Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from 2018 Ice Exercise Activities

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February 2017

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Acronyms and Abbreviations

AFTT	Atlantic Fleet Training and Testing
cm	centimeter(s)
dB	decibels
dB re 1 µPa @ 1 m	decibels referenced to 1 microPascal at 1 meter
EIS	Environmental Impact Statement
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICEX18	Ice Exercise 2018
ICMP	Integrated Comprehensive Monitoring Program
IHA	Incidental Harassment Authorization
km	kilometers
km^2	square kilometer(s)
kHz	kilohertz
m	meter(s)
MMPA	Marine Mammal Protection Act
NAEMO	Navy Acoustic Effects Model
NMFS	National Marine Fisheries Service
NRL	Naval Research Laboratory
OEIS	Overseas Environmental Impact Statement
PL	public law
PTS	permanent threshold shift
SAS	synthetic aperture source
SEL	sound exposure level
TTS	temporary threshold shift
U.S.	United States
U.S.C.	United States code
UUV	unmanned underwater vehicle

CHAPTER 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 Chapter 5) of marine mammals during Ice Exercise 2018 (ICEX18) activities proposed within the Beaufort Sea and Arctic Ocean north of Prudhoe Bay, Alaska.

The Navy is preparing an Environmental Assessment/Overseas Environmental Assessment for the ICEX18 Study Area to evaluate all components of the Proposed Action. A description of the Study Area and various components is provided in Chapter 2. A description of the Proposed Action for which the Navy is requesting IHA is provided in Section 1.2. This request for an IHA is based on the Preferred Alternative (Alternative 2 in the Environmental Assessment/Overseas Environmental Assessment).

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 training 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 training activities that are likely to result in Level B harassment, Level A harassment, or mortality under the MMPA. Of the Navy activities analyzed, the Navy has determined that only the use of acoustic transmission 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

ICEX18 includes the construction of a temporary camp situated on an ice floe (Section 1.2.1), submarine training and testing (Section 1.2.2), and the execution of research activities (Section 1.2.3). The Proposed Action would occur over an approximately six-week period from February through April 2018. The entire Proposed Action, including construction and demobilization of the ice camp, would occur over this approximate six-week period, whereas the submarine training and testing and the research activities would occur over approximately four weeks during the six-week period. The camp should be fully functional within five days after initial flights to drop-off equipment have been made.

1.2.1 Ice Camp

The ice camp generally consists of a command hut, dining tent, sleeping quarters, a powerhouse, runway, and helipad (

Figure 1-1). The number of structures/tents ranges from 15 to 20, and are typically 2 meters (m) by 6 m in size. The completed ice camp, including runway, is approximately 1.6 kilometers (km) in diameter.

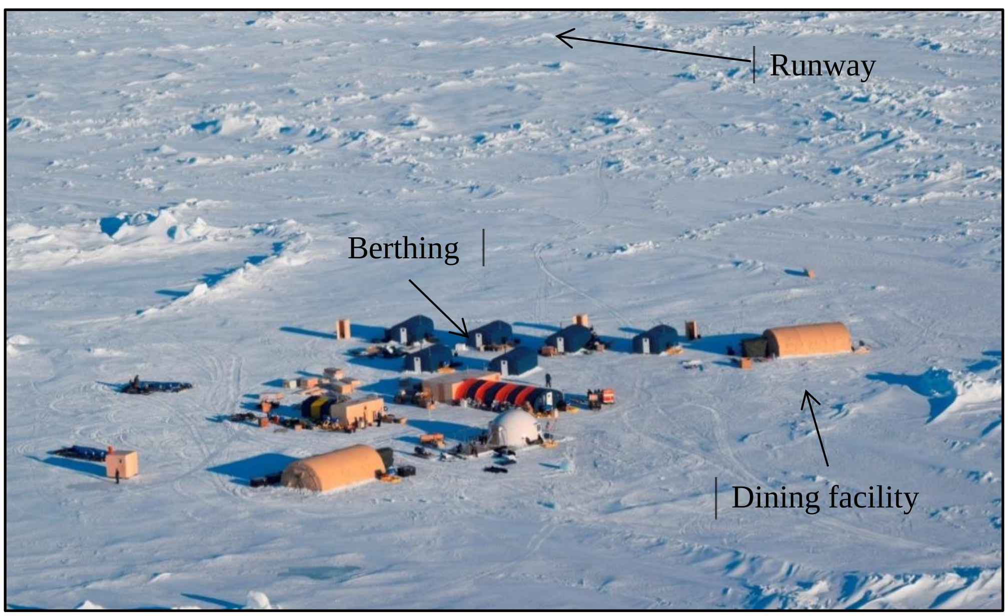

Figure 1-1. Example Ice Camp

All ice camp materials, fuel, and food would be transported from Prudhoe Bay, Alaska, and delivered by air-drop from military transport aircraft (e.g., C-17 and C-130), or by landing at the ice camp runway (e.g., small twin-engine aircraft and military and commercial helicopters). At the completion of ICEX18, the ice camp would be demobilized, and all personnel and materials would be removed from the ice floe. All construction material, solid waste, hazardous waste, and sanitary waste would be removed from the ice upon completion of ICEX18 and disposed of in accordance with applicable laws and regulations.

