Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from Office of Naval Research Arctic Research Activities September 2019 – September 2020

Submitted to:

National Marine Fisheries Service

Submitted by:

Office of Naval Research

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Acronyms and Abbreviations

3S	sea mammals, sonar, and safety
AEWC	Alaska Eskimo Whaling Commission
ADCP	Acoustic Doppler Current Profiler
AMOS	Arctic Mobile Observing System
ARA	Arctic Research Activities
AWSC	Arctic Waterways Safety Commission
BRF	Behavioral Response Function
CGC	Coast Guard Cutter
cm	centimeter(s)
CV	Coefficients of Variation
dB re 1 µPa at 1 m	decibel(s) referenced to 1 micropascal at 1 meter
EMATT	Expendable Mobile Anti-Submarine Warfare Training Targets
ESA	Endangered Species Act
ft	foot/feet
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
IHA	Incidental Harassment Authorization
in	inch(es)
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometers
lb	pound(s)
m	meter(s)
MMPA	Marine Mammal Protection Act
N	population estimate
NAEMO	Navy Acoustic Effects Model
Navy	United States Department of the Navy
nm	nautical miles
NMFS	National Marine Fisheries Service
ONR	Office of Naval Research
PL	Public Law
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SODA	Stratified Ocean Dynamics in the Arctic
SPL	Sound Pressure Level
SPL_{RMS}	root mean square sound pressure level
TTS	Temporary Threshold Shift
UAS	Unmanned Aerial System
U.S.	United States
U.S.C.	United States Code

1 Description of Activities

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

1.1 Introduction

The United States (U.S.) Department of the Navy (Navy) has prepared this request for an Incidental Harassment Authorization (IHA) for the incidental taking (as defined in Section 5) of marine mammals during the Office of Naval Research (ONR) Arctic Research Activities (ARA) proposed within the Beaufort and Chukchi Seas from September 2019 to September 2020.

The Navy prepared an Overseas Environmental Assessment for the ARA Study Area in 2018 to evaluate all components of the Proposed Action. An IHA for activities involving active acoustic source deployments from September 2018 to September 2019 was issued to the Navy. To accommodate changes in the experimental design starting in September 2019 (locations and number of acoustic sources) and the deployment of a very low frequency (VLF) source, a supplement to that OEA is being prepared. A description of the Proposed Action for which the Navy is requesting an IHA is provided in Section 1.2. A description of the Study Area and various components is provided in Section 2. This request for an IHA for the period September 2019 - September 2020 reflects changes in the experimental design that are included in the supplemental OEA.

This document has been prepared in accordance with the applicable regulations of the Marine Mammal Protection Act (MMPA), as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law [PL] 108-136) and its implementing regulations. The request for IHA is based on: (1) the analysis of spatial and temporal distributions of protected marine mammals in the Study Area, (2) the review of aspects of the testing activities that have the potential to incidentally harass marine mammals, and (3) a risk assessment to determine the likelihood of effects. This chapter describes the aspects of the testing activities that are likely to result in Level B harassment under the MMPA; no Level A harassment or mortality would occur as a result of the Proposed Action. Of the Navy activities analyzed, the Navy has determined that the use of acoustic sources and icebreaking noise has the potential to affect marine mammals that may be present within the Study Area, and rise to the level of harassment under the MMPA.

1.2 Proposed Action

ONR's ARA Proposed Action started conduct of scientific experiments in the Beaufort Sea in August 2018 and would continue in September 2019 under a revised experimental design. This request for an IHA would cover activities from September 2019 through September 2020, the time period during which most of the acoustic sources would be left behind. The Navy will seek a renewal of this IHA for September 2020 to September 2021- if it is decided to continue activities requiring an IHA. The approach of yearly IHA requests allows for more accurate IHA applications in out years based on the most current information about actual research activities. The Proposed Action includes several scientific objectives which support the Arctic and Global Prediction Program as well as the Ocean Acoustics Program and the Naval Research Laboratory, for which ONR is the parent command. Specifically, the Proposed Action would include the Stratified Ocean Dynamics of the Arctic (SODA), Arctic Mobile Observing System (AMOS), Ocean Acoustics field work (including the Coordinated Arctic Active Tomography Experiment (CAATEX)), and Naval Research Laboratory experiments. On-ice measurements are also described by the acronym SIDEx (Sea Ice Dynamics Experiment). The Proposed Action would occur within the Study Area, which encompasses parts of the Beaufort and Chukchi Seas (Figure 1-1); the Proposed Action would occur either in the U.S. Exclusive Economic Zone or the global commons. The Study Area has been extended northwards in comparison with the IHA application for the previous year. All activities, except for the transit of ships and aircraft, would take place outside of U.S. territorial waters. Additional details regarding the specific experiments, timeframes, and research objectives are further detailed below.

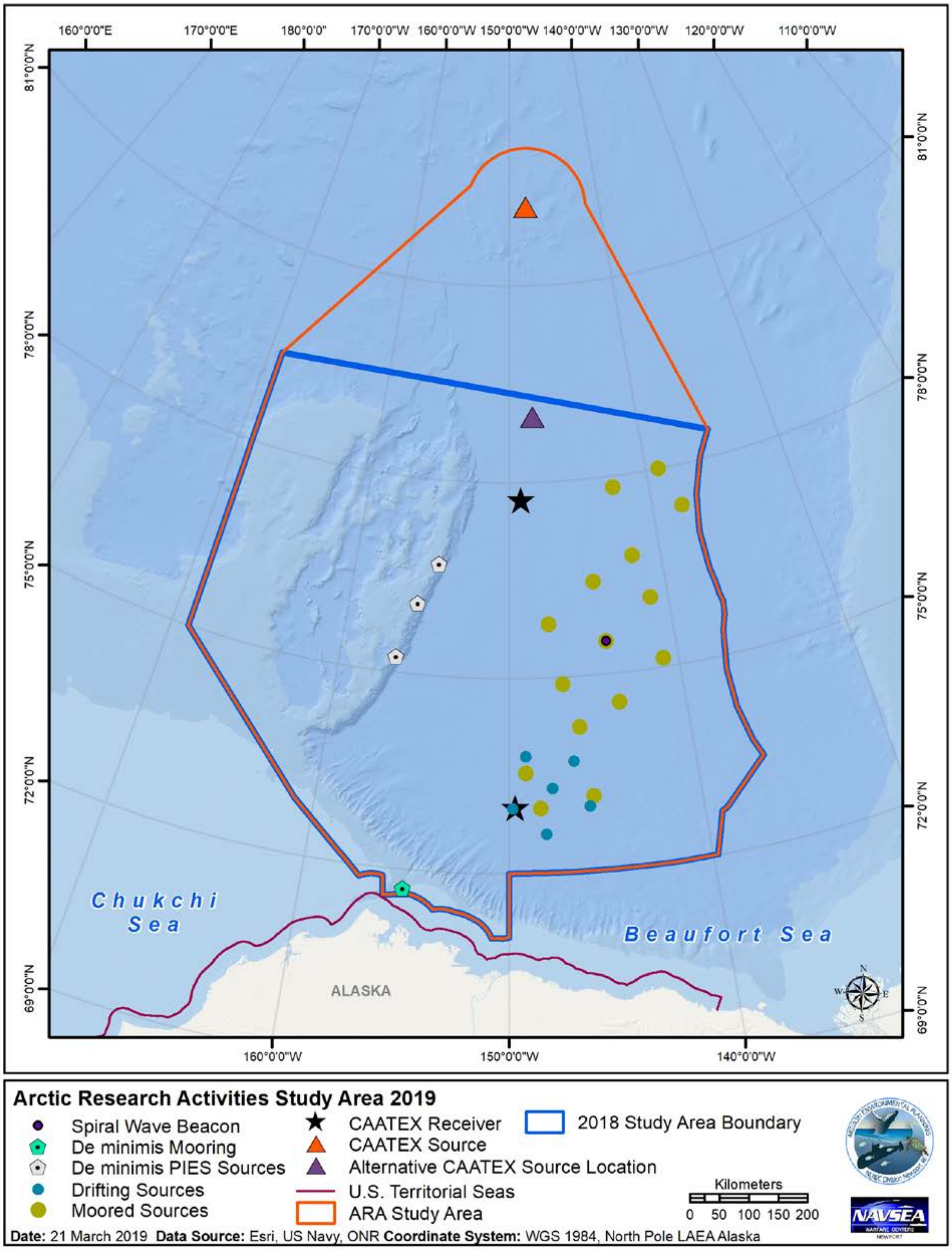

Figure 1-1. Arctic Study Area

The ONR Arctic and Global Prediction Program is supporting two major projects (SODA and AMOS), which will both occur during time period covered by this IHA. The SODA project began field work in August 2018, consisting of research cruises and the deployment of autonomous measurement devices for year-round observation of water properties (temperature and salinity) and the associated stratification and circulation. These physical processes are related to the ice cover and as the properties of the ice cover change, the water properties will change as well. Warm water feeding into the Arctic Ocean also plays an important role changing the environment. Observations of these phenomena require geographical sampling of areas of varying ice cover and temperature profile, and year-round temporal sampling to understand what happens during different parts of the year. Unmanned gliders and autonomous platforms are needed for this type of year-round observation of a representative sample of arctic waters. The SODA project also involved the initial deployment of navigation sources for unmanned vehicles. Under the AMOS project, there will be new deployments of navigation sources in September 2019, as shown in Figure 1-1. Geolocation of autonomous platforms requires the use of acoustic navigation signals, and therefore, year-long use of active acoustic signals.

The ONR Ocean Acoustics Program also supports Arctic field work. The emphasis of the Ocean Acoustics Program field efforts is to understand how the changing environment affects acoustic propagation and the noise environment. The ONR Acoustic Program would be utilizing new technology for year-round observation of the large-scale (range and depth) temperature structure of the ocean at very low frequencies. The use of specialized waveforms and acoustic arrays allows signals to be received over 100 kilometers from a source, while only requiring moderate source levels. The Ocean Acoustics program is planning to perform experiments in conjunction with the Arctic and Global Prediction Program by operating in the same general location and with the same research vessel.

NRL would also conduct Arctic research in the same time frame, using drifting buoys with active acoustic sources that are deployed in the ice. The buoys are deployed for real-time environmental characterization to aid in mid-frequency sonar performance predictions. Real-time assimilation of acoustic data into an ocean model is also planned.

1.3 Research Equipment and Platforms

Below are the descriptions of the equipment and platforms which would be deployed at different times during the Proposed Action.

1.3.1 Research Vessels

Coast Guard Cutter (CGC) HEALY would perform a research cruise for up to 60 days in September-October 2019 as part of the Proposed Action and deploy acoustic sources as part of the cruise. Is it possible that a second, non-icebreaking ship out of Nome, Alaska would perform a cruise of up to 30 days to deploy some of the sources in the fall of 2019 as well. The CGC Healy, a similar icebreaking ship, or a non-icebreaking ship would be used for a research cruise for up to 60 days in August 2020. The cruises would last up to 60 days. If an icebreaking ship is not available for recovery of sources in 2020, sources would remain in the field but would stop transmitting. The research activities would occur within the Study Area (Figure 1-1).

CGC HEALY travels at a maximum speed of 17 knots with a cruising speed of 12 knots (United States Coast Guard 2013), and a maximum speed of 3 knots when traveling through 3.5 feet (ft; 1.07 meters [m]) of sea ice (Murphy 2010). CGC HEALY may be required to perform icebreaking to deploy the moored and ice tethered acoustic sources in deep water. Icebreaking would only occur during the warm season, presumably in the August through October timeframe. CGC HEALY has proven capable of breaking ice up to 8 ft (2.4 m) thick while backing and ramming (Roth et al. 2013). A study in the western Arctic Ocean was conducted while CGC HEALY was mapping the seafloor north of the Chukchi Cap in August 2008. During this study, CGC HEALY icebreaker events generated signals with frequency bands centered near 10, 50, and 100 Hertz (Hz) with maximum source levels of 190 to 200 decibel(s) referenced to 1 microPascal at 1 meter (dB re 1 µPa at 1 m; full octave band) (Roth et al. 2013).

The CGC HEALY or other vessels may perform the following activities during their research cruises:

- Deployment of moored and/or ice-tethered passive sensors (oceanographic measurement devices, acoustic receivers; See Section 1.3.1.4)
- Deployment of moored and/or ice-tethered active acoustic sources to transmit acoustic signals for up to two years after deployment. Transmissions could be terminated during ice-free periods (August-October) each year if needed
- Deployment of unmanned surface, underwater and air vehicles
- Recovery of equipment

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

- Modular Microstructure Profiler, a tethered profiler that would measure oceanographic parameters within the top 984 ft (300 m) of the water column.
- Shallow Water Integrate Mapping System, a winched towed body with a Conductivity Temperature Depth sensor, upward and downward looking Acoustic Doppler Current Profilers (ADCPs), and a temperature sensor within the top 328 ft (100 m) of the water column.
- Three dimensional Sonic Anemometer, which would measure wind stress from the foremast of the ship
- Surface Wave Instrument Float with Tracking (SWIFTs) are freely drifting buoys measuring winds, waves, and other parameters with deployments spanning from hours to days.
- A single mooring (designated as *de minimis* mooring on Figure 1-1) would be deployed to perform measurements of currents with an ADCP.

