Annual Report for 2023

# Winter Ringed Seal Density within Beaufort Sea Oil and Gas Project Areas

AK-21-01, Award No. M21AC00024

To: Bureau of Ocean Energy Management
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## Executive Summary

In Alaska, ringed seals (*Pusa hispida*) are an important subsistence resource to coastal Alaska Natives, and important prey for polar bears (*Ursus maritimus*). Ringed seals create and maintain breathing holes through solid landfast sea ice up to 2 m thick allowing them to use habitat on ice (hauling out to rest, bask, and molt) and under ice (to feed on fish and invertebrates) throughout the winter. Ringed seals also use subnivean lairs built in snow drifts on top of sea ice and within pressure ridges for resting and pupping. Ringed seals were listed as threatened under the U.S. Endangered Species Act in 2012 because predicted declines in sea ice and snow accumulation over the next century were expected to greatly reduce their numbers. In the Beaufort Sea, ringed seal use of landfast ice in winter and early spring overlaps with oil and gas activities (e.g., ice road and gravel island construction, and seismic and drilling operations). Ringed seals spend most of their time underwater and in lairs and are generally not visible from the ice surface, thus determining how many seals may be affected by oil and gas activities is difficult, but necessary, for attaining permits to conduct these activities. In April and May 2023, we used two trained wildlife-detection dogs to survey an area in Prudhoe Bay, near Northstar Island, that was previously studied in 2022. During this survey we found 73 ringed seal structures (60 breathing holes, 10 lairs, and 3 unknowns) in an 88.2 $km^2$ area; a density of 0.83 structures/$km^2$. Fewer structures were identified in 2022 (61; 47 breathing holes and 14 lairs); a density of 0.69 structures/$km^2$. Snow depths at lairs were shallower in 2023 than in 2022 and averaged 56.6 cm (range 40–75 cm) in 2023 compared to 76.9 cm (range 45–120 cm) in 2022. In 2023, four lairs were instrumented with temperature and light sensors and cameras to record lair use. We monitored nine breathing holes that had been opened for basking with cameras to record use by multiple seals, visitation by predators, and other behavior. Temperature sensors instrumented on four lairs did not detect any haul-out bouts, however photographs revealed use of breathing holes by multiple seals for basking and for resting in the hole without hauling out. Breathing holes were found in water as shallow as 2 m and active structures were found within 19.5 m of facilities and within an active ice road.

## Introduction

Ringed seals (*Pusa hispida*) are an important subsistence resource to coastal Alaska Natives and important prey for polar bears (*Ursus maritimus*). In winter, ringed seals create and maintain holes through solid landfast ice up to 2 m thick allowing them to breathe, use habitat on the ice (Smith and Stirling 1975), and forage on fish (mostly Arctic cod, *Boreogadus saida)* and invertebrates (mostly crustaceans) (Crawford et al. 2015) under the ice. Ringed seals also use lairs, built in snow drifts on top of the sea ice and within pressure ridges in sea ice, for resting and pupping (Smith and Stirling 1975). Ringed seals were listed as threatened under the U.S. Endangered Species Act in 2012 (USFWS 2012) because predicted declines in sea ice and snow accumulation over the next century were expected to greatly reduce their abundance. Although ringed seals range widely in summer when the Pacific Arctic is predominately ice-free, ringed seals have small ranges in landfast ice in winter and early spring (Kelly et al. 2010) that overlap with oil and gas activities (e.g., ice road and gravel island construction, and seismic and drilling operations) in the Beaufort Sea. Ringed seals are generally not visible at the ice surface (either under snow or under ice) and thus determining how many seals may be affected by oil and gas activities is difficult but important for attaining permits to conduct industry activities.

Objectives for this study include determining the current density and habitat use of ringed seals in the nearshore Beaufort Sea in the North Slope oil and gas area. Previous studies conducted in this area during the 1980s (Kelly et al. 1986, 1990) will allow us to assess if changes in density have occurred and whether they may be associated with climate change.

### Goals and Objectives

***Overall Objective:*** The overall objective of this study is to document ringed seal distribution, density, and habitat use within the landfast ice zone of the nearshore Beaufort Sea that includes BOEM's Beaufort Sea Planning Area and existing North Slope oil and gas facilities to be used for informing and developing mitigation measures to minimize disturbance from industry activities.

***Objective 1:*** Analyze nearshore ice use by ringed seals by locating and documenting status of wintering seals and their structures to develop avoidance strategies where ringed seal habitat overlaps with North Slope oil and gas activities.

***Objective 2:*** Utilize novel survey technology to expand capabilities to facilitate research on the habitat of ringed seals to improve understanding of ringed seal movements.

***Objective 3:*** Identify winter and spring seasonal movement patterns of adult ringed seals with an emphasis on detecting subnivean lair use in landfast ice in areas bounded by NPR-A, ANWR, and BOEM's Beaufort Sea Planning Area.

***Objective 4:*** Document ringed seal habitat use areas and local foraging behavior by classifying foraging locations and determine if oil and gas development activities create movement barriers for ringed seals to access prey.

***Objective 5:*** Evaluate and compare the efficiencies of the proposed survey technologies with existing methods used to detect ringed seals, their breathing holes, and lairs.

## Methods

### Coordination

***Meetings, communication, and training.*** The Principal Investigator, Lori Quakenbush and Alaska Department of Fish and Game (ADF&G) staff attended Ice Seal Committee meetings, community meetings, professional conferences, and communicated with BOEM, the Bureau of Land Management (BLM), the North Slope Borough (NSB), and Hilcorp Alaska, LLC (Hilcorp) to discuss research needs and required training for working in the oil and gas project area.

### Dog Searches

Two wildlife detection dogs, trained to find seal structures by scent, were used to search the study area in May 2023. Dogs are trained to run ahead of a handler on a snowmachine into a quartering head wind (Fig. 1). When they smell a seal structure they divert from the course and run to the structure. Each dog can work separately, or they can work together.


*Figure 1. Wildlife detection dogs running in front of snowmachines searching for seal structures.*

**Seal Structures**

Seal structures include breathing holes, haul-out lairs, and pupping lairs (Fig. 2). Any of these structures can be used for basking if the seal comes out of the structure to bask on top of the snow (Fig. 3). When a structure was found, its location was recorded using GPS, it was measured, and the structure number was written on a wooden stake placed nearby. Water depth at each structure was also measured and recorded. Depending on the type of structure and its status it may have been instrumented (e.g., temperature probe, light sensor, and motion-activated camera).

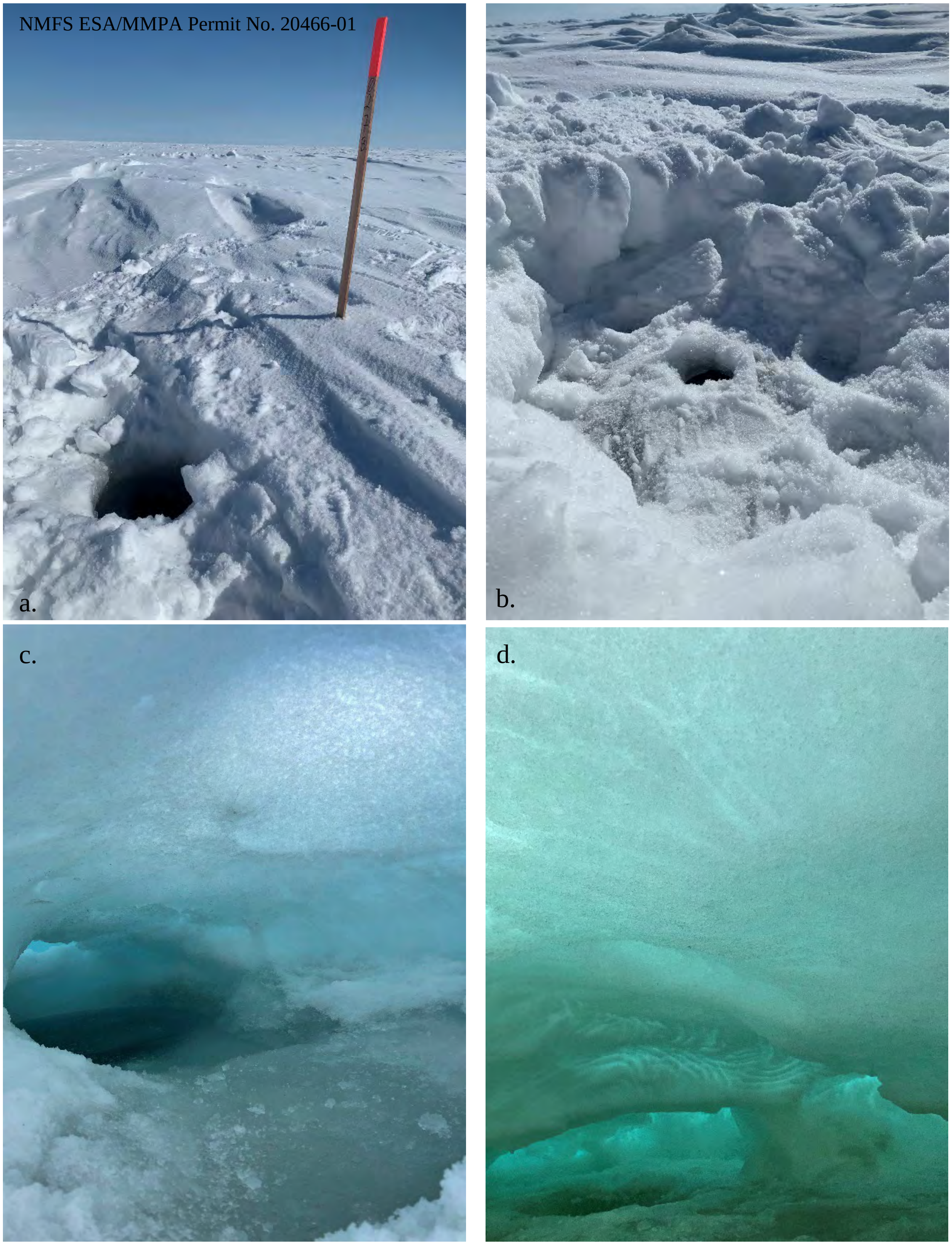



*Figure 2. Seal structures included breathing holes open at the snow surface (a), and beneath the snow (b); haul-out lairs built in snow drifts on top of sea ice and within pressure ridges (c); and pupping lairs (d). Pupping lairs are haul-out lairs with evidence of a pup: small tunnels and chambers, shed lanugo (i.e., natal hair), and small seal claw scratch marks (d).*

*Figure 3. A ringed seal hauled out at a breathing hole in Prudhoe Bay, Alaska in May 2023.*

***Temperature Probes.*** Temperature probes manufactured by Onset™ (Bourne, MA, USA) were used to simultaneously record the temperature inside and outside of a lair (Fig. 4). An increase and subsequent decrease of inside temperature was used to identify when a seal hauled out in a lair.