A portable tracking range for submarine training and testing would be installed in the vicinity of the ice camp; eight hydrophones, located on the ice and extending to 30 m below the ice, would be deployed. The hydrophones would be deployed by drilling holes in the ice and lowering the cable down into the water column. Four hydrophones would be physically connected to the command hut via cables (Figure 1-2) while the remaining four would transmit data via radio frequencies. Additionally, tracking pingers would be configured aboard each submarine to continuously monitor the location of the submarines. Acoustic communications with the submarines would be used to coordinate the training and research schedule with the submarines; an underwater telephone would be used as a backup to the acoustic communications.

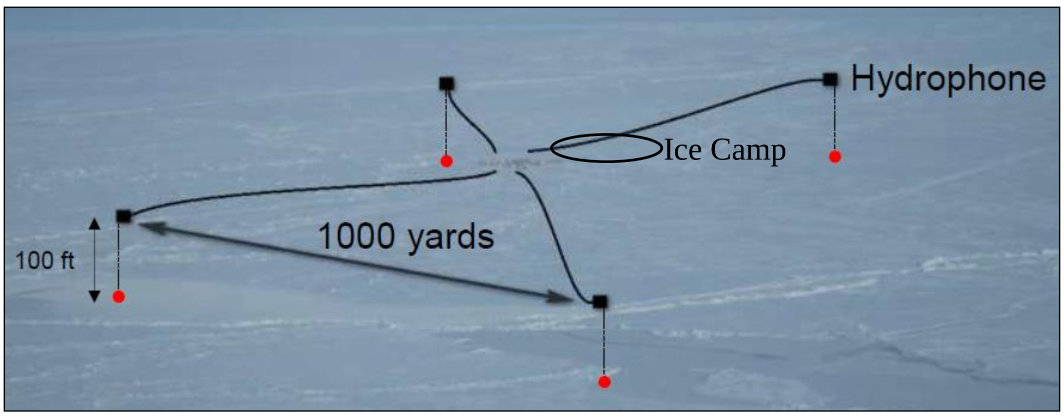

Figure 1-2. Schematic of the Underwater Tracking Range

1.2.2 Submarine Training and Testing

Submarine activities associated with ICEX18 are classified, but generally entail safety maneuvers, active sonar use and exercise torpedo use. These maneuvers and sonar use are similar to submarine activities conducted in other undersea environments; they are being conducted in the Arctic to test their performance in a cold environment. Classified descriptions of submarine training and testing activities planned for ICEX18 can be provided to authorized individuals upon request. Submarine training and testing involves active acoustic transmissions, which have the potential to harass marine mammals. All other categories and activities are fully analyzed within the Environmental Assessment/Overseas Environmental Assessment for Ice Exercises and will not be discussed further in this document as harassment of marine mammals from these activities is not reasonably foreseeable.

1.2.3 Research Activities

Personnel and equipment proficiency testing and multiple research and development activities would be conducted. Each type of activity scheduled for ICEX18 has been reviewed and placed into a general category of actions. In-water device data collection and unmanned underwater vehicle testing involve active acoustic transmissions, which have the potential to harass marine mammals. All other categories and activities are fully analyzed within the Environmental Assessment/Overseas Environmental Assessment for Ice Exercises and will not be discussed further in this document as harassment of marine mammals from these activities is not reasonably foreseeable. Below is a further description of the acoustic testing associated with the Proposed Action for which the IHA is being requested.

Active buoys and moored sources would be used during ICEX18. One active buoy would be the Autonomous Reverberation Measurement System, which would be attached to the bottom of the ice and may be active for up to 30 days of ICEX18. Additionally, a Massachusetts Institute of Technology/Lincoln Lab vertical line array would be deployed through a hole in the ice to a source depth of 150 m. This array would have continuous wave and chirp transmission capability. The continuous wave and chirp transmissions would both be active four hours per day for no more than 8 days during ICEX18. The Naval Research Laboratory would utilize an unmanned underwater vehicle for the deployment of a synthetic aperture source (SAS), which would transmit for 24 hours per day for up to eight days. The SAS would be used to make measurements of the acoustic interaction with the ice/water interface. Source parameters are classified, but can be provided to authorized individuals upon request. Additional details for the active sources described above can be found in Table 1-1.

