in the north Water Area (North Baffin Bay). Arctic 57(2): 129-142.

Boveng, P. 2019. Ice Seal Research and Monitoring. Results from 2018-19 monitoring. Presented to Alaska Eskimo Whaling Commission. October 29, 2019

Boveng, P. L., and M. F. Cameron. 2013. Pinniped movements and foraging: Seasonal movements, habitat selection, foraging and haul-out behavior of adult bearded seals in the

Chukchi Sea. U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Environmental Studies Section, Anchorage, Alaska.

Boveng, P. L., M. Cameron, P. B. Conn, and E. Moreland. 2017. Abundance Estimates of Ice-Associated Seals: Bering Sea Populations that Inhabit the Chukchi Sea During the Open-Water Period. . BOEM Report 2016-077.

Braham, H.W., M.A. Fraker, and B.D. Krogman. 1980. Spring migration of the western Arctic population of bowhead whales. Mar. Fish. Rev. 42:36-46.

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

Brewer, K. D., and J. D. Hall. 1993. Recording, analysis, and verification of low-frequency sounds produced by Arctic offshore drilling equipment. Journal of the Acoustical Society of America 94:1850.

Broadwater, M.H., F.M. Van Dolah, and S.E. Fire. 2018. Vulnerabilities of Marine Mammals to Harmful Algal Blooms. pp 191-220 in Harmful Algal Blooms: A Compendium Desk Reference.Ed. SE Shumway, J.M. Burkholder, and SLMorton. First Edition. John Wiley and Sons.

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 USDI, MMS, Alaska OCS Region, Anchorage, Alaska.

Burek, K.A.,F.M.D. Gulland, and T.M. O'Hara. 2008. Effects of climate change on Arctic marine mammal health. Ecological Applications. 18:S126-S134.

Burns, J. J. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Juneau, AK.

Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51:445-454.

Burns, J. J., and T. J. Eley. 1976. The natural history and ecology of the bearded seal (Erignathus barbatus) and the ringed seal (Phoca (Pusa) hispida). Pages 263-294 Environmental Assessment of the Alaskan Continental Shelf. Annual Reports from Principal Investigators. April 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.77.

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.

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

Cameron, M. F., 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).in U.S. Department of Commerce, editor., Seattle, WA.

Carlens, H., C. Lydersen, B. A. Krafft, and K. M. Kovacs. 2006. Spring haul-out behavior of ringed seals (Pusa hispida) in Kongsfjorden, Svalbard. Marine Mammal Science 22:379-393.

Chan, F.T., K. Stanislawczyk, A. C. Sneekes, A. Dvoretsky, S. Gollasch, D. Minchin, M. David, A. Jelmert, J. Albretsen, S. A. Bailey. 2019. Climate change opens new frontiers for marine species in the Arctic: Current trends and future invasion risks. Global Change Biology.25:25-38.

Christiansen, F., Rojano-Doñate, L., Madsen, P. T., & Bejder, L. (2016). Noise Levels of MultiRotor Unmanned Aerial Vehicles with Implications for Potential Underwater Impacts on Marine Mammals. Frontiers in Marine Science, 3, 277.

Clark, C., W. T. Ellison, B. Southall, L. Hatch, S. M. V. Parijs, A. S. Frankel, D. Ponirakis, and G. C. Gagnon. 2009a. Acoustic masking of baleen whale communications: Potential impacts from anthropogenic sources. Page 56 Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.

Clarke, J. T., A. A. Brower, M. C. Ferguson, A. S. Kennedy, and A. L. Willoughby. 2015. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2014.in A. F. S. C. National Marine Mammal Laboratory, NMFS, NOAA, editor., Seattle, WA.

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

Comiso, J. C. 2012. Large Decadal Decline of the Arctic Multiyear Ice Cover. Journal of Climate 25:1176-1193.

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

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

Crawford, J. A., K. J. Frost, 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.

Crawford, J. A., K. J. Frost, L. Quakenbush, and A. Whiting. 2019. Seasonal and diel diferences in dive and haul-out behavior of adult and subadult ringed seals (Pusa hispida) in the Bering and Chukchi seas. Polar Biology.42:65-80.

Crawford, J.A., L.T. Quakenbush, and J.J. Citta. 2015. A comparison of ringed and bearded seal diet, condition and productivity between historical (1975–1984) and recent (2003–2012) periods in the Alaskan Bering and Chukchi seas. Progress in Oceanography. 136:133-150.

