

**FINAL NUNAVUT WILDLIFE RESEARCH TRUST REPORT
TO THE NUNAVUT WILDLIFE MANAGEMENT BOARD**

1. Project: NWRT-2023-0000000001

2. Project Title: Emerging Infectious Diseases in High Arctic Ungulates

3. Project Leader:

Amélie Roberto-Charron (High Arctic Biologist, Department of Environment, Government of Nunavut)

4. Summary:

Muskoxen are vital to the health and culture of communities in Nunavut. Increasing occurrence of zoonotic pathogens (pathogens that can be transmitted from wildlife to humans) in country food species, such as muskoxen, is causing direct (food safety) and indirect (food availability) health risks to those who rely on wildlife for food. Concerns have been voiced by the High Arctic communities of Resolute Bay and Grise Fiord about the health of their wildlife populations, and the availability and food safety of these species.

Concurrently, a major disease related die-off of muskoxen has been reported on Ellesmere Island serving to further highlight these concerns. Tracking the occurrence, effects, and trends of infectious diseases in species that are important sources of country food is fundamental for supporting food security in the High Arctic. This project aims to address these knowledge gaps and provide invaluable information on the outbreak of *Erysipelothrix rhusiopathia* on Ellesmere Island.

E. rhusiopathiae has caused declines in muskox populations in the western Arctic, on Victoria Island, Banks Island and Prince Patrick Island and has also been linked to mortalities in other species that were found during these outbreaks, including caribou, seal, and fox. The bacteria cause the sudden mortality of wildlife that it infects and may also impact the reproductive capacity of those infected as *E. rhusiopathiae* has been linked to abortions in captive livestock. Infection by *E. rhusiopathiae* can therefore be impacting wildlife doubly, directly through the loss of mature animals through infection and mortality as well as through reduced recruitment into the population. The impact of an outbreak, therefore, could be very significant on wildlife populations and have important impacts on the ecosystem, and on Inuit that rely on country food.

This project was a continuation of an ongoing wildlife health monitoring project that was launched in 2022 in response to the 2021 outbreak of *E. rhusiopathiae* observed near Eureka on the Fosheim Peninsula, Ellesmere Island. This outbreak is the northernmost reported outbreak of this bacterium and was previously unreported in the area. The work that was conducted in 2022 focused on identifying the extent of the outbreak and resulted in determining that the outbreak extended well beyond northern Fosheim Peninsula. Carcasses of infected muskox were found on central western Axel Heiberg approximately 90 km away from the area where the outbreak was first reported. Muskox

carcasses were found at the furthest most extent of the 2022 surveyed area, and therefore, questions arose on the magnitude of the outbreak and the range over which it extends. The survey in 2023 expanded further north on west Axel Heiberg Island, north, west, and south of the Fosheim Peninsula across Greely Fiord, Canon Fiord, and on north end of Ranes Peninsula

5. Project Objectives:

In July and August, the field component of the project was completed. A reconnaissance survey via rotary aircraft of central Ellesmere Island and Axel Heiberg Island was conducted that extended beyond the area surveyed in 2022. During this reconnaissance survey several objectives were undertaken.

Field component:

1. Conduct a reconnaissance survey via rotary of central Ellesmere Island and Axel Heiberg Island beyond the extent surveyed in 2022 to identify any further spread of the outbreak and to elucidate the extent of the outbreak,
2. Sample carcasses to confirm presence of *Erysipelothrix* and any other pathogens,
3. Revisit the previously surveyed area to identify any additional carcasses in the area,
4. Resample carcasses located in 2021 and 2022 to understand the residency time of the bacteria,
5. Sample fecal matter from live muskox to determine the number of infected animals that may be shedding the bacteria,
6. Collect fecal matter from predators and possible vector species to identify possible modes of transmission,
7. Deploy trail cameras focused on presumed infected carcasses to monitor what wildlife interactions may occur and
8. Conduct compositions of muskox and Peary caribou groups to identify the number of adults and young in each herd to provide insight into the effect of the bacteria on the population.

Community-based wildlife health surveillance program:

1. Establish a collaborative community-based wildlife health surveillance program that meets local needs with the communities of Resolute Bay and Grise Fiord,
2. Develop and pilot new technologies that facilitate on-site diagnostics of key zoonotic pathogens and more efficient Arctic wildlife health surveillance and research.

6. Materials and Methods:

Field component:

Fieldwork was conducted from July 30 to August 13, 2023. A rotary-based reconnaissance survey was conducted and was aimed to survey areas beyond the initial outbreak area and extending beyond the identified outbreak area.

Reconnaissance survey:

Based out of Eureka, a reconnaissance survey was conducted using a rotary aircraft. A total of 55 hours were flown. The areas where mortalities were reported in 2021 and 2022 were revisited. The reconnaissance survey extended well beyond the previous year's reports and surveys of the outbreak and expanded further north on west Axel Heiberg Island, north, west, and south of the Fosheim Peninsula across Greely Fiord, Canon Fiord, and on the north end of Raanes Peninsula.