Table 1-1. Active Acoustic Scientific Device Parameters for ICEX18 Research Activities

Research Institution	Source Name	Frequency Range (kHz)	Source Level (dB)	Pulse Length (milliseconds)	Duty Cycle (Percent)	Bin	Source Type
Office of Naval Research	Autonomous Reverberation Measurement System	3 to 6	200	1,000	1.67	MF9	Moored
Naval Research Laboratory	SAS	Classified				-	Unmanned Underwater Vehicle (UUV)
Massachusetts Institute of Technology/ Lincoln Labs	Continuous Wave*	0.20 to 1.2	190	continuous	100	LF4	Moored
	Chirp*	0.25 to 1.2	190	15,000	25	LF4	Moored

*Both sources are located on the Massachusetts Institute of Technology/ Lincoln Labs deployed vertical line array.
General bin parameters are included though specific source modeling was conducted for research activities.

CHAPTER 2 DATES, DURATION, AND GEOGRAPHIC REGION

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

To support submarine training and testing, the Navy would establish an ice camp. The vast majority of submarine training and testing would occur near the ice camp, however, some submarine training and testing may occur throughout the deep Arctic Ocean basin near the North Pole, within the Study Area (Figure 2-1). Though the Study Area is large, the area where the proposed ice camp would be located is a much smaller area (See Ice Camp Proposed Action Area on Figure 2-1).Prior to the set-up of the ice camp, reconnaissance flights will be conducted to locate suitable ice conditions required for the location of the ice camp. The reconnaissance flights will occur over an area of approximately 70,374 square kilometers (km^2); the actual ice camp is no more than 1.6 km in diameter (approximately 2 km^2 in area). The ice camp would be established approximately 100–200 nautical miles north of Prudhoe Bay, Alaska and the exact location cannot be identified ahead of time as required conditions (e.g. ice cover) cannot be forecasted until exercises are expected to commence.

The Proposed Action would occur over approximately a six-week period from February through April 2018, including construction and demobilization of the ice camp. The submarine training and testing and the research activities would occur over approximately four weeks during the six-week period. Active acoustic transmissions (low, mid, and high frequency) are the only aspect of the Proposed Action for which this IHA is being requested.