1.3.1.1 Moored/Drifting Acoustic Sources

Up to 15 acoustic navigation sources would be deployed during the period September 2019 to September 2020 at the locations shown in Figure 1-1. Each navigation source transmits for 8 seconds every 4 hours, with the sources transmitting with a five minute offset from each other. The purpose of the navigation sources is to allow autonomous vehicles and gliders to navigate by receiving acoustic signals from multiple locations and triangulating position. This is needed for vehicles that are under ice and cannot communicate with satellites.

Up to six drifting sources would be deployed for the purpose of near-real time environmental characterization, which is accomplished by communicating information from the drifting buoys to a satellite. They would be deployed in the ice for purposes of buoy stability, but would eventually drift in open water. The sources would transmit signals to each other to measure oceanographic properties of the water between them. The sources would stop transmitting in September 2020 or when they leave the Study Area, whichever comes first.

On the August/September 2020 cruise, a spiral wave beacon source would be tested for fine-scale navigation. The spiral wave beacon is a mid-frequency source that transmits a 50 millisecond signal at 30 second intervals. The source would be deployed from a stationary ship and transmit for up to 5 days.

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

Table 1-1. Characteristics of Modeled Acoustic Sources for the Proposed Action

Source Name	***Frequency Range (Hz)***	***Sound Pressure Level (dB re 1 µPa at 1 m)***	***Pulse Length (milliseconds)***	***Duty Cycle (Percent)***	***Source Type***	***Usage***
Navigation Sources	900	185	8,000	<1 %	Moored	15 sources transmitting 8 seconds every 4 hours, up to 2 years
Real-Time Sensing Sources	900 to 1000	184	60,000	<1%	Drifting	6 sources transmitting 1 minute every 4 hours, up to 2 years
Spiral Wave Beacon	2,500	183	50	<1%	Moored	5 days
Very low Frequency (VLF source)	34	185 (peak)	900,000	<1%	Moored	100 transmits per year

1.3.1.2 *De minimis* Sources

De minimis sources have the following parameters: low source levels, narrow beams, downward directed transmission, short pulse lengths, frequencies above (outside) known marine mammal hearing ranges, or some combination of these factors (Department of the Navy 2013b). Additionally, any sources 200 kilohertz (kHz) or above in frequency and 160 dB or below in source level are automatically considered *de minimis*. Sources 200 kHz or above are considered outside of marine mammal hearing ranges. Assuming spherical spreading for a 160 dB re 1 µPa source, the sound will attenuate to less than 140 dB within 32 ft (10 m) and less than 120 dB within 328 ft (100 m) of the source. Ranges would be even shorter for a source less than 160 dB re 1 µPa source level. All of the sources described in this section are considered *de minimis* (Table 1-2). Since they are not expected to have effects on marine mammals, *de minimis* sources are not quantitatively analyzed. Qualitative analysis is performed when special circumstances (i.e., unusual method of usage, enclosed environment) dictate.

The following are some of the planned *de minimis* sources which would be used during the Proposed Action: Pressure Inverted Echosounders (PIES) sources, ADCPs, ice profilers, upward looking chirp sonar, Expendable Mobile Anti-Submarine Warfare Training Targets (EMATTs), and additional sources below 160 dB re 1 µPa used during towing operations. The PIES sources used in the Proposed Action would have a *de minimis* level of 160 dB within 32-320 ft (10-100 m) of the ocean bottom. Observations of oceanographic phenomena (i.e., temperature, salinity, velocity, turbulence) flowing into the Beaufort Sea would be made using PIES, which would be deployed on the ocean bottom at the white circles with the center dot locations shown in Figure 1-1. PIES are similar to echosounders in their acoustic parameters (pulse length, duty cycle, beamwidth), but transmit acoustic signals upwards rather than downwards. The PIES has an extremely low pulse length and very low duty cycle, as shown in Table 1-2. ADCPs may be used on moorings. Ice-profilers measure ice properties and roughness. The ADCPs and ice-profilers would all be above 200 kHz and therefore out of marine mammal hearing ranges, with the exception of the 75 kHz ADCP which has the characteristics and *de minimis* justification listed in Table 1-2. They may be employed on moorings or unmanned undersea vehicles. An upward looking chirp-sonar would also be deployed for measuring ice and oceanographic properties.

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

The bottom loss measurement system would be used for bottom characterization. The bottom loss measurement system (parameters listed in Table 1-2) from Applied Physics Laboratory could be attached to a Conductivity Temperature Depth Sensor, which is typically found on research vessels. The source would move up and down in the water column, transmitting very short pulses (4 milliseconds) with a low duty cycle (2 percent) and is considered *de minimis* (Department of the Navy 2013a).

Table 1-2. Parameters for De Minimis Non-Impulsive Sources

Source Name	***Frequency Range (kHz)***	***Sound Pressure Level (dB re 1 µPa at 1 m)***	***Pulse Length (milli-seconds)***	***Duty Cycle (Percent)***	***Beamwidth***	***De minimis Justification***
PIES	12	170-180	6	<0.01	45	Extremely low duty cycle, low source level, very short pulse length
ADCP	>200, 150, or 75	190	<1	<0.1	2.2	Very low pulse length, narrow beam, moderate source level
Chirp sonar	2-16	200	20	<1	narrow	Very short pulse length, low duty cycle, narrow beam width
EMATT	700-1100 Hz and 1100-4000 Hz	<150	N/A	25-100	Omni	Very low source level
Coring system	25-200	158-162	< 1	16	Omni	Very low source level[2]
CTD[1] attached Echosounder	5-20	160	4	2	Omni	Very low source level

[1]CTD = Conductivity Temperature Depth
[2]within sediment, not within the water column

1.3.1.3 Drifting Oceanographic Sensors

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

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

1.3.1.4 Moored Oceanographic Sensors

Moored sensors would capture a range of ice, ocean, and atmospheric conditions on a year-round basis. These would be bottom anchored, sub-surface moorings measuring velocity, temperature, and salinity in the upper 1,640 ft (500 m) of the water column. The moorings also collect high-resolution acoustic measurements of the ice using the ice profilers described above. Ice velocity and surface waves would be measured by 500 kHz multibeam sonars from Nortek Signatures.

Additionally, Beaufort Gyre Exploration Project moorings BGOS-A and BGOS-B would be augmented with McLane Moored Profilers. BGOS-A and BGOS-B would be placed on existing Woods Hole Oceanographic Institute moorings. The two BGOS moorings would provide measurements near the Northwind Ridge, with considerable latitudinal distribution. Existing deployments of Nortek Acoustic Wave and Current Profilers on BGOS-A and BGOS-B would also be continued as part of the Proposed Action.

1.3.1.5 Fixed and Towed Receiving Arrays

Horizontal and vertical arrays may be used to receive acoustic signals. Two receiving arrays will be deployed in August-September 2020 to receive signals from the CAATEX source. Other receiving arrays are the Single Hydrophone Recording Units and Autonomous Multichannel Acoustic Recorder. All these arrays would be moored to the seafloor and remain in place throughout the activity.

1.3.2 Activities involving Aircraft and Unmanned Air Vehicles

Naval Research Laboratory would be conducting flights to characterize the ice structure and character, ice edge and wave heights across the open water and marginal ice zone to the ice. Up to four flights, lasting approximately three hours in duration would be conducted, over a 10-day period during February or March for ice structure and character measurements and during late summer/early fall for ice edge and wave height studies. Flights would be conducted with a Twin Otter aircraft over the seafloor mounted acoustic sources and receivers. Most flights would transit at 1,500 ft or 10,000 ft (457 or 3,048 m) above sea level. Twin Otters have flight speeds of 80 to 160 knots, a typical survey speed of 90 to 110 knots, 66 ft (20 m) wing span, and a total length of 26 ft (8 m) (U.S. Department of Commerce and National Oceanic and Atmospheric Administration 2015). At a distance of 2,152 ft (656 m) away, the received pressure levels of a Twin Otter range from 80 to 98.5 A-weighted decibels (expression of the relative loudness in the air as perceived by the human ear) and frequency levels ranging from 20 Hz to 10 kHz, though they are more typically in the 500 Hz range (Metzger 1995). The objective of the flights is to characterize thickness and physical properties of the ice mass overlying the experiment area.

Rotary wing aircraft may also be used during the activity to land on ice. Helicopter transit would be no longer than two hours to and from the ice location. An infrared capable twin engine helicopter may be used to transit scientists from land to an offshore, floating ice location. Once on the floating ice, the team would drill holes with up to a 10 inch (in; 25.4 centimeter [cm]) diameter to deploy scientific equipment (e.g. source, hydrophone array, EMATT) into the water column (Figure 1-2). The science team would depart the area and return to land after three hours of data collection and leave the equipment behind for a later recovery. Fixed wing aircraft may also be used for this purpose instead of rotary wing aircraft.

Figure 1-2. Helicopter Assisted On-Ice Experiments

The Proposed Action includes the use of an Unmanned Aerial System (UAS). The UAS would be utilized for aid of navigation and to confirm and study ice cover. The UAS would be deployed ahead of the ship to ensure a clear passage for the vessel and would have a maximum flight time of 20 minutes. The UAS would not be used for marine mammal observations or hover close to the ice near marine mammals. There would be no videotaping or picture taking of marine mammals as part of the Proposed Action. The UAS that would be used during the Proposed Action is a small commercially available system that generates low sound levels and is smaller than military grade systems. The dimensions of the proposed UAS are, 11.4 in, (29 cm) by 11.4 in (29 cm) by 7.1 in (18 cm) and weighs only 2.5 pounds (lbs; 1.13 kilograms [kg]). The UAS can operate up to 984 ft (300 m) away, which would keep the device in close proximity to the ship. The planned operation of the UAS is to fly it vertically above the ship to examine the ice conditions in the path of the ship and around the area (i.e., not flown at low altitudes around the vessel). Currently acoustic parameters are not available for the proposed models of UASs to be utilized in the Proposed Action. As stated above these systems are very small and are similar to a remote control helicopter. It is likely marine mammals would not hear the device since the noise generated would likely not be audible from greater than 5 ft (1.5 m) away (Christiansen et al. 2016).

1.3.3 On-Ice Measurement Systems

On-ice measurement systems would be used to collect weather data. These would include an Autonomous Weather Station and an Ice Mass Balance Buoy. The Autonomous Weather Station would be deployed on a tripod; the tripod has insulated foot platforms that are frozen into the ice (Figure 1-3). The system would consist of an anemometer, humidity sensor, and pressure sensor. The Autonomous Weather Station also includes an altimeter that is *de minimis* due to its very high frequency (200 kHz). The Ice Mass Balance Buoy is a 20 ft (6 m) sensor string, which is deployed through a two-inch (5 cm) hole drilled into the ice (Figure 1-4). The string is weighted by a 2.2 lb (1 kg) lead weight, and is supported by a tripod. The buoy contains a *de minimis* 200 kHz altimeter and snow depth sensor. Autonomous Weather Stations and Ice Mass Balance Buoys will be deployed, and will drift with the ice, making measurements, until their host ice floes melt, thus destroying the instruments (likely in summer, roughly one year after deployment). After the on-ice instruments are destroyed they cannot be recovered, and would sink to the seafloor as their host ice floes melted.

Figure 1-3. Autonomous Measurement System

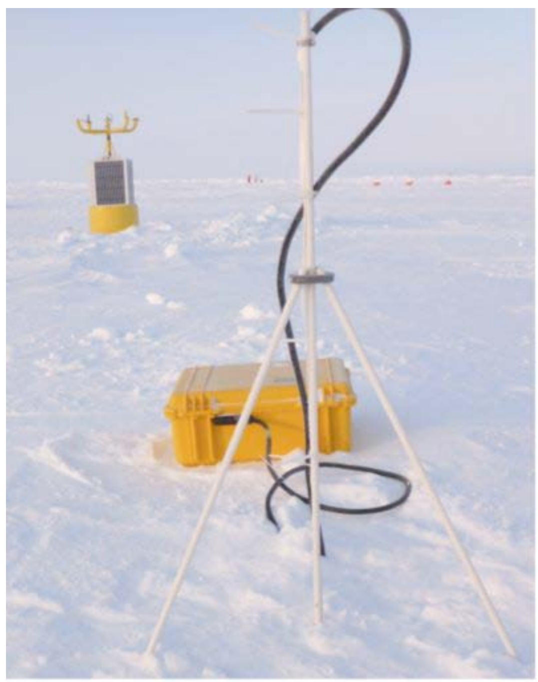

Figure 1-4. Ice Mass Balance Buoy (foreground).

1.3.4 Bottom Interaction Systems

Coring of bottom sediment could occur anywhere within the Study Area to obtain a more complete understanding of the Arctic environment. Coring equipment would take up to 50 samples of the ocean bottom in the Study Area annually. The samples would be roughly cylindrical, with a 3.1 in (8 cm) diameter cross-sectional area; the corings would be between 10 and 20 ft (3 and 6 m) long. Coring would only occur during research cruises, during the summer or early fall. The coring equipment moves very slowly through the muddy bottom, at a speed of approximately 1 m per hour, and would not create any detectable acoustic signal within the water column, though very low levels of acoustic transmissions may be created in the mud (parameters listed in Table 1-2).