The objective of the reconnaissance survey was to identify locations of muskox herds and any suspicious carcasses to delineate the area affected. Suspicious carcasses were identified as carcass without an obvious cause of death, such as predation or starvation. Intact carcasses that were not emaciated were deemed suspicious, and the cause of death could be due to *E. rhusiopathiae* infection.

Sampling of newly discovered carcasses:

Suspicious carcasses were investigated following the field necropsy procedures established in 2021, with some additional sampling conducted.

Standard sampling includes collecting a site and carcass description, taking photos of the site and the carcass, performing a field necropsy, taking soil and water samples, and the collection of a standard set of samples that were preserved either through freezing or in formalin. Additional sampling that took place this year included collection of the whole eye, eyelid, urinary bladder, as well as touch impressions of the liver and spleen.

The extent of sampling of the carcass depended on the condition and availability of the sample types. This was driven by the level of decay and whether scavenging had taken place.

The samples and measurements taken were:

1. Back fat measurements are used to assess general body condition.
2. Blood on filter paper strips to test for a variety of pathogens, including herpesvirus, brucellosis, pestivirus, toxoplasma, neospora, and *E. rhusiopathiae*.
3. 2.5 x 7.5cm strip of skin with fur from the rump to test for stress hormones and trace minerals and contaminants in hair testing for annual exposure (through the analysis of qiviut) and for longer exposure (through the analysis of the guard hairs).
4. Fecal pellets for various parasites in the digestive tract, lungworms, and microbiome.
5. Any cysts, sores, parasites, or other abnormalities were noted and sampled.

6. Lower left hind leg (metatarsus) with skin to determine body condition and body size, and to test for *Besnoitia*.
7. A 2.5 x 2.5cm patch of nose skin to test for the presence of *Besnoitia*.
8. Jawbone to determine body size, to perform a dental evaluation, and to age the individual (based on tooth eruption sequence).
9. Left kidney with fat and kidney tissue for contaminants analysis.
10. Fist size portion of liver tissue for contaminants and trace mineral analyses.
11. Whole eye and the ventral eyelid.
12. Soil samples were collected from below carcass, 1,3, 5, and 15m from carcass.
13. Water samples collected from bodies of water near the carcass.

Resampling of previously identified carcasses:

Fresh carcasses identified in 2021 and 2022 were revisited and soil and bone samples were collected to determine the residency time of the bacteria within the system.

Composition:

Composition surveys of muskox herds were conducted to identify the number of adults and young in each herd, and the proportion of males and females. All muskox herds were classified in the field, with reference photos taken, when possible, and locations recorded by GPS. All incidental observations of wolves and Peary caribou were also noted, and the locations recorded.

Fecal collection:

Fecal samples were collected from muskox herds by locating and observing muskoxen from a distance, and sampling the fecal matter observed in previously vacated areas to minimize disturbance. Fecal samples were analyzed for presence of parasites, including lungworm, and for any signs of stress and or diet.

A total of 88 muskox fecal samples were collected from 24 separate herds. Additionally, three Peary caribou fecal samples were collected from the only observed group.

Trail camera:

One motion activated trail camera was deployed facing a presumed infected carcass. The camera was deployed 5 m away from the carcass, with a target of 30 cm above the ground, to monitor any wildlife interactions that occurred with the carcass. The objective was to identify possible vectors and provide insight on methods of spread and transmission. The camera was deployed at the fresh muskox carcass from August 4 to August 10, 2023. The camera was set to take a series of three photos when motion activated as well as a timed photo every hour. No scavenging occurred throughout the 6 days, the camera was active and only one gull was observed at the carcass.

Community-based wildlife health surveillance program:

A collaborative community-based wildlife health surveillance program was initiated in Grise Fiord and Resolute Bay.

Harvesters are compensated for filling in a hunter kill return sheet, which details the age, location, and harvest zone of the harvest, and for collecting samples. Samples can include blood on filter paper, lower jaw or front teeth, skin and fur, lower leg bone, kidney with fat, feces, and spleen. Thus far four muskox sample kits have been filled by Grise Fiord.

The development of on-site diagnostic tools is currently being investigated through a collaboration with Health Canada, National Research Council, and the University of Calgary by building on previously developed technologies, such as lab-on-a-chip technology and the PowerBlade.

The PowerBlade is a device that can rapidly detect pathogens in food, that is portable and field deployable, and that does not require highly trained personnel to operate. The technology is customizable to any type of assay and is fully automated. The PowerBlade is operated by putting a harvest sample on a chip, the chip is loaded into the PowerBlade, which automatically mixed the sample with chemicals and detects the presence of potentially harmful pathogens. Results are available in hours.

Current work is ongoing to develop a chip that can test common pathogens in country food.

7. Results:

Field observations:

Muskoxen:

A total of 981 muskoxen were observed during the reconnaissance program, with 576 observed on Axel Heiberg Island, 377 on central Ellesmere Island (Fosheim Peninsula and north end of Raanes Peninsula), and 28 on north Ellesmere Island (north across Greely Fiord and West across Canon Fiord) (Figure 1). Of the total observed muskoxen, 109 were calves (Figure 3); 70 were observed on Axel Heiberg, 37 on central Ellesmere, and 2 on north Ellesmere Island.

