MAKING COMPLEX EASY

Protected Species Mitigation and Monitoring Report

Marine Geophysical (Seismic) Survey
Arctic Ocean
18 August 2021 – 30 September 2021

R/V *Sikuliaq*

Prepared for:

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Acronyms and Abbreviations

ADCP – Acoustic doppler current profiler
BioOp – Biological Opinion (US)
BOEM – Bureau of Ocean Energy Management
BSS – Beaufort Sea States
BZ – Buffer Zones
DAQ – Data acquisition
dB - decibels
DSLR – Digital Single Lens Reflex
EA – Environmental Assessment (US)
ESA – Endangered Species Act (US)
EEZ – Economic Exclusion Zone
EZ – Exclusion Zone
FONSI – Finding of No Significant Impact (US)
FWS – Fish and Wildlife Service (US)
GPS – Global Positioning System
HZ - Hertz
IHA – Incidental Harassment Authorization (US)
ITS – Incidental Take Statement (US)
LDEO – Lamont-Doherty Earth Observatory (US)
MBES – Multibeam Echosounder
MMPA – Marine Mammal Protection Act (US)
NMFS – National Marine Fisheries Service (US)
NRP – Navigation Reference point
NSF – National Science Foundation (US)
OBS – Ocean-bottom seismometers
OEIS – Overseas Environmental Impact Statement (US)
PEIS – Programmatic Environmental Impact Statement (US)
PI – Principal Investigator
PTS – Permanent threshold shift
PSO – Protected Species Observer
RMS – Root mean square
RPS- PSO Provider company name (not an acronym)
R/V – Research vessel
SBP – Sub bottom Profiler
US – United States
UTC – Coordinated Universal Time

1. EXECUTIVE SUMMARY

The U.S National Science Foundation (NSF) owned research vessel (R/V) Sikuliaq, operating under an existing cooperative agreement by the College of Fisheries and Ocean Sciences at University of Alaska Fairbanks (UAF), conducted a two-dimensional (2D) marine geophysical (seismic) survey in the Arctic Ocean from 18 August 2021 to 30 September 2021. The operational activities were conducted for a research survey proposed by Principal Investigator (PI) Dr. B. Coakley.

The purpose of the study was to use 2D seismic reflection data to document the history, structure, and stratigraphy of the Chukchi Borderland and adjacent Canada Basin, and to use 2D seismic refraction data in the Canada Basin to characterize the deep crustal structure associated with an extinct mid-ocean ridge in the central basin.

This report complies with the reporting requirements for the survey under the US Marine Mammal Protection Act (MMPA) and the US Endangered Species Act (ESA). On 12 February 2021, UAF submitted an application to the US National Marine Fisheries Service (NMFS) for an Incidental Harassment Authorization (IHA) that would allow for the potential harassment of small numbers of protected marine mammals incidental to the seismic survey. On 07 June 2021, the US Fish and Wildlife Service (USFWS) issued a Letter of Concurrence (LOC) concluding that the survey could temporarily disturb, but was unlikely to adversely affect, ESA-listed spectacled eiders, Steller's eider, short-tailed albatross, polar bears, or critical habitat for eiders or polar bears. The NSF Final Environmental Assessment (EA) was issued on 15 July 2021, and on 10 August 2021 and 11 August 2021, NMFS issued and IHA and Biological Opinion (BiOp).

Mitigation measures were implemented to minimize potential impacts to marine mammals and endangered or threatened sea birds during the survey. These measures included, but were not limited to, the use of NMFS approved Protected Species Observers (PSOs) for visual monitoring, and the implementation of buffer zones (BZ) and exclusion zones (EZ) (where the presence of a protected species would trigger a mitigation action), ramp-up procedures, and mitigation actions (including delayed operations, power-downs, and shut-downs). Continuous protected species observation coverage during the survey was provided by RPS, the environmental consulting company contracted by L-DEO for the project. PSOs monitored and reported on the presence and behavior of protected species and directed the implementation of the mitigation measures as described in the regulatory documents issued for the survey.

PSO activities were consistent with the PSO standards identified in the Programmatic Environmental Impact Statement (PEIS) / Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the NSF or conducted by the U.S. Geological Survey and Record of Decision (referred to herein as the PEIS), to which the NSF EA tiered. Six PSOs, one of which was designated as the Lead, were present on-board R/V Sikuliaq throughout the survey operations to conduct visual monitoring.

PSOs onboard the R/V Sikuliaq conducted visual observations for a total of 764 hours 59 minutes. The seismic source was active for a total of 574 hours 34 minutes, which occurred during 55% (420 hours 54 minutes) of the total visual monitoring effort.

There were 52 detections of protected species during the survey, all consisting of marine mammals. This total included: two sightings of bowhead whales, two sightings of gray whales, two sightings of a humpback whale, one sighting of fin whales, three sightings of unidentified whales, one sighting of killer whales, one sighting of Dall's porpoise, six sightings of bearded seals, nine sightings of ringed seals, 13 sightings of unidentified seals, nine sightings of walruses, and three sightings of polar bears. Only the NMFS listed species are included in the data analysis portion or take numbers of this report. All detections are listed in the appendices for continuity purposes.

Protected species detections resulted in the implementation of two mitigation actions, including two shutdowns for ringed seals totaling 20 minutes. In addition, there were two avoidance maneuvers implemented during the survey, including one speed reduction for one sighting of bowhead whales on the

transit to the survey area, and two speed reductions and a course alteration for one sighting of gray whales on the transit from the survey area.

NMFS issued an IHA and ITS authorizing 13,762 takes for 13 species of marine mammals. All authorized takes were for Level B harassment only – there were no Level A takes authorized for the survey. Authorized Level B takes included: three bowhead whales, two gray whales, two fin whales, two humpback whales, two minke whales, 697 beluga whales, six killer whales, two narwhal, two harbor porpoise, 907 bearded seals, 1,849 ribbon seals, 10,269 ringed seals, and 19 spotted seals.

During survey operations, seven protected species, including five ringed seals and two unidentified seals, were observed within the predicted 160 decibel radius (where there is a potential for a behavioral response) while the seismic source was active, constituting potential Level B takes. No protected species were observed within the smaller predicted radius at which there is a potential for auditory injury (based upon each species hearing range and how that overlaps with the frequencies produced by the sound source) while the seismic source was active, which would have constituted a potential Level A take.

2. INTRODUCTION

The following report details the protected species monitoring and mitigation as well as seismic survey operations undertaken as part of the 2D seismic survey onboard the R/V Sikuliaq in the Arctic Ocean from 18 August 2021 to 30 September 2021.

This document serves to meet the reporting requirements dictated in the ITS and IHA issued for the survey by NMFS on 10 and 11 August 2021, respectively. The IHA and ITS authorized takes of specific protected species, incidental to the marine seismic survey. NMFS has stated that seismic source received sound levels equal to or greater than 160 dB re 1 µPa (root mean square (rms)) could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered non-lethal 'takes' (Level B harassment). In July 2016, NMFS released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing, which established new thresholds for permanent threshold shift (PTS) onset, Level A harassment (auditory injury), for marine mammal species. Predicted distances to Level A harassment vary based on species specific hearing groups – low frequency cetaceans, mid frequency cetaceans, high frequency (HF) cetaceans, phocid pinnipeds, otariid pinnipeds, and sea otters – and how each group's hearing range overlaps with the frequencies produced by the sound source.