***Light Sensors.*** Light sensors manufactured by Onset™ were used to record when light levels changed in a lair (Fig. 4). An increase in light level could indicate when a seal dug out of a lair to bask or when a predator entered the lair.

***Motion Activated Cameras.*** Motion activated cameras manufactured by Stealth Cam™ (Irving, TX, USA) were placed inside each lair (Fig. 4) and at some breathing holes (Fig. 5). Cameras were pointed toward the access hole to document seals hauling out and seals breathing at the hole without hauling out.


*Figure 4. Instruments deployed in seal lairs (from left to right: camera, temperature sensor (black wire protruding through ceiling), and light sensor).*

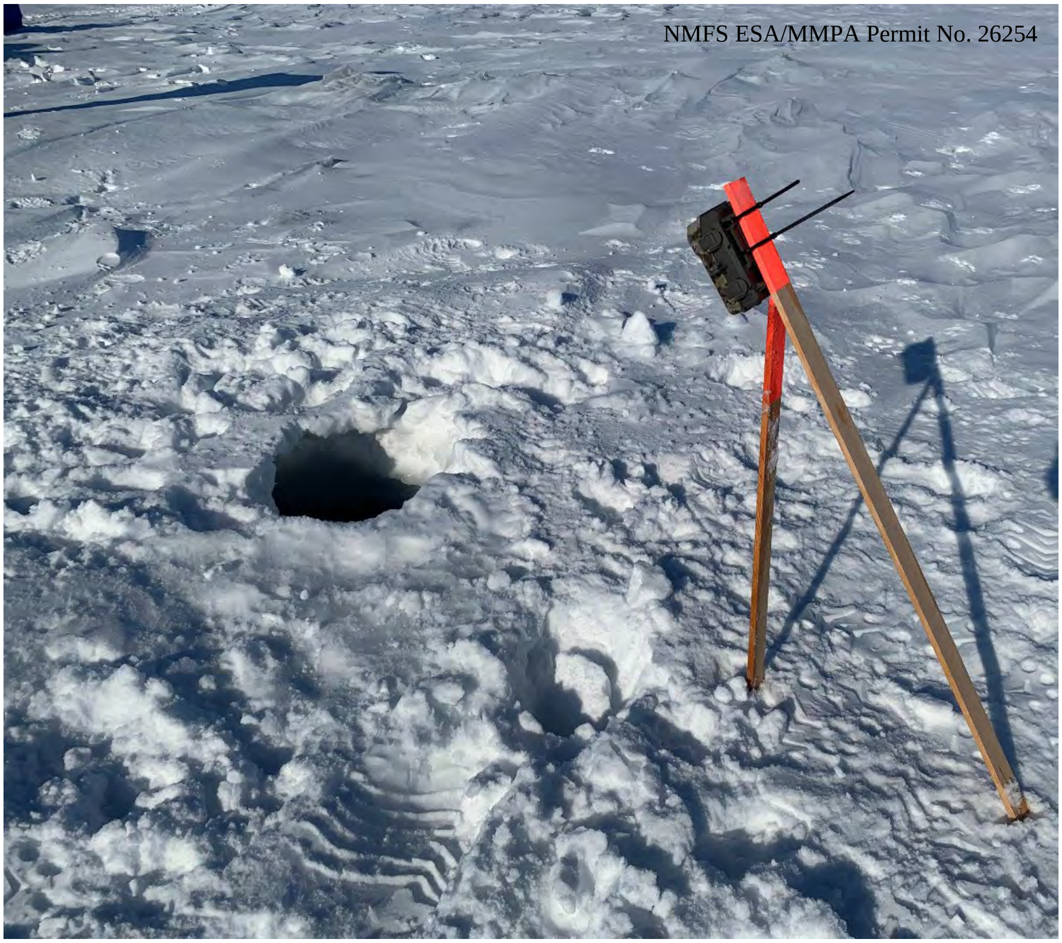



*Figure 5. Motion-activated camera deployed at a breathing hole (opened by the seal for basking) to assess ringed seal use.*

***Weather Station.*** Meteorological data are available at the Seawater Treatment Plant (STP), which is within our study area; however, the station is on the top of a six-story building on top of a causeway and the wind speed, wind direction, and temperature are often different than the weather encountered during surveys on the sea ice in our study area. Therefore, we deployed a meteorological (MET) station, manufactured by Onset™, on the sea ice in our study area (Fig. 6).

**Mapping**

We produced maps of the locations of seal structures for analysis and reports for BOEM, BLM, Hilcorp Alaska, LLC, and NSB. ArcGIS version 10.8 (ESRI 2020) was used for all mapping.

*Figure 6. Meteorological (MET) station deployed on the sea ice in our study area. Data were downloaded from the MET station onto a laptop computer weekly.*

### Safety

We purchase, own, and maintain safety equipment and train participants in its use. Safety equipment includes personal satellite-linked locator beacons (Garmin InReach™) and GPS units. A daily safety plan is made with a shore base prior to each trip onto the sea ice. Our crew checks in with the base if any changes in the daily plan occur and closes the safety plan upon return.

## Results

### Coordination

***Meetings, communication, and training.*** We communicated with Hilcorp regarding housing, meals, and safety training to work in the Prudhoe Bay area. We completed training provided by the North Slope Training Cooperative (NSTC) and Alaska Safety Alliance and wildlife and environmental training provided by Hilcorp to operate unescorted in the Prudhoe Bay area. We also completed firearms safety and proficiency training required and conducted by ADF&G to carry firearms for polar bear protection. Prior to field work, we informed the Ice Seal Committee, the NSB, BLM, and NOAA about this project. Activities for the first and second year of this study, beginning in September 2021, are summarized in Table 1.

Table 1. Project history from September 2021 through September 2023.

| Month | Year | Event |
|---|---|---|
| September | 2021 | Received grant award. |
| October | | Post award meeting with BOEM.<br>Submitted post award meeting summary to BOEM.<br>Submitted application to NMFS for new seal research permit to replace #20466. |
| November | | Met with Hilcorp regarding project support and NSTC safety training. |
| December | | Met with Hilcorp Wildlife Support Staff to register for training. |
| January | 2022 | Submitted Quarterly Report to BOEM.<br>NSTC training. |
| February | | ADF&G firearms training and proficiency testing in Anchorage.<br>Researched and purchased instruments; temperature sensors, light sensors, and motion detection cameras. |
| March | | Procured field supplies. |
| April | | Submitted and received an updated Animal Care and Use Committee Assurance of Animal Care protocol (ADF&G ACUC #0027-2022-40).<br>Met with Hilcorp to plan fieldwork logistics.<br>Submitted Fieldwork Plan and Quarterly Report to BOEM.<br>Met with NMFS permit office regarding new seal research permit. |
| May | | Conducted fieldwork. |
| June | | Preliminary field report to BOEM, BLM, Hilcorp, and NSB<br>Presented preliminary results to Hilcorp in online meeting. |
| July-August | | Submitted Quarterly Report to BOEM.<br>Responded to questions from NMFS regarding research permit application.<br>Submitted and received an extension for our current ice seal research permit #20466-01. This will extend our permit for a year or until the new permit is issued. |
| September | | Prepared Annual Report to BOEM. |
| October | | Submitted Annual Report to BOEM.<br>ADF&G firearms training and proficiency testing in Fairbanks.<br>Submitted abstract to AMSS for oral presentation. |
| November | | Analyzed data. |
| December | | Prepared oral and video presentations for AMSS (Abstract in Appendix A). |
| January | 2023 | Presented oral and video presentation at AMSS. |
| February | | Tested instruments; temperature sensors, light sensors, and motion detection cameras. |
| March | | Presentation to the Ice Seal Committee |
| April | | Submitted and received an updated Animal Care and Use Committee Assurance of Animal Care protocol (ADF&G ACUC #0027-2023-0025).<br>Submitted Fieldwork Plan and Quarterly Report to BOEM. |
| May | | Received new seal research permit #26254, expires 15 May 2028.<br>Conducted fieldwork. |
| July | | Submitted Quarterly Report to BOEM. |
| August | | Reviewed photos from cameras on breathing holes. |
| September | | Prepared Annual Report to BOEM |

***Website.*** A webpage on the State of Alaska, Division of Wildlife Conservation website has been created for this project (see link below).

Winter Ringed Seal Density, Alaska Department of Fish and Game

## Dog Searches

Dog searches occurred on 11 days in April and May and covered an 88.2 $km^2$ area in which 73 ringed seal structures were found, resulting in a seal structure density of 0.83 structures/$km^2$. Survey routes averaged 11 km/day (range: 6–18) and covered a total of 126 km. Wind direction and speed measured at our MET station was variable during the searches. Wind speed ranged from 0 to 32.6 km/hr with predominant directions of northeast (45°) and west (277°) (Fig. 7).

