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Muskox (*Ovibos moschatus*) abundance estimate on Victoria Island Group, MX-07

2023 - 2024

Report

Lisa-Marie Leclerc[1]
&
Terry Milton[1]

1- Government of Nunavut, Wildlife Research Division, Department of Environment, P.O. Box 377, Kugluktuk, NU, X0B 0E0, Canada

Department of Environment
Government of Nunavut
Kugluktuk, NU

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ABSTRACT

Victoria Island (Canada) was once the habitat of a dense muskox (*Ovibos moschatus*) population. In the Muskox Management Zone Victoria Island Group, MX-07, the number of muskoxen declined to 10,026 in 2013-2014. In 2023, there was a need to conduct an abundance estimate, as hunters have not seen sign of recovery and were adapting to this new reality by changing their harvest location to the Canadian mainland. An aerial survey was designed using Distance Sampling paired with a dependent double observer configuration. The aim was to have a new abundance estimate for this management zone. This vast landmass was surveyed in two parts, the south section between October 23rd and November 1st, 2023 and the north section between August 26th to September 1st, 2024. In total, 48 muskox groups were seen, and the average group size was 6.13 (sd = 4.11) excluding lone bulls. There were 17 lone bulls. The number of muskoxen seen on transect was too low to derive an abundance estimate (n = 43). Most of the muskoxen were observed in Stratum 13 with 11 groups and a minimum count of 47 muskoxen. For the totality of the management zone, the minimum count was 180 muskoxen in 60,384 km^2 of survey area for a total density of 0.003 muskox/km^2 during the 2023-2024 survey. The health conditions of the muskox, increase number of grizzly bear and wolf sightings, migration of muskox off the island to the mainland might have contributed to the observed decline of muskox in MX-07. The limited number of muskox left is worrisome, and warrant more research to explain the cause of decline and work with co-management partners to seek opportunities to promote recovery.

INTRODUCTION

Two subspecies of muskox (*Ovibos moschatus*) roam across the Canadian Arctic; the subspecies *Ovibos moschatus wardi* found in the Arctic Archipelagos and the subspecies *Ovibos moschatus moschatus* found on the Canadian mainland. Hunters from Kugluktuk and Cambridge Bay (Nunavut) can differentiate between these two muskoxen types. *Ovibos moschatus wardi* has a slight physical differentiation with their whiter faces, saddles, stocking horns, as well as longer tooth row and styles on the upper molars (van Coeverden de Groot, 2001). This separation is supported by recent genetic analysis that showed distinct clustering between these two groups (Lok et al., 2024). However, muskox overall have a very low genetic diversity and this genetic clustering between the two subspecies remains unclear compare to other subspecies with higher genetic diversity. More studies are needed to confirm the designation of muskox subspecies (Lok et al., 2024)

Because of the immensity of Victoria Island (Northwest Territories and Nunavut), the second largest arctic island, it is difficult to estimate wildlife abundance. Until 1976, no systematic survey for wildlife, including muskox, was done on Victoria Island (Spencer, 1976). Surveys were usually limited to a very low coverage and only a part of the island was surveyed at a time, because of its size and associated logistical challenges. In August 1980, the first transect survey occurred on the southeastern part of Victoria Island, by flying only three percent of its coverage. They counted 91 muskoxen to derive an estimate of 1,760 (CV = 68%) (Jakimchuk and Carruthers, 1980). Three years later, the same area was surveyed at a coverage of 20%, which provided an estimate of 3,300 muskoxen (CV = 10%) (Jingfors, 1984). These results were consistent with local hunter reports of an increasing trend in muskoxen.

To monitor the change in muskox abundance overtime, three surveys in 1988, 1993, and 1999 occurred in southeastern portion of Victoria Island (Gunn and Patterson, 2012). The 1988 survey estimated 12,372 ± 1,064 (SE) muskoxen in a study area of 44,390 km^2, while in 1993 and 1999 the estimates were 12,563 ± 1,254 (SE) and 18,290 ± 1,100 (SE) muskoxen respectively in a study area of 39,100 km^2 (Gunn and Patterson, 2012). Muskoxen density was used as an indicator of trend, and a positive change in density was found significant between 1993 and 1999 (Gunn and Patterson, 2012). The study area was not representative of the real population boundary and interpreting this trend was ambiguous, as it was impossible to refute possible immigration from the rest of the island into the study area.