NMFS requires that provisions such as buffer zones (BZ), exclusion zones (EZ), delayed operations, ramp-ups, power-downs, and shut-downs be implemented to mitigate for potentially adverse effects of the acoustic source sounds on protected species. The BZs and EZs were established from any element on the seismic source array as areas where the presence of a protected species would trigger the implementation of a mitigation action (delayed operations for the BZ, and power-downs and/or shut-downs for the EZ depending on the species – see section 3.1). For marine mammals, the occurrence of an individual detected approaching, entering, or within their designated EZ would trigger the implementation of a shut-down of the acoustic source. NMFS specified EZs that encompass all zones within which auditory injury (Level A harassment) could occur on the basis of instantaneous exposure, provides additional protection from the potential for more severe behavioral reactions for marine mammals at relatively close range to the acoustic source, provides a consistent area for PSOs to conduct effective observational effort, and is a distance within which detection probabilities are reasonably high for most species under typical conditions.

2.1. PROJECT OVERVIEW AND LOCATION

The project was comprised of a 2D seismic reflection and refraction survey in the Arctic Ocean between approximately 73.5 to 81 degrees North and 139.5 to 168 degrees West. The survey was located within the US Exclusive Economic Zone (EEZ) and International Waters in water depths ranging from 200 to 4,000 meters (
Figure **1**).

The purpose of the survey was to collect 2D reflection data to document the history, structures, and stratigraphy of the Chukchi Borderland and adjacent Canada Basin, and 2D refraction data in the Canada Basin to characterize the deep crustal structure associated with an extinct mid-ocean ridge in the central basin. This data will be utilized to better understand the history of the Borderland and the surrounding structures and provide critical constraint on the history of the Amerasia Basin and the continents adjacent to it. The data will also image sites for potential future scientific ocean drilling under the International Ocean Discovery Program and potentially be used for a U.S claim of extended continental shelf for seabed resources under Article 76 of the United Nation's Convention on the Law of the Sea.

All survey activities were conducted solely by the R/V Sikuliaq. The vessel is 80 meters in length and can break through ice up to one meter thick. The vessel has a cruising speed of approximately 10 to 12 knots during transits, and approximately three to four knots when towing equipment. Seismic operations of the reflection data were collected from 21 August 2021 to 11 September 2021 (western survey lines) and from 20 September 2021 to 27 September 2021 (eastern survey lines). Seismic acquisition of the refraction data was collected between 13 and 14 September 2021 for the first site and between 17 and 19

September 2021 for the second site. There was a total of 52 reflection survey lines surveyed and five refraction lines surveyed during the project, totaling approximately 4,514 kilometers

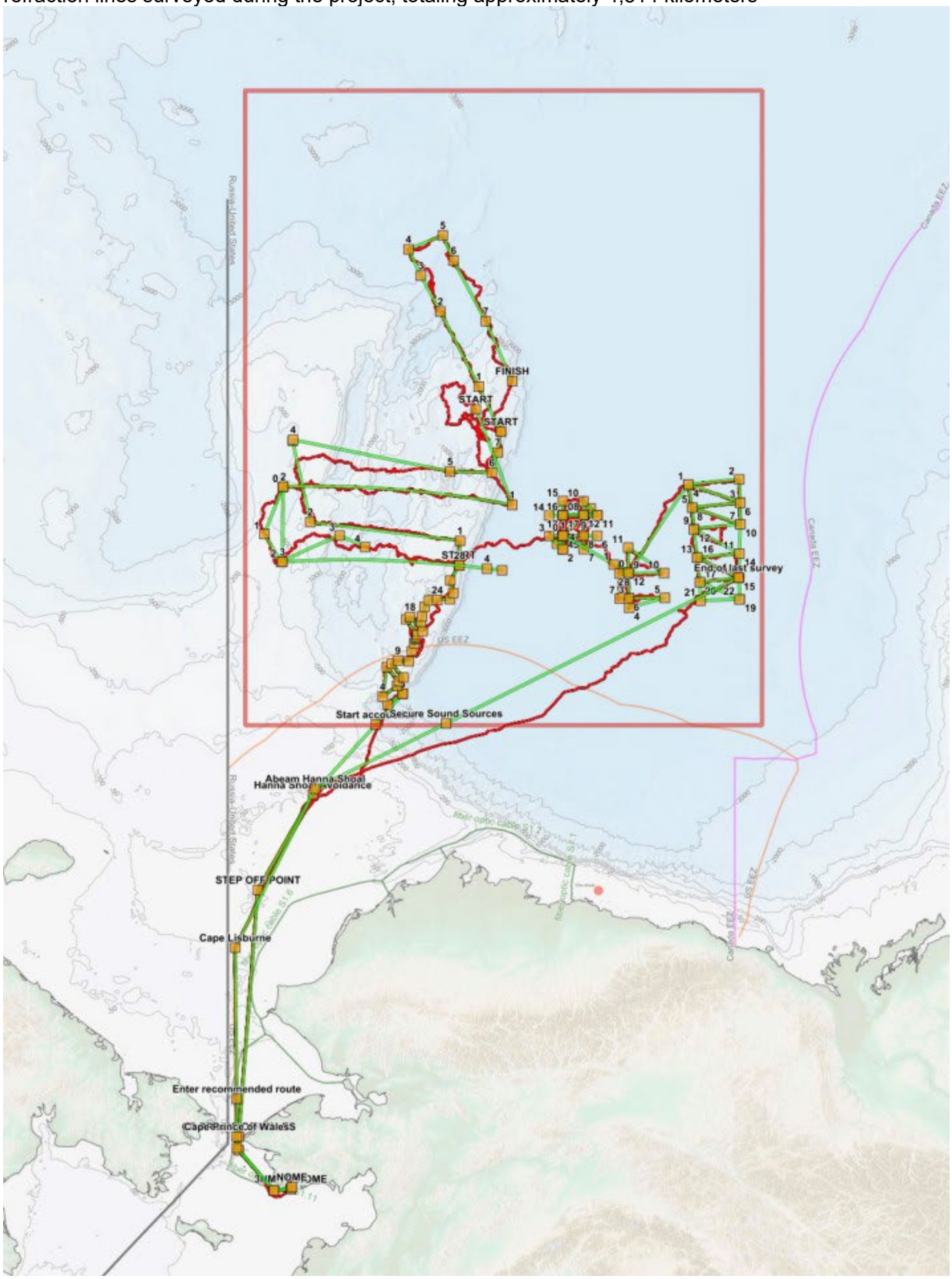

Figure 1. Location and planned track lines of the marine geophysical survey.

2.1.1. Energy Source and Receiving Systems

There were two different energy sources utilized during the survey. For the reflection survey lines, an array consisting of two seismic elements was towed directly aft of the vessel. For the refraction survey lines, two sub-arrays consisting of two seismic elements each (for a total of four elements) was towed aft of the vessel. For both operations, one two-element sub-array was towed 30 meters directly astern of the mid-ship. For the refraction surveys, the second two-element sub-array was towed 30 meters directly off the port stern of the vessel.