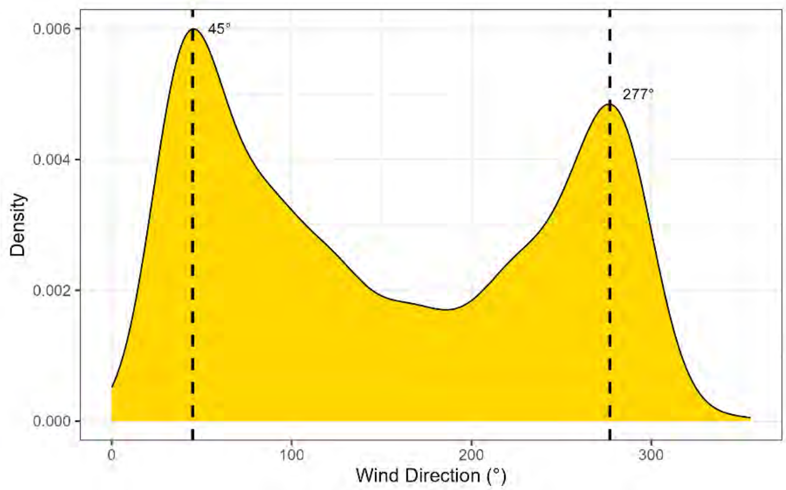



*Figure 7. Predominant wind directions during dog searches for ringed seal structures.*

## Seal Structures

Information for all seal structures found in 2023 is included in Table 2. Only breathing holes were used for basking during our study period (Table 2). Hole diameter, snow depth, and water depth were generally greater for haul-out lairs than for breathing holes (Table 3). In 2023, three structures were identified from afar by the presence of a basking seal and not approached or measured because the warm conditions made travel to them difficult. Therefore, we estimated their location and documented their structure type as “unknown”. For seven breathing holes and two lairs, the holes (called aglus) were covered with an ice dome formed by water splashing up when the hole is used for breathing (Fig. 8).; therefore, we did not measure the hole diameter in those structures.

Table 2. Ringed seal structures found in 2023 by structure type, covariates, and instrumentation deployed.

| Structure ID | Structure type | Date found | Hole dia. (cm) | Snow depth (cm) | Water depth (m) | Structure length if lair (cm) | Instruments* |
|---|---|---|---|---|---|---|---|
| 001B23 | Breathing hole | 4/29/2023 | 10 | 36 | 5.4 | | |
| 002H23 | Haul-out lair | 4/29/2023 | 38 | 75 | 7.4 | 47 | T, L, C |
| 003B23 | Breathing hole | 4/29/2023 | 30 | 35 | 8.5 | | |
| 004B23 | Breathing hole | 5/3/2023 | 29 | 63 | 9.5 | | |
| 005B23 | Breathing hole | 5/3/2023 | 16 | 55 | 9 | | |
| 006B23 | Breathing hole | 5/3/2023 | 34 | 45 | 9 | | |
| 007B23 | Breathing hole | 5/4/2023 | 49 | 32 | 9.5 | | C |
| 008B23 | Breathing hole | 5/4/2023 | 39 | 45 | 10.5 | | |
| 009B23 | Breathing hole | 5/4/2023 | 35 | 47 | 9.5 | | |
| 010B23 | Breathing hole | 5/4/2023 | 26 | 60 | 9 | | |
| 011H23 | Haul-out lair | 5/4/2023 | 45 | 50 | 8.5 | 122 | T, L, C |
| 012B23 | Breathing hole | 5/4/2023 | 48 | 37 | 9.5 | | C |
| 013B23 | Breathing hole | 5/6/2023 | 44 | 41 | 8 | | C |
| 014B23 | Breathing hole | 5/6/2023 | -- | 26 | 8 | | |
| 015B23 | Breathing hole | 5/6/2023 | 18 | 65 | 8.5 | | |
| 016B23 | Breathing hole | 5/6/2023 | 35 | 40 | 6 | | C |
| 017B23 | Breathing hole | 5/6/2023 | -- | 30 | 5 | | |
| 018H23 | Haul-out lair | 5/6/2023 | 24 | 42 | 5 | 122 | T, L, C |
| 019B23 | Breathing hole | 5/7/2023 | 48 | 23 | 6 | | C |
| 020B23 | Breathing hole | 5/7/2023 | 34 | 33 | 7 | | |
| 021B23 | Breathing hole | 5/7/2023 | 20 | 65 | 8.5 | | |

| Structure ID | Structure type | Date found | Hole dia. (cm) | Snow depth (cm) | Water depth (m) | Structure length if lair (cm) | Instruments* |
|---|---|---|---|---|---|---|---|
| 022B23 | Breathing hole | 5/7/2023 | 28 | 92 | 8.5 | | |
| 023B23 | Breathing hole | 5/7/2023 | 21 | 76 | 8.5 | | |
| 024H23 | Haul-out lair | 5/7/2023 | | 58 | | | |
| 025B23 | Breathing hole | 5/7/2023 | 21 | 70 | 9 | | |
| 026B23 | Breathing hole | 5/7/2023 | 18 | 62 | 9 | | |
| 027B23 | Breathing hole | 5/7/2023 | 20 | 65 | 9 | | |
| 028B23 | Breathing hole | 5/7/2023 | 18 | 65 | 9 | | |
| 029H23 | Haul-out lair | 5/7/2023 | 15 | 66 | 9 | 142 | |
| 030B23 | Breathing hole | 5/7/2023 | | 60 | 9 | | |
| 031H23 | Haul-out lair | 5/7/2023 | 31 | 68 | 9 | 103 | |
| 032B23 | Breathing hole | 5/10/2023 | 39 | 21 | 2 | | C |
| 033H23 | Haul-out lair | 5/10/2023 | 50 | 52 | 3 | 109 | C |
| 034B23 | Breathing hole | 5/10/2023 | | 40 | 4 | | |
| 035B23 | Breathing hole | 5/10/2023 | | 36 | 4 | | |
| 036H23 | Haul-out lair | 5/11/2023 | | 40 | | | |
| 037B23 | Breathing hole | 5/11/2023 | 40 | 30 | 6.5 | | C |
| 038B23 | Breathing hole | 5/13/2023 | 30 | 40 | 9.5 | | |
| 039B23 | Breathing hole | 5/13/2023 | 40 | 55 | 11 | | |
| 040B23 | Breathing hole | 5/13/2023 | | 35 | 11 | | |
| 041B23 | Breathing hole | 5/13/2023 | 33 | 20 | 11 | | C |
| 042B23 | Breathing hole | 5/13/2023 | 40 | 46 | 9 | | C |
| 043P23 | Pupping lair | 5/13/2023 | 42 | 70 | 10 | 201 | T, L, C |

| Structure ID | Structure type | Date found | Hole dia. (cm) | Snow depth (cm) | Water depth (m) | Structure length if lair (cm) | Instruments* |
|---|---|---|---|---|---|---|---|
| 044B23 | Breathing hole | 5/13/2023 | 31 | 33 | 9 | | |
| 045B23 | Breathing hole | 5/18/2023 | 36 | 38 | 4 | | |
| 046B23 | Breathing hole | 5/18/2023 | 41 | 30 | 5 | | |
| 047H23 | Haul-out lair | 5/18/2023 | 50 | 45 | 4 | 116 | |
| 048B23 | Breathing hole | 5/18/2023 | 43 | 42 | 2.5 | | |
| 049B23 | Breathing hole | 5/18/2023 | | 30 | | | |
| 050B23 | Breathing hole | 5/18/2023 | 36 | 16 | 2 | | |
| 051B23 | Breathing hole | 5/18/2023 | 43 | 44 | 2.5 | | |
| 052B23 | Breathing hole | 5/18/2023 | 56 | 18 | 7 | | |
| 053B23 | Breathing hole | 5/18/2023 | 50 | 10 | 6 | | |
| 054B23 | Breathing hole | 5/19/2023 | 37 | 24 | 2.5 | | |
| 055B23 | Breathing hole | 5/19/2023 | 37 | 29 | 3 | | |
| 056B23 | Breathing hole | 5/19/2023 | 40 | 64 | 6 | | |
| 057B23 | Breathing hole | 5/19/2023 | 34 | 41 | 6 | | |
| 058B23 | Breathing hole | 5/19/2023 | 34 | 29 | 6.5 | | |
| 059B23 | Breathing hole | 5/19/2023 | 35 | 38 | 7.5 | | |
| 060B23 | Breathing hole | 5/19/2023 | 33 | 28 | 7.5 | | |
| 061B23 | Breathing hole | 5/19/2023 | 32 | 29 | 7.5 | | |
| 062B23 | Breathing hole | 5/19/2023 | 40 | 20 | 9 | | |
| 063B23 | Breathing hole | 5/19/2023 | 44 | 30 | 8 | | |
| 064B23 | Breathing hole | 5/19/2023 | 37 | 14 | 9 | | |
| 065B23 | Breathing hole | 5/19/2023 | 40 | 37 | 8.5 | | |

| Structure ID | Structure type | Date found | Hole dia. (cm) | Snow depth (cm) | Water depth (m) | Structure length if lair (cm) | Instruments* |
|---|---|---|---|---|---|---|---|
| 066B23 | Breathing hole | 5/19/2023 | 42 | 31 | 7 | | |
| 067B23 | Breathing hole | 5/19/2023 | 37 | 34 | 6 | | |
| 068U23 | Unknown | 5/19/2023 | | | | | |
| 069U23 | Unknown | 5/19/2023 | | | | | |
| 070U23 | Unknown | 5/19/2023 | | | | | |
| 071B23 | Breathing hole | 5/20/2023 | 47 | 33 | 6 | | |
| 072B23 | Breathing hole | 5/20/2023 | 44 | 25 | 5.5 | | |
| 073B23 | Breathing hole | 5/20/2023 | 36 | 30 | 6 | | |

* Instruments: T: Temperature sensor, L: Light sensor, C: Camera

Table 3. Summary of all 2023 structures by structure type.

| Structure type | N (n used for basking) | Hole diameter: (mean and range) in cm | Snow depth: (mean and range) in cm | Water T (mean and range) in ℃ | Water depth mean and range (m) |
|---|---|---|---|---|---|
| Breathing holes | 60 (31) | 34.9 (10–56) | 39.8 (10–92) | -2.2 (-2.6– -1.9) | 7.2 (2–11) |
| Haul-out lair | 9 (2) | 36.1 (15–50) | 55.1 (40–175) | -2.2 (-2.5– -2.1) | 6.6 (3–9) |
| Pupping lair | 1 (0) | 42 | 70 | -2.1 | 10 |
| Unknown | 3 (3) | * | * | * | * |

* = not measured


*Figure 8. A ringed seal breathing hole covered by ice formed by water splashing at the surface and freezing.  The seal can continue to breath under the splash dome, but little or none of the breathing hole may be open to the surface.*

Recent polar bear activity was detected in 2023 at three lairs and 10 breathing holes, most of which were close together along a northeast-southwest crack in the sea ice in the northeast portion of our study area (Fig. 9; i.e., southwest of Reindeer I.). Tracks from at least three polar bears investigating ringed seal structures along this crack were observed (Figs. 10 and 11).