In fact, muskoxen were documented to inhabit the southwestern and the northeast of Victoria Island. In 1983, a survey in the southwestern part of Victoria Island resulted in an estimate for the area of 135 muskoxen. At this location, muskox appeared sparsely distributed on the landscape and at a very low density (Poole, 1985). Muskoxen were also known to be distributed to the northeast of the island. So in August 1990, the east and south of Hadley Bay, as far south as Washburn Lake, was systematically surveyed. On transect, 700 muskoxen were counted for an estimate of 5,452 ± 521 (SE) muskoxen (Gunn and Lee, 2000). There again, the muskoxen were relatively evenly dispersed, and the density appeared lower than the southeastern part of the island. The heterogeneity of vegetation cover and the climatic variations across Victoria Island might have been significant factors in determining muskox density, but such did not appear to be playing limiting factors to their distribution extent.

In 2015, the harvest regulations were repealed and new comprehensive regulations package was brought into force, implementing the Nunavut *Wildlife Act* (S. Nu. 2003, c.26). This included new muskox management zones (R-026-2015) that were defined via extensive consultations with co-management partners and approved via the Nunavut Wildlife Management Board processes outlined in Article 5 of the *Nunavut Agreement*. In 2013 and 2014, MX-07 was surveyed in two consecutive years. On transect, 1,296 muskoxen were counted, which resulted in an estimate of 10,026 ± 597 (SE) (CV = 6%) muskoxen. Muskox density across the island varied from 0.0617 to 0.1321 muskox/km^2, where the density was consistently higher in the southeastern part of the island (Leclerc, 2015a). Since it was the first time that such an extensive area was surveyed, it was difficult to compare this result with the previous surveys of Victoria island. Nonetheless, the 2013-2014 estimate highlighted a decline in the muskox abundance, which was consistent with local observations.

While abundance surveys are usually point-events characterized with change in survey area and method through time, traditional knowledge provides a longer and smoother time series. Traditional knowledge collected from Cambridge Bay allowed to represent the muskox abundance from 1960 to 2014. While the muskox abundance was low in the 1960s, it slowly increased to peak around 1990 to 2000, and soon after, declined to reach the lowest number in 2014 (Tomaselli et al., 2018). The participants described an 85% decline in muskoxen. Reasons behind this decline included climate changes, an increase in predators, and a decrease in health conditions. Local hunters have observed muskox carcasses on the land (acute mortalities), which they associated with disease outbreaks (Tomaselli et al., 2018).

Since 2013-2014, no additional aerial survey occurred. Since then, a continuous decline in muskox number was observed by local hunters with no sign of recovery. Throughout a community-based health surveillance program (2012 to 2024), emerging diseases were detected, such as brucellosis (*Brucella sp.)* and orf virus (genus *Parapoxvirus*), while low pregnancy rates and deficiencies in important trace minerals, such as Selenium, were documented. All these health conditions negatively affected the reproduction and survival rate of individuals, which affected the population dynamics (Tomaselli et al*.,* 2014; Dalton et al., 2024; Aguilar et al., 2024; Hee et al., 2024; Dickinson et al.,2025). In response to the low muskox abundance, the Ekaluktutiak Hunters and Trappers Association (EHTA) has been proactive by voluntarily stopping sport harvesting in MX-07 and establishing a period of harvest moratorium (April 15th to July 30th) in an attempt to increase calf survival (EHTA pers. com). With the muskox scarcity in MX-07, both the ETHA and Kugluktuk Angoniatit Association (KAA) have shifted their muskox harvest to the Central Kitikmeot Group, MX-11, to ease pressure and to promote recovery. The KAA have stated that the muskox population follows a cyclical pattern of population highs followed by population lows, like caribou, and that the population is at present very low (KAA pers. com.).

Since the documented decline in muskox numbers identified in 2013-2014, the decline seems to have continued. As a result of suspected continued population decline, we completed an aerial survey of MX-07. The results from this survey will be used to inform actions to address the muskox recovery on Victoria Island.

OBJECTIVES

The main objectives of this study were:

1) To establish a new abundance, estimate of MX-07 and identify the population trend.
2) To review the current management regime and propose new recommendations if necessary.