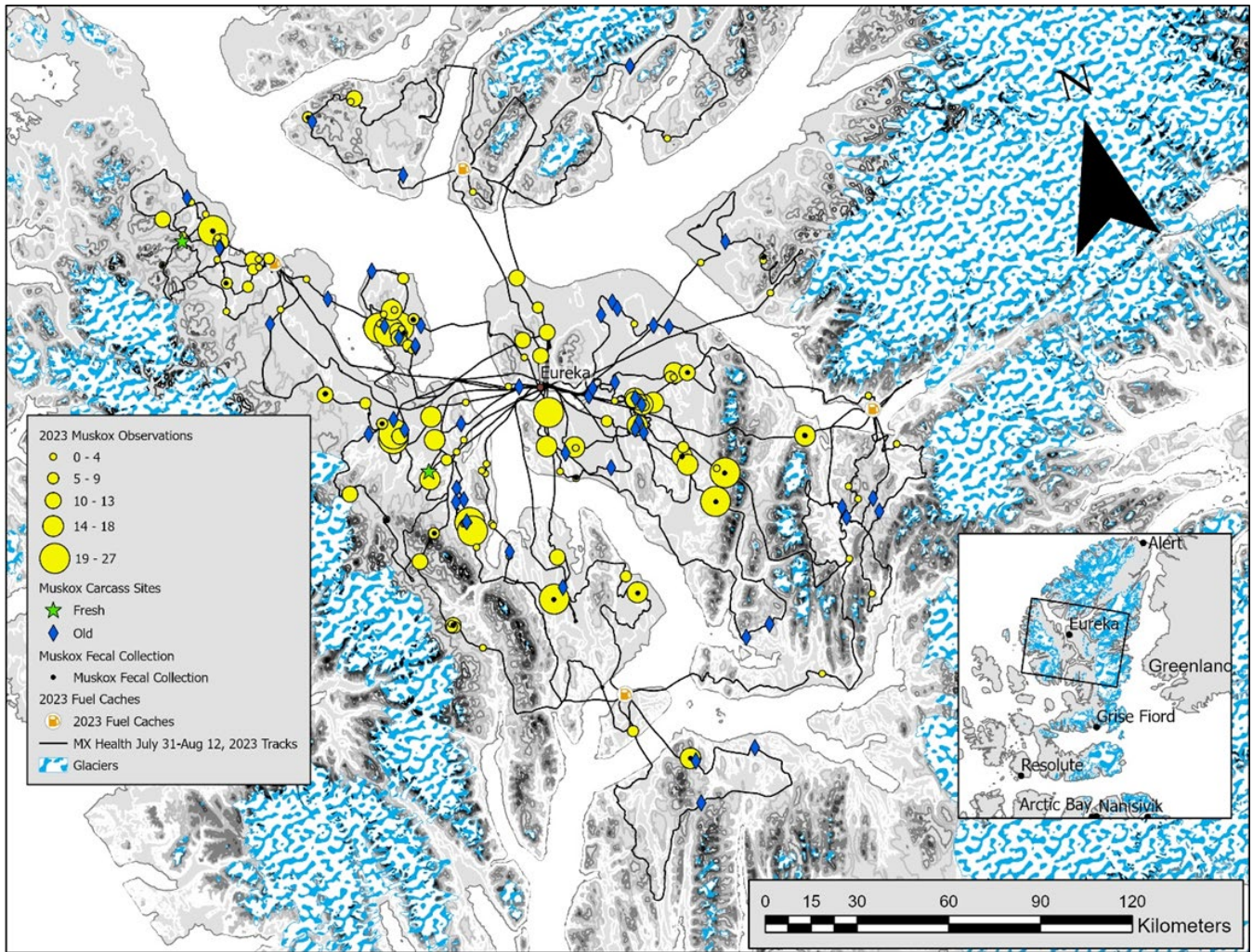


Figure 1: Flight track flow during the investigation of the muskox mortality event on Ellesmere and Axel Heiberg Island July 31 to August 12, 2023. Shown are observations of muskox herds (yellow circles where the size of each herd is represented by the size of the symbol), locations of fecal samples (black circles) and the locations of fresh (green star) and old (blue diamond) carcass locations.

Peary caribou:

Three Peary caribou (two adults and one calf) were observed across Canon Fiord in north Ellesmere Island. No Peary caribou were observed on Axel Heiberg or in central Ellesmere Island during the program (Figure 2).

Wolves:

A total of 16 wolves were observed on Axel Heiberg (11 adults and 5 pups), 15 on central Ellesmere (10 adults and 5 pups), and 12 on north Ellesmere Island (5 adults and 7 pups) (Figure 2).

Polar bear:

A single polar bear was observed on Axel Heiberg Island (Figure 2).