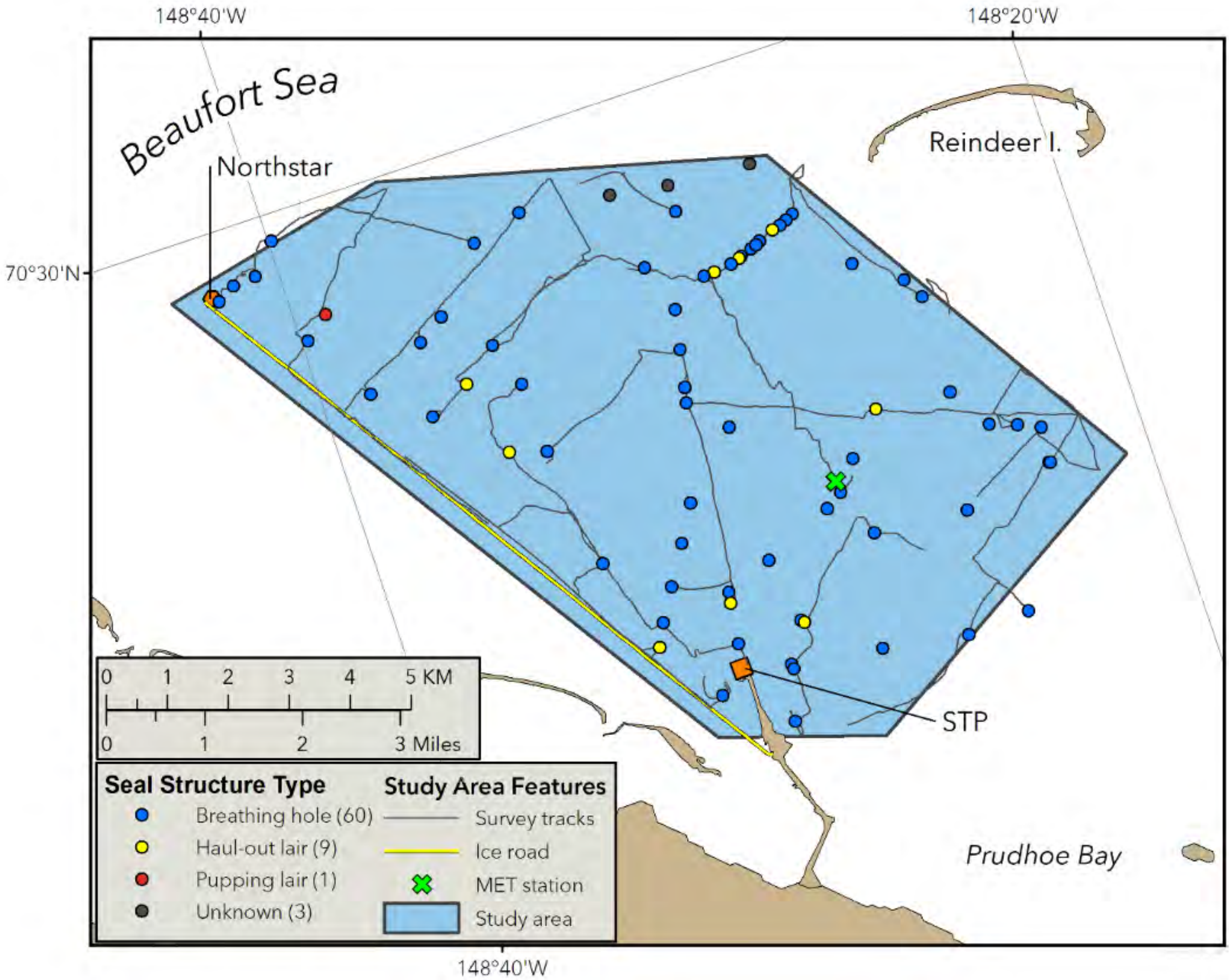


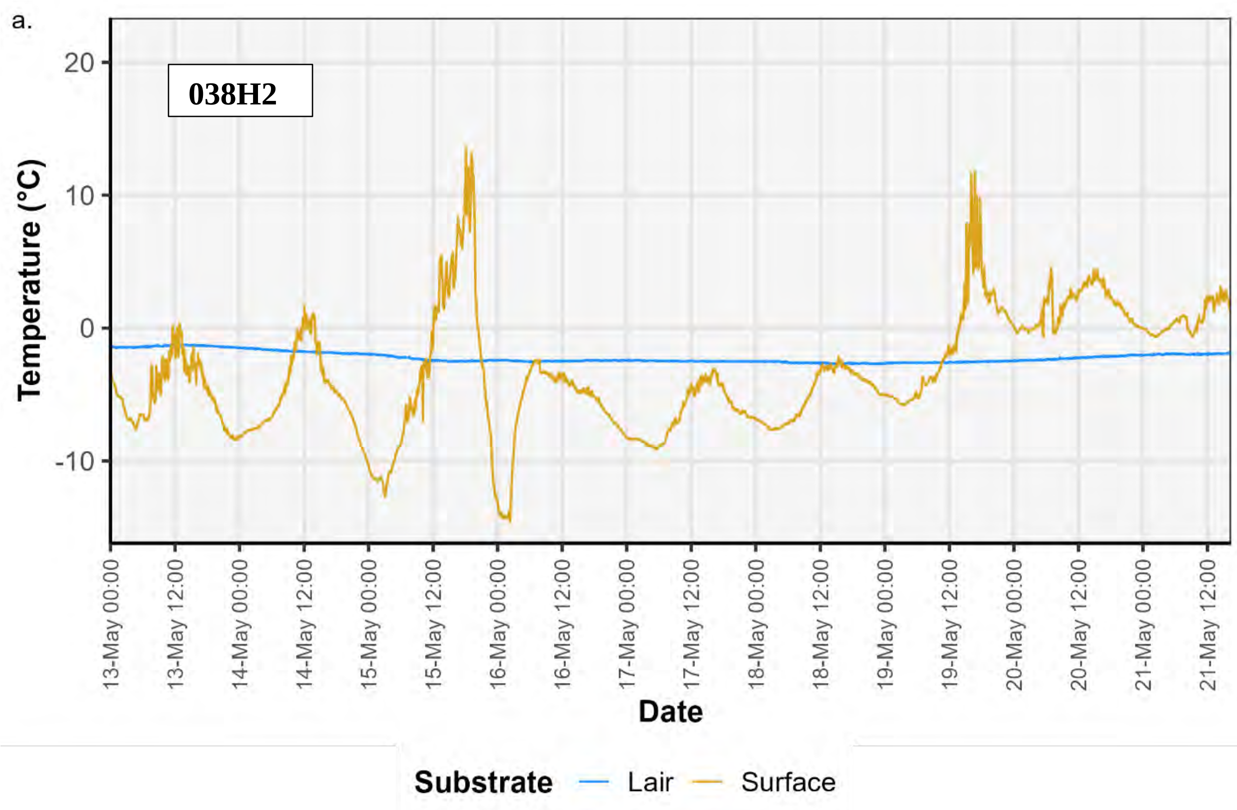

*Figure 9. Map of ringed seal winter density study area boundary in the Beaufort Sea Planning Area with locations and type of 73 seal structures and routes taken by dogs to find the structures in May 2023.*