MATERIALS AND METHODS

Study Area

The Victoria Island Group, MX-07, is surrounded by water: Hadley Bay to the north, M'Clintock Channel to the east, and to the south: the Dolphin and Union Strait, Coronation Gulf, and Dease Strait (Figure 1). The boundary of the west side of the muskox management zone is defined by the Northwest Territories border. The total land area of MX-07 is 141, 677 km^2 including Stefansson Island and Jenny Lind Island or 136,430 km^2 not including island. Muskox were previously distributed widely over most of the management zone, where variation in muskox density was observed across the island, because of the heterogeneity of the landscape (Poole, 1985, Gunn and Lee, 2000, Gunn and Patterson, 2012, Leclerc, 2015). Victoria Island topography is characterized by its predominantly low elevation that ranges from 100 to 200 metres above sea level (asl), except the Shaler Mountains in the central part of Victoria Island, where the elevation reaches up to 760 metres (Environment Canada, 1995). After the Wisconsin glaciation, the retreat of the Laurentide ice sheet left many glacial landforms (i.e. drumlins, till plains, moraines, eskers, dried river valleys and meltwater channels) on Victoria Island (Saarela et al., 2020). The southwestern coast of Prince Albert Sound, the northeast coast of Hadley Bay and an extensive area between Namaycush and Washburn lakes are xeric and sandy, with very poorly vegetated to unvegetated areas. The ground is rough and mostly composed of rocky and gravelly substrates. In this denuded landscape, arctic aven (*Dryas integrifolia*) is usually the dominant species that colonizes scoured substrate, as this shrub grows in cold and wet habitat (Environment Canada, 1995). Hygric sedge and sedge fen communities are found on the coast adjoining the M'Clintock Channel and Lady Franklin Point. The landscape of Victoria Island is well-known for its many ponds, lakes, and rivers and the vegetation north of Namaycush Lake seems to be restrained to the edge of water bodies and drainage areas.

There are two bio-climate subzones on Victoria Island, Subzone C and D (CAVM Team, 2003), and the boundary between these two zones runs from southeast to northwest approximately. To the north, zone C, the cold summer temperature of 5 to 7ºC limit the cover of vascular plants (5 to 50%) and the species richness from 75 to 150 species of local floras (Saarela et al., 2020). The warmer summer temperature of the southern zone D, 7 to 9 ºC, allows for an increase in cover of vascular plants (50 to 80%), as well as an increase in species of local floras from 125 to 205 species (Saarela et al*.,* 2020). Plant communities live primarily on a calcareous substrate that is found across the island.

Figure 1: Map of the Victoria Island Group Muskox Management Zone, MX-07. A Digital Elevation Model (DEM) was used to depict the very subtitle change in elevation from 0 green to 760 red in metres (Arctic DEM, Porter, 2023).

Integration of Inuit Qaujimajatuqangit (IQ) in the Survey Design

Meetings with the EHTA, the KAA, and the Kitikmeot Regional Wildlife Board (KRWB) occurred on January 5th and August 7th, 2024. During these meetings, the KAA suggested that there was no need to survey MX-07, since *IQ* indicated that the muskox number was at the low point in their population cycle. They suggested that surveying MX-07 in totality would be an expensive endeavour where the funds could be used for alternative programs. As an alternative to a full island survey, information from the 2023 Dolphin and Union caribou (DU) herd survey was used in combination with a new survey in 2024 covering the remaining portion of the island that was not surveyed in 2023. Although the focal species for the DU survey was caribou, others species observed, such as muskox, were recorded as non-target species (Leclerc et al., 2024). Both Hunters and Trappers Organizations were not comfortable with a multi-species survey approach, but saw advantages of using the muskox observations from 2023 to derive a muskox estimate and to avoid flying the same survey area a second time at lower effort (10-15%) to get the same results. All parties supported this modified survey methodology.

The north part of Victoria Island, the unsurveyed area during the 2023 DU survey, was completed in August-September, 2024. Since hunters seldomly travel to the north of Victoria Island, there was more confidence in using the muskox distribution from the last 2013-2014 survey to stratify this area than rely solely on hunter observations. There, the survey coverage was originally set at ~36% in the three main strata (12, 13, and 15) in aim to have a minimum of 60 muskox observations to derive an estimate. However, after discussing with the air charter company, the coverage was lowered to approximately 25% to 27%, because of the remoteness of the survey location and associated logistic challenges involved. Still, the coverage was set higher than the 1990 and 2014 surveys, that had 13% and 10% coverage, respectively (Gunn and Lee, 2000; Leclerc, 2015). In the final survey design, a similar coverage for Stratum 12, 13, and 15 was established. In addition, the orientation of the transect lines for the Stratum 15 was adjusted based on recommendations from EHTA. By working closely together, early in the design phase, *IQ* and all perspectives were considered to ensure confidence in the results and more effective management outcome.