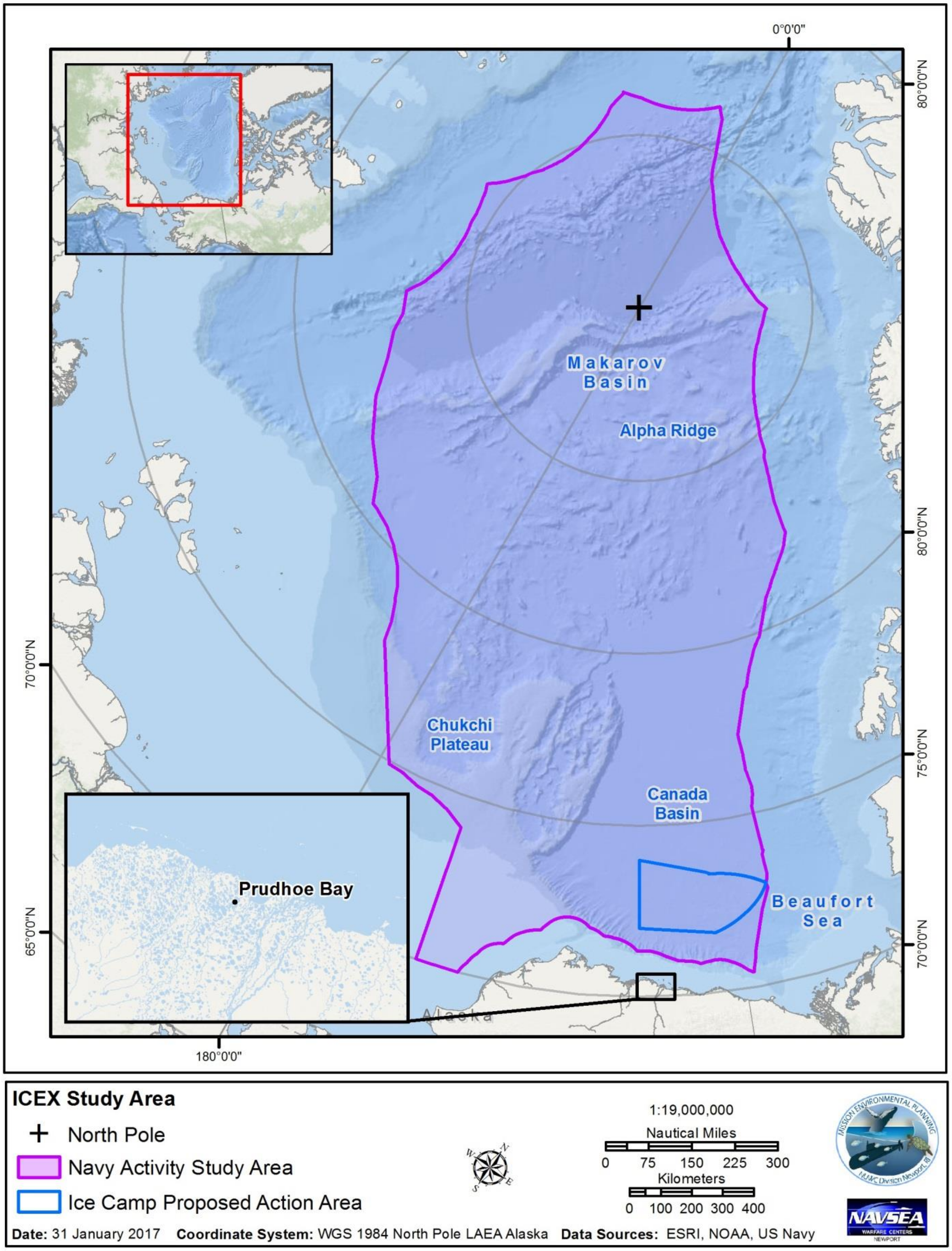

Figure 2-1. ICEX Study Area

CHAPTER 3 SPECIES AND NUMBERS OF MARINE MAMMALS

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

Only the ringed seal (*Pusa hispida hispida*) is expected in the Study Area during the Proposed Action. Activities conducted during the Proposed Action are expected to cause harassment, as defined by the MMPA as it applies to military readiness, to the ringed seal. No other marine mammal species are expected to be affected by Proposed Action activities that could rise to the level of harassment and, therefore, are not discussed further. The minimum estimated ringed seal population in the Arctic is 300,000 animals (Kelly et al. 2010b). Additional relevant information on the ringed seal status, life history, and distribution is presented in Chapter 4.

CHAPTER 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.

The marine mammal species discussed in this section are those for which general regulations governing potential incidental harassment of marine mammals are sought. The ringed seal is not listed under the Endangered Species Act.[1] All subspecies are listed as depleted under the MMPA. Relevant information on their status, life history, and distribution is presented below, as well as additional information about the numbers of ringed seals likely to be found within the Study Area.

4.1 RINGED SEAL (*PHOCA HISPIDA*)

4.1.1 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 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.

Ringed seals have at least two distinct types of subnivean lairs: haul-out lairs and birthing lairs (Smith and Stirling 1975). Haul-out 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 seal populations pup on both land-fast ice as well as stable pack ice. Lentfer (1972) found that ringed seals north of Barrow, Alaska (west of the Ice Camp), 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 ice camp proposed action 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 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 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

[1] In March 2016, the U.S. District Court in Alaska vacated NMFS' listing of the of the Arctic/Bering Sea subspecies of ringed seal (*Phoca hispida hispida*) as threatened. While NMFS has appealed, no decision has been rendered as of the time of this application.

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), and therefore are in the Study Area (Figure 2-1). Passive acoustic monitoring of ringed seals from a high frequency recording package deployed at a depth of 240 m in the Chukchi Sea 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 km^2 for adult females). Most (94 percent) of the home ranges were less than 3 km^2 during the subnivean period (Kelly et al. 2010a). Near large polynyas, ringed seals maintain ranges up to 7,000 km^2 during winter and 2,100 km^2 during spring (Born et al. 2004). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010a). The size of winter home ranges can, however, vary by up to a factor of 10 depending on the amount of fast ice; seal movements were more restricted during winters with extensive fast ice, and were much less restricted where fast ice did not form at high levels {Harwood, 2015 #233}. Ringed seals may occur within the Study Area throughout the year and during the Proposed Action.

In general, ringed seals prey upon fish and crustaceans. Ringed seals are known to consume up to 72 different species in their diet; their preferred prey species is the polar cod (Jefferson et al. 2008). Ringed seals also prey upon a variety of other members of the cod family, including Arctic cod (Holst et al. 2001) and saffron cod, with the latter being particularly important during the summer months in Alaskan waters (Lowry et al. 1980). Invertebrate prey seems to become prevalent in the ringed seals diet during the open-water season and often dominates the diet of young animals (Holst et al. 2001; Lowry et al. 1980). Large amphipods (e.g., *Themisto libellula*), krill (e.g., *Thysanoessa inermis*), mysids (e.g., *Mysis oculata*), shrimps (e.g., *Pandalus* spp., *Eualus* spp., *Lebbeus polaris*, and *Crangon septemspinosa*), and cephalopods (e.g., *Gonatus* spp.) are also consumed by ringed seals.

4.1.2 Population and Abundance

4.1.2.1 Status of Stock

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 (EEZ) 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 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 40 km of shore.