1.3.5 Weather Balloons

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

2 Dates, Duration, and Geographic Region

The date(s) and duration of such activity and the specific geographical region where it will occur.

ARA, the Proposed Action, would conduct scientific experiments in the Beaufort and Chukchi Seas from August 2018 to December 2021, with the ability to disable non-impulsive acoustic sources yearly. A supplemental OEA is being prepared to accommodate changes to the scientific plan starting in September 2019. The Proposed Action would occur within the Study Area depicted in Figure 1-1. All activities, except for the transit of ships or aircraft, would take place outside U.S. territorial waters. The Proposed Action would occur in either the U.S. Exclusive Economic Zone or the global commons.

The Proposed Action would occur year-round to obtain the proper scientific data. The acoustic sources in Table 1-1 and icebreaking noise that would occur between September 2019 and September 2020 are the only aspects of the Proposed Action for which this IHA is being requested.

3 Species and Numbers of Marine Mammals

The species and numbers of marine mammals likely to be found within the activity area.

The following marine mammals are managed by the National Marine Fisheries Service (NMFS) and are expected in the Study Area during the Proposed Action: beluga whale (*Delphinapterus leucas*), bowhead whale (*Balaena mysticetus*), gray whale (*Eschrichtius robustus*), bearded seal (*Erignathus barbatus*), spotted seal (*Phoca largha*), ribbon seal (*Histriophoca fasciata*), and ringed seal (*Phoca hispida*). Activities conducted during the Proposed Action are expected to cause harassment, as defined by the MMPA as it applies to military readiness (Section 5), to the beluga whale and ringed seal. Since there were no calculated exposures for the bowhead whale, bearded seal, gray whale, spotted seal, and ribbon seal from quantitative modeling of non-impulsive acoustic and icebreaking sources harassment is not expected, and therefore, those species will not be discussed in this IHA.

Population estimates for the species discussed in this IHA are found in Table 3-1. Additional relevant information on the beluga whale, bearded seal, and ringed seal status, life history, and distribution are presented in 4.

Table 3-1. Population Sizes of Species within Study Area

Species	***Status***	***Stock***	***Population Size (Potential Biological Removal)***	***Source***
Beluga whale	Not listed	Beaufort Sea	39,258 (649)	Allen and Angliss (2014), Duval (1993)
		Eastern Chukchi Sea	20,752	Lowry et al. 2017).
Ringed seal	Threatened	Alaska	300,000 (5,100[1])	Kelly et al. (2010b)

[1]Potential biological removal only for the Bering Sea. Potential biological removal for Chukchi and Beaufort Seas unavailable.

4 Affected Species Status and Distribution

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities.

Relevant information regarding the status, life history and distribution of beluga whale and ringed seal are presented below, as well as additional information about the number of animals anticipated to be present within the Study Area.

4.1 Beluga whale (Beaufort Sea Stock)

4.1.1 Regional and Seasonal Distribution

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Belugas are both migratory and residential (non-migratory), depending on the population. Furthermore, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern Bering Sea (i.e., Yukon Delta, Norton Sound), eastern Chukchi Sea, and the Mackenzie Delta (Hazard 1988). Beluga whales are found primarily in shallow coastal waters (in depths as shallow as 3 to 10 ft [1 to 3 m]), but can be found in waters deeper than 2,624 ft (800 m) (Jefferson et al. 2012; Richard et al. 2001).

Seasonal distribution is affected by ice cover, tidal conditions, and access to prey, temperature, and human interaction (Frost et al. 1985). It has also been observed in a 2016 study that irregular sea ice conditions during the spring and summer months can influence beluga whales to adjust their migratory tracks to summering areas (O'Corry-Crowe et al. 2016). There are two migration areas used by belugas that overlap the Study Area. One, located in the Eastern Chukchi and Alaskan Beaufort Sea, is a migration area in use from April to May. The second, located in the Alaskan Beaufort Sea, is used by migrating belugas from September to October (Calambokidis et al. 2015). During the winter, they can be found foraging in offshore waters associated with pack ice. When the sea ice melts in summer, they move to warmer river estuaries and coastal areas for molting and calving (Muto et al. 2017). Annual migrations can span over thousands of kilometers (Richard et al. 2001). The residential populations participate in short distance movements within their range throughout the year. Based on satellite tags (Suydam et al. 2001) there is some overlap in distribution with the eastern Chukchi Sea beluga whale stock.

4.1.2 Population and Abundance

4.1.2.1 Status of Stock

Beluga whales from this stock are not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act (ESA). The sources of information to estimate abundance for belugas in the waters of northern Alaska and western Canada have included both opportunistic and systematic observations. The most recent aerial survey was conducted in July 1992, and resulted in an estimate of 19,629 (Coefficients of Variation [CV] = 0.229) beluga whales in the eastern Beaufort Sea (Harwood et al. 1996). However, the 1992 surveys did not encompass the entire summer range of Beaufort Sea belugas (Richard et al. 2001), thus are negatively biased. A correction factor for this species is not available. However, Duval (1993) recommended a population abundance estimate of 39,258 (or 19,629 X 2).

Using the population estimate (N) of 39,258 whales and an associated CV(N) of 0.229, the minimum population estimate for this stock is 32,453 whales (Muto et al. 2016). Because the survey data are more than 8 years old, it would not be considered a reliable minimum population estimate for calculating a potential biological removal and minimum population estimate is considered unknown. However, trend data from Harwood and Kingsley (2013) indicate the stock is at least stable or increasing; therefore, the Alaska Scientific Review Group[1] recommended at the 2014 meeting that NMFS retain the minimum population estimate of 32,453 whales. Recent trend data suggest that the stock is at least as large as it was during the last minimum population estimate; thus potential biological removal (defined by the MMPA as the maximum number of animals, not including natural mortalities, that can be removed from a marine mammal stock while allowing the stock to reach or maintain an optimum stable population) for this stock is 649 whales (National Marine Fisheries Service 2005).

4.1.2.2 Density

The beluga whale density numbers utilized for quantitative acoustic modeling are from the Navy Marine Species Density Database (U.S. Department of the Navy 2014). The density estimate is based on the habitat-based modeling by Kaschner *et al.* (2006) and Kaschner (2004), resulting in a maximum value of 0.0087 animals per square kilometer (km^2) in the cold and warm seasons.

4.1.3 Hearing and Vocalization

In general, odontocete hearing is very broad, including low-frequency, mid-frequency, and high-frequency cetaceans. Beluga whales are members of the mid-frequency cetacean functional hearing group, which also includes 32 species of dolphins and sperm whales. Functional hearing in mid-frequency cetaceans is conservatively estimated to be between 150 Hz and 160 kHz (Southall et al. 2007). Mid-frequency cetaceans also generate short-duration (50-200 µs) specialized clicks used in echolocation with peak at frequencies between 10 and 200 kHz (Au 1993; Wartzok and Ketten 1999). Echolocation is used to detect, localize, and characterize underwater objects, including prey items (Au 1993). These clicks are often more intense than other communicative signals, with reported source levels as high as 229 dB re 1 µPa at 1 m peak-to-peak (Au et al. 1974). Castellote et al. (2014) found that wild beluga whales can hear in the range of 4 to 150 kHz. Klishin et al. (2000) tested a single beluga whale and found its hearing to be most sensitive from 32 kHz to 108 kHz.

4.2 Beluga whale (Eastern Chukchi Sea Stock)

4.2.1 Regional and Seasonal Distribution

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern

[1]Scientific Review Group: Advise NMFS and the U.S. Fish and Wildlife Service on the status of marine mammal stocks (under Section 117 of the MMPA) within three areas: Alaskan waters; Atlantic Ocean, including the Gulf of Mexico; and Pacific Ocean, including Hawaii.

Bering Sea (i.e., Yukon Delta, Norton Sound), eastern Chukchi Sea, and the Mackenzie Delta (Hazard 1988). Seasonal distribution is affected by ice cover, tidal conditions, and access to prey, temperature, and human interaction (Frost et al. 1985). During the winter, they occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982; Suydam 2009) and give birth to and care for their calves (Sergeant and Brodie 1969). Eastern Chukchi Sea belugas move into coastal areas, including Kasegaluk Lagoon (outside of the Study Area), in late June and animals are sighted in the area until about mid-July (Frost and Lowry 1990; Frost et al. 1993).

Satellite tags attached to eastern Chukchi belugas captured in Kaseguluk Lagoon during the summer showed these whales traveled 593 nautical miles (nm; 1,100 kilometers [km]) north of the Alaska coastline, into the Canadian Beaufort Sea within three months (Suydam et al. 2001). Satellite telemetry data from 23 whales tagged during 1998-2007 suggest variation in movement patterns for different age and/or sex classes during July-September (Suydam et al. 2005). Adult males used deeper waters and remained there for the duration of the summer; all belugas that moved into the Arctic Ocean (north of 75°N) were males, and males traveled through 90 percent pack ice cover to reach deeper waters in the Beaufort Sea and Arctic Ocean (79-80°N) by late July/early August. Adult and immature female belugas remained at or near the shelf break in the Chukchi Sea. After October, only three tags continued to transmit, and those whales migrated south through the eastern Bering Strait into the northern Bering Sea, remaining north of Saint Lawrence Island over the winter. A whale tagged in the eastern Chukchi Sea in 2007 overwintered in the waters north of Saint Lawrence Island during 2007/2008 and moved to near King Island in April and May before moving north through the Bering Strait in late May and early June (Suydam 2009).

4.2.2 Population and Abundance

4.2.2.1 Status of Stock

Beluga whales from this stock are not designated as depleted under the MMPA or listed as threatened or endangered under the ESA. According to Muto et al. (2016) it is not possible to estimate the abundance for this stock. DeMaster et al. (1998) conducted aerial surveys in the eastern Chukchi Sea resulting in a maximum single day count of 1,172 whales, but a large number of whales were unavailable for counting and a correction factor does not exist for beluga whales. Frost et al. (1993) estimated a minimum size of the eastern Chukchi beluga whale stock at 1,200, based on counts of animals from aerial surveys conducted during 1989-1991. These surveys provided only a minimum raw count, but are still considered the most reliable estimate for this stock. As a result, the abundance estimate from the 1989-91 surveys is 3,710 whales. Clarke et al. (2013) did conduct aerial surveys in the summer of 2012 in the northeastern Chukchi and Alaska Beaufort seas, but the Alaska Beluga Whale Committee is analyzing the information to update population abundance estimates (Muto et al. 2016).

Although CVs of the correction factors are not available, the Alaska Scientific Review Group concluded that the population estimate of 3,710 belugas can serve as the estimated minimum population size because the survey did not include all areas where beluga are known to occur (Small and DeMaster 1995). That is, if the beluga distribution in the eastern Chukchi Sea is similar to beluga distribution in the Beaufort Sea, which is likely based on satellite tag results (Lowry and Frost 2002; Suydam 2009), then a substantial fraction of the population was likely to have been in offshore waters during the survey period (DeMaster 1997).In 2017, (Lowry et al. 2017) conducted line-transect analysis which resulted in an estimate of 5,547 surface-visible beluga whales (CV= 0.22). Data from satellite-linked dive records were used to develop correction factors to account for missed animals in the area during the study. The results of that data, estimated a total abundance of 20,752 beluga whales (CV=0.70) (Lowry et al. 2017). The minimum population estimate of stock is estimated .

4.2.2.2 Density

The beluga whale density numbers utilized for quantitative acoustic modeling are from the Navy Marine Species Density Database (U.S. Department of the Navy 2014). The density estimate is based on the habitat-based modeling by Kaschner *et al.* (2006) and Kaschner (2004), resulting in a maximum value of 0.0087 animals per km^2 in the cold and warm seasons.

4.2.3 Hearing and Vocalization

See Section 4.1.3 above.

4.3 Ringed Seal (Alaska Stock)

4.3.1 Regional and Seasonal Distribution

Ringed seals are the most common pinniped in the Study Area and have wide distribution in seasonally and permanently ice-covered waters of the Northern Hemisphere (North Atlantic Marine Mammal Commission 2004). Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying both shore-fast and pack ice (Kelly 1988b). Ringed seals can be found further offshore than other pinnipeds since they can maintain breathing holes in ice thickness greater than 6.6 ft (2 m) (Smith and Stirling 1975). Breathing holes are maintained by ringed seals' sharp teeth and claws on their fore flippers. They remain in contact with ice most of the year and use it as a platform for molting in late spring to early summer, for pupping and nursing in late winter to early spring, and for resting at other times of the year (Muto et al. 2017).

Ringed seals have at least two distinct types of subnivean lairs: haulout lairs and birthing lairs (Smith and Stirling 1975). Haulout lairs are typically single-chambered and offer protection from predators and cold weather. Birthing lairs are larger, multi-chambered areas that are used for pupping in addition to protection from predators. Ringed seals pup on both land-fast ice as well as stable pack ice. Lentfer (1972) found that ringed seals north of Barrow, Alaska build their subnivean lairs on the pack ice near pressure ridges. Since subnivean lairs were found north of Barrow, Alaska, in pack ice, they are also assumed to be found within the sea ice in the Study Area. Ringed seals excavate subnivean lairs in drifts over their breathing holes in the ice, in which they rest, give birth, and nurse their pups for 5–9 weeks during late winter and spring (Chapskii 1940; McLaren 1958; Smith and Stirling 1975). Snow depths of at least 20–26 in (50–65 cm) are required for functional birth lairs (Kelly 1988a; Lydersen 1998; Lydersen and Gjertz 1986; Smith and Stirling 1975), and such depths typically are found only where 8–12 in (20–30 cm) or more of snow has accumulated on flat ice and then drifted along pressure ridges or ice hummocks (Hammill 2008; Lydersen et al. 1990; Lydersen and Ryg 1991; Smith and Lydersen 1991). Ringed seals are born beginning in March, but the majority of births occur in early April. About a month after parturition, mating begins in late April and early May.