Crowley, T. J. 2000. Causes of climate change over the past 1,000 years. Science 289:270-277.

Cummings, W. C., D. V. Holliday, and B. J. Lee. 1986. Potential impacts of man-made noise on ringed seals: Vocalizations and reactions. NOAA, Anchorage, AK.

Curry, B. E., and E. F. Edwards. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean: research planning. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-254, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, La Jolla, California.

Deecke, V. B., P. J. B. Slater, and J. K. B. Ford. 2002. Selective habituation shapes acoustic predator recognition in harbour seals. Nature 417:171-173.

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 394:235-236.

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

Dietz R., C. Sonne, N. Basu, B. Braune, T. O'Hara et al., 2013. What are the toxicological effects of mercury in Arctic biota? Sci. Total Environ. 443: 775–790.

Drake, J. M., and Lodge, D. M. 2007. Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems. Aquatic Invasions. 2:121–131.

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

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

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

Fang, C., R. Zheng, Y. Zhang, F. Hong, J. Mu, M. Chen, P. Song, L. Lin, H. Lin, F. Le, J. Bo. 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 6:348-350.

Fedoseev, G. A. 2000. Population Biology of Ice-Associated Forms of Seals and their Role in the Northern Pacific Ecosystems. Russian Marine Mammal Council, Moscow, Russia.

Ferguson, S. H., B. G. Young, D. J. Yurkowski, R. Anderson, C. Willing and O. Nielsen. 2017. Demographic, ecological, and physiological responses of ringed seals to an abrupt decline in sea ice availability. PeerJ 5:e2957; DOI 10.7717/peerj.2957

Fey, S.B., A.M. Siepielski, S. Nussle, 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 animl mass mortality events. Proceedings of the National Academy of Sciences. 112:1083-1088.

Finneran, J.J. 2015. Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. Journal of the Acoustical Society of America 138, 1702

Finneran, J. J., Carder, D. A., Schlundt, C. E., & Ridgway, S. H. 2005. Temporary Threshold Shift in Bottlenose Dolphins (Tursiops truncatus) Exposed to Mid-frequency Tones. Journal of the Acoustic Society of America, 118(4), 2696-2705.

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway. 2003. Auditory and behavioral responses of California sea lions (Zalophus californianus) to single underwater impulses from an arc-gap transducer. Journal of the Acoustical Society of America 114:1667-1677.

Finneran, J. J., & Jenkins, A. K. 2012. Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report. SPAWAR Marine Mammal Program.

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

Fischer, H. et al., 2018: Palaeoclimate constraints on the impact of 2ºC anthropogenic warming and beyond. Nat. Geosci., 11, 474–485, doi:10.1038/s41561-018-0146-0

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

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

Frost, K.J. and S. Karpovich. 2008. Gray Whale. Alska Department of Fish and Game. Wildlife Notebook series. https://www.adfg.alaska.gov/static/education/wns/gray_whale.pdf

Frost, K. J., and L. F. Lowry. 1981. Ringed, Baikal and Caspian seals Phoca hispida Schreber, 1775; Phoca sibirica Gmelin, 1788 and Phoca caspica Gmelin, 1788. Pages 381-401 in S. H. Ridgway and R. J. Harrison, editors. Handbook of marine mammals. Academic Press, New York, London, United Kingdom.

Frost, K. J., and L. F. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea.in P. W. Barnes, D. M. Schell, and E. Reimnitz, editors. The Alaskan Beaufort Sea: Ecosystemsand Environments. Academic Press, Inc., New york, NY.

Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2002. Monitoring distribution and abundance of ringed seals in northern Alasaka. Juneau, AK.

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

Frost, K. J., A. Whiting, M. F. Cameron, and M. A. Simpkins. 2008. Habitat use, seasonal movements and stock structure of bearded seals in Kotzebue Sound, Alaska. Tribal Wildlife Grants Program, Fish and Wildlife Service, Achorage, AK.

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. Prep. By LGL Alaska Research Assoc., Inc., Anchorage, AK; LGL Limited environmental research associates, King City, Ont. Canada; and Greenridge Sciences and JASCO Applied Sciences for Shell Offshore, Inc., NMFS and USFWS., 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. Environ Sci Technol 43:3646-3651.

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

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 70:37-46.

Geyer,R., J.R. Jambeck,and K.L. Law. 2017. Production, use, and fate of all plastics ever made. Science Advances. 3:1-5.