4.1.2.2 Density

The ringed seal density numbers utilized for quantitative acoustic modeling are from the Navy Marine Species Density Database (Hanser et al. 2012). The density estimate is based on the habitat-based modeling by Kaschner *et al.* (2006) and Kaschner (2004), resulting in 0.3957 animals per km^2 in the cold season (defined as December through May). The density numbers are assumed static throughout the ice camp proposed action area for this species. The density obtained for this species was extracted from within the ice camp proposed action area (Figure 2-1**Error! Reference source not found.**).

4.1.3 Hearing and Vocalization

Ringed seals fall into the phocid seal hearing group. Functional hearing limits for this hearing group are estimated to be 75 hertz (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 decibels referenced to 1 microPascal at 1 meter (dB re 1µPa) 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.

CHAPTER 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 ringed seals, incidental to proposed ICEX activities in the Beaufort Sea between February and April 2018. This taking would occur as a result of acoustic transmissions during the ICEX event. 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 National Defense Authorization Act of Fiscal Year 2004 (PL 108-136) amended the definition of “harassment” as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 3(18)(B) of the MMPA[16 U.S.C. §1362 (18)(B)]. The Fiscal Year 2004 National Defense Authorization Act adopted the definition of “military readiness activity” as set forth in the Fiscal Year 2003 National Defense Authorization Act (PL 107-314). Military training activities within the Study Area compose of military readiness activities as that term is defined in PL 107-314 because training activities constitute “training and operations of the Armed Forces that relate to combat” and “adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use.” For military readiness activities, the relevant definition of harassment is any act that:

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

The Environmental Assessment/Overseas Environmental Assessment for ICEX18 analyzed the following stressors for potential impacts to marine mammals:

- Acoustic (active acoustics [sonar], aircraft noise, and on-ice vehicle noise)
- Physical disturbance and strikes (aircraft, on-ice, and in-water vessel/vehicle strike, and human presence)
- Expended material (bottom disturbance, entanglement, and ingestion)

In that analysis, the Navy determined the only stressor that could potentially result in the incidental taking of marine mammals is from active acoustic transmissions.

5.2 INCIDENTAL TAKE REQUEST

The methods of incidental take associated with the acoustic transmissions from the Proposed Action are described within Chapter 2. Acoustic transmissions from submarine and research activities have the potential to disturb or displace marine mammals. Specifically, only underwater active transmissions may result in the "take" in the form of Level B harassment. Mitigation and monitoring measures discussed in Chapter 11 and Chapter 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 ICEX18 training and research activities from February through March 2018. Only level B takes are anticipated to occur from the Proposed Action. Derivation of these values is described in more detail in Chapter 6.

Table 5-1. Total Number of Exposures Requested per Species During ICEX18 Training Activities.

Common Name	Level B Takes Requested
Ringed Seal	1676

CHAPTER 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 Section 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 Chapter 5 are provided below. The method is consistent with that of the Atlantic Fleet Training and Testing (AFTT) and Hawaii and Southern California Training and Testing (HSTT) Environmental Impact Statements/Overseas Environmental Impact Statements (EIS/OEIS) marine mammal modeling and the newest Navy and NMFS acoustic criteria (National Marine Fisheries Service 2016). The stressor that is estimated to result in Level B harassment is active acoustic transmissions. In this analysis, the only marine mammal species being assessed is the ringed seal.

The information presented in this chapter includes a summary of the vocalization and hearing capabilities of marine mammal groups, the types of 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; 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 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 Groups.

Functional Hearing Group	Species Which May Be Present in the Area	Sound Production		General Hearing Ability Frequency Range
		Frequency Range	Source Level dB re:1uPa@1m	
Phocidae	Ringed seal	100 Hz to 12 kHz	103 to 180	75 Hz to 75 kHz (in water)

Adapted and derived from Southall *et al.* (2007)
dB re 1 µPa @ 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. 2009b). 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) 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). 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 @1m; thus, seals may actually receive levels adequate to produce TTS before avoiding the source.

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 grey 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 Behavioral Response Function for pinnipeds most closely resembles a traditional sigmoidal dose-response function at the upper received levels (Figure 6-1**Error! Reference source not found.**), and has a 50% probability of response at 166 dB re 1 µPa. Additionally, to account for proximity to the source discussed above and based on the best scientific information, a conservative distance of 10 km is used beyond which exposures would not constitute a take under the military readiness definition.