In Alaskan waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort seas (Frost 1985; Kelly 1988b). Passive acoustic monitoring of ringed seals from a high frequency recording package deployed at a depth of 787 ft (240 m) in the Chukchi Sea (65 nm) 120 km north-northwest of Barrow, Alaska detected ringed seals in the area between mid- December and late

May over the four year study (Jones et al. 2014). With the onset of the fall freeze, ringed seal movements become increasingly restricted and seals will either move west and south with the advancing ice pack with many seals dispersing throughout the Chukchi and Bering Seas, or remain in the Beaufort Sea (Crawford et al. 2012; Frost and Lowry 1984; 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 km2 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).

4.3.2 Population and Abundance

4.3.2.1 Status of Stock

Ringed seals from this stock are designated as depleted under the MMPA and listed as threatened under the MMPA. On February 12, 2018, in Alaska Oil & Gas Association v National Marine Fisheries Service (Case No. 16-35380), the U.S. Court of Appeals for the Ninth Circuit reversed the 2016 decision that vacated a final regulation listing the Arctic subspecies of ringed seals as threatened. The taxonomic status of the arctic subspecies remains unresolved (Berta and Churchill 2012). For the purposes of this analysis, the Alaska stock of ringed seals is considered the portion of the Arctic subspecies (*P. hispida hispida*) that occurs within the U.S. Exclusive Economic Zone of the Beaufort, Chukchi, and Bering seas. Ringed seal population surveys in Alaska have used various methods and assumptions, had incomplete coverage of their habitats and range, and were conducted more than a decade ago; therefore, current, comprehensive, and reliable abundance estimates or trends for the Alaska stock are not available (Muto et al. 2016). Frost *et al*. (2004) conducted surveys within 21.6 nm (40 km) of shore in the Alaska Beaufort Sea during May-June 1996-1999, and observed ringed seal densities ranging from 0.81 seal/km^2 in 1996 to 1.17 seals/km^2 in 1999. Moulton *et al*. (2002) conducted similar, concurrent surveys in the Alaska Beaufort Sea during 1997-1999 but reported substantially lower ringed seal densities (0.43, 0.39, and 0.63 seals/km^2 in 1997-1999, respectively) than Frost *et al*. (2004). Using the most recent estimates from surveys by Bengtson *et al*. (2005) and Frost *et al*. (2004) in the late 1990s and 2000, Kelly *et al*. (2010b) estimated the total population in the Alaska Chukchi and Beaufort seas to be at least 300,000 ringed seals, which Kelly *et al*. (2010b) states is likely an underestimate since the Beaufort surveys were limited to within 21.6 nm (40 km) of shore.

4.3.2.2 Density

The ringed seal density numbers utilized for quantitative acoustic modeling are from the Navy Marine Species Density Database (U.S. Department of the Navy 2014). The density estimate is based on the habitat-based modeling by Kaschner et al. (2006) and Kaschner (2004), resulting in a maximum value of 0.3760 animals per km^2 in the cold and warm seasons.

4.3.3 Hearing and Vocalization

Ringed seals fall into the phocid seal hearing group. Functional hearing limits for this hearing group are estimated to be 75 Hz–30 kHz in air and 75 Hz–75 kHz in water (Kastak and Schusterman 1999; Kastelein et al. 2009a; Kastelein et al. 2009b; Møhl 1968a, 1968b; Reichmuth 2008; Terhune and Ronald 1971, 1972). Phocids can make calls between 90 Hz and 16 kHz (Richardson et al. 1995). The generalized hearing for phocids (underwater) (National Marine Fisheries Service 2016) ranges from 50 Hz to 86 kHz, which includes the suggested auditory bandwidth for pinnipeds in water proposed by Southall *et al.* (2007), ranging between 75Hz to 75 kHz. Based on a study by Sills *et al*. (2015), the best frequencies for ringed seal hearing were 12.8 and 25.6 kHz at 49 and 50 dB re 1µPa at 1 m respectively. The best hearing range for ringed seals combined was 0.4 to 52 kHz (Sills et al. 2015). Data on ringed seal hearing indicates an upper frequency limit to be 60 kHz (Terhune and Ronald 1976), which falls within the phocid hearing group.

5 Type of Incidental Taking Authorization Requested

> The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

5.1 Take Authorization Request

The Navy is requesting an IHA for the incidental taking of a specified number of beluga whales from the Beaufort Sea and Eastern Chukchi Sea stocks, and ringed seals from the Alaska stocks, incidental to proposed 2019-20 ARA activities in the Beaufort and Chukchi Seas. This taking would occur as a result of non-impulsive acoustic sources and icebreaking noise during these activities. The term “take,” as defined in Section 3 (16 United States Code [U.S.C.] § 1362 (13)) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential disturbance).

The Proposed Action constitutes a military readiness activity as defined in Public Law 107-314 (Migratory Bird Treaty Act (as amended) at 16 U.S.C. § 703 note) because these proposed scientific research activities directly support the “adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use” by providing critical data on the changing natural and physical environment in which such materiel will be assessed and deployed. This proposed scientific research also directly supports fleet training and operations by providing up to date information and data on the natural and physical environment essential to training and operations. 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)].

The Preferred Alternative of the Overseas Environmental Assessment for ARA analyzed the following stressors for potential impacts to marine mammals:

- Acoustic (non-impulsive acoustic sources, aircraft noise, icebreaking noise, and vessel noise)
- Physical disturbance and strikes (aircraft strike, vessel and in-water vehicle strike, icebreaking [physical impacts] and bottom disturbance)
- Expended material (entanglement and ingestion)

In that analysis, the Navy determined the only stressors that could potentially result in the incidental taking of marine mammals are from non-impulsive acoustic sources (beluga whale and ringed seal) and icebreaking noise (beluga whale and ringed seal).

5.2 Incidental Take Request

The methods of incidental take associated with the non-impulsive acoustic sources and icebreaking noise from the Proposed Action are described within Section 1.3.4. Non-impulsive acoustic sources and icebreaking noise from research activities and icebreaking have the potential to disturb or displace marine mammals and may result in the "take" in the form of Level B harassment. Mitigation and monitoring measures discussed in 11 and 13 will be implemented to further minimize the potential for takes of marine mammals. Table 5-1 summarizes the Navy's final take request based on quantitative acoustic modeling for the 2019-20 ARA year-round research activities. Only Level B takes are anticipated to occur from the Proposed Action. Derivation of these values is described in more detail in 6.

Table 5-1. Total Number of Exposures Requested for Marine Mammals During 2019-20 ARA

Common Name	***Level B Takes Requested***	
	Behavioral Response	***Temporary Threshold Shift***
Beluga whale (Beaufort Sea Stock)	363	0
Beluga whale (Eastern Chukchi Sea Stock)	196	0
Ringed seal	7,845	0

6 Take Estimates for Marine Mammals

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in Chapter 5, and the number of times such takings by each type of taking are likely to occur.

The methods for estimating the number and types of exposures identified in 5 are provided below. The method is consistent with that of the Phase III Atlantic Fleet Training and Testing and Hawaii and Southern California Training and Testing Environmental Impact Statements/Overseas Environmental Impact Statements marine mammal modeling and the newest Navy and NMFS acoustic criteria (National Marine Fisheries Service 2016). The stressors that are estimated to result in Level B harassment are non-impulsive acoustic sources and icebreaking noise.

The information presented in this chapter includes a summary of the vocalization and hearing capabilities of marine mammal groups, the types of non-impulsive acoustic impacts potentially resulting from the Proposed Action, criteria and thresholds against which the types of impacts are analyzed, and a description of the quantitative analysis used to estimate impacts to marine mammals.

6.1 Vocalization and Hearing of Marine Mammals

All marine mammals that have been studied can produce sounds and use sounds to forage, orient, detect and respond to predators, and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology (Au 1993; Houser et al. 2008; Mulsow et al. 2014; Nachtigall et al. 2007; Schusterman 1981; Wartzok and Ketten 1999). Behavioral audiograms, which are plots of animals' exhibited hearing threshold versus frequency, are obtained from captive, trained live animals using standard testing procedures with appropriate controls, and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity.

Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Hearing response in relation to frequency for both methods of evaluating hearing ability is a generalized U-shaped curve or audiogram showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al. 2010). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

Table 6-1 provides a summary of sound production and general hearing capabilities for the beluga whale and ringed seal (note that values in this table are not meant to reflect absolute possible maximum ranges, rather they represent the best known ranges of each functional hearing group). A detailed discussion of the functional hearing groups can be found in Finneran and Jenkins (2012).

Table 6-1. Marine Mammal Functional Hearing and Sound Production

Functional Hearing Group	*Species Which May Be Present in the Area*	*Sound Production*		*General Hearing Ability Frequency Range*[1]
		Frequency Range	*Source Level dB re:1µPa at 1m*	
Mid frequency cetaceans	Beluga whale	Above 100 kHz	Up to 279	150 Hz to 160 kHz
Pinnipeds	Ringed seal	100 Hz to 12 kHz	103 to 180	75 Hz to 75 kHz (in water)

[1]Adapted and derived from Southall (2007)

Note: dB re 1 µPa at 1 m: decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa) at 1 meter; Hz: Hertz; kHz: kilohertz

6.2 Analysis Framework

The potential impacts were analyzed in terms of potential hearing loss and behavioral reactions as a result of the Proposed Action.

6.2.1 Hearing Threshold Shifts

The most familiar effect of exposure to high intensity sound is hearing loss, meaning a shift in the hearing threshold. This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). The distinction between permanent threshold shift (PTS) and temporary threshold shift (TTS) is based on whether there is complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is considered a TTS. The recovery to pre-exposure threshold from studies of marine mammals is usually on the order of minutes to hours for the small amounts of TTS induced (Finneran et al. 2005; Nachtigall et al. 2004). The recovery time is related to the exposure duration, sound exposure level (SEL), and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Mooney et al. 2009). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS.

Studies of marine mammals have been designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicates the amount of TTS. Kastelein *et al*. (2016) studied the effects of intermittent anthropogenic sounds such as sonar and the onset of TTS in harbor porpoise. The study found that relatively short intermittent sounds such as sonar had a much smaller impact on TTS than a constant anthropogenic sound such as pile driving (Kastelein et al. 2016). Other species studied include the bottlenose dolphin (total of nine individuals), beluga (2), finless porpoise (2), California sea lion (3), harbor seal (1), and northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels–exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example (Schlundt et al. 2000)).

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated by assuming some upper limit of TTS that equates to the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS.

6.2.2 Behavioral Reactions or Responses

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 also 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). Reviews by Nowacek et al. (2007) and Southall *et al.* (2007) 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.

Multi-year research efforts have conducted sonar exposure studies for odontocetes and mysticetes (Miller et al. 2012; Sivle et al. 2012). Several studies with captive animals have provided data under controlled circumstances for odontocetes and pinnipeds (Houser et al. 2013a; Houser et al. 2013b). Moretti et al. (2014) published a beaked whale dose-response curve based on passive acoustic monitoring of beaked whales during U.S. Navy training activity at Atlantic Underwater Test and Evaluation Center during actual Anti-Submarine Warfare exercises. This new information has necessitated the update of the Navy's behavioral response criteria.

Southall et al. (2007), and more recently Southall et al. (2019), synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007; Southall et al. 2019). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions, consistent avoidance reactions were noted at higher sound levels depending on the marine mammal species or group allowing conclusions to be drawn. Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa at 1m; thus, seals may actually receive levels adequate to produce TTS before avoiding the source.

Odontocete Phase III behavioral criteria was updated based on controlled exposure studies for dolphins and sea mammals, sonar, and safety (3S) studies where behavioral responses of whales were reported after exposure to sonar (Antunes et al. 2014; Houser et al. 2013b; Miller et al. 2011; Miller et al. 2014; Miller et al. 2012). Overall exposure levels were from 70–180 dB re 1µPa for the killer, pilot and sperm whales, and 115–185 dB re 1µPa for the bottlenose dolphin. For the 3S study the sonar outputs included 1–2 kHz up- and down-sweeps and 6–7 kHz up-sweeps; source levels were ramped-up from 152–158 dB re 1µPa at 1m to a maximum of 198–214 dB re 1µPa at 1m. Sonar signals were ramped up over several pings while the vessel approached the mammals. The study did include some control passes of ships with the sonar off to discern the behavioral responses of the mammals to vessel presence alone versus active sonar. The controlled exposure studies with the Navy's trained bottlenose dolphins were exposed to mid-frequency sonar while they were in a pen. Mid-frequency sonar was played at six different exposure levels from 125–185 dB re 1µPa (rms). It was noted bottlenose dolphins in this experiment had probably not been exposed to intense sounds such as nearby tactical sonar in the past, but due to their training may be less sensitive to noise exposure than wild animals. Responses occurred at received levels from 94–185 dB re 1µPa, the means of the response data were from 126–169 dB re 1µPa. In order to give equal weighting to the data from the field studies and the controlled exposure studies data for all ten exposure sessions per individual were combined into one response, such that the overall response was assumed to have occurred if the mammal responded in any single trial. The resulting behavioral response function (BRF; Figure 6-1A) has a 50 percent probability of response at 157 dB re 1µPa. Additionally, distance cutoffs were applied to exclude exposures beyond which the potential of significant behavioral responses is considered to be unlikely (see Section 6.5.1 for specific distance cut-offs for odontocetes/mid-frequency cetaceans).