Design of Distance Sampling Surveys

Survey Design

Because of the immensity of MX-07, the management unit was surveyed less than a year apart in two separate surveys. The southern strata (Figure 2, dark grey area) were surveyed in October-November, 2023. This area was divided into 11 strata of unequal coverage allocations, where a stratum had a minimum of 8 to 59 transect lines, or an effort varying from 21% to 74% (Table 1). The coverage allocations and direction of the transect lines were done based on the best available knowledge of the Dolphin and Union caribou herd fall distribution, to maintain the orientation of the sides of the strata, and to assure transects of relatively equal length (Buckland et al., 2001). The remaining part of the management zone was surveyed in August-September, 2024 (Figure 2, light grey area). The northern area was separated into four strata and was labeled stratum 12 to 15 (Table 1). The lowest effort (12%) was allocated on the coast of M'Clintock Channel, while the three others strata had relatively the same percentage of effort, about 25% to 27%, as muskox density was expected to be consistent across these areas. Stefansson Island was not included, as the soil was made up principally of sand, lacked vegetation, and consequently no muskox was observed in 2014 (Leclerc, 2015). The package *dssd* in the R Statistical Platform (R Development Core Team 2009, Marshall and Rexstad, 2023) was used to draw the transect lines with a random starting point in each stratum.