*Figure 10. A ringed seal haul-out lair (029H23) entered by a polar bear.*

*Figure 11. A polar bear track in the ringed seal study area in 2023.*

## Seal behavior in lairs

***Temperature.*** Outside temperature fluctuates with higher day and lower night temperatures, while inside of lairs temperature does not fluctuate because the sea water below provides a steady input of approximately -2°C and the snow on top, when sufficiently deep, insulates the lair from surface temperatures (Fig. 12a). When a seal hauls out in the lair, its body temperature warms it quickly and when the seal leaves the lair the temperature decreases more gradually (Fig. 12b). Therefore, we can use temperature sensors inside and outside (at the snow surface) of lairs to document haul-out bouts (Kelly and Quakenbush 1990). Small and short increases in temperature were observed in the temperature record for some lairs in 2022 and likely represent a seal spending some time breathing in the access hole, without hauling out (Fig. 12c).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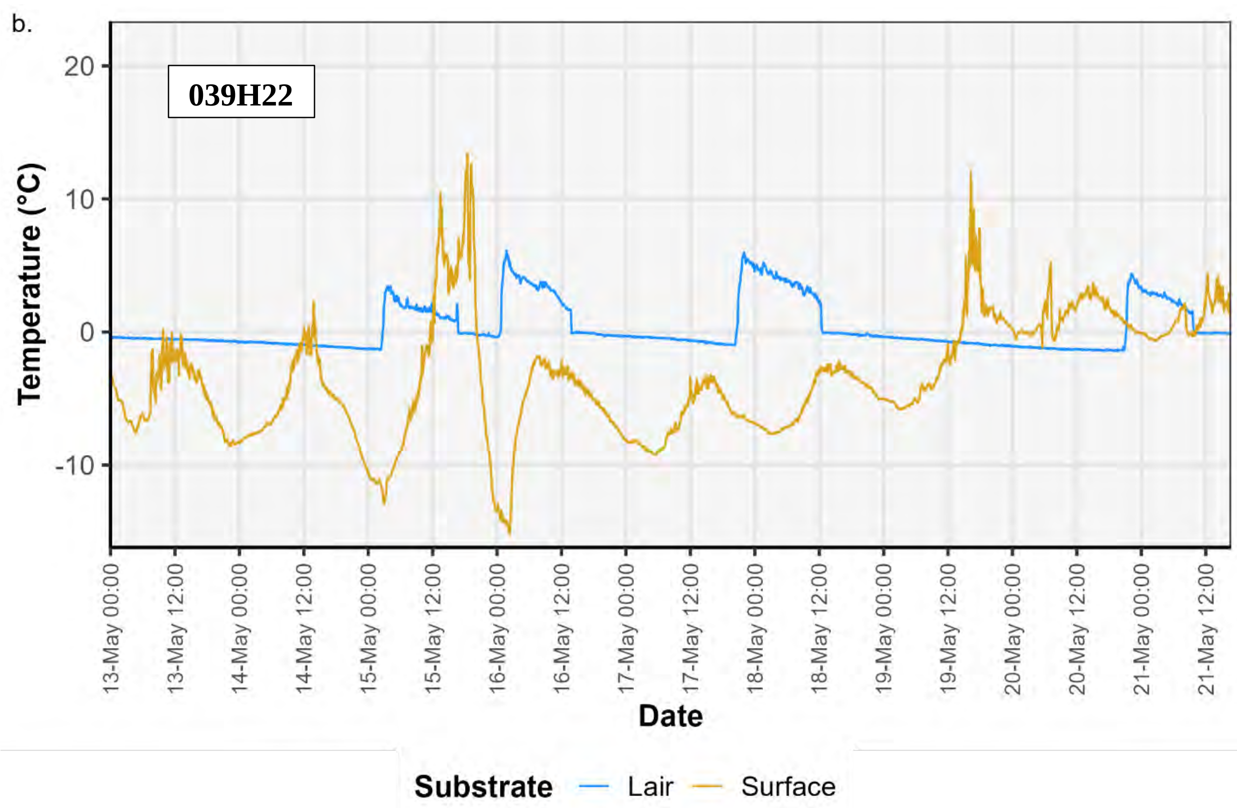
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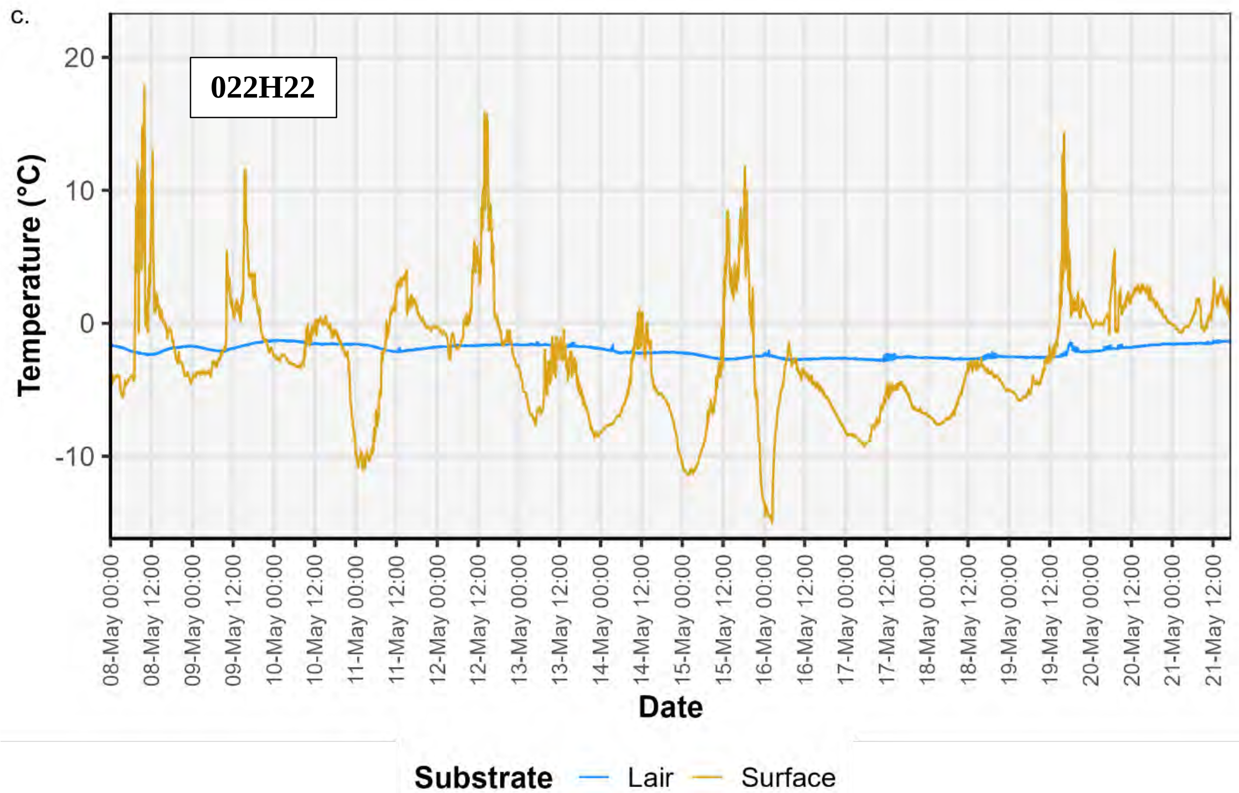
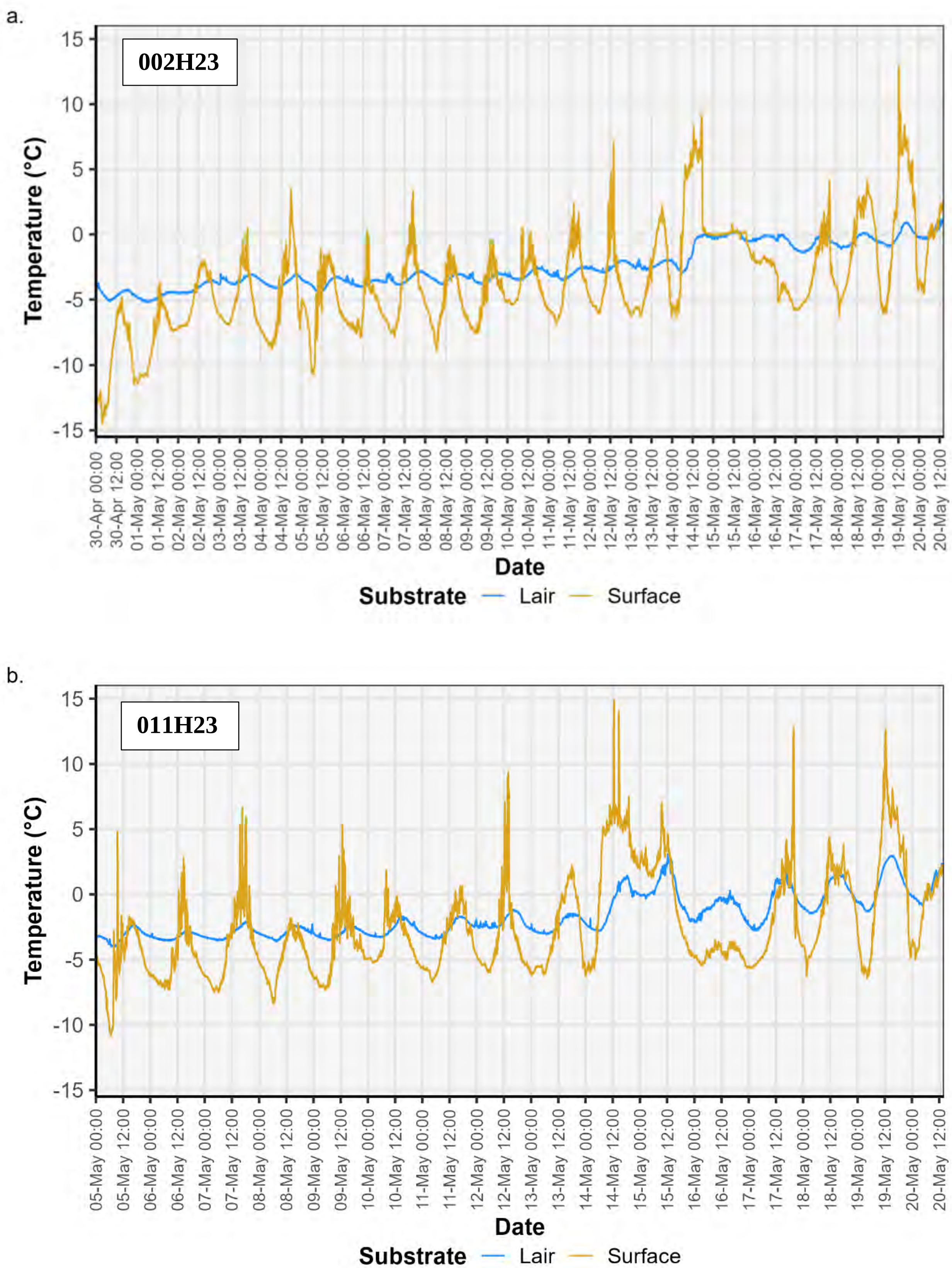