The Phase III pinniped behavioral criteria was updated based on controlled exposure experiments on the following captive animals: hooded seal, gray seal, and California sea lion (Götz et al. 2010; Houser et al. 2013a; Kvadsheim et al. 2010). Overall exposure levels were 110–170 dB re 1 µPa for hooded seals, 140–180 dB re 1 µPa for gray seals and 125-185 dB re 1 µPa for California sea lions; responses occurred at received levels ranging from 125 to 185 dB re 1 µPa. However, the means of the response data were between 159 and 170 dB re 1 µPa. Hooded seals were exposed to increasing levels of sonar until an avoidance response was observed, while the gray seals were exposed first to a single received level multiple times, then an increasing received level. Each individual California sea lion was exposed to the same received level ten times, these exposure sessions were combined into a single response value, with an overall response assumed if an animal responded in any single session. Because these data represent a dose-response type relationship between received level and a response, and because the means were all tightly clustered, the Bayesian biphasic BRF for pinnipeds most closely resembles a traditional sigmoidal dose-response function at the upper received levels (Figure 6-1B), and has a 50 percent probability of response at 166 dB re 1 µPa. Additionally, distance cutoffs were applied to exclude exposures beyond which the potential of significant behavioral responses is considered to be unlikely (see Section 6.5.1 for specific distance cut-offs for pinnipeds).

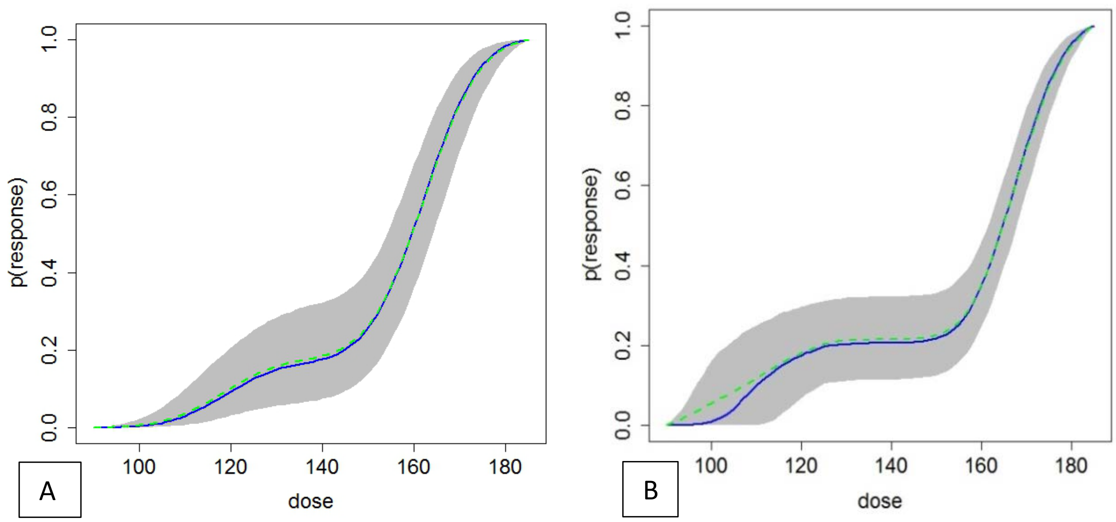

Figure 6-1. A) The Bayesian biphasic dose-response BRF for Odontocetes. B) The Bayesian biphasic dose-response BRF for pinnipeds. The blue solid line represents the Bayesian Posterior median values, the green dashed line represents the biphasic fit, and the grey represents the variance. [X-Axis: Received Level (dB re 1 µPa), Y-Axis: Probability of Response]

Icebreaking is generally characterized as a low-frequency (10-100 Hz), non-impulsive sound. Icebreaking is a combination of the sounds made by the vessel's engine and propeller while icebreaking and the sound(s) created by the breaking of ice. As such, it is not appropriate to use the behavioral risk function to evaluate potential impacts to marine mammals because the behavioral risk function was derived from mid-frequency sonar sources that are narrow band (versus the broadband noise from icebreaking). Generic received levels (RL) thresholds for behavioral disturbance (120 dB re 1 μPa_{rms}), regardless of functional hearing group, have been applied, although efforts have been made to improve data, including the addition of unique RL thresholds for behavioral disturbance specific to species (harbor porpoise and beaked whales; 80 FR 31738; 2015). Specific to the harbor porpoise, a step function and not a curve (and assuming uniform density) was applied to evaluate take from Level B harassment (80 FR 31738; 2015). Although a step function may over-estimate the effects of icebreaking, a step function at a sound pressure level (SPL) of 120 dB re 1 µPa was conservatively used.

6.3 Criteria and Thresholds for Predicting Non-Impulsive and Icebreaking Impacts on Marine Mammals from the Proposed Action

Harassment criteria for marine mammals are evaluated based on thresholds developed from observations of trained cetaceans exposed to intense underwater sound under controlled conditions (Finneran et al. 2003; Kastak and Schusterman 1996; Kastak and Schusterman 1999; Kastak et al. 2005; Kastelein et al. 2012). These data are the most applicable because they are based on controlled, tonal sound exposures within the typical sonar frequency ranges and because the species studied are closely related to the animals expected in the Study Area. Studies have reported behavioral alterations, or deviations from a subject's normal trained behavior, and exposure levels above which animals were observed to exhibit behavioral deviations (Finneran and Schlundt 2003; Schlundt et al. 2000).

Criteria and thresholds used for determining the potential effects from the Proposed Action are from NMFS technical guidance on acoustic thresholds for PTS/TTS. The behavioral criteria for non-impulsive acoustic sound was developed in coordination with NMFS to support Phase III environmental analyses and MMPA Letter of Authorization renewals (U.S. Department of the Navy 2017a). . For weighting function derivation, the most critical data required are TTS onset exposure levels as a function of exposure frequency. These values can be estimated from published literature by examining TTS as a function of SEL for various frequencies. The 120 dB re 1 µPa step function (unweighted) was determined to be most appropriate for icebreaking.

Table 6-2 below provides the criteria and thresholds used in this analysis for estimating quantitative non-impulsive acoustic and icebreaking exposures of marine mammals from the Proposed Action. Weighted criteria for non-impulsive acoustic sources and unweighted behavioral criteria for icebreaking are shown in the table below. Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. For weighting function derivation, the most critical data required are TTS onset exposure levels as a function of exposure frequency. These values can be estimated from published literature by examining TTS as a function of SEL for various frequencies.

To estimate TTS onset values for non-impulsive acoustic sources, only TTS data from behavioral hearing tests were used. To determine TTS onset for each subject, the amount of TTS observed after exposures with different SPLs and durations were combined to create a single TTS growth curve as a function of SEL. The use of (cumulative) SEL is a simplifying assumption to accommodate sounds of various SPLs, durations, and duty cycles. This is referred to as an “equal energy” approach, since SEL is related to the energy of the sound and this approach assumes exposures with equal SEL result in equal effects, regardless of the duration or duty cycle of the sound. It is well-known that the equal energy rule will over-estimate the effects of intermittent noise, since the quiet periods between noise exposures will allow some recovery of hearing compared to noise that is continuously present with the same total SEL (Ward 1997). For continuous exposures with the same SEL but different durations, the exposure with the longer duration will also tend to produce more TTS (Finneran et al. 2010; Kastak et al. 2007; Mooney et al. 2009).

As in previous non-impulsive acoustic effects analysis (Finneran and Jenkins 2012; Southall et al. 2007), the shape of the PTS exposure function for each species group is assumed to be identical to the TTS exposure function for each group. A difference of 20 dB between TTS onset and PTS onset is used for all marine mammals including pinnipeds. This is based on estimates of exposure levels actually required for PTS (i.e. 40 dB of TTS) from the marine mammal TTS growth curves, which show differences if 13 to 37 dB between TTS and PTS onset in marine mammals. Details regarding these criteria and thresholds can be found in National Marine Fisheries Service (2016).

Table 6-2. Non-Impulsive Acoustic Injury (PTS) and Disturbance (TTS, Behavioral) Thresholds for Underwater Sounds[1]

Group	Species	*Behavioral Criteria*		*Physiological Criteria*	
		Non-Impulsive Acoustic Sources	*Icebreaking Sources*	*Onset TTS*	*Onset PTS*
Mid Frequency Cetaceans	Beluga whale	Mid-Frequency BRF dose response function[2]	120 dB re 1 µPa step function	178 dB SEL cumulative	198 dB SEL cumulative
Phocidae (in water)	Ringed seal	Pinniped Dose Response Function[2]	120 dB re 1 µPa step function	181 dB SEL cumulative	201 dB SEL cumulative

[1]The threshold values provided are assumed for when the source is within the animal's best hearing sensitivity. The exact threshold varies based on the overlap of the source and the frequency weighting.
[2]See Figure 6-1

6.4 Quantitative Modeling

The Navy performed a quantitative analysis to estimate the number of mammals that could be harassed by the underwater non-impulsive acoustic sources and icebreaking during the Proposed Action. Inputs to the quantitative analysis included marine mammal density estimates obtained from the Navy Marine Species Density Database, marine mammal depth occurrence distributions (U.S. Department of the Navy 2017b), oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. Densities for each species analyzed within this IHA can be found in 4 under each respective species density subsection. 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 Navy developed a set of software tools and compiled data for estimating non-impulsive acoustic effects on marine mammals without consideration of behavioral avoidance or Navy's standard mitigations. These databases and tools collectively form the Navy Acoustic Effects Model (NAEMO). In NAEMO, animats are distributed nonuniformly based on species-specific density, depth distribution, and group size information, and animats record 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. Site-specific bathymetry, sound speed profiles, wind speed, and bottom properties are incorporated into the propagation modeling process. NAEMO calculates the likely propagation for various levels of energy (sound or pressure) resulting from each source used during the testing event.

NAEMO then records the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects on the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are counted as if they occurred within the Study Area boundary. NAEMO provides the initial estimated impacts on marine species with a static horizontal distribution.

There are limitations to the data used in the acoustic effects model, and the results must be interpreted within this context. While the most accurate data and input assumptions have been used in the modeling, when there is a lack of definitive data to support an aspect of the modeling, modeling assumptions believed to overestimate the number of exposures have been chosen:

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

Because of these inherent model limitations and simplifications, model-estimated results must be further analyzed, considering such factors as the range to specific effects, avoidance, and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to predict acoustic effects on marine mammals.

6.4.1 Icebreaking Noise Modeling

The underwater radiated noise signature for icebreaking in the central Arctic Ocean by CGC HEALY during different types of ice-cover was characterized in Roth et al. (2013). The radiated noise signatures were characterized for various fractions of ice cover. For modeling, the 8/10 ice cover was used. Each modeled day of icebreaking consisted of 6 hours of 8/10 ice cover. Icebreaking was modeled for eight days for each of the 2019 and 2020 cruises. For each cruise, this includes four days of icebreaking for the deployment (or recovery) of the VLF source and four days of icebreaking for the deployment (or recovery) of the northernmost navigation sources. Since ice forecasting cannot be predicted more than a few weeks in advance it is unknown if icebreaking would be needed to deploy or retrieve the sources after one year of transmitting. Therefore, icebreaking was conservatively analyzed within this IHA. Figure 5a and 5b in Roth et al. (2013) depicts the source spectrum level versus frequency for 8/10 ice cover. The sound signature of the ice coverage level was broken into 1-octave bins (Table 6-3). In the model, each bin was included as a separate source on the modeled vessel. When these independent sources go active concurrently, they simulate the sound signature of CGC HEALY. The modeled source level summed across these bins was 196.2 dB for the 8/10 signature ice signature. These source levels are a good approximation of the icebreaker's observed source level (provided in Figure 4b of (Roth et al. 2013)). Each frequency and source level was modeled as an independent source, and applied simultaneously to all of the animats within NAEMO. Each second was summed across frequency to estimate sound pressure level (root mean square [SPL_{RMS}]). For PTS and TTS determinations, sound exposure levels were summed over the duration of the test and the transit to the deployment area. The method of quantitative modeling for icebreaking is considered to be a conservative approach; therefore, the number of takes estimated for icebreaking are likely an over-estimate and would not be expected.