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

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

Götz, T., and V. M. Janik. 2011. Repeated elicitation of the acoustic startle reflex leads to sensation in subsequent avoidance behaviour and induces fear conditioning. BMC Neuroscience 12:13.

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

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

Greene, C. R., and 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, Inc., San Diego, California.

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 83:2246-2254.

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

Hamilton, C.D. K.M. Kovacs, R.A. Ims, and C. Lyderson. 2018. Haul-out behaviour of Arctic ringed seals (Pusa hispida): inter-annual patterns and impacts of current environmental change. Polar Biology. 41:1063-1082.

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 17:795-812.

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 68:193-209.

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 70:891-900.

Heide-Jørgensen, M., Laidre, K., Wiig, Ø., Jensen, M., Dueck, L., Maiers, L., Schmidt, H., & Hobbs, R. (2003). From Greenland to Canada in ten days: tracks of bowhead whales, Balaena mysticetus, across Baffin Bay. Arctic, 21-31.

Helker, V. T., M. M. Muto, and L. A. Jemison. 2016. Human-caused injury and mortality of NMFS-managed Alaska marine mammal stocks, 2010-2014.in U. S. D. o. Commerce, editor.

Heptner, L. V. G., K. K. Chapskii, V. A. Arsenev, and V. T. Sokolov. 1976. Bearded seal. Erignathus barbatus (Erxleben, 1777). Pages 166-217 in L. V. G. Heptner, N. P. Naumov, and J. Mead, editors. Mammals of the Soviet Union. Volume II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti. Vysshaya Shkola Publishers, Moscow, Russia.

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

Hezel, P. 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.

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

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

Houghton, J. 2001. The science of global warming. Interdisciplinary Science Reviews 26:247-257.

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

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

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. Washington, DC. .

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

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

IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. New York, NY.

IPCC. 2014. Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, Chapter 1 Framing and Context of the Report 1 1 122 M.P.R. and L.L. White (eds.)]. Cambridge UnivIPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)].

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

Jakobsson, M., L. Mayer, B. Coakley et al. 2012. The International bathymetric chart of the Arctic Ocean (IBCAO) Version 3.0. Geophysical Research Letters. Vol. 39.

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

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

Jensen, A.S. and G.K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR- , 37 pp.

Jones, J.M., B.J. Thayre, E.H. Roth, M. Mahoney, I. Sia, K. Merculief, C. Jackson, C. Zeller, M. Clare, A. Bacon, S. Weaver, Z. Gentes, R.J. Small, I. Stirling, S. M. Willins, and J.A. Hildebrand. 2014. Ringed, Bearded, and Ribbon Seal Vocalizations North of Barrow, Alaska: Seasonal Presence and Relationship with Sea Ice. Arctic. 67:203-222.

Lüthi, D. et al., 2008: High-resolution carbon dioxide concentration record 650,000–800,000 years before present. Nature, 453, 379–382, doi:10.1038/nature06949.

Kanhai, L.D.K., K. Gardfeldt, O. Lyashevska, M. Hassellov, R.C. Thompson, I. O'Conner. 2018. Microplastics in sub-surface waters of the Arctic Central Basin. 2018. Marine Pollution Bulletin. 130:8-18.

Kastak, D., Southall, B. L., Schusterman, R. J., & Kastak, C. R. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. Journal of the Acoustical Society of America, 118: 3154-3163.

Keller, R. P., Drake, J. M., Drew, M. B., and Lodge, D. M. 2011. Linking environmental conditions and ship movements to estimate invasive species transport across the global shipping network. Diversity and Distributions 17(1): 93-102.

Kelly, B. P. (1988a). Bearded seal, Erignathus barbatus. Washington, D.C.: Marine Mammal Commission.

Kelly, B. P. (1988b). Locating and characterizing ringed seal lairs and breathing holes in coordination with surveys using forward looking infra-red sensors Fisheries and Oceans Freshwater Institute Final Report. p. 17.

Kelly, B. P., Badajos, O. H., Kunnasranta, M., Moran, J. R., Martinez-Bakker, M., Wartzok, D., & Boveng, P. L. 2010a. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology, 33, 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. Department of Commerce, Seattle, WA.

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 68:2503-2512.

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

Kovacs, K.M. and C. Lydersen. 2008. Climate change impacts on seals and whales in the North Atlantic Arctic and adjacent shelf seas. Science Progress. 91:117-150.

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

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 64:1246-1256.