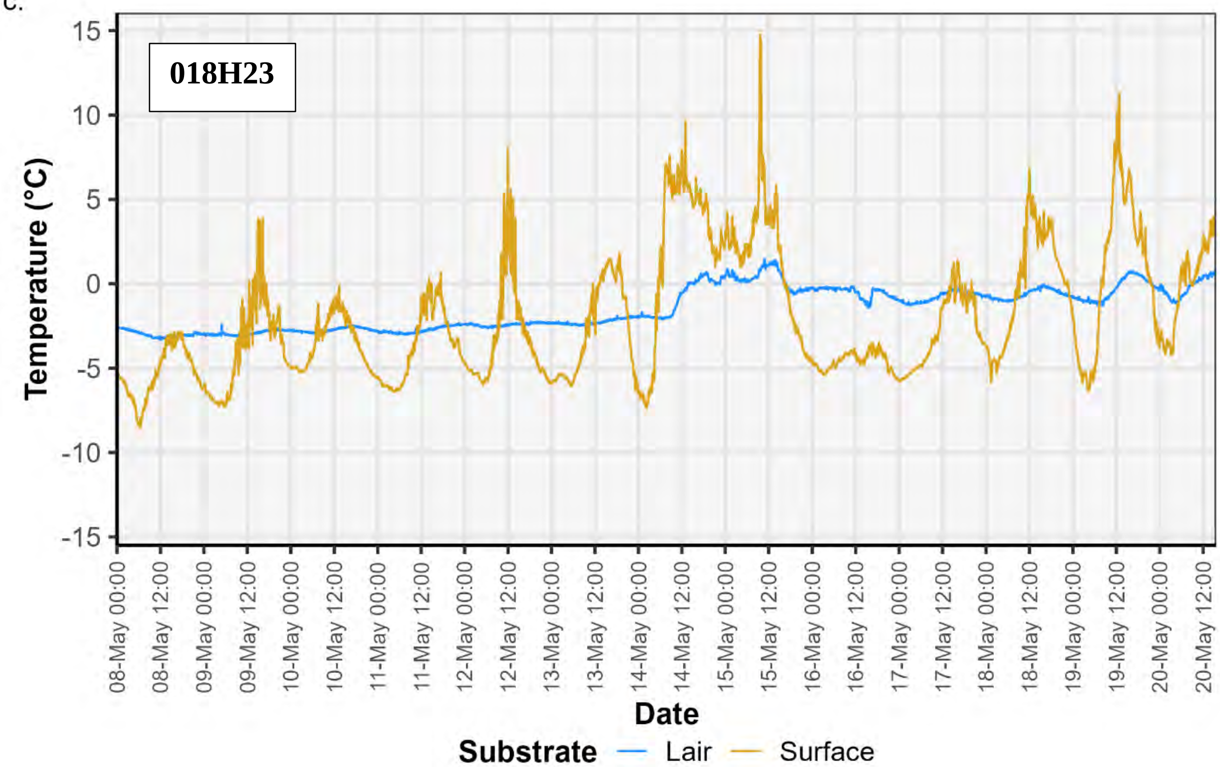

*Figure 12. Temperature records from inside (blue) and outside (at the snow surface, gold) three lairs instrumented in 2022. No haul-out bouts were detected in lair 038H22 (a). Increases and decreases in inside lair temperature (blue) mark the start and end of four haul out bouts in lair 039H22 (b). Small and short increases in temperature mark the use of access holes for resting without hauling out in lair 022H22 (c).*

Temperature sensors in four haul-out lairs in 2023 did not detect any haul-out bouts (Fig. 13). In three of the four lairs (002H23, 011H23, and 018H23), lair temperatures fluctuated similarly to the air temperature, but with less intensity (Fig. 13 a–c). Lair temperatures in these same three lairs increased with air temperature, reaching highs around 12:00 on 14-May. This warming event occurred during a 36-hour period where the ambient temperature rose from -6.3 to 6.3 °C according to our MET station (Fig. 14). The subsequent increases in lair temperatures were not the result of seals resting in the lairs. During this warming event, the maximum lair temperature reached at least 0 °C in these three lairs. In 2022, temperatures recorded during known haul-outs were higher at ~ 4–5 °C (e.g., Fig. 12b). In the fourth lair (043P23), lair temperature did not fluctuate with ambient temperature and there was only a slight increase in lair temperature during the 14-May warming event (Fig. 13d).

The cyclic fluctuations in lair temperature and large increase during the warm event may have been partly due to shallower snow cover above the lairs (i.e., ceiling thickness) allowing some heat transfer through the snow cover. However, ceiling thickness alone did not explain this. Lair 018H23 had the lowest ceiling thickness at 42 cm followed by 011H23 at 50 cm, and 002H23 at 75 cm. Lair 043P23, which did not show a response to the warm event had a ceiling thickness of 70 cm (Table 2).


a.
002H23
Temperature (°C)
Date
Substrate Lair Surface
b.
011H23
Temperature (°C)
Date
Substrate Lair Surface

c.




d.

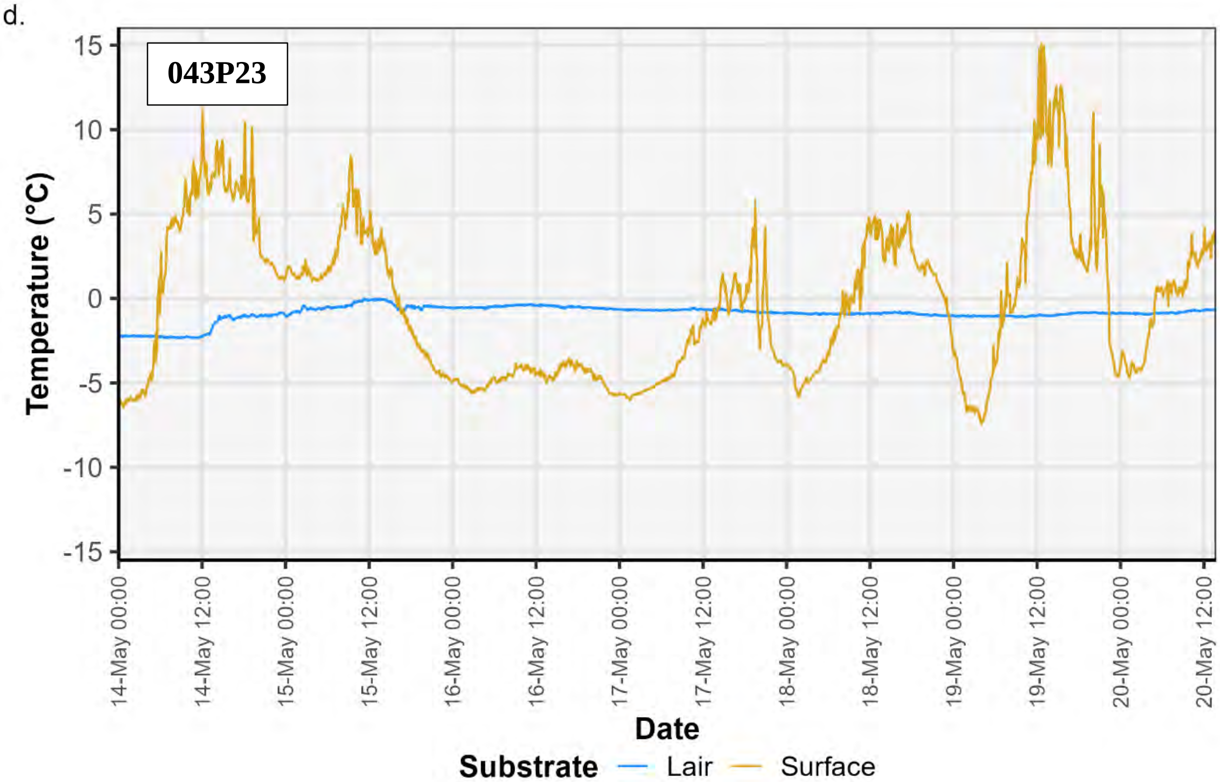



*Figure 13. Temperature records from inside (blue) and outside (gold) four lairs in 2023; 002H23 (a), 011H23 (b), 018H23 (c), and 043P23 (d). No haul-outs were detected in any lair.*

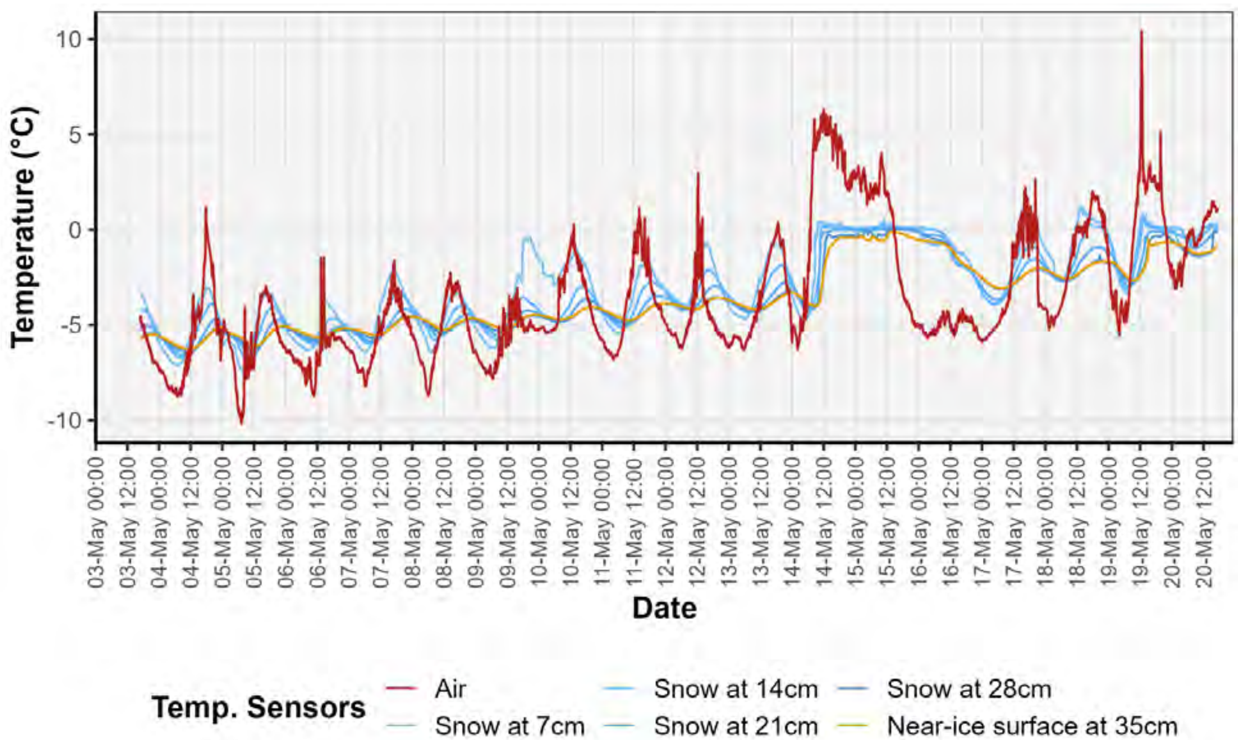



*Figure 14. Temperature records in air and snow from the weather (i.e., MET) station between 3 and 20 May 2023 in the study area and showing the extended warming event on 14–15 May.*

***Light Sensors.*** All light sensors recorded consistently low light penetration; none recorded an increase that would indicate the collapse of the lair roof either by predation, the seal digging out to bask, or melting of the roof due to warm outside air temperatures. However, in 2023, the light data had the same daily cyclic pattern as the lair temperature data, possibly indicating that the quality of the snow was different in 2023 than in 2022 when we did not observe such fluctuations.