Table 6-3. Modeled bins for 8/10 ice coverage (full power) ice breaking on CGC HEALY

Frequency (Hz)	*Source Level (dB)*
25	189
50	188
100	189
200	190
400	188
800	183
1600	177
3200	176
6400	172
12800	167

6.5 Impacts on Marine Mammals

6.5.1 Range to Effects

For non-impulsive acoustic sources, NAEMO calculates the SPL and SEL for each active emission during an event. This is done by taking the following factors into account over the propagation paths: bathymetric relief and bottom types, sound speed, and attenuation contributors such as absorption, bottom loss and surface loss. Platforms such as a ship using one or more sound sources are modeled in accordance with relevant vehicle dynamics and time durations by moving them across an area whose size is representative of the testing event's operational area. Table 6-4 provides range to effects for non-impulsive acoustic sources, and icebreaking noise proposed for ARA to mid-frequency cetacean, and pinniped specific criteria. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting non-impulsive acoustic impacts, but also in verifying the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher level effects, especially physiological effects to marine mammals. Therefore, the ranges in Table 6-4 provide realistic maximum distances over which the specific effects from the use of non-impulsive acoustic sources during the Proposed Action would be possible.

Table 6-4. Range to Temporary Threshold Shift and Behavioral Effects in the Study Area

Source	*Range to Behavioral Effects (m)*		*Range to TTS Effects (m)*		*Range to PTS Effects (m)*	
	MF Cetacean	*Pinniped*	*MF Cetacean*	*Pinniped*	*MF Cetacean*	*Pinniped*
Navigation and real-time sensing sources	20,000	10,000	0	6	0	0
Spiral Wave Beacon source	20,000	10,000	0	0	0	0
Icebreaking noise	4,275	4,525	3	12	0	0

Empirical evidence has not shown responses to non-impulsive acoustic sources that would constitute take beyond a few km from a non-impulsive acoustic source, which is why NMFS and Navy conservatively set a distance cutoff of 5.4 nm (10 km) for pinnipeds, and 10.8 nm (20 km) for mid-frequency cetaceans (U.S. Department of the Navy 2017a). Regardless of the received level at that distance; take is not estimated to occur beyond 10 and 20 km from the source for pinnipeds and cetaceans, respectively. Sources that show a range of zero do not rise to the specified level of effects (i.e., there is no chance of PTS for beluga whales [mid-frequency cetacean] from the navigation source).

6.5.2 Avoidance Behavior and Mitigation Measures

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

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

6.6 Estimated Take of Marine Mammals

As discussed further in 7, if exposure were to occur, beluga whales and ringed seals could exhibit behavioral responses such as avoidance, increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, individuals affected by non-impulsive acoustic sources or icebreaking noise resulting from the Proposed Action would move away from the sound source and be temporarily displaced from their foraging, migration, or breeding areas or haul-out sites within the ARA Study Area. Ringed seals would have to be within 10 km from the source, while beluga whales would have to be within 20 km from the source (see Table 6-4 for range to effects from the non-impulsive acoustic sources and icebreaking noise in the Proposed Action) for any behavioral reaction (e.g. flushing from a lair). Any effects experienced by individual species are anticipated to be limited to short-term disturbance of normal behavior, temporary displacement or disruption of animals which may occur near the Proposed Action. Therefore, the exposures requested are expected to have no more than a minor effect on individual animals and no adverse effect on the populations of the ringed seals and beluga whales.

Table 6-5 shows the exposures expected for the beluga whale and ringed seal based on NAEMO modeled results. Results from the quantitative analysis should be regarded as conservative estimates that are strongly influenced by limited marine mammal population data. While the numbers generated from the quantitative analysis provide conservative overestimates of marine mammal exposures mitigation measures would further limit actual exposures.

Table 6-5. Quantitative Modeling Results of Potential Exposures for 2019-20 ARA Activities.

Common Name	*Level B Harassment*		*Level A Harassment*	*Percentage of Stock Taken*
	Behavioral	*TTS*		
Odontocete				
Beluga whale (Beaufort Sea) Stock	363	0	0	0.92
Beluga whale (Eastern Chukchi Sea Stock)	196	0	0	0.94
Pinniped				
Bearded Seal	[a]5	0	0	<0.01
Ringed Seal	7,845	0	0	2.165

[a] Bearded Seals were added upon request of NMFS, NAEMO modeling did not have any actual takes of bearded seals.

7 Anticipated Impact of the Activity

The anticipated impact of the activity upon the species or stock of marine mammal

The conclusions and predicted exposures in this analysis find that overall impacts on marine mammal species and stocks would be negligible, despite the potential Level B harassment to beluga whales and ringed seals, for the following reasons:

- All estimated acoustic harassments for the Proposed Action are within the non-injurious temporary threshold shift (TTS) or behavioral effects zones (Level B harassment).
- Marine mammal densities input into the model are also overly conservative, particularly when considering species where data is limited in portions of the Study Area and seasonal migrations extend throughout the Study Area. The assumption for mammal density assumed the maximum population size of beluga whales and ringed seals were in the area.

Mitigation measures described in Section 11 are designed to reduce sound exposure to marine mammals to minimize adverse effects on marine mammal species or stocks.

Based on the current state of science, to include behavioral response studies, it is not currently possible to distinguish between significant and insignificant behavioral reactions using the functions derived using this data. However, it is assumed for the purposes of this analysis that more intense and longer duration activities would lead to a higher probability of animals having significant behavioral reactions. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to a sound source that may exceed an animal's behavioral threshold for only a single ping to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant verses non-significant behavioral reactions are currently impossible to predict.

Consideration of negligible impact is required for NMFS to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates).

Behavioral reactions of marine mammals to sound are known to occur but can be difficult to predict, due to the variability in the severity of the response of specific individuals. Recent behavioral studies indicate that reactions to sounds, if any, are highly contextual and vary between species and individuals within a species (Moretti et al. 2010; Southall et al. 2011; Thompson et al. 2010; Tyack 2009; Tyack et al. 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. When sound becomes potentially disruptive, cetaceans at rest become active, and feeding or socializing cetaceans or pinnipeds often cease these events by diving or swimming away. If the sound disturbance occurs around a haul out site, pinnipeds may move back and forth between water and land or temporarily abandon the haul out. When attempting to understand behavioral disruption by anthropogenic sound, a key question to ask is whether the exposures have biologically significant consequences for the individual or population (National Research Council 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be detrimental to the individual. For example, researchers have found during a study focusing on dolphins response to whale watching vessels in New Zealand, that when animals can adapt with constraint and easily feed or move elsewhere, there is little effect on survival (Lusseau and Bejder 2007). On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a period long enough to cause an impact and they do not have an alternate equally desirable area, impacts on the marine mammal could be negative because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to grow, reproduce, and survive. These key elements could be defined as follows:

- Growth: adverse effects on ability to feed;
- Reproduction: the range at which reproductive displays can be heard and the quality of mating/calving grounds; and
- Survival: sound exposure may directly affect a species' ability to live.

The importance of the disruption and degree of consequence for individual marine mammals often has much to do with the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as acoustic transmissions from non-impulsive acoustic sources usually have minimal consequences or no lasting effects for marine mammals. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is also reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences.

7.1 The Context of Behavioral Disruption and TTS - Biological Significance To Populations

The exposure estimates calculated by predictive models currently available predict propagation of sound and received levels and measure a short-term, immediate response of an individual using applicable criteria. Consequences to populations are much more difficult to predict and empirical measurement of population effects from anthropogenic stressors is limited (National Research Council 2005). To predict indirect, long-term, and cumulative effects, the processes must be well understood and the underlying data available for models.

No research has been conducted on the potential behavioral responses of beluga whales and ringed seals to the type of non-impulsive used during the Proposed Action. However, data are available on effects of non-impulsive acoustic sources (e.g., sonar transmissions) on marine mammals. All of this available information was assessed and incorporated into the findings of this analysis.

7.1.1 Effects of Non-Impulsive Acoustic Sources on Marine Mammals

For non-impulsive acoustic sounds (i.e., similar to the sources used during the Proposed Action), data suggest that exposures of pinnipeds to sources between 90 and 140 dB re 1 µPa do not elicit strong behavioral responses; no data were available for exposures at higher received levels for Southall *et al.* (2007) to include in the severity scale analysis. Reactions of harbor seals (*Phoca vitulina*) were the only available data for which the responses could be ranked on the severity scale. For reactions that were recorded, the majority (17 of 18 individuals/groups) were ranked on the severity scale as a 4 (moderate change in movement, brief shift in group distribution, or moderate change in vocal behavior) or lower; the remaining response was ranked as a 6 (minor or moderate avoidance of the sound source). Additional data on hooded seals (*Cystophora cristata*) indicate avoidance responses to signals above 160–170 dB re 1 µPa (Kvadsheim et al. 2010), and data on gray (*Halichoerus grypus*) and harbor seals indicate avoidance response at received levels of 135–144 dB re 1 µPa (Götz et al. 2010). In each instance where food was available, which provided the seals motivation to remain near the source, habituation to the signals occurred rapidly. In the same study, it was noted that habituation was not apparent in wild seals where no food source was available (Götz et al. 2010). This implies that the motivation of the animal is necessary to consider in determining the potential for a reaction. In one study aimed to investigate the under-ice movements and sensory cues associated with under-ice navigation of ice seals, acoustic transmitters (60–69 kHz at 159 dB re 1 µPa at 1 m) were attached to ringed seals (Wartzok et al. 1992a; Wartzok et al. 1992b). An acoustic tracking system then was installed in the ice to receive the non-impulsive acoustic signals and provide real-time tracking of ice seal movements. Although the frequencies used in this study are at the upper limit of ringed seal hearing, the ringed seals appeared unaffected by the non-impulsive acoustic sources, as they were able to maintain normal behaviors (e.g., finding breathing holes).

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

A controlled exposure study to simulated mid-frequency sonar was conducted with U.S. Navy California sea lions (*Zalophus californianus*) at the Navy Marine Mammal Program facility specifically to study behavioral reactions (Houser et al. 2013a). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions included increased respiration rates, prolonged submergence, and refusal to participate, among others. Younger animals were more likely to respond than older animals, while some sea lions did not respond consistently at any sound source level.

While not many studies have been done on odontocete responses to sonar, behavioral response studies have been conducted. In studies that examined sperm whales and false killer whales (both in the mid-frequency cetacean hearing group), the marine mammals showed temporary cessation of calling and avoidance of sonar sources (Akamatsu et al. 1993; Watkins and Schevill 1975). Sperm whales resumed calling and communication approximately two minutes after the pings stopped (Watkins and Schevill 1975). False killer whales did move away from the sound source, but returned to the area between 0 and 10 minutes after the end of the transmissions (Akamatsu et al. 1993). Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would not occur during the Proposed Action. Odontocete behavioral responses to acoustic transmissions from non-impulsive acoustic sources used during the Proposed Action would likely be a result of the animal's behavioral state and prior experience rather than external variables such as ship proximity; thus, if significant behavioral responses occur they would likely be short-term. In fact, no significant behavioral responses such as panic, stranding or other severe reactions have been observed during monitoring of actual training exercises (Department of the Navy 2011, 2014; Smultea and Mobley 2009; Watwood et al. 2012).

7.1.2 Effects of Icebreaking Noise on Marine Mammals

Marine mammals have been recorded in several instances altering and modifying their vocalizations to compensate for the masking noise from vessels, or other similar sounds (Holt et al. 2011; Parks et al. 2011). Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic sources such as sonar, vessel noise, and seismic surveying.

Icebreaking noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction (Huntington et al. 2015; Pirotta et al. 2015; Williams et al. 2014). Icebreaking in fast ice during the spring can cause behavioral reactions in beluga whales. Icebreaking associated with the Proposed Action would only occur during the warm season from August through October, which lessens the probability of a whale encountering the vessel (in comparison to other sources in the Proposed Action that would be active year-round).

Ringed seals on pack ice showed various behaviors when approached by an icebreaking vessel; a majority of seals dove underwater when the ship was within 0.5 nm (0.93 km) while others remained on the ice. However, as icebreaking vessels came closer to the seals, most dove underwater. Ringed seals have also been observed foraging in the wake of an icebreaking vessel (Richardson et al. 1995). In studies by Alliston (Alliston 1980; Alliston 1981), there was no observed change in the density of ringed seals in areas that had been subject to icebreaking. Alternatively, ringed seals may have preferentially established breathing holes in the ship tracks after the icebreaker moved through the area. Due to the time of year of the activity (August through October), ringed seals are not expected to be within the subnivean lairs nor pupping (Chapskii 1940; McLaren 1958; Smith and Stirling 1975).

7.1.3 Effects on Pinniped Haul Out Sites and Ringed Seal Subnivean Lairs

Adult ringed seals spend up to 20 percent of the time in subnivean lairs during the winter season (Kelly et al. 2010a). Ringed seal pups spend about 50 percent of their time in the lair during the nursing period (Lydersen and Hammill 1993). During the warm season ringed seals haul out on the ice. In a study of ringed seal haul out activity by Born et al. (2002) ringed seals spent 25-57 percent of their time hauled out in June which is during their molting season. The non-impulsive acoustic modeling does not account for seals within subnivean lairs or seals hauled out on the ice; all animals are assumed to be in the water and susceptible to hearing the non-impulsive acoustic transmissions. Therefore, the non-impulsive acoustic modeling output likely over-states the amount of sound that individual animals would receive, given the percentage of time that ringed seals are expected to be in subnivean lairs made of snow and ice, and seals hauled out on the ice rather than in the water. Although the exact amount of transmission loss of sound traveling through ice and snow is unknown, it is clear that some sound attenuation would occur. In-air, the best hearing sensitivity for ringed seals has been documented between 3 and 5 kHz; at higher frequencies, the hearing threshold rapidly increases (Sills et al. 2015).