Laist DW (1997) Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe JM, Rogers DB (eds) Marine debris. Springer New, York, pp 99–139

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17:35-75.

Law, A.L. 2017. Plastics in the marine environment. Annual Review of Mar. Sci. 9:205-229

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.

Lithner, D., N. Ildikó, D. Göran. 2012. Comparative acute toxicity of leachates from plastic products made of polypropylene, polyethylene, PVC, acrylonitrile-butadiene-styrene, and epoxy to Daphnia magna.

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.

Logerwell, E., Busby, M., Carothers, C., Cotton, S., Duffy-Anderson, J., Farley, E., Goddard, P., Heintz, R., Holladay, B., Horne, J., Johnson, S., Lauth, B., Moulton, L., Neff, D., Norcross, B., ParkerStetter, S., Seigle, J., Sformo, T. 2015. Fish communities across a spectrum of habitats in the western Beaufort Sea and Chukchi Sea, Progress in Oceanography.doi: http://dx.doi.org/10.1016/j.pocean.2015.05.013

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

Lusher, A.L., V. Tirelli, I. O'Conner, and R. Officer. 2015. Microplastics in Arctic polar waters: the first reported values of particles in surface and sub-surface samples. 2015. Nature Scientific Reports. 5:14947 DOI: 10.1038/srep14947

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

Lydersen, C. 1998. Status and biology of ringed seals (Phoca hispida) in Svalbard. 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 71:991-996.

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. Norsk Polarinstitutt Rapportserie.

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

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

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

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.

Mahoney, B. 2019. Marine Mammal Unusual Mortality Event Initiation Protocol. Issued July 2019.

Malme, C., Miles, P., Miller, G., Richardson, W., & Roseneau, D. (1989). Analysis and ranking of the acoustic disturbance potential of petroleum-industry activities and other sources of noise in the environment of marine mammals in Alaska. Final report. Bolt, Beranek and Newman, Inc., Cambridge, MA (USA). 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.

Mate, B.R., G. K. Krutzikowsky, and M. H. Winsor. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi seas during the late-summer feeding season and fall migration.Canadian Journal of Zoology. 78:1168-1181.

Mathis, J. T., and J. M. Questel. 2013. Assessing seasonal changes in carbonate parameters across small spatial gradients in the Northeastern Chukchi Sea. Continental Shelf Research 67:42-51.

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

McCabe, R.M., B. M. Hickey, R. M. Kudela, K. A. Lefebvre, N. G. Adams, B. D. Bill, F. M. D. Gulland, R. E. Thomson, W. P. Cochlan, and V. L. Trainer. 2016. An unprecedented coastwide toxic algal bloom linked to anomalous ocean conditions, Geophys. Res. Lett., 43:10,366–10,376. doi:10.1002/2016GL070023.

McCarthy, J. J. 2001. Climate change 2001: impacts, adaption, and vulnerability: contribution of working gorup II to the third assessment report of the intergovenmnertal panel on climate change. . Cambridge University Press.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006a. Increases in deep ocean anibient noise in the northeast pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America 120:711-718.

McLaren, I.A. 1958. The Biology of the Ringed Seal (Phoca hispida Schreher) in the Eastern Canadian Arctic. Published by the Fisheries Research Board of Canada under the Control of the Honourable Minister of Fisheries. Bulletin Number 118. 97 pp.

N. Melia, K. Haines, and E. Hawkins.2016. Sea ice decline and 21st century trans-Arctic shipping routes. Geophysical Research Letters. , 43, 9720–9728, doi:10.1002/ 2016GL069315.

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

Miles, P. R., C. I. Malme, and W. J. Richardson. 1987. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea.in M. M. S. U.S. Departmemt of Interior, Alaska Outer Continental Shelf Region,, editor., Anchorage, AK.

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

Miller, A.W. and G.M. Ruiz. 2014. Arctic shipping and marine invaders. Nature Climate Change 4:413-416.

Molnar, J. L., Gamboa, R. L., Revenga, C., and Spalding, M. D. 2008. Assessing the global threat of invasive species to marine biodiversity. Frontiers in Ecology and the Environment 6(9): 485-492.

Moore, S.E., and Reeves, R.R. 1993. Distribution and movement. In The bowhead whale. Edited by J.J. Burns, J.J. Montague, and C.J. Cowles. Spec. Publ. No. 2, The Society for Marine Mammalogy, Lawrence, Kans. pp. 313–386.