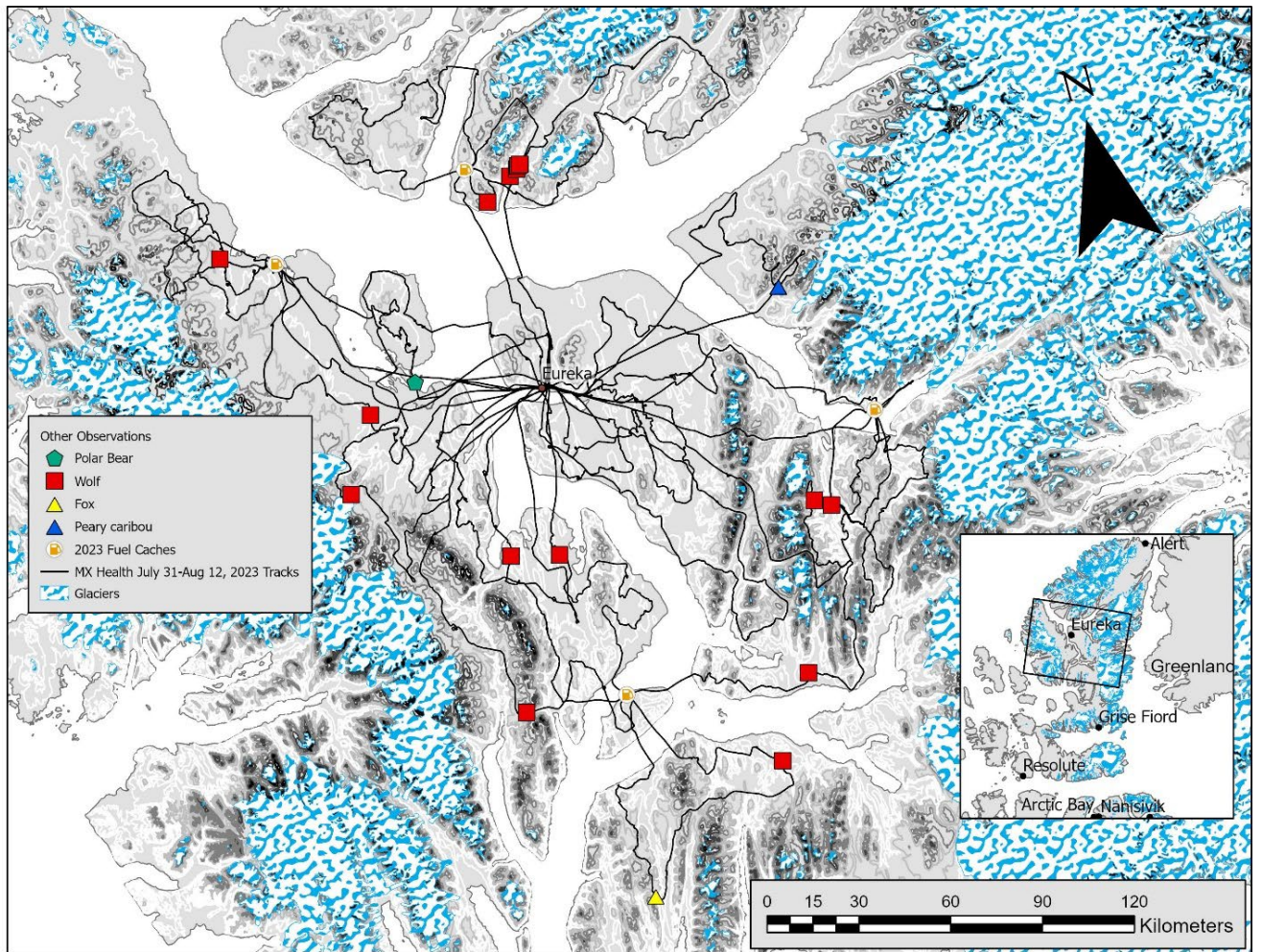


Figure 2- Flight track flow during the investigation of the muskox mortality event on Ellesmere and Axel Heiberg Island July- August 2023. Shown are observations of other species seen during the survey polar bear (green hexagon), wolves (red square), fox (yellow triangle), and Peary caribous (blue triangle).