Each seismic element was 520 cubic inches (in^3), giving a total volume of 1,040 in^3 for the two-element array and 2,080 in^3 for the four-element array. The elements had dominant frequency components between six and 20 kilohertz (kHz), and nominal source levels between 245.13 dB re: 1 µPa (peak-to-beak) and 240.51 dB re: 1 µPa (zero-to-peak). For the two-element reflection survey lines, the shot-point interval was approximately 35 meters (15 seconds) and the source depth varied between six and 15 meters. For the four-element refraction survey lines, the shot-point interval was approximately 139 meters (60 seconds) and the source depth were fixed at six meters. The depth variability for the two-element array was due to the elements be towed freely astern of the vessel without a surface float, which aided in preventing damage to the equipment by the ice. However, for the four-element array, surface floats had to be used to prevent entanglement of the gear, resulting in the fixed depth for the elements. Due to this, the port side array had to be brought closer to the vessel or fully retrieved if the vessel had to go through any ice which may have damaged the equipment due to its location.

The receiving system for the reflection survey lines consisted of a hydrophone streamer 200 meters long deployed directly astern of the vessel. As the seismic source was towed along the track lines, the hydrophone streamer received the returning signal and transferred the data to the on-board processing system. The receiving system for the refraction survey lines consisted of both a 200-meter hydrophone streamer and six ocean bottom seismometers (OBS) (four on the first site and two on the second site). The OBSs receive and store the returning signal internally for later analysis. The tow depth for the streamer for both survey lines varied between six and 25 meters. The OBSs utilized were made by Sercel MicrOBS and have a height and diameter of approximately one meter. When deployed, the OBSs were attached to an anchor weighing approximately 80 kilograms (kg), which kept the device on the seafloor during seismic operations. To retrieve the OBS, and acoustic release transponder (10 to 11 kHz) was used to signal the device to release from the anchor (which remains on the seafloor) and float to the surface where the vessel could retrieve it. In addition, for both surveys, 96 AN/SSQ-53G (GPS) DIFAR sonobuoys supplied by the US Navy were deployed throughout the survey area. Once deployed from the vessel, the sonobuoys released a hydrophone which recorded data and transmitted it back to the vessel. The sonobuoys had a life of approximately eight hours after which they would scuttle to the seafloor. Specification sheets for both the OBSs and sonobuoys can be found in Appendix C and Appendix D.

Additional sound sources utilized were mounted under the hull of the vessel and included a Kongsberg EM 302 multibeam echosounder (MBES), a Kongsberg EM 710 multibeam echosounder (MBES), and a Kongsberg Topas PS18 - sub-bottom profiler (SBP). While the vessel was equipped with two acoustic doppler current profilers, neither were utilized during the survey. The EM 302 MBES operated at 30 kHz by emitting a series of 0.7 to 200 millisecond pulses with a maximum source level of 241 dB re: 1 µPa. The EM 710 MBES operated at 71 kHz by emitting a series of 0.3 to three millisecond pulses with a maximum source level of 229 dB re: 1 µPa. The SBP operated at 0.6 to 6 kHz and a sound source level of 209 dB re: 1 µPa. The MBESs and SBP operated simultaneously while the vessel was in the survey area to provide information about seafloor sedimentary features and to map the topography of the ocean floor.

3. MITIGATION AND MONITORING METHODS

The PSO monitoring program on the R/V Sikuliaq was established to meet the standards set forth in the PEIS, NSF EA, and NMFS IHA and ITS requirements. Survey mitigation measures were designed to minimize potential impacts of the R/V Sikuliaq's seismic activities on marine mammals and other protected species of interest. The following monitoring protocols were implemented to meet these objectives.

- Visual observations were conducted to provide real-time sighting data, allowing for the implementation of mitigation procedures as necessary.
- Effects of marine mammals exposed to sound levels constituting a take were observed and documented. The nature of the probable consequences was discussed when possible.

In addition to the mitigation objectives outlined in the PEIS, NSF EA, and NMFS IHA and ITS, PSOs collected and analyzed necessary data mandated by the IHA (see Appendix A).

3.1. MITIGATION METHODOLOGY

Mitigation actions were implemented for visual detections of protected species, including marine mammals, as outlined in the NMFS IHA, ITS and BiOp. These actions included the establishment of separation distances, buffer zones and exclusion zones (the size of which was dependent on both the source volume and the species as outlined in Table 1), and the implementation of delayed operations, power-downs (during which the source volume was reduced to a single active element), and shut-downs (during which the source was fully silenced) for protected species visually detected approaching, entering, or within their designated exclusion zones.

Separation distances were implemented while the vessel was in transit and not towing any equipment. The vessel was required to take action to maintain the species-specific separation distances (i.e., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt course changes until the animal had left the area) to the maximum extent possible. These requirements did not apply in any case where compliance would create an imminent and serious threat to personnel or the vessel. If a marine mammal was sighted within the relevant separation distance, the vessel was required to reduce speed, shift the engine to neutral, and not engage the engines until the animals were clear of the area. In the event of a sighting of a mother and calf pair, or large assemblages (six or more individuals) of any marine mammal observed near the vessel, the vessel was required to reduce speed to 10 knots or less as well as following the species-specific separation distances as outline in Table 1.

Before the seismic source could be activated from silence, day or night, two PSOs conducted a 30-minute clearance survey of the buffer and exclusion zones. In the event of a detection of protected species within their designated buffer or exclusion zones, a delay of source operations would be implemented as outlined in Table 1. Source operations would not be cleared to begin until the protected species were observed exiting their designated zones. If the protected species were not observed exiting their designated zones (i.e., if they dove/submerged within the zone and were not re-sighted), operations would not be cleared to begin until a specific time following the final detection of the animals. For detections of small odontocetes and pinnipeds, this time was 15 minutes following their last sighting within their designated zone. For detections of mysticetes and all other odontocetes, including beluga whales and killer whales, this time was 30 minutes following their last sighting within their designated zone.

Once the seismic source was active, the buffer zones from any element on the arrays were established as areas in which the presence of a protected species would initiate an alert to the seismic operators that the animal was detected, and that the implementation of a mitigation action may soon be required. PSOs would keep in frequent contact with the seismic team during the sighting, relaying information on the location and movement of the animals in relation to their designated zones as well as requesting the implementation of any needed mitigation actions. The exclusion zones from any element on the arrays were established as areas in which the presence of a protected species approaching, entering, or within

the zone would trigger a power-down or a shut-down of the seismic source, depending on the species present as outline in Table 1. For marine mammals, the individuals had to be in the water in their designated exclusion zone for a mitigation action to be implemented (i.e., not on the ice).

Upon the implementation of a power-down mitigation action, seismic source activity could be resumed at the previous operating volume without a ramp-up once the exclusion zones were confirmed to be clear of protected species. Upon the implementation of a shut-down mitigation action, a ramp-up was required to resume seismic source activity once the exclusion zones were confirmed to be clear of protected species. For both power-downs and shut-downs, clearance of the exclusion zones required either all individuals sighted to be observed exiting their designated zone, or a delay was implemented as outlined in Table 1.