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 Feature (July-August-September 2013) 6 p. (.pdf, 5.86 MB).

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

Moulton, V. D., R. E. Elliott, and M. T. Williams. 2003. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites in 2002. Anchorage, AK.

Moulton, V. D., W. J. Richardson, T. L. McDonald, R. E. Elliott, and M. T. Williams. 2002. Factors influencing local abundance and haulout behavior of ringed seals (Phoca hispida) on landfast ice of the Alaskan Beaufort Sea. Canadian Journal of Zoology-Revue Canadienne De Zoologie 90:1900-1917.

Moulton, V.D., M.T. Williams, S.B. Blackwell, W.J. Richardson, R.E. Elliot, and B.J. Streever. 2008. Zone of displacement for ringed seals (Pusa hispida) wintering around offshore oilindustry operations in the Alaskan Beaufort Sea. Appendix O In: W.J. Richardson (ed.). 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea, 1999–2004. LGL Rep. P1004. for BP Explor. (Alaska) Inc., Anchorage, AK.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizorch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N.

Zerbini. 2017. Alaska Marine Mammal Stock Assessments, 2016. Page 366 in N. U.S. Department of Commerce, editor.

Navy. 2019. Biological Evaluation for species listed under the Endangered Species Act Under National Marine Fisheries Service Jurisdiction. Submitted August 2019, revised November 2019 Submitted by: Commander, United States Fleet Forces Command.

NASA. 2020. https://climate.nasa.gov/news/2945/nasa-noaa-analyses-reveal-2019-second-warmest-year-on-record/ viewed 1/16/2020.

NCDC. 2020. https://www.ncdc.noaa.gov/sotc/global/201913 viewed 1/16/2020

NCEI. 2016. State of the climate: global analysis for annual 2015.in N.O.A.A. National Centers for Environmental Information, U.S. Department of Commerce,, editor., Published online at: http://www.ncdc.noaa.gov/sotc/global/201513.

NCEI. 2020. https://www.ncei.noaa.gov/sites/default/files/2019-Global-Significant-Events-Map.png viewed 1/16/2020.

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

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

Nelson, A.A., L.T. Quakenbush, B.D. Taras, Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endangered Species Research. 14:1-6. doi.org/10.3354/esr00973

NMFS. 2006. Endangered Species Act section 7 consultation biological opinion on the United States Navy's 2006 Rim-of-the-Pacific Joint Training Exercises. Office of Protected Resources, National Marine Fisheries ServiceNational Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

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

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

NMFS. 2014b. Endangered Species Act section 7(a)(2) biological opinion on the issuance of an incidental harassment authorization under 101(a)(5)(D) of the Marine Mammal Protection Act to BP Exploration (Alaska), Inc. (BPXA) for shallow geohazard survey in the U.S. Beaufort Sea, Foggy Island Bay, Alaska, during the 2014 open water season.in N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Juneau, Alaska., editor.

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

NMFS. 2015a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Section 7(a)(4) Conference Report on Lease Sale 193 Oil and Gas Exploration Activities in the U.S. Chukchi Sea, Alaska. Issued June 4, 2016. Page 342.

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

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

NMFS. 2016a. Effects of Oil and Gas Activities in the Arctic Ocean Draft Environmental Impact Statement. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protective Resources, Silver Spring, MD.

NOAA. 2016b.Technical guidance for assessing the effects of anthropogenic sound on marine mammals: Underwater acoustic thresholds for onset of permanent and temporary threshold shifts. National Oceanic and Atmospheric Administration, U.S. Department of Commerce,NOAA Technical Memorandum NMFS-OPR-55 July 2016, 178 pp. http://www.nmfs.noaa.gov/pr/acoustics/Acoustic%20Guidance%20Files/opr55_acoustic_guidance_tech_memo.pdf

NMFS. 2017. Endangered Species Act section 7(a)(2) biological opinion on the issuance of incidental harassment authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Quintillion Subsea Operations, LLC, Proposed Subsea Fiber Optic Cable-laying and Operations and Maintenance Activities and Associated Proposed Issuance of an Incidental Harassment Authorization in the Bering, Chukchi, and Beaufort Seas, Alaska.in N. M. F. S. Alaska Region, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, editor., Juneau, Alaska.

NMFS. 2018. Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

NMFS 2019a. Ice Seal Stranding Data Tables. 2019.