If the non-impulsive acoustic transmissions are heard and are perceived as a threat, ringed seals within subnivean lairs could react to the sound in a similar fashion to their reaction to other threats, such as polar bears (their primary predators), although the type of sound would be novel to them. Responses of ringed seals to a variety of human-induced noises (e.g., helicopter noise, snowmobiles, dogs, people, and seismic activity) have been variable; some seals entered the water and some seals remained in the lair (Kelly et al. 1988). However, in all instances in which observed seals departed lairs in response to noise disturbance, they subsequently reoccupied the lair (Kelly et al. 1988).

Ringed seal mothers have a strong bond with their pups and may physically move their pups from the birth lair to an alternate lair to avoid predation, sometimes risking their lives to defend their pups from potential predators (Smith 1987). If a ringed seal mother perceives the non-impulsive acoustic sources as a threat, the network of multiple birth and haul-out lairs allows the mother and pup to move to a new lair (Smith and Hammill 1981; Smith and Stirling 1975). However, the non-impulsive acoustic sources, and icebreaking noise are unlike the low frequency sounds and vibrations felt from approaching predators. Additionally, the non-impulsive acoustic sources and icebreaking noise are not likely to impede a ringed seal from finding a breathing hole or lair, as captive seals have been found to primarily use vision to locate breathing holes and no effect to ringed seal vision would occur from the non-impulsive acoustic sources (Elsner et al. 1989; Wartzok et al. 1992a). It is anticipated that a ringed seal would be able to relocate to a different breathing hole relatively easily without impacting their normal behavior patterns.

7.2 Conclusion

The Navy concludes that testing activities within the Study Area would result in Level B takes, as summarized in Table 5-1. Based on best available science, the Navy concludes that exposures to the Alaska stocks of ringed seals, and the Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales due to the Proposed Action would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival.

Based on the life history information of beluga whales and ringed seals, expected behavioral patterns in the Study Area, the majority of modeled exposures resulting in temporary behavioral disturbance (Table 6-5), and the application of mitigation procedures proposed in Section 11, the Proposed Action is anticipated to have a negligible impact on the Alaska stocks of ringed seals and the Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales within the Study Area.

8 Anticipated Impacts on Subsistence Uses

The anticipated impact of the activity on the availability of the species or stock of marine mammals for subsistence uses.

Subsistence hunting is important for many of the Alaska Native communities. A study of the North Slope villages of Nuiqsut, Kaktovik, and Barrow identifies the primary resources used for subsistence and the locations for harvest (Stephen R. Braund & Associates 2010), including terrestrial mammals (caribou, moose, wolf, and wolverine), birds (geese and eider), fish (Arctic cisco, Arctic char/Dolly Varden trout, and broad whitefish), and marine mammals (bowhead whale, ringed seal, bearded seal, and walrus). The bearded seal, ringed seal, and beluga whale would be located within the Study Area during the Proposed Action. The permitted deep water sources would be placed outside of the range for subsistence hunting, and have been communicated to the Native communities. The closest active acoustic source within the Study Area (except *de minimis* ADCP), is approximately 145 mi (233 km) from land.

Ringed seals are of lesser importance to many North Slope communities, and have historically been used as a primary source of food for dog teams; this need has lessened with the introduction of snowmachines. Ringed seal meat is used to supplement bearded seal and other meat. Ringed seal hunting typically occurs during the summer months, though hunting has occurred year-round. Harvest locations for ringed seals can extend up to 40 mi (64 km) from shore including north of Barrow in the summer; the winter harvest of ringed seals typically occurs closer to shore, within several miles (Stephen R. Braund & Associates 2010). From 1985 through 2012, for years in which data were available, an average of 491 ringed seals were harvested per year for the villages of Barrow, Nuiqsut, and Kaktovik (Stephen R. Braund & Associates 2010); with the addition of the North Slope villages of Wainright, Point Lay, and Point Hope, an average of 1,104 ringed seals were harvested per year (Ice Seal Committee 2014). The number of seals harvested in a given year can vary considerably, depending upon environmental (e.g., ice) conditions.

Beluga whales provide important resources for local residents, where beluga meat and outer layers of skin and blubber are used as a source of food. The subsistence of beluga whales within U.S. waters is reported by the Alaska Beluga Whale Committee. Hunting takes place in the spring and summer, when concentrations of belugas move to coastal waters, such as Kasegaluk Lagoon near Point Lay (Suydam et al. 2001). Muto et al. (2017) reports that the annual subsistence take of beluga whales from the Eastern Chukchi Sea stock by Alaska Native hunters averaged 57.4 belugas, during the 5-year period from 2008 to 2012.

As stated above, the range to effects for non-impulsive acoustic sources in this experiment is relatively small (12.4 mi [20 km]). In addition, the Proposed Action would not remove individuals from the population, therefore there would be no impacts caused by this action to the availability of ringed seal, or beluga whale for subsistence hunting. Therefore, subsistence uses of marine mammals would not be impacted by the Proposed Action.

9 Anticipated Impacts on Habitat

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

Marine mammal habitat and prey species may be temporarily impacted by non-impulsive acoustic sources or icebreaking noise associated with the Proposed Action. The potential for non-impulsive acoustic sources or icebreaking noise to impact marine mammal habitat or prey species is discussed below.

9.1 Expected Effects on Habitat

The effects of the introduction of sound into the environment are generally considered to have a lesser impact on marine mammal habitat than the impacts from physical alteration of said habitat. Active acoustics from the Proposed Action would occur intermittently year-round for the ARA duration, though could be shut down annually if needed. Icebreaking noise would only occur during the warm season. Non-impulsive acoustic sources and icebreaking noise are not expected to result in long-term physical alteration of the water column, as the occurrences are of limited duration and would occur intermittently. The determination of temporary impacts to the physical environment includes minimal possible impacts to ringed seal and beluga whale habitat.

9.2 Effects on Marine Mammal Prey

9.2.1 Invertebrates

Marine invertebrates occur in the world's oceans, from warm shallow waters to cold deep waters, and are the dominant animals in all habitats of the Study Area. Although most species are found within the benthic zone, marine invertebrates can be found in all zones (sympagic [within the sea ice], pelagic [open ocean], or benthic [bottom dwelling]) of the Beaufort Sea (Josefson et al. 2013). Excluding microbes, approximately 5,000 known marine invertebrates have been documented in the Arctic; the number of species is likely higher, though, since this area is not well studied (Josefson et al. 2013).

Hearing capabilities of invertebrates are largely unknown (Lovell et al. 2005; Popper and Schilt 2008). Outside of studies conducted to test the sensitivity of invertebrates to vibrations, very little is known on the effects of anthropogenic underwater noise on invertebrates (Edmonds et al. 2016). While data are limited, research suggests that some of the major cephalopods and decapods may have limited hearing capabilities (Hanlon 1987; Offutt 1970), and may hear only low-frequency (less than 1 kHz) sources (Offutt 1970), which is most likely within the frequency band of biological signals (Hill 2009). In a review of crustacean sensitivity of high amplitude underwater noise by Edmonds *et al.* (2016), crustaceans may be able to hear the frequencies at which they produce sound, but it remains unclear which noises are incidentally produced and if there are any negative effects from masking them. Acoustic signals produced by crustaceans range from low frequency rumbles (20-60 Hz) to high frequency signals (20-55 kHz) (Henninger and Watson 2005; Patek and Caldwell 2006; Staaterman et al. 2016). Aquatic invertebrates that can sense local water movements with ciliated cells include cnidarians, flatworms, segmented worms, urochordates (tunicates), mollusks, and arthropods (Budelmann 1992a, 1992b; Popper et al. 2001). Some aquatic invertebrates have specialized organs called statocysts for determination of equilibrium and, in some cases, linear or angular acceleration. Statocysts allow an animal to sense movement and may enable some species, such as cephalopods and crustaceans, to be sensitive to water particle movements associated with sound (Goodall et al. 1990; Hu et al. 2009; Kaifu et al. 2008; Montgomery et al. 2006; Popper et al. 2001; Roberts and Breithaupt 2016; Salmon 1971). Because any acoustic sensory capabilities, if present at all, are limited to detecting water motion, and water particle motion near a sound source falls off rapidly with distance, aquatic invertebrates are probably limited to detecting nearby sound sources rather than sound caused by pressure waves from distant sources.

9.2.1.1 Non-Impulsive Acoustic Sources

Studies of sound energy effects on invertebrates are few, and identify only behavioral responses. Non-auditory injury, permanent threshold shift, temporary threshold shift, and masking studies have not been conducted for invertebrates. Both behavioral and auditory brainstem response studies suggest that crustaceans may sense frequencies up to 3 kHz, but best sensitivity is likely below 200 Hz (Goodall et al. 1990; Lovell et al. 2005; Lovell et al. 2006). Most cephalopods likely sense low-frequency sound below 1 kHz, with best sensitivities at lower frequencies (Budelmann 2010; Mooney et al. 2010; Offutt 1970). A few cephalopods may sense higher frequencies up to 1,500 Hz (Hu et al. 2009).

Within the Study Area, marine invertebrate abundance is low within the sea ice and in the water column. The highest densities are on the seafloor, further reducing the likelihood of invertebrates hearing the frequencies of the non-impulsive acoustic sources due to the dissipation of the non-impulsive acoustic sources in the water column. In studies by Christian et al. (2003) and Payne et al. (2007), neither found damage to lobster or crab statocysts from high intensity air gun firings (which is of greater intensity than the non-impulsive acoustic sources in the Proposed Action). Furthermore, in the study by Christian et al., (2003), no changes were found in biochemical stress markers in snow crabs.

It is expected that most marine invertebrates would not sense the frequencies of the acoustic transmissions from non-impulsive acoustic sources associated with the Proposed Action. Most marine invertebrates would not be close enough to non-impulsive acoustic sources to potentially experience impacts to sensory structures. Any marine invertebrate capable of sensing sound may alter its behavior if exposed to non-impulsive acoustic sources. Although non-impulsive acoustic sources used during the Proposed Action may briefly impact individuals, intermittent exposures to non-impulsive acoustic sources are not expected to impact survival, growth, recruitment, or reproduction of widespread marine invertebrate populations.

9.2.1.2 Icebreaking Noise

Impacts to invertebrates from icebreaking noise is relatively unknown, but it is likely that some species including crustaceans and cephalopods would be able to perceive the low frequency sources generated from icebreaking that occurs during the Proposed Action, which could result in masking acoustic communication in invertebrates such as crustaceans (Staaterman et al. 2011). Avoidance behavior, short term temporary responses (such as feeding cessation, increased stress, or other minor physiological harm) may occur if invertebrates were close enough to the icebreaking (Edmonds et al. 2016; Roberts and Breithaupt 2016). Masking of important acoustic cues used by invertebrates during larval orientation and settlement may lead to maladaptive behavior that could reduce successful recruitment (Simpson et al. 2011).

Icebreaking associated with the Proposed Action would be short-term and temporary as the vessel moves through an area, and it is not anticipated that this short-term noise would result in significant harm via masking; nor is it expected to result in more than a temporary behavioral reaction of marine invertebrates in the vicinity of the icebreaking event. Icebreaking noise, if perceived by an invertebrate, would likely result in temporary behavioral reactions.

9.2.2 Fish

The fish species located in the Study Area include those that are closely associated with the deep ocean habitat of the Beaufort Sea. Nearly 250 marine fish species have been described in the Arctic, excluding the larger parts of the sub-Arctic Bering, Barents, and Norwegian Seas (Mecklenburg et al. 2011). However, only about 30 are known to occur in the Arctic waters of the Beaufort Sea (Christiansen and Reist 2013). Largely because of the difficulty of sampling in remote, ice-covered seas, many high-Arctic fish species are known only from rare or geographically patchy records (Mecklenburg et al. 2011). Aquatic systems of the Arctic undergo extended seasonal periods of ice cover and other harsh environmental conditions. Fish inhabiting such systems must be biologically and ecologically adapted to surviving such conditions. Important environmental factors that Arctic fish must contend with include reduced light, seasonal darkness, ice cover, low biodiversity, and low seasonal productivity.

All fish have two sensory systems to detect sound in the water: the inner ear, which functions very much like the inner ear in other vertebrates, and the lateral line, which consists of a series of receptors along the fish's body (Popper and Fay 2010; Popper et al. 2014). The inner ear generally detects relatively higher-frequency sounds, while the lateral line detects water motion at low frequencies (below a few hundred Hz) (Hastings and Popper 2005). Lateral line receptors respond to the relative motion between the body surface and surrounding water; this relative motion, however, only takes place very close to sound sources and most fish are unable to detect this motion at more than one to two body lengths distance away (Popper et al. 2014). Although hearing capability data only exist for fewer than 100 of the 32,000 fish species, current data suggest that most species of fish detect sounds from 50 to 1,000 Hz, with few fish hearing sounds above 4 kHz (Popper 2008). It is believed that most fish have their best hearing sensitivity from 100 to 400 Hz (Popper 2003). Permanent hearing loss has not been documented in fish. A study by Halvorsen *et al.* (2012) found that for temporary hearing loss or similar negative impacts to occur, the noise needed to be within the fish's individual hearing frequency range; external factors, such as developmental history of the fish or environmental factors, may result in differing impacts to sound exposure in fish of the same species. The sensory hair cells of the inner ear in fish can regenerate after they are damaged, unlike in mammals where sensory hair cells loss is permanent (Lombarte et al. 1993; Smith et al. 2006). As a consequence, any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Smith et al. 2006), and no permanent loss of hearing in fish would result from exposure to sound.