Table 1: Separation distances, and buffer and exclusion zone sizes for each species/species group expected to occur in the survey area

Species/Species Group	Separation Distance	Buffer Zone[3]	Exclusion Zone[3]	Delay Duration
Large whale with a calf	Species dependent[1]	Any Distance	Any Distance	30 min
Aggregation of 6+ large whales	Species dependent[1]	Any Distance	Any Distance	30 min
Any species with no authorized takes	None	160 dB radius	160 dB radius	15 min or 30 min[6]
Any species that has reached authorized takes	None	160 dB radius	160 dB radius	15 min or 30 min[6]
Bowhead whales	500m[2]	6-elements: 1500m[8] 2-elements: 500m	6-elements: 1500m[8] 2-elements: 500m	30 min
Mysticetes (baleen whales)	100m	6-elements: 1000m 2-elements: 200m	6-elements: 500m 2-elements: 100m	15 min or 30 min[6]
All other cetaceans (toothed whales, dolphins, porpoises), and pinnipeds	50m	6-elements: 1000m 2-elements: 200m	6-elements: 500m 2-elements: 100m	15 min or 30 min[6]

1: Specific distance is species dependent as outline in rest of table; however, the vessel is also required to reduce speed to 10 knots or less for these groups as well.
2: If the whale cannot definitely be determined as not being a bowhead, the whale must be assumed to be a bowhead whale the vessel should use this separation distance
3: Marine mammals have to be in the water (not on the ice) within the BZ or EZ for a mitigation action to be implemented
6: Delay is 15 minutes for small odontocetes and pinnipeds. Delay is 30 minutes for mysticetes and all other odontocetes, including belga whales and killer whales.
7: SD = shut-down and PD = power-down
8: In the event of greatly reduced visibility due to darkness or precipitation, as only four elements were being utilized instead of the planned six-element array, PSOs cleared a minimum of 1000m if the full 1500m zone was not visible.

Specific seismic source operation procedures outlined in the IHA, ITS and BiOp included:

1. Ramp-ups for an array with more than two elements had a minimum requirement of 20 minutes (no minimum time for ramp-up of a two-element array).
2. The time between end of ramp-up and start of line needed to be minimized.
3. Brief periods (less than 30 minutes) of operational silence for reasons other than a protected species shut-down did not require a ramp-up to resume full volume source operations provided that: (1) PSOs maintained constant visual observation, and (2) no visual detections of protected species occurred within the applicable exclusion zone during that silent period. For any brief period of silence at night or in periods of poor visibility (e.g., BSS of four or greater), a ramp-up was required, but if constant observation was maintained, a pre-start clearance watch was not required. For any longer shut-down, both a pre-start clearance watches and a ramp-up were required.

4. Testing of the seismic source involving all elements required a ramp-up. Testing of individuals elements or strings did not require a ramp-up but did require a pre-start clearance watch.

Table 2 outlines the predicted 160 decibel radius (Level B harassment zone for marine mammals) for the different seismic source volumes utilized during the survey as well the different water depths expected in the survey area. Table 3 outlies the predicted Level A harassment zones for each protected species hearing group per the NMFS guidelines, and the species that could occur in the survey area assigned to each group.

Table 2: Predicted 160 Decibel Zones* Implemented during the survey.

Source	Volume (in^3)	Water Depth (m)	160 dB radius – Level B harassment zone for marine mammals
2 elements	1040	> 1,000	1604
		100-1,000	2406
6 elements (4 elements)**	3120 (2080)	> 1,000	4640
		100-1,000	6960
*Distances are from any single element on the array. **Survey plan had intended on using a six-element array; however, only a four-element array was utilized during the survey. As no distances were calculated for a four-element array, the distances for the six-element array were utilized during that part of the survey.			

Table 3: Predicted Level A Harassment Zones* for each Marine Mammal Hearing Group Implemented during the survey.

Source	Volume (in^3)	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Phocid Pinnipeds (m)
2 elements	1040	17.2	2.9	72.8	11.6
6 elements (4 elements)	3120 (2080)	50.6	7.2	211.5	33.6
*Distances are from any single element on the acoustic source arrays *Shut-downs occur at each species relevant zones (i.e., 1500 meters, 500 meters, 100 meters)		• Bowhead Whale • Gray Whale • Fin Whale • Humpback Whale • Minke Whale	• Beluga Whale • Killer Whale • Narwhal	• Harbor Porpoise	• Bearded Seal • Ribbon Seal • Ringed Seal • Spotted Seal

3.2. VISUAL MONITORING SURVEY METHODOLOGY

There were six experienced PSOs onboard the R/V Sikuliaq (Figure 2) during the survey to conduct visual monitoring for protected species, record and report detections, and request mitigation actions in accordance with the PEIS, NSF EA, NMFS IHA, ITS, and BiOp. The PSOs on board were NMFS approved and held certifications from a recognized Bureau of Ocean Energy Management (BOEM) course. Visual monitoring was primarily carried out from bridge of the vessel located 15.5 meters above the surface of the water. During good weather conditions, visual monitoring could also be conducted

outside from deck two or deck three, which were 12.7 and 9.9 meters above the surface of the water respectively.

Figure 2: R/V Sikuliaq, University of Alaska Fairbanks

PSOs were equipped with reticule binoculars (7x50 and 10x50) and digital cameras with zoom lenses ranging between 250 and 600 millimeters (maximum) for visual monitoring. A NightOwl NOB5X night vision device was supplied by the vessel for visual monitoring during reduced/restricted lighting conditions if needed (see Appendix E for specifications). Inside the bridge, PSOs had access to telephones and radios to contact the seismic team as well as data screens that displayed information about the vessel, including position, speed, heading, water depth, sea temperature, wind speed and direction, and air temperature. Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHA and ITS. Two PSOs visually monitored for protected species during all daylight hours throughout the survey, from port to port. Visual monitoring during the transits between the ports and the survey area were conducted for vessel strike avoidance of protected species. Visual monitoring during periods of acoustic source silence was conducted to gather baseline data on the presence and abundance of protected species in the areas. Throughout the survey, visual monitoring was conducted each day from 30 minutes before sunrise until 30 minutes after sunset as required by the IHA and ITS. Observation times at the beginning of the survey were 24 hours a day and at the end of the survey were from approximately 16:50 to 05:20 Coordinated Universal Time (UTC). Scheduled watches were a maximum of four hours in duration followed by at least one hour of scheduled break time.

Visual observations were conducted around the entire area of the vessel and seismic source, divided between the two PSOs on watch. The smaller monitoring area for each observer increased the probability

of protected species being sighted. PSOs searched for blows, fins, splashes or disturbances of the sea surface, large flocks of feeding sea birds, and other sighting cues indicating the possible presence of a protected species. Upon the visual detection of a protected species, PSOs would identify the animals' range to the vessel and acoustic source. Range estimations were made using reticle binoculars, the naked eye, and by relating the animal(s) to an object at a known distance, such as the seismic equipment or nearby ice packs that a distance from the vessel could be obtained from the vessels ice radar. PSOs would also identify to species, if possible, upon initial detection to ensure that the proper mitigation measures were implemented, should any be required.