NOAA 2019a. National Centers for Environmental Information, State of the Climate: National Climate Report for August 2019, published online September 2019, retrieved on November 12, 2019 from https://www.ncdc.noaa.gov/sotc/national/201908/supplemental/page-4.

NOAA 2019b. Alaska Fisheries Science Center. 2019. Presented at the October 29, 2019 Alaska Eskimo Whaling Commission meeting.

NOAA 2019c. Vessel stranding spreadsheet.

Nong, D., M. Countryman, T. Warziniack, and E. K. Grey. 2018. Arctic Sea Routes: Potential New Pathways for Nonindigenous Species Spread. Arctic. 71(3): 249-363.

Noongwook, G., H. P. Huntington, and J. George. 2007. Traditional knowledge of the bowhead whale (Balaena mysticetus) around St. Lawrence Island, Alaska. Arctic 60:47-54.

Nordon. 2014. Marine Invasive Species in the Arctic. Nordic Council of Ministers. TemaNord 2014:547.

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

Norse, E.A. and L.B. Crowder. 2005. Marine Conservation Biology: The science of maintining the sea's biodiversity. Island Press.

NRC. 2014. Responding to Oil Spills in the U.S. Arctic Marine Environment. The National Academies Press.

NRC (Nation Research Council). 2000. Marine Mammals and Low Frequency Sound: Progress since 1994. National Academy Press, Washington, DC.

NRC (Nation Research Council). 2003. Ocean Noise and Marine Mammals. Ocean Study Board, National Academy Press, Washington, DC.

NRC (Nation Research Council). 2005. Marine Mammal Populations and Ocean Noise: Determining when noise causes biologically significant effects. National Research Council of the National Academies, Washington, D.C.

NRC (Nation Research Council) Committee on the Bering Sea Ecosystem. 1996. The Bering Sea Ecosystem. National Academy Press, Washington, D.C.

NRC (National Research Council). 1994. Improving the Management of U.S. Marine Fisheries. National Research Council of the National Academies, Washington, D.C. .

NSIDC. 2018. 2018 winter Arctic sea ice: Bering down.

NSIDC. 2019. Monthly Archives, 2019.nsidc.org

NSIDC 2019. Monthly Archives. September 2019. http://nsidc.org/arcticseaicenews/2019/09/

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.AGU Publications. 2:315-320.

Ogata, Y. H. Takada, K.Mizukawa, H. Hirai, S. Iwasa, S. Endo, Y. Mato M. Saha et al. 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 Bull.58:1437-1446.

Olson, L. J. 2006. The economics of terrestrial invasive species: a review of the literature. Agricultural and Resource Economics Review 35(1): 178-194.

Ontario Drive and Gear Ltd. (2017). Argo Retrieved from http://argoatv.com/ as accessed on March 23, 2017.

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

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

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.

Overland, J. E., E. Hanna, I. Hanssen-Bauer, S. J. Kim, J. E. Walsh, M. Wang, U. S. Bhatt, and R. L. Thoman. 2017. Surface Air Temperature pp. 5-11 in NOAA Arctic Report Card 2018.

Overland, J. E., and M. Y. Wang. 2007. Future regional Arctic sea ice declines. Geophysical Research Letters 34:L17705.

Pachauri, R. K., and A. Reisinger. 2007. Climate Change 2007: Synthesis Report. construction of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Plan on Climate Change 1. .

Parks, S. E. 2003. Response of North Atlantic right whales (Eubalaena glacialis) to playback of calls recorded from surface active groups in both the North and South Atlantic. Marine Mammal Science 19:563-580.

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

Parry, M. L. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Fourth Assessment Report of the IPCC Intergovernmental Panel on Climate Change. Cambridge University Press.

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

Pepper, C. B., Nascarella, M. A., & Kendall, R. J. (2003). A review of the effects of aircraft noise on wildlife and humans, current control mechanisms, and the need for further study. Environmental Management, 32(4), 418-432. doi: 10.1007 /s00267 -003-3024-4.

Perovich, D, W. Meier, M. Tschudi, S. Farrell, S.Hendricks, S. Gerland, C. Haas, T. Krumpen, C. Polashenski, R. Ricker, M. Webster. 2018. Sea Ice. pp. 25-32. In NOAA Acrtic Report Card.

Pike, G.C. 1962. Migration and Feeding of the Gray Whale (*Eschrichtius gibbosus*). Journal Fish Res Bd Canada. 19:815-838.