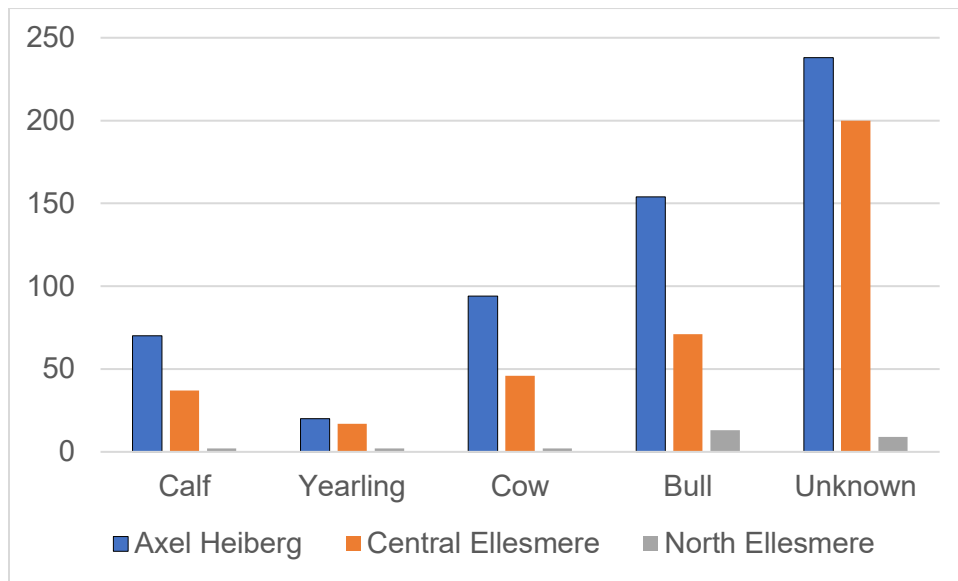


Figure 3- Composition of muskoxen on Axel Heiberg Island (blue), Fosheim and Raanes Peninsula (orange) and north and east of Greely Fiord and Canon Fiord respectively (grey)

During the reconnaissance survey, 981 muskoxen were observed, and we were able to accurately identify the sex and age of 528. Classification was rapid to avoid disturbance and only one opportunity was taken to visually identify the age and sex composition of the herd. In addition, photos were taken to assist in the classification and to verify field identifications.

Carcass sampling:

During the 2023 field work, two muskoxen died, and the cause was deemed suspicious. One carcass was found following the mortality, was bloated, and it was concluded that a field necropsy would not be viable, as the organs would be deteriorated and yield poor quality samples. Therefore, a subset of samples was collected. The second muskox was observed prior to mortality, and upon return, the muskox was deceased, and a full necropsy was conducted.

Additionally, 48 carcasses from mortalities prior to the 2023 field season were investigated, and samples collected. Samples were also collected from live muskox herds, and during site investigations to identify possible vectors and residency times in the system.

Table 1 - Complete list of samples collected during the 2023 field program and further defined by sample type.

Samples	Fresh Carcass Sites	Old Carcass Site	Feces (Live)	Environmental Samples	Fox	Arctic Hare	Lemming	Bird	Unknown	Wolf	Total
Blood (Strips)	2	0	0	0	0	0	0	0	0	0	2
Conjunctiva	1	0	0	0	0	0	0	0	0	0	1
Conjunctival Swab(s)	2	0	0	0	0	0	0	0	0	0	2
Eye	2	0	0	0	0	0	0	0	0	0	2
Feces	3	0	91	0	12	0	8	11	0	29	154
Femur	0	7	0	0	0	0	0	0	0	0	7
Filtered water	0	0	0	3	0	0	0	0	0	0	3
Foot	0	0	0	0	0	3	0	0	0	0	3
Hair w/ skin	2	0	0	0	0	0	0	0	0	0	2
Heart	1	0	0	0	0	0	0	0	0	0	1
Humerus	0	4	0	0	0	0	0	0	0	0	4
Insects	2	26	0	0	0	0	0	0	0	0	28
Joint swab(s)	3	0	0	0	0	0	0	0	0	0	3
Kidney	1	0	0	0	0	0	0	0	0	0	1
Liver	1	0	0	0	0	0	0	0	0	0	1
Lungs	1	0	0	0	0	0	0	0	0	0	1
Lymph node(s)	1	0	0	0	0	0	0	0	0	0	1
Mandible(s)	0	11	0	0	0	0	0	0	1	0	12
Metacarpus	3	48	0	0	0	0	0	0	0	0	51
Metatarsus	3	16	0	0	0	0	0	0	1	0	20
Nasal skin	3	9	0	0	0	0	0	0	0	0	12
Nasal swab(s)	3	0	0	0	0	0	0	0	0	0	3
Radius/Ulna	0	2	0	0	0	0	0	0	0	0	2
Rectal swab(s)	1	0	0	0	0	0	0	0	0	0	1
Rumen contents	1	0	0	0	0	0	0	0	0	0	1
Small intestine	1	0	0	0	0	0	0	0	0	0	1
Soil	3	42	0	3	0	0	0	0	0	0	48
Spleen	1	0	0	0	0	0	0	0	0	0	1
Urinary bladder	1	0	0	0	0	0	0	0	0	0	1
Whole animal	0	0	0	0	0	0	1	1	0	0	2
Total	42	165	91	6	12	3	9	12	2	29	371

Analysis

The samples collected were sent to the lab at the University of Calgary and are currently being analyzed to determine the presence of *E. rhusiopathiae* through culturing of live bacteria and using direct qPCR to detect traces of dead bacteria having been present. Below an incomplete list of the preliminary analyses conducted are reported (Table 2), further analysis will follow.

The tissue samples from the muskoxen carcasses have not yet been analyzed. However, the analysis to date has noted there were some fecal samples from live muskox samples that tested positive for *E. rhusiopathiae*. As the tests are grouped by herd, further analysis will be needed to investigate this further and determine the proportion of individuals that tested positive for the bacteria (Table 2).