As required by the IHA (section 5(d)(iii)), PSOs recorded the following information for each protected species detection:

I. Date, time of first and last sighting, observers on duty during the detection, location of the observers, vessel information (e.g., position, speed, heading), water depth, and acoustic source activity (e.g., volume and number of active elements).
II. Species, detection cue, group size (including number of adults, juveniles, and calves), visual description (e.g., overall size, shape of the head, position and shape of the dorsal fin, shape of the flukes, height, and direction of the blow), observed behaviors (e.g., porpoising, logging, diving, etc.), and the initial and final pace, heading, bearing, and direction of travel in relation to both the vessel and the source (e.g., towards, away, parallel, perpendicular, etc.).
III. Initial, closest, and final distance to the vessel and the source, time when entering and exiting the EZs, type of mitigation action implemented, total time of the mitigation action, description of other vessels in the area, and any avoidance maneuvers conducted.

During or immediately after each sighting event, the PSOs recorded the detection details per the requirements of the IHA and ITS in a provided detection datasheet. Each sighting event was linked to an entry on an effort datasheet where specific environmental conditions (e.g., Beaufort Sea state, wind force, swell height, visibility, and glare) and vessel activity were logged.

Species identifications were made whenever the distance from the observer, length of the sighting, and visual observation conditions allowed. Whenever possible during detections photographs were taken to aid with species identification. Marine mammal identification manuals were consulted as needed utilizing the following guides:

1. Wynne, K. 2012. Guide to Marine Mammals of Alaska Fourth Edition.
2. Shirihai, H. and Jarrett, B. 2006. Princeton Field Guides Whales Dolphins and Other Marine Mammals of the World.

4. MONITORING EFFORT SUMMARY

4.1. SURVEY OPERATIONS SUMMARY

4.1.1. General survey parameters

The Arctic Ocean survey began on 18 August 2021 when the R/V Sikuliaq departed port in Nome, Alaska and concluded on 30 September 2021 when the vessel retrieved to port in Nome, Alaska (Table 4).

Table 4: Survey parameters

Survey Parameter	Date	Time (UTC)	Location
Langseth			
Mobilization	2021-08-18	04:41	Nome, Alaska
First Source Activity	2021-08-21	11:31	Arctic Ocean
Start of Acquisition	2021-08-21	11:58	Arctic Ocean
End of Acquisition	2021-09-25	07:00	Arctic Ocean
Demobilization	2021-09-30	18:38	Nome, Alaska

During the survey, data was acquired continuously according to the survey plan, with source operations only suspended when operationally necessary, as outlined in Appendix F. The majority of these suspended operations were due to ice conditions, mechanical/technical silence, and the gear being retrieved for maintenance. Twenty-six of the suspended source operations were due to ice conditions, including 23 occasions where the source had to be briefly paused while the vessel became unstuck from the ice and three occasions where all gear had to be retrieved to allow the vessel to break through heavier ice. Fifty-two of the suspended source operations were attributed to mechanical/technical silences, mainly due to issues with the source controller software that occurred between 02 and 03 September 2021. There were also 29 occasions of source silence attributed to the gear having to be retrieved for maintenance.

4.1.2. MBES, SBP and ADCP operations

The two multibeam echosounders (MBESs) and sub-bottom profiler (SBP) were active throughout the majority of the survey while the vessel was within the survey area for a total of 888 hours 48 minutes. The EM 302 MBES was activated for the first time of the survey at 04:59 UTC on 21 August 2021 and deactivated for the last time at 05:47 UTC on 27 September 2021, totaling 750 hours 21 minutes of operation. The EM 710 MBES was activated for the first time at 16:53 UTC on 21 August 2021 and deactivated for the last time at 23:31 UTC on 11 September 2021, totaling 234 hours 43 minutes. The sub-bottom profiler was activated for the first time at 06:16 UTC on 21 August 2021 and deactivated for the last time at 05:47 UTC on 27 September 2021, totaling 750 hours 52 minutes of operation.

4.1.3. Acoustic source operations

The seismic source was active for a total of 574 hours 34 minutes throughout the survey. This total included: 13 hours 20 minutes of ramp-up, 14 minutes of testing, 554 hours 54 minutes of operations on a survey line (536 hours 25 minutes at full volume and 18 hours 29 minutes at reduced volume), and six hours six minutes of operations not on a survey line (all at full volume). Table 5 summarizes the seismic source operations over the course of the survey.

The seismic source was ramped-up 39 times of the course of the survey, including 37 times to commence source operations from a period of silence and two times to resume source operations from a mitigation shut-down for protected species. Thirty-one ramp-ups were conducted during daylight hours and eight were conducted during hours of darkness. Ramp-ups for the two-element array ranged between 15 and 20 minutes in duration while ramp-ups for the four-element array ranged between 20 minutes and one hour. Ramp-ups were conducted by enabling the elements at the lowest possible pressure and then increasing the pressure of the system until it was at full pressure.

There were no operations of a single source element conducted for protected species mitigation action power-downs during the survey.

There were 10 tests of the seismic source conducted during the survey, including seven single element tests totaling seven minutes and three single source tests totaling seven minutes.

The geospatial data for source operations conducted during the survey are provided as a shapefile attachment to this report. Throughout the survey, the volume of the acoustic source was changed (reduced or increased) on only a few occasions during active source operations, mainly due to issues with individual source elements and ice conditions.

Table 5. Total acoustic source operations during the seismic survey.

Acoustic Source Operation	Number	Duration
Source Tests	10	00:14
Ramp-up	39	13:20
Day-time ramp-ups from source silence	31	09:48
Night-time ramp-ups from source silence	8	03:32
Full (6600 in^3)/Reduced Volume on a Survey Line[1]		554:54
Full (6600 in^3)/Reduced Volume not on a Survey Line[2]		06:06
Single Source Element (for mitigation)		00:00
Total Time Acoustic Source Was Active		
1. **On a Survey Line:** 536:25 at full volume an 18:29 at reduced volume 2. **Not on a Survey Line:** 06:06 at full volume and none at reduced volume		

4.1.4. Interactions with Other Vessels

In addition to visually monitoring for protected species, PSOs also observed and documented interactions with other marine vessel traffic. Such interactions included but were not limited to another vessel or another vessels' towed gear/equipment interacting with the R/V Sikuliaq's towed gear/equipment, and the R/V Sikuliaq having to deviate from planned survey operations (i.e., diverge from the survey line, increase/decrease speed) because of another vessel. There were no instances where the R/V Sikuliaq had such an interaction with another vessel.

4.2. VISUAL MONITORING SURVEY SUMMARY

Visual monitoring was conducted by two PSOs during all daylight hours throughout the survey, beginning 30 minutes before sunrise ending 30 minutes after sunset each day, initiating when the vessel left the port at the beginning of the project and terminating upon the vessels return to port at the end of the project (Table 6). This included times when the vessel was in transit and deploying and retrieving equipment. Visual monitoring during transit was conducted for vessel strike avoidance, and visual monitoring during times with no source operations was conducted to collect baseline data about protected species abundance in the survey areas.

Table 6: Initiation and termination of visual monitoring during the survey.

Visual Monitoring	Date	Time (UTC)
Initiation for the survey	2021-08-18	04:41
Termination for the survey	2021-09-30	18:38

Visual monitoring was conducted over a period of 44 days for a total of 764 hours 59 minutes. Of the overall total visual monitoring effort, 55% (420 hours 54 minutes) was undertaken while the seismic source was active and 45% (344 hours five minutes) was undertaken while the seismic source was silent (Table 7). Visual monitoring while the acoustic source was silent was mainly conducted during the transits to and from the survey sites, and during equipment deployment, recovery, and maintenance. There were also several 43 hours 48 minutes of visual monitoring conducted at night to clear source operations.