Pirotta, V. A. Grech.ID.D. Jonsen,W. F. Laurence,and R.G. Harcourt. 2019. Consequences of global shipping traffic for marine giants. Front Ecol Environ 17:39-47.

Qi, D., L. Chen, B. Chen, Z. Gao, W. Zhong, R. A. Feely, L. 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 7:195-201. DOI: 10.1038/NCLIMATE3228

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

Quakenbush, L., R. Small, and J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. US Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 1110:60.

Ray, C., W. A. Watkins, and J. J. Burns. 1969. Underwater song of *Erignathus* (bearded seal). Zoologica-New York 54:79-83.

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. NAMMCO Scientific Publications, Volume 1, Tromsø, Norway.

Rexford, B. 1997. A native whaler's view.

Rice, D. W. 1998. Marine mammals of the world: Systematics and distribution. The Society for Marine Mammology, Lawrence, Kansas.

Richardson, W. J., Jr., C. R. G., Malme, C. I., & Thomson, D. H. (1991). Effects of Noise on Marine Mammals. (OCS Study MMS 90-0093). Herndon, VA: U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region. p. 462.

Richardson, W. J. 1998. Marine mammal and acoustical monitoring of BP Exploration (Alaska)'s open-water seismic program in the Alaskan Beaufort Sea, 1997. LGL Rep. TA2150-3. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc.

Richardson, W. J. 1999. Marine mammal and acoustical monitoring of Western Geophysical's openwater seismic program in the Alaskan Beaufort Sea, 1998. . TA2230-3, 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.

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

Richter-Menge, J. M. L. Druckenmiller, and M. Jeffries. 2019. Executive Summary. *In* Arctic Report Card 2019, J. Richter-Menge, M. L. Druckenmiller, and M. Jeffries, Eds., http://www.arctic.noaa.gov/Report-Card.

Rochman, C.M. 2015. The complex mixture, fate and toxicity of chemicals associated with plastic debris in the marine environment.*In* M. Bergmann et al. (eds.), Marine Anthropogenic Litter. Chapter 5 pp 117-140.

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

Rugh, D.J. (1984) Census of gray whales at Unimak Pass, Alaska, November–December 1977–1979. In: The Gray Whale, Eschrichtius Robustus (Ed. by M.L. Jones, S.L. Swartz & S.

Leatherwood), pp. 225–248. Academic Press, Inc., Orlando, FL. Rugh, D.J. & Fraker, M.A. (1981) Gray whale,

Rugh, D.J. K.E.W Sheldon, and A. Schulman-Janiger. 2001. Timing of the gray whale southbound migration. Journal of Cetacean Res. Management 3:31-39.

Savage, K. 2019. Stranding Report for 2019. September 14-30, 2019.

Scarlett, L., A. Fraas, R. Morgenstern, and T. Murphy. 2011. Managing Environmental, Health, and Safety Risks: A Comparative Assessment of the Minerals Management Service and Other Agencies.

Scholin, C.A., Gulland, F., Doucette, G.J., Benson, S., Busman, M., Chavez, F.P., Cordaro, J., DeLong, R., De Vogelaere, A., Harvey, J., Haulena, M., Lefebvre, K., Lipscomb, T., Loscutoff, S., Lowenstine, L.J., Marin, R., 3rd, Miller, P.E., McLellan, W.A., Moeller, P.D., Powell, C.L., Rowles, T., Silvagni, P., Silver, M., Spraker, T., Trainer, V., Van Dolah, F.M. 2000. Mortality of sea lions along the central California coast linked to a toxic diatom bloom. Nature 403:80–84.

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

Serreze, M. C., J. E. Walsh, F. S. Chapin, T. Osterkamp, M. Dyurgerov, V. Romanovsky, W. C. Oechel, J. Morison, T. Zhang, and R. G. Barry. 2000. Observational evidence of recent change in the northern high-latitude environment. Climatic Change 46:159-207.

Silber GK and Adams JD (2019) Vessel Operations in the Arctic, 2015–2017. Front. Mar. Sci. 6:573. doi: 10.3389/fmars.2019.00573

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 26:577-586.

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

Smith, T.G. 1973. Population dynamics of the ringed seal in the Canadian eastern Arctic. Department of the Environment, Fisheries Research Board of Canada. Bulletin 181. 55p.

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

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

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

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

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

SMRU Consulting. 2017. Liberty Project Construction and Production Marine Mammal Asouctic Exposure Estimate.