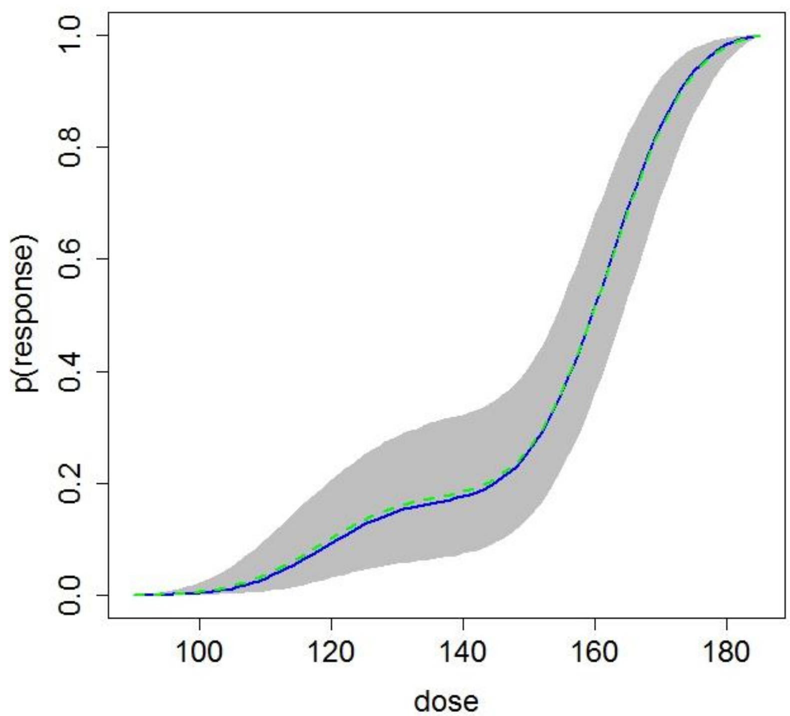

Figure 6-1. The Bayesian biphasic dose-response BRF for Pinnipeds. The blue solid line represents the Bayesian Posterior median values, the green dashed line represents the biphasic fit, and the grey represents the variance. [X-Axis: Received Level (dB re 1 µPa), Y-Axis: Probability of Response]

6.3 Criteria and Thresholds for Predicting Acoustic 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 was developed in coordination with NMFS to support Phase III environmental analyses and MMPA Letter of Authorization renewals (U.S. Department of the Navy In Prep-b). 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, 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. 2009a).

As in previous 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 below provides the criteria and thresholds used in this analysis for estimating quantitative acoustic exposures of marine mammals from the Proposed Action. Weighted criteria 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.

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

Group	Species	Behavioral Criteria	Physiological Criteria	
			Onset TTS	Onset PTS
Phocidae (in water)	Ringed seal	Pinniped Dose Response Function[2]	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 acoustic transmissions 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 In Prep-a), oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential animal exposures. The model calculates sound energy propagation from the proposed sonars, 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 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 training 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 these 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.

6.5 IMPACTS ON MARINE MAMMALS

6.5.1 Range to Effects

For non-impulsive sources, NAEMO calculates the sound pressure level (SPL) and sound exposure level (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 training event's operational area. Table 6-3 provides range to effects for active acoustic sources proposed for ICEX18 to phocid specific criteria. Phocids within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting 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 6-3 provide realistic maximum distances over which the specific effects from the use of sonar during the proposed action would be possible.

Table 6-3. Range to Temporary Threshold Shift and Behavioral Effects in the ICEX Study Area.

Source/Exercise	Range to Effects Cold Season (m)	
	Behavioral	TTS
Submarine Exercise	10,000	100
Autonomous Reverberation Measurement System	10,000	<50
Massachusetts Institute of Technology/Lincoln Labs Continuous Wave/chirp	10,000	<50
Naval Research Laboratory Synthetic Aperture Sonar	10,000	90

Empirical evidence has not shown responses to sonar that would constitute take beyond a few km from an acoustic source, which is why NMFS and Navy conservatively set a distance cutoff of 10 km. Regardless of the source level at that distance; take is not estimated to occur beyond 10 km from the 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 training or testing activities that reduce the likelihood of physiological impacts are not considered in quantitative analysis. Therefore, the current model overestimates 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

When sound sources are active, exposure to increased sound pressure levels would likely involve individuals that are moving through the area during foraging trips. Ringed seals may also be exposed en route to haul-out sites or subnivean lairs. As discussed further in Chapter 7, if exposure were to occur, the ringed seal could exhibit behavioral responses such as avoidance, increased swimming speeds, increased surfacing time, or decreased foraging. Most likely, individuals affected by acoustic transmissions resulting from the Proposed Action would move away from the sound source and be temporarily displaced from their subnivean lairs within the ice camp proposed action area. Any ringed seal would have to be at least within 10 km from the source (see Table 6-3 for range to effects from the sonar in the Proposed Action) for any behavioral reaction (i.e. flushing from a lair). Any effects experienced by individual ringed seals 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 ringed seals.

Table 6-4 shows the exposures expected for the 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, the short duration, limited geographic extent of ICEX activities, and mitigation measures would further limit actual exposures.

Table 6-4. Quantitative Modeling Results of Potential Exposures for ICEX Activities.