Table 7. Total visual monitoring effort during the survey.

Visual Monitoring Effort	Duration (hh:mm)	% of Overall Visual Monitoring Effort
Total monitoring while acoustic source active	420:54	55
Total monitoring while acoustic source silent	344:05	45
Total monitoring effort	**764:59**	**-**

Visual observations were mainly conducted from the bridge of the vessel, which provided an excellent view of the water around the vessel and the seismic source towed astern and provided shelter from the arctic elements. When weather conditions permitted it, visual watches were also held outside on the lower decks. Monitoring was also conducted simultaneously from the bridge and lower outside decks on a few occasions. Table 8 summarizes the duration of visual monitoring efforts from different locations on the vessel.

Table 8: Total visual monitoring effort from observation locations during the survey.

Observation Location During Visual Effort	Duration (hh:mm)	% of Overall Effort
Bridge	727:21	95
Outside Decks	37:38	5

4.3. ENVIRONMENTAL CONDITIONS

Environmental conditions can have an impact on the probability of detecting protected species. The environmental conditions present during visual observations undertake during this survey were generally considered to be moderate to good.

Visibility was classified as 'excellent' if it extended to greater than 10 kilometers and 'very good' if it was between seven and 10 kilometers. During the survey 6% and 30% of all visual monitoring effort was undertaken during 'excellent' and 'very good' visibility conditions, respectively (Table 9). Throughout the survey, the entire predicted harassment zone radii, buffer zones, and exclusion zones were not fully visible on several occasions, mainly due to precipitation. During these times, it is possible that protected species were not detected within these zones.

Table 9. Visibility during the survey.

Total	<0.05 km	0.05-0.1 km	0.1-0.3 km	0.3-0.5 km	0.5-1 km	1-2 km	2-5 km	5-7 km	7-10 km	>10 km
Duration (hh:mm)	00:00	04:21	16:38	21:24	71:07	79:41	141:55	157:00	230:29	42:24

Reduced visibility was mainly attributed to periods of fog and snow, and periods of reduced lighting when monitoring was conducted at night or in the dawn and dusk hours. Throughout the survey, precipitation was recorded during visual monitoring for a total of 446 hours eight minutes, the majority of which was snow (33%, 252 hours 56 minutes) (Table 10).

Table 10. Precipitation during the survey.

Total	None	Heavy Rain	Moderate Rain	Light Rain	Heavy Fog	Moderate Fog	Thin Fog	Haze	Sleet	Snow
Duration (hh:mm)	318:51	00:08	01:28	10:37	25:20	84:37	59:47	09:45	01:30	252:56

The Beaufort Sea state recorded during visual monitoring ranged from level zero to level six over the course of the survey. The majority of visual observations were undertaken in conditions where the Beaufort state was a level two or three, which were considered good conditions for the detection of protected species (Table 11). The majority of the recorded level zero and level one sea states occurred during times when there was little to no visible unfrozen water around the vessel in heavy ice conditions.

Table 11. Beaufort Sea State during the survey.

Total	B0	B1	B2	B3	B4	B5	B6
Duration (hh:mm)	84:44	99:24	294:40	206:30	48:37	13:52	17:12

Wind speeds recorded during visual monitoring throughout the survey ranged between less than less than 10 and greater than 30 knots. The majority of visual monitoring occurred during recorded wind speeds of less than 10 knots and 10 to 15 knots (Table 12).

Table 12. Wind speed during the survey.

Total	<10	10-15	16-20	21-25	26-30	>30
Duration (hh:mm)	248:17	263:28	167:21	63:10	20:49	01:54

Swell heights during visual observations were low, with swells of less than two meters recorded for the majority of visual observations (Table 13). Swells of two to four meters were only recorded during the transit back to port at the end of the survey. While within the survey area, low swells even during higher winds were attributed to the ice conditions present.

Table 13. Swell Height during the survey.

Total	<2m	2-4m	>4m
Duration (hh:mm)	759:56	05:03	00:00

The majority of visual monitoring was conducted while no glare was present (Table 14). During times of moderate to severe glare, it is possible that detections of protected species was hindered.

Table 14. Glare during the survey.

Total	None	Mild	Moderate	Severe
Duration (hh:mm)	601:29	56:33	21:12	85:45

5. MONITORING AND DETECTION RESULTS

5.1. VISUAL DETECTIONS

Visual monitoring efforts during the survey resulted in a total of 40 detections of NMFS protected species (summarized in Appendix G). This total included one detection of dolphins, one detection of porpoises, ten detections of whales, and 28 detections of pinnipeds. Table 15 summarizes the total number of detections and the total number of animals recorded for each species observed during the survey. Photographs taken of visual detections can be found in Appendix H.

Maps of the detections of the protected species are shown in Figure 3 and Figure 4.

Of the 15 detections which occurred within the survey area, nine occurred while the seismic source was active. These detections included six sightings of ringed seals and three sightings of unidentified seals. The remaining detections occurred while the seismic gear was not deployed, including three sightings of ringed seals and one sighting of an unidentified seal while the vessel was transiting within the survey area.

While the seismic source was active, ringed seals had closest observed approaches to the elements between 81 and 1,911 meters, averaging 444 meters, unidentified seals ranged between 240 and 3,221 meters, averaging 1,345 meters. One of the ringed seals and one of the unidentified seals remained on the ice during the sightings. The remaining seven seals (five ringed and two unidentified) were in the water while the source was active. Table 16 summarizes the number of each species and the mean closest observed approach to both the active and inactive elements while the seismic source was deployed.

Table 15. Number of visual detection records collected for each protected species during the survey.

Species	Total Number of Detection Records	Total Number of Animals
Killer whale	1	8
Dolphin totals	**1**	**8**
Dall's porpoise	1	2
Porpoise totals	**1**	**2**
Bowhead whale	2	9
Gray whale	2	16
Humpback whale	2	4
Fin whale	1	2
Unidentified whale	3	5
Whale totals	**10**	**36**
Bearded seal	6	7
Ringed seal	9	9
Unidentified seal	13	13
Pinniped totals	**28**	**29**
Total	**40**	**75**