Soil samples that were collected from previous carcass locations with know dates of death from over two years ago are still showing evidence of active *E. rhusiopathiae*.

Table 2 - Samples analyzed and tested for *E. rhusiopathiae* completed up to April 25, 2024.

Location	Sample Origin	Sample Type	<i>E. rhusiopathiae</i> Culture Result		<i>E. rhusiopathiae</i> Direct qPCR Result	
			Negative	Positive	Negative	Positive
Axel Heiberg Island	Arctic fox	Feces	5	1	2	3
	Arctic hare	Dried Muscle/Tendon			1	
	Arctic wolf	Feces	9	5	1	8
	Collared lemming	Body Cavity Swab			1	
		Feces	4	1	4	
	Environmental	Filtered Water	1		1	
		Sediment	1		1	
		Soil - Carcass	6	10	3	2
		Soil - 1m	11	5	6	4
		Soil - 3m	14	2	9	4
		Soil - 5m	16		12	3
		Soil - 15m	16		12	3
	Insect	Larvae/Pupae	7	10	4	3
	Muskox	Feces	43		24	1
	Unknown	Cast	1			1
Feces		2	2		2	
	Total	136	36	81	34	
Ellesmere Island	Arctic fox	Feces	5	1	4	1
	Arctic hare	Dried Muscle/Tendon			2	

	Arctic wolf	Feces	12	3	1	11
	Collared lemming	Feces	3		3	
	Environmental	Filtered Water	2		2	
		Sediment	2		2	
		Soil - Carcass	17	1	9	3
		Soil - 1m	20		12	1
		Soil - 3m	20		13	
		Soil - 5m	20		12	1
		Soil - 15m	20		13	
	Insect	Larvae/Pupae	6	5	2	4
	Muskox	Feces	47		30	4
	Snow bunting	Body Cavity Swab			1	
	Unknown	Feces	4	2	1	3
		Total	178	12	107	28

8. Discussion

Following the 2022 survey and the identification that the outbreak was more widespread than anticipated, the survey coverage for the 2023 field season was extended. This provided important context on the outbreak on Ellesmere Island and Axel Heiberg Island. The 2023 work also provided added insight into deterioration rate of carcasses and the effect of scavenging and vegetation growth on carcass remains.