Common Name	**Level B Harassment**		**Level A Harassment**	**Percentage of Stock Taken (%)**
	Behavioral	**TTS**		
Pinnipeds				
Ringed seal	1665	11	0	0.559

CHAPTER 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 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 inputted 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 was static throughout the area and assumed the maximum population size of ringed seals were in the area.

Mitigation measures described in Chapter 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 of the National Academies 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's 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 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 of the National Academies 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 ringed seals to the type of acoustic sources used during the Proposed Action. However, data are available on (1) effects of non-impulsive sources (e.g., sonar transmissions) on other phocids in water, and (2) reactions of ringed seals while in subnivean lairs. All of this available information was assessed and incorporated into the findings of this analysis.

7.1.1 Effects of Non-Impulsive Sources on Phocids in Water

For non-impulsive 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 grey (*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 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 acoustic transmissions, as they were able to maintain normal behaviors (e.g., finding breathing holes).

Seals exposed to non-impulsive sources with a received sound pressure level within the range of calculated exposures, (142–193 dB re 1 μPa), have been 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).

7.1.2 Effects on Ringed Seals within Subnivean Lairs

Adult ringed seals spend up to 20 percent of the time in subnivean lairs during the timeframe of the Proposed Action (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). Ringed seal lairs are typically used by individual seals (haul-out lairs) or by a mother with a pup (birthing lairs); large lairs used by many seals for hauling out are rare (Smith and Stirling 1975). The acoustic modeling does not account for seals within subnivean lairs, and all animals are assumed to be in the water and susceptible to hearing acoustic transmissions 100 percent of the time. Therefore, the acoustic modeling output likely represents an overestimate, given the percentage of time that ringed seals are expected to be in subnivean lairs 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 due to the environment itself. In-air (i.e., in the subnivean lair), 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 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 and Arctic foxes (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). Additionally, it is not unusual to find up to three birth lairs within 100 m of each other, probably made by the same female seal, as well as one or more haul-out lairs in the immediate area (Smith et al. 1991). If a ringed seal mother perceives the acoustic transmissions 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 acoustic transmissions are unlike the low frequency sounds and vibrations felt from approaching predators. Additionally, the acoustic transmissions 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 acoustic transmissions (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 training and 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 stock of ringed seals 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 ringed seals, expected behavioral patterns in the Study Area, the majority of modeled exposures resulting in temporary behavioral disturbance (Table 6-4), and the application of mitigation procedures proposed in Chapter 11, the Proposed Action is anticipated to have a negligible impact on the Alaska stock of ringed seals within the Study Area.

CHAPTER 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

Potential marine mammal impacts resulting from the Proposed Action will be minimal. The Proposed Action would occur outside of the primary subsistence use season (i.e. summer months), and the Study Area is seaward of known subsistence use areas.

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). Of these species, only ringed seals would be located within the Study Area during the Proposed Action.

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 extends up to 80 mi (129 km) from shore, particularly in summer; the winter harvest of ringed seals typically occurs closer to shore (Stephen R. Braund & Associates 2010). From 1985 through 2003, for years in which data were available, an average of 419 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 1,099 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.

The Study Area is at least 100-150 miles from land, well seaward of known subsistence use areas and the Proposed Action would conclude prior to the start of the summer months, during which the majority of subsistence hunting would occur. 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 seals for subsistence hunting. Therefore, subsistence uses of marine mammals would not be impacted by this action.

CHAPTER 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 acoustic sources associated with the Proposed Action. The potential for acoustic sources 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 over four weeks of the six week ICEX period, intermittently. Acoustic transmissions 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. Acoustic transmissions also would have no impact to subnivean lairs in the ice, because ice dampens acoustic transmissions (Richardson et al. 1995). The determination of temporary impacts to the physical environment includes minimal possible impacts to ringed seal 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). The diverse range of species include oysters, crabs, worms, ghost shrimp, snails, sponges, sea fans, isopods, and stony corals (Chess and Hobson 1997; Dugan et al. 2000; Proctor et al. 1980).

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.

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).

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

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.

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 mid-frequency sonar above 1 kHz and could have behavioral reactions or experience auditory masking during these activities. These effects are expected to be transient and long-term consequences for the population are not expected. 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 acoustic transmissions and is able to perceive the transmissions, they are expected to exhibit short-term behavioral reactions, when initially exposed to acoustic transmissions, which would not significantly alter breeding, foraging, or populations. Overall effects to fish from active sonar sources would be localized, temporary, and infrequent.

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 seals.

CHAPTER 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 ringed seals may be encountered feeding in the proposed Study Area, the proposed activity would not be expected to have any habitat-related effects that could cause significant or long-term consequences for individual ringed seals or their populations, because operations would be limited in duration. There would not be any expected habitat-related effects from acoustic transmissions that could impact subnivean lairs, the primary habitat of ringed seals, during the Proposed Action. Based on the discussions in Chapter 9, there will be no loss or modification of ringed seals prey or prey habitat, and as a result no impacts to marine mammal populations.