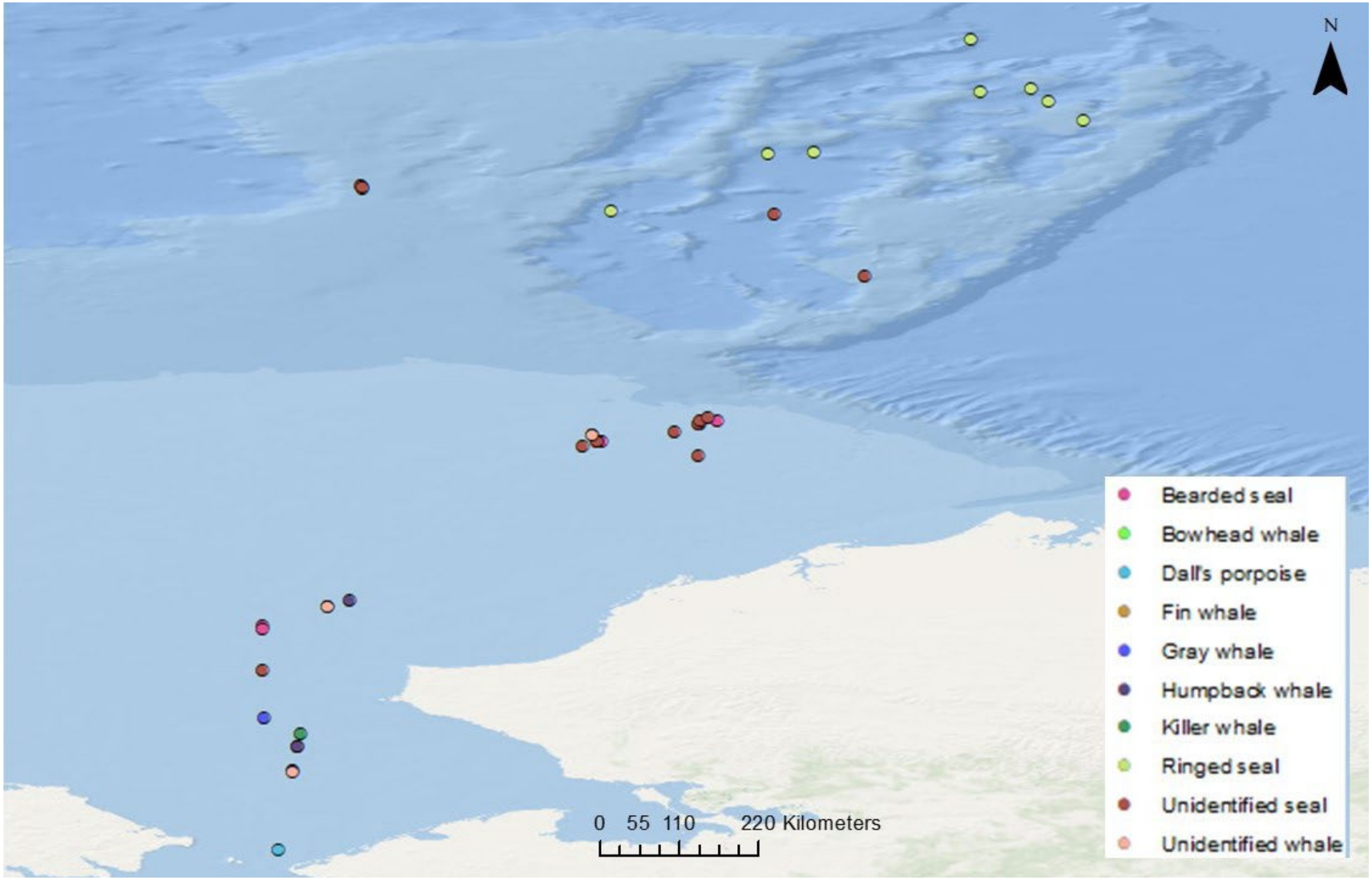

Figure 3: All protected species detections during the survey.

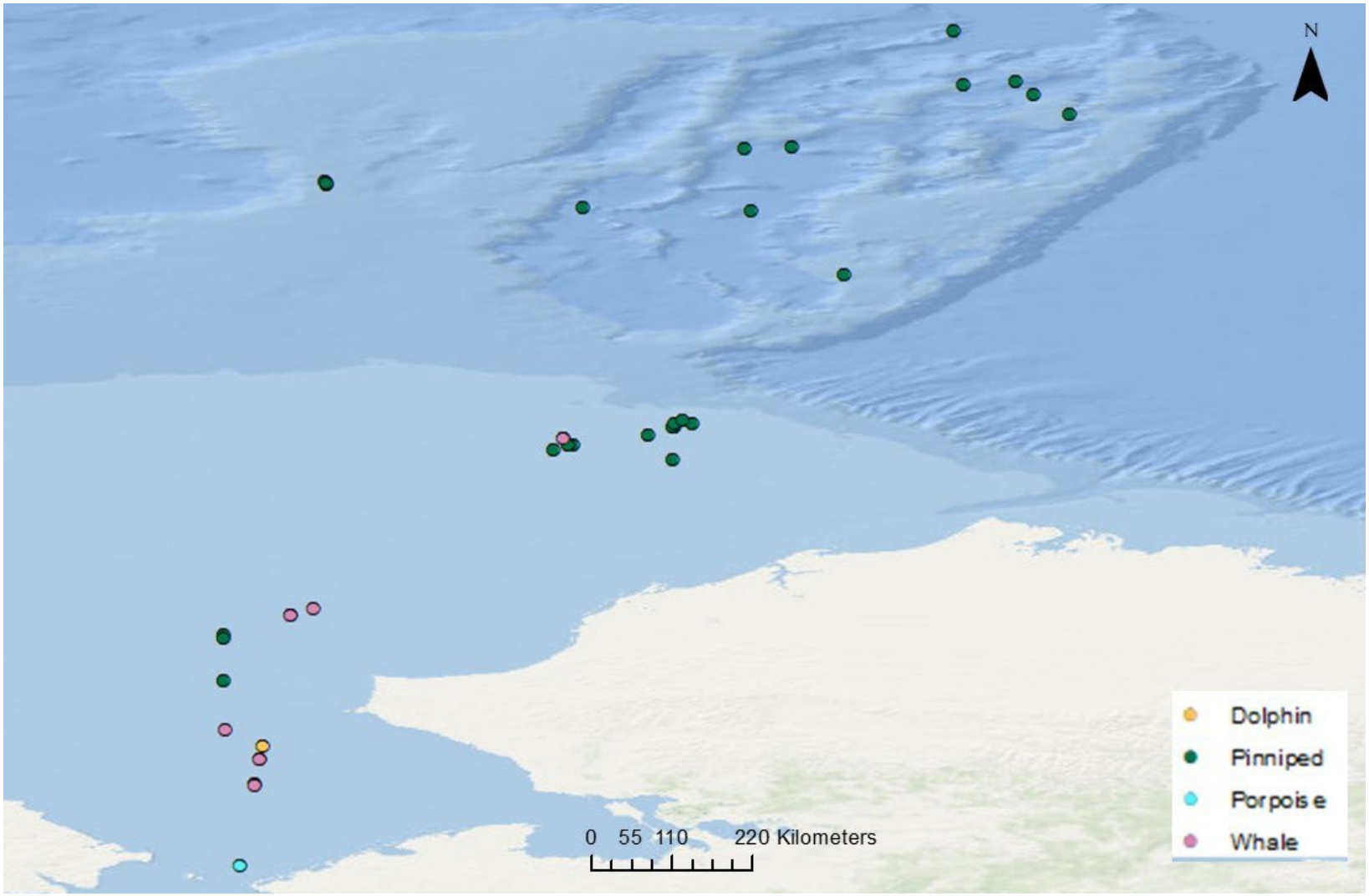

Figure 4: All protected species observed during the survey by species group.

Table 16. Average closest approach of protected species to the seismic source during the survey.