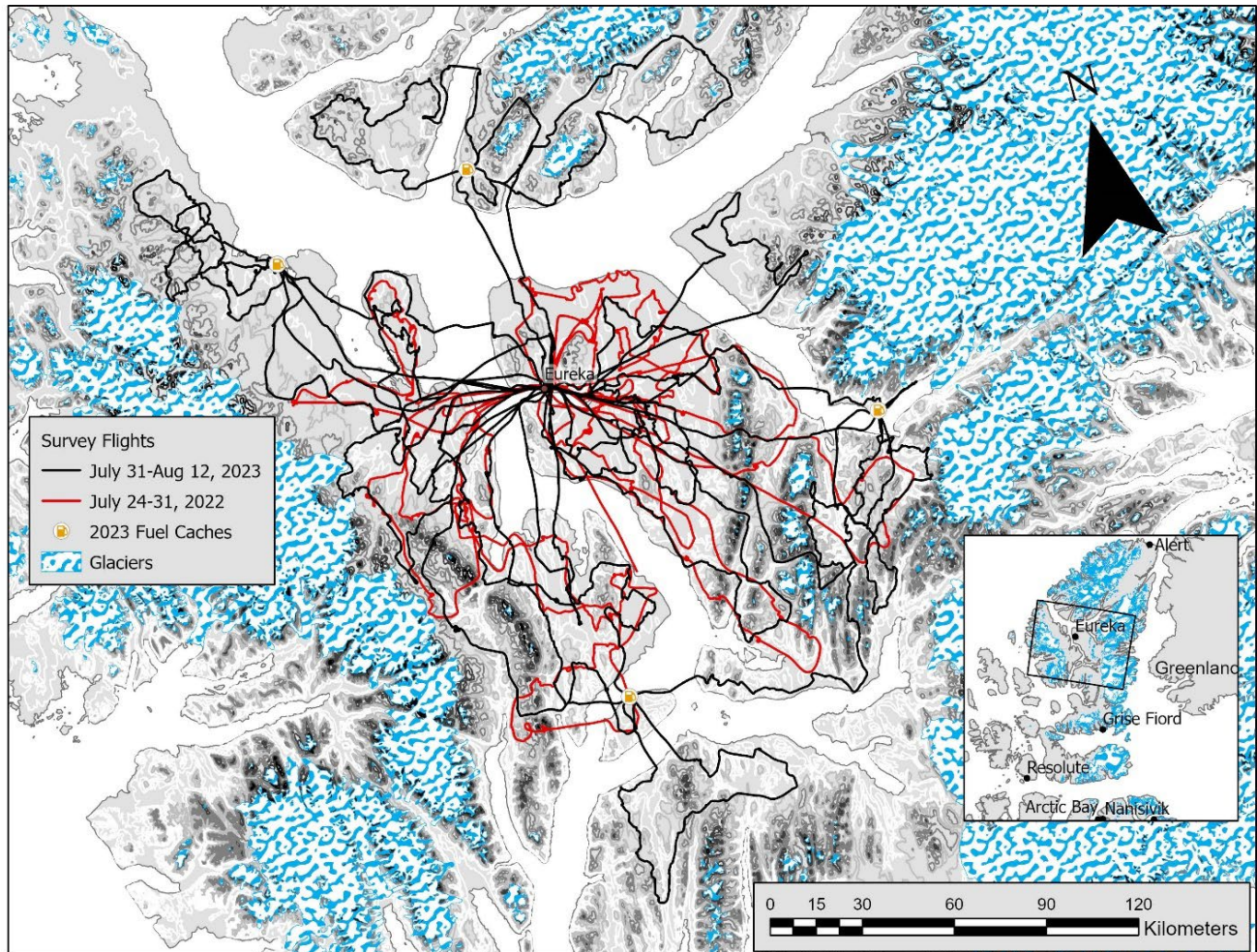


Figure 4: Flight tracks for the 2022 (red line) and 2023 (black line) field seasons.

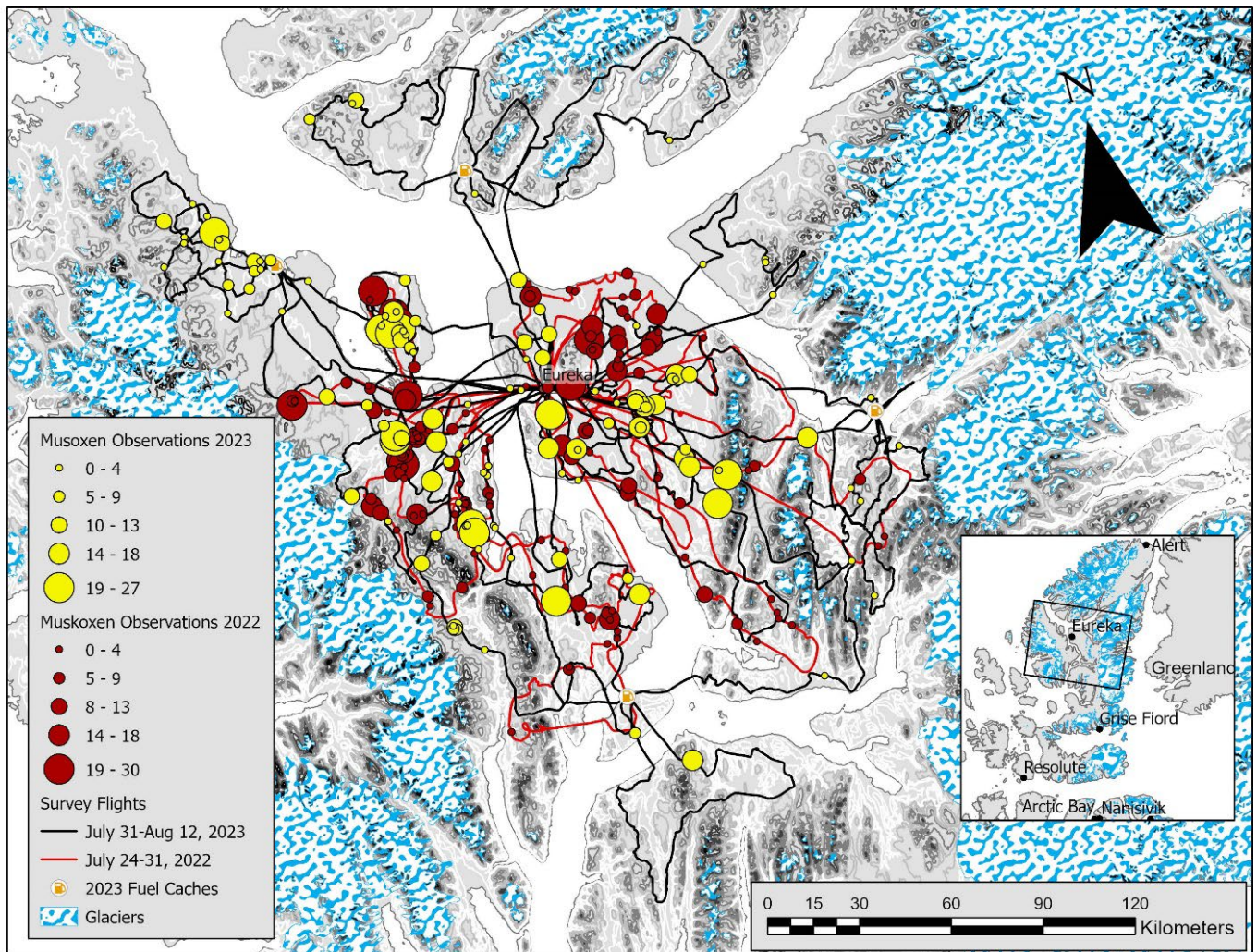


Figure 5: Flight tracks and muskox observations for the 2022 and 2023 field seasons. The 2022 flight line is indicated by the red line and observations are denoted by maroon circles of varying sizes depending on the size of the herd. The 2023 flight line is represented by the black line and observations by yellow circles of varying size depending on the herd size.