Smultea, M. A., K. Lomac-MacNair, P. Haase, and C. E. Bacon. 2014. 90-Day Report for Marine Mammal Monitoring and Mitigation during BPXA Liberty Shallow Geohazard Seismic and Seabed Mapping Survey, Beaufort Sea, Alaska, July-August 2014. .

Smultea, M. A., J. R. Mobley J.R., D. Fertl, and G. L. Fulling. 2008. An Unusual Reaction and Other Observations of Sperm Whales Near Fixed-Wing Aircraft. Gulf and Caribbean Research 20:75.

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

Southall, B. L. 2009. Marine mammal noise exposure criteria: Initial scientific recommendations. The Journal of the Acoustical Society of America 125: 2517

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

Stafford, K.M., S.E. Moore, M. Spollane, and S. Wiggins. 2007. Gray whale calls recorded near Barrow, Alaska, throughout the winter of 2003-2004. Arctic 60:167-172.

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

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

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

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

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

Stocker, T. F., Q. Dahe, and G. K. Plattner. 2013. Climate Change 2013: The Physical Science Basis. Working Group I contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Swartz, S.L., B.L. Taylor, and D.J. Rugh. 2006. Gray whale Eschrichtius robustus population and stock identity. Mammal Rev 36:66-84.

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 77:1934-1946.

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

Terhune, J. M. and Verboom, W. C. 1999. Right whales and ship noises. Marine Mammal Science, 15(1), 256-258.

Teuten,E.L.,J.M. Saquing, D.R.U. Knappe, M.A. Barlaz, S. Jonsson, A. Björn, S.J. Rowland, R. C. Thompson, T.S. Galloway, R. Yamashita, D. Ochi, Y. Watanuki, C. Moore, P.H. Viet, T.S. Tana, M. Prudente, R. Boonyatumanond, M.P. Zakaria, K. Akkhavong, Y. Ogata, H. Hirai, S. Iwasa, K. Mizukawa, Y. Hagino, A. Imamura, M. Saha, H. Takada. 2009 Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society of London, Series B, 364:2027-2045.

Thode, A., K. H. Kim, C. R. Greene 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:EL181-EL187.

Thoman, R. & J. E. Walsh. (2019). Alaska’s changing environment: documenting Alaska’s physical and biological changes through observations. H. R. McFarland, Ed. International Arctic Research Center, University of Alaska Fairbanks.

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

Trombulak, S.C., K.S. Omland, J. A. Robinson, J.J. Lusk, T.L. Fleischner, G. Brown, and M. Domroese. 2004. Principles of conservation biology: recommended guidelines for conservation literacy from the education committee of the Society for Conservation Biology. Conservation Biology 18(5):1180-1190.

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

Urick, R. J. 1983. Principles of underwater sound. Peninsula Publishing, Los Altos, CA.

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. NatureReseach. 9:15569 doi.org/10.1038/s41598-019-51699-4

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

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

Wartzok, D., W. A. Watkins, B. Wursig, and C. I. Malme. 1989. Movements and behaviors of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. AMOCO Production Co., Anchorage, Alaska.

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

Wathne, J. 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.

Watkins, W. A. (1986). Whale Reactions to Human Activities in Cape Cod Waters. Marine Mammal Science, 2(4), 251-262.

Watson, R. T., and D. L. Albritton. 2001. Climate change 2001: Synthesis report: Third assessment report of the intergovernmental panel on climate change. Cambridge University Press.

Wieting, D. 2016. Interim Guidance on the Endangered Species Act Term "Harass".in N. M. F. S. United States Department of Commerce, editor.

Williams, M.T. , C. S. Nations, T.G. Smith, V. D. Moulton and C.J. Perham 2008. Ringed Seal (Phoca hispida) use of subnivian structures in the Alaskan Beaufort Sea during development of an oil production facility. Appendix N in: Richardson, W.J. ed. 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil development, Alaskan Beaufort Sea,1999-2004. LGL Report P1004 for BP Explor. (Alaska) Inc., Anchorage AK. 428 pp + Appendices.

Wilson SC, et al. (2017) Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. Biol Conserv 214: 213–222.

Yablokov, A. V. 1994. Validity of whaling data. Nature 367:108.

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

Zarnke, R. L. et al. Serologic survey for Brucella spp., phocid herpesvirus-1, phocid herpesvirus-2, and phocine distemper virus inharbor seals from Alaska, 1976–1999. 2006. Journal of Wildlife Diseases 42: 290–300.