***Motion Activated Cameras.*** Cameras in lairs documented seals hauled out and seals resting and breathing in the access hole without hauling out. In 2023, cameras were deployed in four lairs, three of which detected seal activities. Lair 043P23, a pupping lair did not have any activity. Preliminary photo analysis of lair 002H23 indicated one short haul-out lasting 13 min, which was not detected by the lair temperature sensor. Four bouts, lasting at least 15 min (average 65 min; range: 15–110 min), of seals resting in the access hole were also detected. A camera in lair 011H23 also documented two bouts of a seal resting in the access hole; each bout lasted 32 min. Seals were also documented breathing in the access holes of lairs 002H23 and 011H23, these breathing bouts lasted from 30 sec to 10 min at a time. A single 30 sec breathing bout was detected in lair 018H23.

A camera was also placed at the access hole of a lair that had been previously opened to the surface (033H23) by a seal. Seal activity at this structure included breathing at the surface and hauling out (basking) on four different days.

Preliminary analysis of cameras deployed at nine breathing holes, all of which had been opened for basking, documented seal activity (Fig. 15). Activities included basking (Fig. 15a), breathing, and resting in the breathing hole, and two seals at the same hole (Fig. 15b). Seals were observed breathing and resting in holes from 30 sec up to 166 min. Seals were documented basking at breathing holes for up to 16.25 hours.  Cameras also documented other species that visited the structures (Fig. 16 a–d).


*Figure 15. Stealth Cam™ photos of seal activity at breathing holes opened for basking, including a ringed seal basking at a breathing hole (a), and two different ringed seals interacting at a breathing hole (b).*

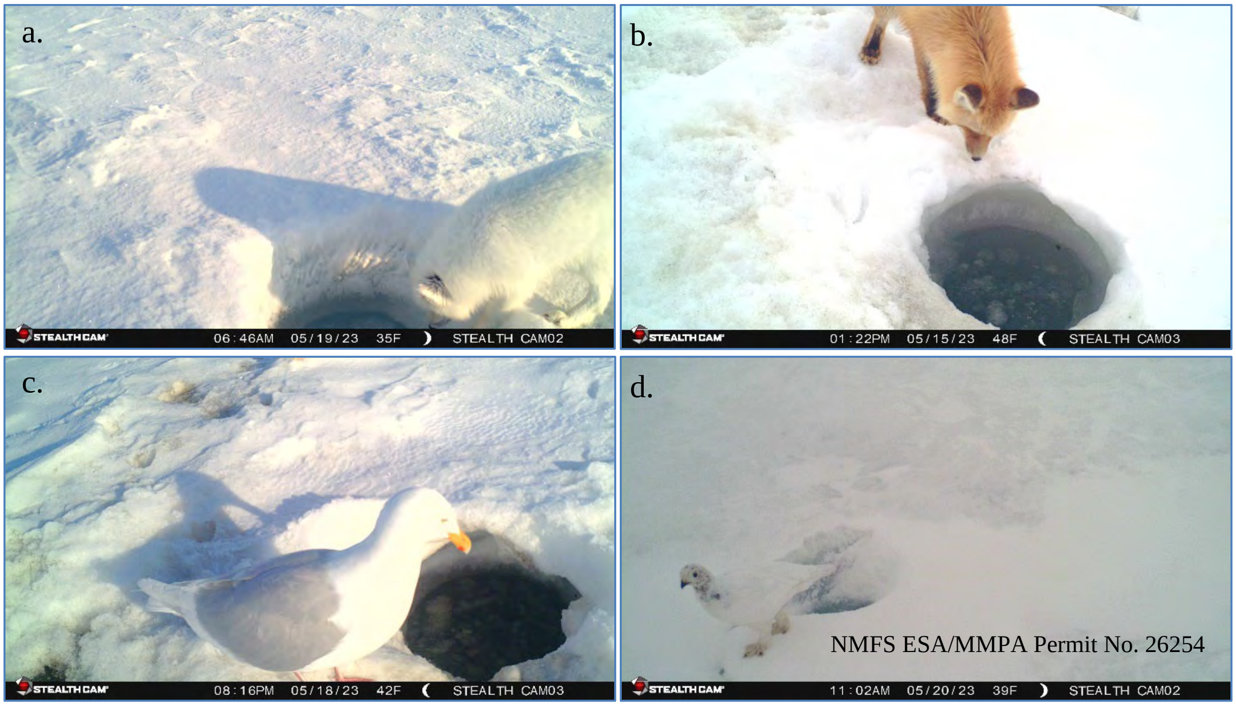



*Figure 16. Non-seal species captured on cameras deployed at ringed seal breathing holes opened for basking in 2023 included an arctic fox (a), a red fox (b), a gull (c), and a ptarmigan (d).*

**Accomplishment of Objectives**

***Overall Objective:*** The overall objective of this study is to document ringed seal distribution, density, and habitat use within the landfast ice zone of the nearshore Beaufort Sea that includes BOEM's Beaufort Sea Planning Area and existing North Slope oil and gas facilities to be used for informing and developing mitigation measures to minimize disturbance from industry activities.

During the 2023 field season we documented 73 ringed seals structures in an 88.2 $km^2$ area within the landfast ice zone of the nearshore Beaufort Sea that includes BOEM's Beaufort Sea Planning Area and existing North Slope oil and gas facilities. Some seal structures were found close to infrastructure (Fig. 9) and at water depths ranging from 2–11 m (Fig. 17).

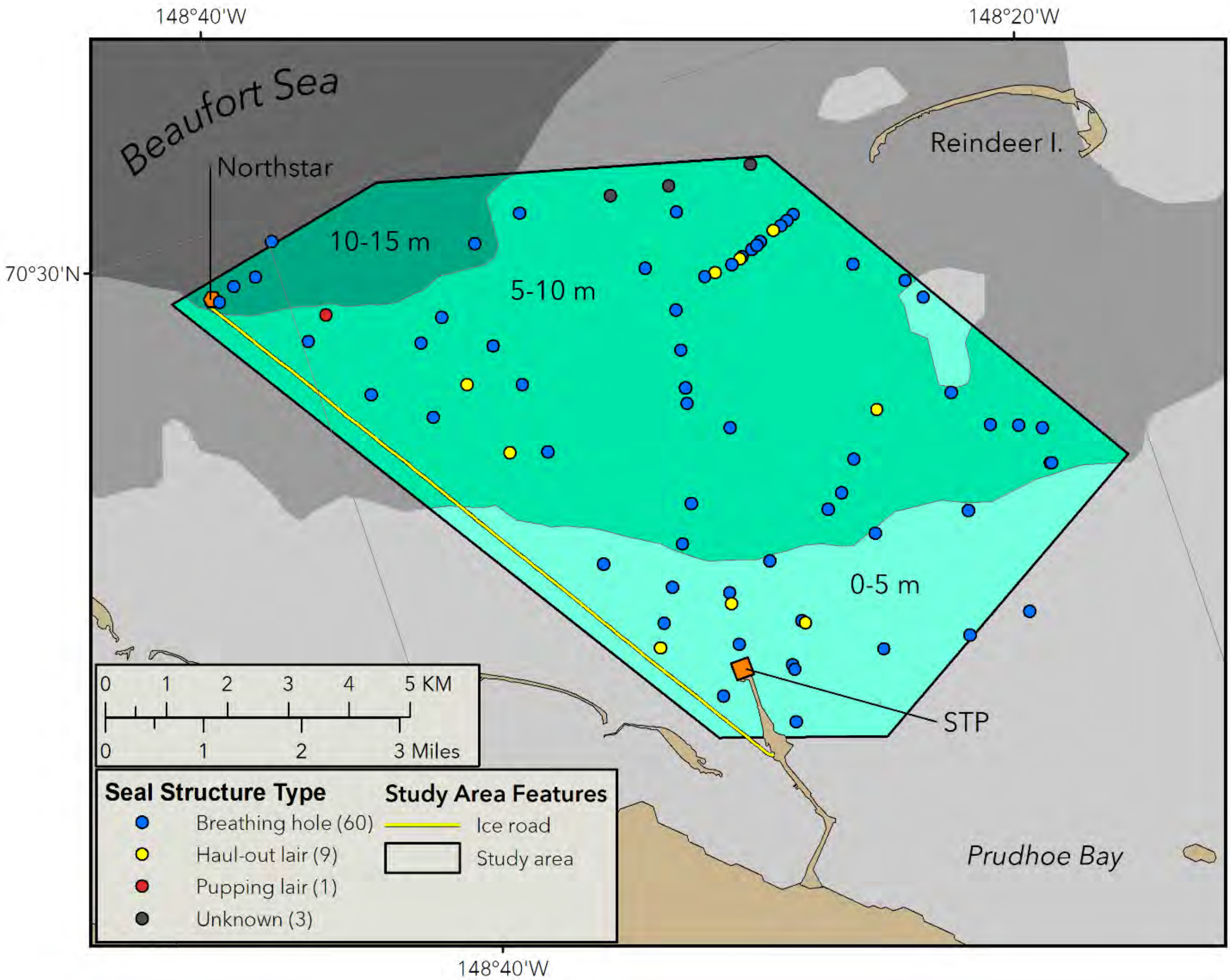



*Figure 17. Locations and type of seal structures relative to water depth.*

***Objective 1:*** Analyze nearshore ice use by ringed seals by locating and documenting status of wintering seals and their structures to develop avoidance strategies where ringed seal habitat overlaps with North Slope oil and gas activities.