9.2.2.1 Non-Impulsive Acoustic Sources

Fish species in the Study Area are expected to hear the low-frequency sources associated with the Proposed Action, but most are not expected to detect sounds above this threshold. Only a few fish species are able to detect the mid-frequencies of non-impulsive acoustic sources above 1 kHz and could have behavioral reactions or experience auditory masking during these activities. These effects are expected to be transient. Fish with hearing specializations capable of detecting high-frequency sounds are not expected to be within the Study Area. If hearing specialists were present, they would have to in close vicinity to the source to experience effects from the acoustic transmission. Human-generated sound could alter the behavior of a fish in a manner that would affect its way of living, such as where it tries to locate food or how well it can locate a potential mate; behavioral responses to loud noise could include a startle response, such as the fish swimming away from the source, the fish "freezing" and staying in place, or scattering (Popper 2003). Auditory masking could also interfere with a fish's ability to hear biologically relevant sounds, inhibiting the ability to detect both predators and prey, and impacting schooling, mating, and navigating (Popper 2003). If an individual fish comes into contact with low-frequency non-impulsive acoustic sources and is able to perceive the transmissions, they are expected to exhibit short-term behavioral reactions, when initially exposed, which would not significantly alter breeding, foraging, or populations. Overall effects to fish from non-impulsive acoustic sources would be localized, temporary, and infrequent.

9.2.2.2 Icebreaking Noise

Icebreaking noise has the potential to expose fish to both sound and general disturbance, which could result in short-term behavioral or physiological responses (e.g., avoidance, stress, increased heart rate). Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 160 to 489 ft (49 to 149 m). Avoidance behavior of vessels, vertically or horizontally in the water column, has been reported for cod and herring, and was attributed to vessel noise.

It is not anticipated that temporary behavioral reactions (e.g., temporary cessation of feeding) would harm the individual fitness of a fish as individuals are expected to resume feeding upon cessation of the sound exposure and unconsumed prey would still be available in the environment. Furthermore, while icebreaking noise may influence the behavior of some fish species (e.g., startle response, masking), other fish species can be equally unresponsive (Becker et al. 2013). The noise associated with the Proposed Action would result in insignificant and short-term reactions of fish.

9.3 Conclusion

Based on the discussion above, the proposed activities would not result in any permanent impact on habitats or prey sources (such as fish and invertebrates) used or consumed by ringed seal or beluga whales.

10 Anticipated Effects of Habitat Impacts on Marine Mammals

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

While the ringed seal and beluga whale may be encountered feeding, breeding, or migrating in the Study Area, the Proposed Action would not be expected to have any habitat-related effects that could cause significant or long-term consequences for individual ringed seals or beluga whales or their populations, because testing of towed sources and icebreaking sources, would be limited in duration, in addition the sources that would be left behind for a year or more have low duty cycles and lower source levels. There would not be any expected habitat-related effects from non-impulsive acoustic sources or icebreaking noise that could impact subnivean lairs, the primary habitat of ringed seals, during the Proposed Action. There would also be no expected beluga whale habitat-related effects from the non-impulsive acoustic or icebreaking noise sources of the Proposed Action, as beluga whale habitats are within the water column. Based on the discussions in Section 9, there will be no loss or modification of ringed seal or beluga whale prey or prey habitat, and as a result no impacts to marine mammal populations.

11 Mitigation Measures

> The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Both standard operating procedures and mitigation measures would be implemented during the Proposed Action. Standard operating procedures serve the primary purpose of providing safety and mission success, and are implemented regardless of their secondary benefits (e.g., to a resource), while mitigation measures are used to avoid or reduce potential impacts.

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

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

11.1 Mitigation Measures

- While in transit, ships shall be alert at all times, use extreme caution, and proceed at a "safe speed" so that the ship can take proper and effective action to avoid a collision with any marine mammal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
- Mitigation zones for the spiral wave beacon source transmission will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed and relative motion between the animal and the source, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min, (4) the ship has transited more than 400 yd. (366 m) beyond the location of the last sighting. During mooring deployment visual observation would start 15 minutes prior to and during the deployment within a mitigation zone of 55 m around the deployed mooring. Deployment will stop if a marine mammal is visually detected within the mitigation zone. Deployment will re-commence is any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 15 min.

- Ships would avoid approaching marine mammals head on and would maneuver to maintain a mitigation zone of 500 yd. (457 m) around observed whales, and 200 yd. (183 m) around all other marine mammals, providing it is safe to do so during ice free waters.
- With the exception of the spiral wave beacon, moored/drifting sources are left in place and cannot be turned off until the following year during ice free months. Once they are programmed they will operate at the specified pulse lengths and duty cycles until they are either turned off the following year or there is failure of the battery and are not able to operate. Due to the ice covered nature of the Arctic is in not possible to recover the sources or interfere with their transmit operations in the middle of the permit year.
- These requirements do not apply if a vessel's safety is at risk, such as when a change of course would create an imminent and serious threat to safety, person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. No further action is necessary if a marine mammal other than a whale continues to close on the vessel after there has already been one maneuver and/or speed change to avoid the animal. Avoidance measures should continue for any observed whale in order to maintain a mitigation zone of 500 yd. (457 m).

12 Arctic Plan of Cooperation

> Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

ONR, along with the cooperating and participating scientists, regularly conduct informational sessions and meetings with the communities and tribes in Alaska, including the Alaska Eskimo Whaling Commission (AEWC), the Arctic Waterways Safety Committee (AWSC), community meetings, and information sessions on Utquiagvik (Barrow) radio stations. The ONR-sponsored chief scientist for SODA and AMOS, with a Program Officer for ONR Ocean Acoustics in attendance, gave a briefing on ONR research planned for 2019-2020 at the ASWC meeting on March 18 in Anchorage, Alaska. ASWC attendees included representatives of subsistence hunting communities, including the Alaska Beluga Whale Committee and members of the AEWC. Experimental plans will also be communicated to the AEWC, which consists of representatives from 11 whaling villages (Wainwright, Utqiavik (Barrow), Savoonga, Point Lay, Nuiqut, Kivalina, Kaktovik, Wales, Point Hope, Little Diomede and Gambell). The chief scientist communicated the Navy's determination regarding subsistence hunting, which is essentially based on the distance of the sources from subsistence hunting areas. ONR-supported scientists attend ASWC and AEWC meetings on a regular basis to discuss past, present and future research activities.

ONR-supported scientists are planning to visit Utqiagvik (Barrow) in summer 2019 to ensure further communication with the local communities about activities planned for the area. The scientists will visit several communities as science fair judges as part of a collaborative effort to facilitate scientific education in the area. Given the determination of no effect, the distance of the activity from subsistence hunting areas (excluding the *de minimis* ADCP source in Barrow Canyon), and the positive interaction with the communities at the AEWC and AWSC meetings, the Navy does not intend to prepare a formal Plan of Cooperation. If any communities express concern regarding project impacts to subsistence hunting of marine mammals, further communication between Navy and those communities will take place, including provision of any project information, and clarification of any mitigation and minimization measures that may reduce impacts to marine mammals. The North Slope communities have been generally supportive of ONR research as it has non-military applications regarding the changing Arctic environment and how it may affect these communities. Points of contact for at-sea communication between the ship captains and the whalers are also established so that there is no conflict of ship transit with hunting activity.

13 Monitoring and Reporting

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

13.1 Monitoring Plan

The U.S. Navy has coordinated with NMFS to develop an overarching program plan in which specific monitoring would occur. This plan is called the Integrated Comprehensive Monitoring Program (ICMP) (U.S. Department of the Navy 2011). The ICMP has been developed in direct response to Navy permitting requirements established in various MMPA Final Rules, Endangered Species Act consultations, Biological Opinions, and applicable regulations. As a framework document, the ICMP applies by regulation to those activities on ranges and operating areas for which the Navy is seeking or has sought incidental take authorizations. The ICMP is intended to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of effort based on set of standardized research goals, and in acknowledgement of regional scientific value and resource availability.

The ICMP is focused on Navy training and testing ranges where the majority of Navy activities occur regularly as those areas have the greatest potential for being impacted. ARA in comparison is a less intensive test with little human activity present in the Arctic. Human presence is limited to the deployment of sources which would take place over several weeks. Additionally, due to the location and nature of the testing, vessels and personnel would not be within the Study Area for an extended period of time. As such, a dedicated monitoring project would not be feasible as it would require additional personnel and equipment to locate seals and a presence in the Arctic during a period of time other then what is planned for source deployment.

The research activities included in these documents will, in addition to meeting military readiness objectives, further knowledge in the areas of ice extent and characterization, oceanographic changes, acoustic propagation and scattering. As the results become published, they will be incorporated into Navy predictions of acoustic effects on marine mammals and improve their accuracy. They will provide information, such as predictions of ice cover in the future, relevant to changes in the environment that may affect the life-cycle and survival of marine mammals. While these results will not be available until sources are recovered and the data is analyzed, it does represent a monitoring of environmental conditions over time that allows us to more accurately assess the future of marine life in the Arctic.

13.2 Reporting

The Navy is committed to documenting and reporting relevant aspects of research and testing activities to verify implementation of mitigation, comply with current permits, and improve future environmental assessments. If any injury or death of a marine mammal is observed during the 2019-20 ARA activity, the Navy will immediately halt the activity and report the incident consistent with the stranding and reporting protocol in other Navy documents such as the Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement.

14 Suggested Means of Coordination

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing incidental taking and evaluating its effects.

The Navy strives to be a world leader in marine species research and has provided more than $100 million over the past five years to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to increase the understanding of marine species physiology and behavior.

The Navy sponsors 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. Major topics of Navy-supported research include the following:

- Gaining a better understanding of marine species distribution and important habitat areas
- Developing methods to detect and monitor marine species before and during testing
- Understanding the effects of sound on marine mammals
- Developing tools to model and estimate potential effects of sound

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and outside research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods into Navy activities. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential monitoring tool. Overall, the Navy will continue to research and contribute to university/external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include monitoring programs, data sharing with NMFS from research and development efforts, and future research as previously described.

The primary focus of these efforts since the 1990s is on understanding the effects of sound on marine mammals, including physiological, behavioral and ecological effects. ONR's current Marine Mammals and Biology Program thrusts include, but are not limited to: 1) monitoring and detection research; 2) integrated ecosystem research including sensor and tag development; 3) effects of sound on marine life [such as hearing, behavioral response studies, physiology (diving and stress), Population Consequences of Acoustic Disturbance (PCAD)]; and 4) models and databases for environmental compliance. ONR is funding a current project to develop methodologies for passive acoustic monitoring for marine mammal density estimation in the Beaufort Sea, using receiver array data from the Canadian Basin Acoustic Propagation Experiment (CANAPE) 2016/17 experiment. Woods Hole Oceanographic Institute is analyzing whale and seal call data on multiple receiver array and is working on an integrated approach including acoustic propagation, habitat suitability and soundscape models. Data from 10 receiving arrays in the Beaufort Sea basin is available for marine mammal analysis. ONR has also funded a project which is looking at the habitat based use of ice seals in Alaska and the Bering Sea. Though not directly overlapping with the Study Area, the research gives insight to ice seal movements and habitat use in the changing Arctic environment. The results of these efforts will be published in the future and used as best available science for modeling and prediction of animal use and movement.

15 List Of Preparers

Name	Role	Education and Experience
Naval Undersea Warfare Center, Division Newport		
Code 1023, Environmental Branch, Mission Environmental Planning Program		
Jennifer James	Project Lead, Biologist	MESM Wetlands Biology, B.S. Wildlife Biology and Management. Experience: 12 years Environmental Planning, Biological Research 15 years.
Emily Robinson	Environmental Scientist, Document Development	Masters of Environmental Science and Management, B.S. Integrated Science and Technology, Environmental Planning, 4 years
Laura Sparks	GIS Support	Masters of Environmental Science and Management, B.A. Political Science, B.A. Marine Affairs. GIS Experience: 5 years
Benjamin Bartley	GIS Support	B.S. Fisheries Science and Management, Modeling Experience: 5 years, GIS experience: 4 years
Code 70, Ranges, Engineering, and Analysis Department		
Cassandra DePietro	Mathematician, Marine Mammal Modeling and Prototyper	Masters of Applied Math, B.S. Mathematics. Modeling and Prototype Experience:2 years
Joseph Fayton	Mathematician, Marine Mammal Modeling and Prototyper	Ph.D. of Mathematics, Masters of Applied Math, B.A. Physics and Mathematics. Modeling and Prototype Experience:10 years
Jessica Fothergill	Mathematician, Marine Mammal Modeling and Prototyper	Masters of Applied Math, B.A. Mathematics. Modeling and Prototype Experience: 3 years
Office of Naval Research		
Raymond Soukup	Program Officer, Acoustician, and Environmental Planner	M.A. Mathematical Statistics, B.S. Physics, Ocean Acoustics Research and Program Management: 29 years

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