During the 2023 field season, more muskoxen were observed on Axel Heiberg Island (576 muskoxen) than on Ellesmere Island (407 muskoxen). Similarly, in 2022 more muskoxen were seen on Axel Heiberg when compared to Ellesmere Island, where respectively 631 muskoxen were observed compared to 397 muskoxen.

Interestingly, this is the inverse of what was observed in surveys conducted in 2017 for Central Ellesmere and 2019 for Axel Heiberg Island, where a higher abundance was noted for Central Ellesmere than Axel Heiberg Island. The population estimate for Axel Heiberg Island in 2019 was 3,772 muskoxen (95% CI [3,001-4,742]; Mallory et al. 2020), and the estimate for Central Ellesmere in 2017 was 6,902 muskoxen (95% CI [5,134-9,278]; Fredlund et al. 2018). This reversal in population abundances may be the result of the ongoing outbreak, however, additional research is required.

The search effort was increased between survey years, from 3,000 km coverage in 24 hours of rotary aircraft flight time during the 2022 field season to 5,700 km in 55 hours in 2023, however in 2023, less muskoxen were observed overall. Notably, however, despite the decrease in overall muskox numbers twice as many calves were observed in 2023 (981 Muskoxen including 109 calves) when compared to 2022 (1,208 muskoxen including 49 calves).

As *E. rhusiopathiae* has demonstrated negative reproductive effects on livestock, the increase on both Axel Heiberg Island and Ellesmere Island in calf to cow ratio is positive and may indicate a recovery from the *E. rhusiopathiae* and possibly a nearing of the end of the outbreak cycle. System recovery may be complex, due to viable bacteria still being found in the soil around carcasses after two years. It is unclear what mechanism for recovery will take place. The system should be revisited to assess the longevity of viable *E. rhusiopathiae* in the Arctic environment following an outbreak.

Only three Peary caribou were observed during the entire survey. The three caribou observed were a cow, a calf, and an adult of unknown sex, and were observed east of Canon Fiord. The preliminary analysis of the Peary caribou fecal samples was positive for *E. rhusiopathiae* bacteria. This is of note; however, it is difficult to infer much from a single observation. The data deficit on the abundance of Peary caribou on Ellesmere Island also detracts from the ability to make any conclusions as to the status of the population or the effect of *E. rhusiopathiae*.

Notably, no caribou were observed north of Greely Fiord, an area that has previously reported high numbers of Peary caribou during the 2006 survey of Central and Northern Ellesmere Island (Jenkins et al. 2011). Few muskox observations were made in the Greely Fiord area, but twelve wolves were observed in the area, which was the highest density of wolves observed during the 2023 field work and may have had an impact on both muskox and Peary caribou observations.

In 2023 more wolves (26 adults and 17 pups) were observed comparatively to the number observed in 2022 (nine adults and one pup), with far more pups observed. It is possible the increased search area could have resulted in increased wolf detections. Of the 29 wolf fecal samples collected 27 tested positive for *E. rhusiopathiae* through culture or through direct qPCR. This may be due to wolves feeding on carcasses of animals that were infected with *E. rhusiopathiae*.

Further analysis is underway and will be reported in a final report that will be shared with co-management partners. In addition to the data the GN has collected the U of C will continue to collect information on the residency time of *E. rhusiopathiae* in the environment. To further this work, harvest sample collection programs will continue to monitor the health of muskoxen and Peary caribou in the High Arctic.

The development of on-site diagnostic tools is being undertaken through a collaboration with Health Canada, National Research Council, and the University of Calgary by creating lab-on-a-chip technology for common pathogens found in country food.

9. Reporting to communities/resource users:

Reporting to the communities was proposed January 2024, however, had to be cancelled due to capacity issues and shifting priorities. In the interim, communication with the affected communities has taken place via email and phone. Reports and results will be distributed as they are available.

Community / HTO	Before research (Date/consultation type)	During research (Date/consultation type)	After Research (Date/consultation type)
Grise Fiord HTO (Iviq HTO)	August 2, 2022 in-person community consultation	When possible, we were not able to directly contact the HTO, though with the HTO member part of the team information returned to the community when possible	Sept 2023 email correspondence about the field work was sent. May 2024 Field Report was shared via email. Final report will be distributed when available.
Resolute Bay HTO	Multiple Email correspondence sent, unable to meet with board though did try in Aug 2022	When possible	May 2024 Field Report was shared via email. Final report will be distributed when available.
Qikiqtaaluk Wildlife Board	Dec 2022/ In-person AGM		Nov 2023 In-person AGM. May 2024 Field Report was shared via email. Final report will be distributed when available.