CHAPTER 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 for 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. Even though not all of the Standard Operating Procedures and Mitigation Measures listed below are applicable to reduce impacts to ringed seals, they were included for completeness.

Though the Proposed Action would utilize both standard operating procedures and mitigation measures in a variety of manners, the activities using active acoustics would utilize passive acoustic listening. Submarines conducting training activities would utilize passive acoustic sensors to listen for vocalizing marine mammals, and active transmissions would be halted in the event that vocalizing marine mammals are detected.

Additional mitigations were considered for testing activities, however, because those activities that result in exposures to marine mammals occur under the ice, there are no methods to visually or acoustically monitor the area, therefore no additional mitigation is feasible.

11.1 STANDARD OPERATING PROCEDURES

The following procedures would be implemented:

- The location for any air-dropped equipment and material would be visually surveyed prior to release of the equipment/material to ensure the landing zone is clear. Equipment and materials would not be released if any animal is observed within the landing zone.
- Air drop bundles would be packed within a plywood structure with honeycomb insulation to protect the material from damage.
- Spill response kits/material would be on-site prior to the air-drop of any hazardous material (e.g. fuel).

11.2 MITIGATION MEASURES

In addition to the standard operating procedures above, the following mitigation measures would be implemented to reduce or avoid potential harm to marine resources.

- Submarines would utilize passive acoustic sensors to listen for vocalizing marine mammals. Submarine active transmissions would be halted in the event vocalizing marine mammals are detected
- Passengers on all on-ice vehicles would observe for marine and terrestrial animals; any marine or terrestrial animal observed on the ice would be avoided by 328 ft (100 m). On-

ice vehicles would not be used to follow any animal, with the exception of actively deterring polar bears if the situation requires.

- Personnel operating on-ice vehicles would avoid areas of deep snow drifts near pressure ridges, which are preferred areas for subnivean lair development.
- Camp development is scheduled to begin mid-February and would be completed well before ringed seal pupping season begins. This allows ringed seals to avoid the camp area prior to pupping, further reducing potential impacts.
- All material (e.g., construction material, unused food, excess fuel) and wastes (e.g., solid waste, hazardous waste) would be removed from the ice floe upon completion of ICEX18.
- Dish soap would be selected from the U.S. Environmental Protection Agency's "Safer Choice" list.
- All cooking and food consumption would occur within designated facilities to minimize attraction of nearby animals.

CHAPTER 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.

The proposed project is not known to occur in a subsistence hunting area, as it takes place a significant distance seaward of any known subsistence hunting activities. Furthermore, the Proposed Action would occur for a brief period of time outside of the subsistence hunting season. Based on the results from the acoustic analysis (see section 6.6) no mortality of ringed seals are expected, eliminating the possibility of removal of individual ringed seals from the population that could impact Alaska Native harvests. Navy plans to provide advance public notice to local residents and other users of the Prudhoe Bay region of Navy activities and measures used to reduce impacts on resources. This will include notification to local Alaska Native tribes that may have members who hunt marine mammals for subsistence. Though ringed seal is used for subsistence off the North Slope of Alaska, the Study Area is seaward of all subsistence hunting areas. If any tribes express concerns regarding project impacts to subsistence hunting of marine mammals, further communication between Navy will take place, including provision of any project information, and clarification of any mitigation and minimization measures that may reduce impacts to marine mammals.

CHAPTER 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. ICEX in comparison is a short duration exercise that occurs approximately every other year. Additionally, due to the location and expeditionary nature of the ice camp, the number of personnel is extremely limited and is constrained by the requirement to be able to evacuate all personnel in single day with small planes. As such, a dedicated monitoring project would not be feasible as it would require additional personnel and equipment to locate, tag and monitor the seals.

13.2 REPORTING

The Navy is committed to documenting and reporting relevant aspects of training and research activities to verify implementation of mitigation, comply with current permits, and improve future environmental assessments. All sonar usage will be collected via the Navy's Sonar Positional Reporting System database and reported. If any injury or death of a marine mammal is observed during the 2018 ICEX activity, the Navy will immediately halt the activity and report the incident consistent with the stranding and reporting protocol in the AFTT stranding plan. This is also consistent with other Navy documents such as the Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement.

CHAPTER 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 training
- 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.

As discussed above, the Navy does not anticipate any marine mammal specific research conducted in conjunction with the Proposed Action. However, the Navy is currently developing marine mammal species density models for the Arctic region to assist with Navy environmental planning and those density models will be available to other entities. Additionally, numerous environmental and climatological studies are conducted during ICEX that increase the scientific communities understanding of the Arctic region and that information is also freely available.

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