Ringed seal structures were common throughout the nearshore sea ice area used by North Slope oil and gas activities. Some structures were found close to infrastructure where industrial activity occurred regularly, indicating that some seals are tolerant of such activity. A seal breathing hole was found in nearly the same location in both 2022 (013B22) and 2023 (038B23) at 19 m from the southeast corner of Northstar Island, an oil production facility that is actively drilling (Figs. 9 and 18). In 2023, a seal was reported by oil workers hauling out almost daily on the east side of the bridge on the causeway leading to STP, south of our study area. This seal began hauling out prior to our arrival and continued through the duration of our field season.


*Figure 18. Ringed seal breathing holes located 19 m southeast of Northstar. Structure 013B22 in 2022 (a) and 038B23 in 2023 (b). Photo credit: C. Perham, BLM).*

***Objective 2:*** Utilize novel survey technology to expand capabilities to facilitate research on the habitat of ringed seals to improve understanding of ringed seal movements.

Although dogs have been used by indigenous hunters to find seal holes (e.g., Nelson 1969) and thus may not be considered novel, dogs are the most reliable method available for conducting research on winter ringed seal habitat. Dogs can survey large areas in a single day (~25 km) and can detect breathing holes and lairs up to 3 km away. They can also detect old breathing holes that are frozen and no longer active. Understanding individual ringed seal movements requires satellite or VHF tracking devices placed on live-captured ringed seals. Capture efforts are expensive, time consuming, and cause disturbance to the study area, especially at the structures in which captures occur. It is unclear how capture activities influence the movements of seals within the area of interest.

The use of drones would expand our capability to study ringed seal density and habitat during the basking and snow melt season. Most drones are currently not allowed by the Department of Interior due to security concerns. We were unable to fly a traditional aerial survey with a single engine airplane during the peak of basking this year due to low ceilings in late May and scheduling conflicts with aircraft availability. Having a drone and pilot on site would allow us to take advantage of brief good weather windows during basking. We had several discussions with drone pilots; however, many operate drones that are not allowed by the Department of Interior and others were restricted by line of sight and ground operation requirements that greatly reduce flight distances, such that coverage of the study area would not be sufficient. Getting a count of the minimum number of seals and breathing holes in the study area to compare with the number of structures found would provide useful comparisons.

***Objective 3:*** Identify winter and spring seasonal movement patterns of adult ringed seals with an emphasis on detecting subnivean lair use in landfast ice in areas bounded by NPR-A, ANWR, and BOEM's Beaufort Sea Planning Area.

Winter and spring are seasons when adult ringed seals move minimally in landfast ice habitats. Adults set up their breeding territories in winter and pups are born and reared in spring. Mating occurs after pupping and is followed by molting, which occurs as the snow and landfast ice are melting. This study is focused on BOEM's Beaufort Sea Planning Area however, similar methods could be used in NPR-A and ANWR. Our current methods do not allow us to assess movements of individual seals during this period.

***Objective 4:*** Document ringed seal habitat use areas and local foraging behavior by classifying foraging locations and determine if oil and gas development activities create movement barriers for ringed seals to access prey.

In general, ringed seals in Alaska gain weight in fall and winter and lose weight in spring during pupping, lactating, mating, and molting (Quakenbush 2020). As mentioned above, ringed seals in landfast ice habitats make localized movements in winter and spring because they cannot range too far from their breathing holes; in summer and fall they make long-distance movements because they are no longer restricted by breathing hole locations (Crawford et al. 2012, 2019; Von Duyke et al. 2020). During winter and spring when ringed seals are located near oil and gas development activities, they are likely foraging locally in a relatively small area, mostly on invertebrates (amphipods). In May 2022 we often saw pelagic invertebrates floating in the seal holes (Fig. 19).

*Figure 19. Pelagic invertebrates, including* Gammaracanthus sp.*, were found floating in a seal breathing hole. Ringed seals are known to eat* Gammarus sp.*, but not* Gammaracanthus sp.*, during winter (Crawford et al. 2015).*

***Objective 5:*** Evaluate and compare the efficiencies of the proposed survey technologies with existing methods used to detect ringed seals, their breathing holes, and lairs.

Comparing the number of structures found by an aerial survey in late spring during basking to the number found in winter/spring by trained wildlife-detection dogs could be informative regarding the effectiveness of dogs. In addition, if the numbers are comparable, an aerial survey conducted when most seal holes are visible could be used to estimate seal hole density annually. We tried to conduct a survey in late May and early June 2022 and 2023 during the peak of basking, however low ceilings and aircraft availability prevented flights. More work needs to be done to assess how seal hole density relates to seal density.

**Other Activities:** Although not an objective of this study, we were able to collect under-ice water samples from seal holes for Dr. Krista Longnecker, a biochemist from Woods Hole Oceanographic Institute (WHOI). Longnecker studies how bacteria change the chemistry of the ocean. As part of a NASA-funded project Longnecker, and colleagues Dr. Samuel Laney (WHOI) and the late Dr. Stephen Okkonen (University of Alaska Fairbanks), use the water samples to quantify bacterial consumption of dissolved organic carbon found in the near-shore environment under the sea ice. In 2023, we provided 52 water samples, from 44 different seal holes for Longnecker's study. The data from these samples will improve estimates of the role of bacteria in geochemical cycling in the region.

## Discussion

Dogs were effective at finding ringed seal structures in deep snow and when seals were basking on the surface when winds were sufficient (i.e., > 5 kts). When winds are calm or variable it is more difficult to locate structures because scents do not broadcast far, therefore the effective survey width along each survey track is smaller.

Instruments were effective in recording weather conditions in the study area and documenting temperature, light, and behavior in lairs, and breathing holes, without disturbing seals. Temperature sensors capable of recording haul-out bouts did not detect any. However, cameras documented that one seal hauled out in a lair for 13 min and others spent up to 1.8 hrs resting and sleeping in lair access holes without hauling out. This behavior resulted in no change or subtle changes in the lair temperature that went unnoticed until we reviewed consecutive photos from the cameras. This extensive use of lair access holes has not been documented before this study and changes what we know about ringed seal use of lairs. Cameras outside of breathing holes opened for basking, identified seals hauled out (basking), seals resting in breathing holes, interactions between seals, and documented non-seal species investigating the holes. Ringed seal use of breathing holes and lair access holes for resting and sleeping suggests that the importance of lairs for hauling out and resting needs to be further investigated. The considerable use of lair access holes and breathing holes for resting in water, found during this study using cameras, has likely been underreported previously. Resting in the water in lair access holes and breathing holes may cost less energy in some circumstances than hauling out because seals do not heat their skin and extremities when resting in the water. Also, resting in access holes may provide a faster escape from predators. Regardless, lairs are still important for pupping and pup rearing.

We were not able to accomplish an aerial survey during peak basking or when seal holes were visible after snow melt in 2023 due to low ceilings and limited aircraft availability. A comparison of the number of holes counted in an aerial survey and the number found by dogs would be useful for developing ways to monitor structure and seal densities. If the numbers are comparable, it may be possible to monitor seal density by monitoring hole density using aerial survey methods.

## Acknowledgments

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## List of Appendices

Appendix A. Quakenbush, L., A. Bryan, and J. Crawford. 2023. Ringed seal behavior and winter density in Prudhoe Bay, Alaska, determined by wildlife-detection dogs and instrumentation of subnivean lairs. Alaska Marine Science Symposium, Anchorage, 23–27 (Abstract for oral presentation).

## List of Project Presentations

Oral presentation at AMSS January 2023.
Oral presentation to the Inuvialuit-Iñupiat (I-I) Polar Bear Commission, August 2023.

Appendix A.

# Ringed seal behavior and winter density in Prudhoe Bay, Alaska, determined by wildlife-detection dogs and instrumentation of subnivean lairs

Lori Quakenbush, Alaska Department of Fish and Game
Anna Bryan, Alaska Department of Fish and Game
Justin Crawford, Alaska Department of Fish and Game

In Alaska, ringed seals (*Pusa hispida*) are an important subsistence resource to coastal Alaska Natives, and important prey for polar bears (*Ursus maritimus*). Ringed seals create and maintain breathing holes through solid landfast sea ice up to 2 m thick allowing them to use habitat both on (hauling out for resting, basking, and molting) and under (access to fish and invertebrate prey) sea ice during the winter. Ringed seals also use subnivean lairs built in snow drifts on top of sea ice and within pressure ridges for resting and pupping. Ringed seals were listed as threatened under the U.S. Endangered Species Act in 2012 because predicted declines in sea ice and snow accumulation over the next century were expected to greatly reduce their numbers. In the Beaufort Sea, ringed seal use of landfast ice in winter and early spring overlaps with oil and gas activities (e.g., ice road and gravel island construction, and seismic and drilling operations). Ringed seals spend most of their time underwater and in lairs and are generally not visible from the ice surface, thus determining how many seals may be affected by oil and gas activities is difficult, but necessary, for attaining permits to conduct these activities. In May 2022, we used two trained wildlife-detection dogs to survey an area in Prudhoe Bay, near Northstar Island, that was previously studied in 1983. During this survey we found 61 ringed seal structures (47 breathing holes and 14 lairs) in an 88.2 $km^2$ area; a density of 0.68 structures/$km^2$. Fewer structures were identified in 1983 (43; 16 breathing holes and 27 lairs) in a 96.8 $km^2$ area; a density of 0.44 structures/$km^2$. Snow depths at lairs were similar between studies and averaged 76.9 cm (range 45–120 cm) in 2022 compared to 78.7 cm (range 45–130 cm) in 1983. Lairs (12 of 14) were instrumented with temperature sensors, light sensors, and cameras to record lair use. Temperature sensors detected 10 haul-out bouts in three lairs, however photographs revealed extensive use of access holes for resting without hauling out and with minimal and brief increases in lair temperature. Breathing holes were found in water as shallow as 2 m and active structures were found within 19.5 m of facilities and within an active ice road. Two different basking seals were observed to stay on the ice during the close passage of a hovercraft. This area will be surveyed again in 2023 for further comparison.

Abstract for Alaska Marine Science Symposium January 23–27, 2023.