Species Detected	Regulated Source Active		Regulated Source Inactive	
	Number of detections	Mean closest observed approach to source (meters)	Number of detections	Mean closest observed approach to source (meters)
Killer whale	0	-	1	3000
All dolphin species	**0**	**-**	**1**	**3000**
Dall's porpoise	0	-	1	200
All porpoise species	**0**	**-**	**1**	**200**
Bowhead whale	0	-	2	750
Gray whale	0	-	2	500
Humpback whale	0	-	2	1000
Fin whale	0	-	1	1000
Unidentified whale	0	-	3	6833
All whale species	**0**	**-**	**10**	**2600**
Bearded seal	0	-	6	673
Ringed seal	6	444	3	1550
Unidentified seal	3	1345	10	869
All pinniped species	**9**	**744**	**19**	**915**

5.1.1. Other Wildlife

Observations of other wildlife during the survey included 29 species of birds and one species of marine invertebrates. A complete list of these species as well as the approximate number of individuals and days on which they were observed can be found in Appendix I. There was one observation of a white-crowned sparrow on the vessel in the survey area that was observed briefly before it left the area. As this was a few weeks into the survey, it was unclear where the sparrow had come from. No impacts to any other wildlife species as a result of research activities were observed during the survey.

6. MITIGATION ACTION SUMMARY

There were two mitigation actions implemented during the survey due to protected species being observed approaching, entering, or within their designated exclusion zones. This included two shutdowns for ringed seals totaling 20 minutes (Table 17). Both shutdowns occurred during operations of the two-element array. The first shutdown was for a ringed seal that was observed entering but not exiting the 100-meter exclusion zone. The duration of the mitigation action was 15 minutes for the delay; however, the was 18 minutes of silence due to a further delay from the seismic operators. The second shutdown was for a ringed seal that was observed both entering and exiting the 100-meter exclusion zone, and both the mitigation action and silent time were a total of two minutes.

Table 17. Number and duration of mitigation actions implemented during the survey.

Mitigation Action	Dolphins		Whales		Porpoises		Pinnipeds		All Species	
	No	Mitigation Downtime	No.	Mitigation Downtime	No.	Mitigation Downtime	No.	Mitigation Downtime	No.	Mitigation Downtime
Delay of Initiation of Operation	0	-	0	-	0	-	0	-	**0**	**-**
Shutdown of Operation	0	-	0	-	0	-	2	00:20	**2**	**00:20**
Total Mitigation	**0**	**-**	**0**	**-**	**0**	**-**	**2**	**00:20**	**2**	**00:20**

6.1. PROTECTED SPECIES KNOWN TO HAVE BEEN EXPOSED TO 160 DECIBELS OR GREATER OF RECEIVED SOUND LEVELS

NMFS issued an IHA for the Arctic survey on 11 August 2021 authorizing Level B takes for 13 species of marine mammals totaling 13,762 individuals. There were no authorized Level A takes.

During the survey, there were five ringed seals and two unidentified seals observed within the Level B harassment zone (exposure to sound pressure levels equal to or greater than 160 dB re: 1 µPa (rms) where there is a potential for behavioral changes). This total represents 0.05% of the total authorized Level B takes for both ringed seals as well as the overall total for all species. There were no protected species observed within the Level A harassment zone.

The number of takes may be an underestimation, and therefore, may be a minimum estimate of the actual number of protected species potentially exposed to received sound levels within the predicted Level A and Level B harassment zones. It is possible that the estimated number of animals potentially exposed to the seismic source at the harassment levels was underestimated due to some individuals not being visually sighted. In addition to visual monitoring not being conducted during the majority of the seismic operations which occurred during hours of darkness, there was a large amount of ice present throughout the survey area, which may have concealed seals in the water within the harassment zones.

Table 18. Number of authorized and potential Level A and B Harassment Takes during the survey.

Species	IHA Authorized Level A Takes	Potential Level A Takes/PTS During the Program	IHA Authorized Level B Takes	Potential Level B Takes/TTS During the Program	Total IHA Authorized Takes	Total Potential Takes During the Program
Bowhead Whale	-	-	3	-	3	-
Gray Whale	-	-	2	-	2	-
Fin Whale	-	-	2	-	2	-
Humpback Whale	-	-	2	-	2	-
Minke Whale	-	-	2	-	2	-
Beluga Whale	-	-	697	-	697	-
Killer hale	-	-	6	-	6	-
Narwhal	-	-	2	-	2	-
Harbor Porpoise	-	-	2	-	2	-
Bearded Seal	-	-	907	-	907	-
Ribbon Seal	-	-	1849	-	1849	-
Ringed Seal	-	-	10269	5	10269	5
Spotted Seal	-	-	19	-	19	-
Unidentified Seal	-	-	-	2	-	2

6.2. IMPLEMENTATION AND EFFECTIVENESS OF THE BIOLOGICAL OPINION'S ITS AND IHA

In order to minimize the potential impacts to marine mammals during the survey, UAF and PSOs were prepared to implement mitigation measures whenever these protected species were detected approaching, entering, or within their designated exclusion zones as outline in the IHA, ITS, BiOp, and Final EA. There were two mitigation actions implemented during the survey for protected species, both shutdowns totaling 20 minutes. The confirmation of the implementation of each term and condition of the project permit documents are described in this report.

In the event that an injured or dead protected species was discovered during the course of the survey, the incident was to be reported to the Office of Protected Resources (OPR), NMFS, and the NMFS Alaska Regional Stranding Coordinator as soon as possible. The report would include a detailed description of the incident (time, date, location, species identification, description of the animal, condition of the animal/carcass, observed behaviors if the animal was alive, and general circumstances under which the animal was discovered), including pictures when possible. There were no sightings of dead or injured protected species during the survey.

In order to prevent the occurrence of the vessel striking a marine mammal during transits, PSOs and vessel crew members maintained a vigilant watch for marine mammals, and the vessel was prepared to slow down, stop, or alter course as appropriate to avoid striking a protected species. The vessel speed had to be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans were observed near the vessel. The vessel had to maintain the minimum separation distances as described in Table 1 in Section 3.1. If a marine mammal was sighted during transits, the vessel was to take action as necessary to avoid violating the relevant separation distances (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal left the area). If marine mammals were sighted within the relevant separation distances, the vessel was required to reduce speed, shift the engines to neutral, and not engage the engines until the animals were clear of the area. These requirements did not apply in any case where compliance would create an imminent and serious threat to a person or vessel, or if the vessel was restricted in maneuverability due to towed equipment. In the event of the vessel striking a marine mammal, the incident was to be reported to NMFS and to the Alaska Regional Standing Coordinator as soon as possible.

There were two instances of avoidance maneuvers being implemented during the survey. On the transit to the survey area at the beginning of the project, a speed reduction was implemented for a group of eight bowhead whales sighted, and on the transit from the survey area at the end of the project, two speed reductions and a course alteration were implemented for a sighting of approximately 15 gray whales sighted around the vessel. There were no instances of the vessel striking a marine mammal during the survey.

PSOs likely did not detect all animals present; however, it is highly unlikely that the actual number of animals present during survey operations reached anywhere near the fully authorized levels for all species. The combination of conservative predicted mitigation zones combined with conservative take estimation by NMFS (*i.e.,* the precautionary approach), appears for most species to have resulted in an overestimation of take and of overall impact on marine species from the activity. The monitoring and mitigation measures required by the IHA and ITS appear to have been an effective means to protect the marine species encountered during survey operations.

7. LITERATURE CITED

NOAA, 2020. Endangered Species Act Section 7 Consultation Biological Opinion for a marine seismic survey by Lamont-Doherty Earth Observatory in the North Pacific Ocean and NFMS IHA issuance.