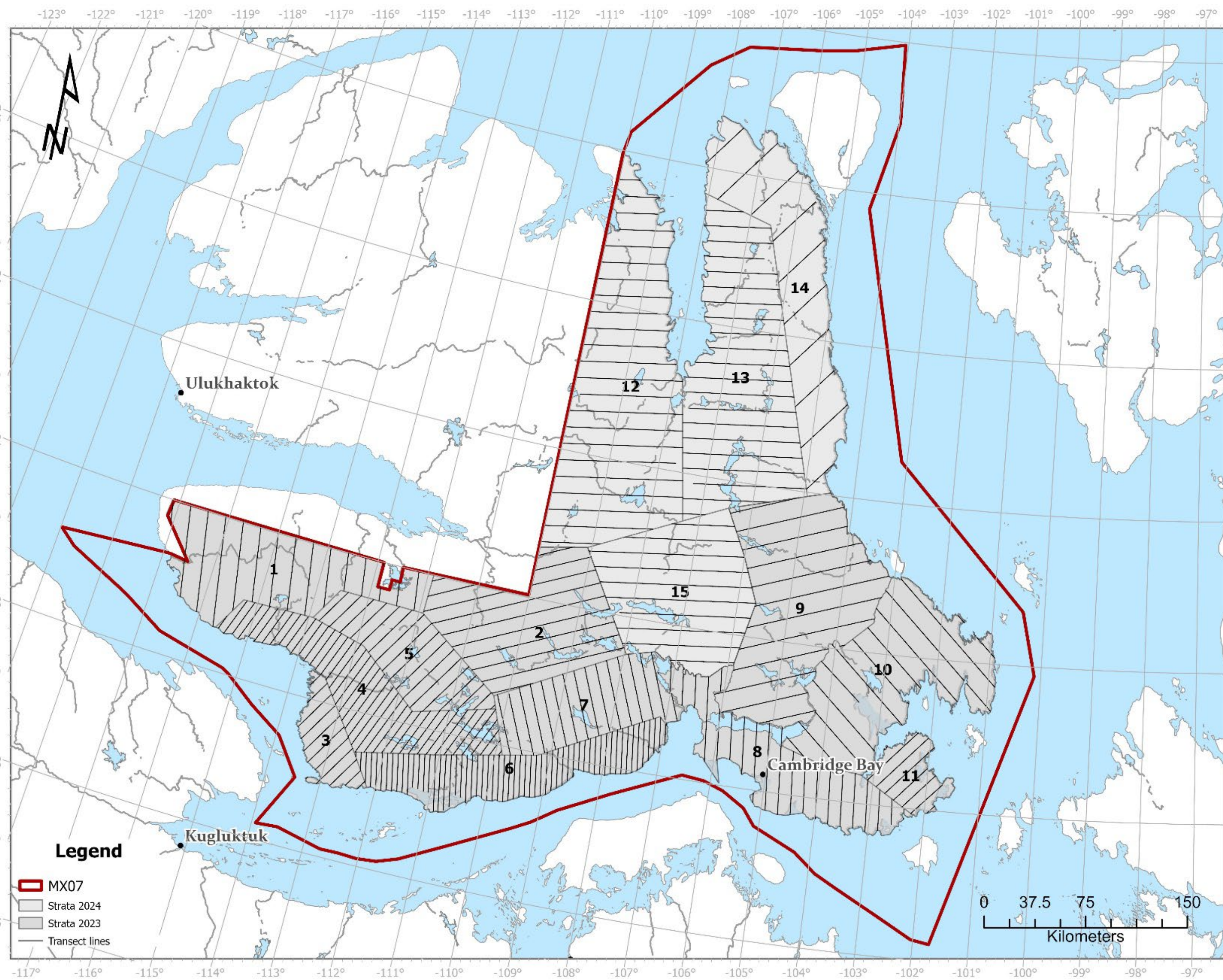

Figure 2 :Stratification and transect lines design for the 2023 Dolphin and Union caribou survey (dark grey) and 2024 muskox abundance survey (light grey) of the Victoria Island Group, MX-07.

Table 1: Summary of the survey design with the number of transect lines, distance between transects, transect length, and the percentage of coverage.

Year	Stratum	Area (km)	Number of Transects	Distance between Transects (km)	Transect Length (km)	Coverage (%)
2023	1	9,328	16	13.5	1,558	21.89
	2	9,787	10	10	1,383	29.50
	3	2,375	11	8	495	36.36
	4	8,101	42	5.5	1,990	53.94
	5	5,622	17	8.5	958	34.93
	6	6,972	59	4	2,258	74.32
	7	6,581	16	8.5	1,036	35.24
	8	7,577	21	9.5	1,310	30.67
	9	13,297	12	14	1,336	21.51
	10	11,064	12	14	1,177	21.30
	11	2,151	8	8	426	38.07
2024	12	18,340	24	12	2,113	24.89
	13	10,415	22	11	1,890	27.07
	14	10,871	10	25	946	11.97
	15	13.950	12	11	1,252	26.82
	---	136,430	292	---	20,128	---

Distance Sampling and Field Setting

The 20,128 km of transect lines were flown by Twin Otter at a speed of 160-180 km/hr and at an altitude of 122 metres using a radar altimeter to maintain a constant altitude, while following the topography of the terrain. Using Gunn and Patterson's (2012) recommendations, the Distance Sampling method was used to decrease the bias of the estimate and compare the density estimated between strata. The wing struts were divided into five bins marked with a different color of electric tape to identify the distance of the observations. The bins represented a distance from the survey line of 0-200 metres, 200-400 metres, 400-600 metres, 600-1,000 metres, and 1,000-1,500 metres. Precaution was taken to extend the 0 mark beyond the blind spot directly under the aircraft and the total sampling distance was three kilometers (Leclerc et al., 2024). Observations made farther than 1,500 meters or during the ferry were recorded as "off" transect. A dependent double-pair observer configuration was used, where the experienced trained observers work together to detect and confirm their observations (Buckland et al., 2005). Muskox group was used as the sampling unit, and if the group moved, the original distance before the movement was recorded. The number of adults and calves were both recorded. In 2024, other species sightings of wolverine (*Gulo gulo*), wolf (*Canis lupus*), polar bear (*Ursus maritimus*), and caribou (*Rangifer tarandus*) were also acknowledged and logged. Two data recorders, left and right, were recording the observations of the front and back observers sitting on their respective side of the airplane. Recorders used ArcGIS Survey123 application to record date, time, location, species, group size, distance of the observations, and survey conditions (snow cover, presence of fog, and cloud cover). The data were secured and saved to the online cloud to be retrieved later by logging on to the password protected website.

Data Analysis

Since the field design and the data collection were consistent in 2023 and 2024, the two muskox observation datasets were merged for the analysis. The "on" and "off" transect observations (n = 48) were used to increase the sample size in order to infer on the muskox spatial distribution pattern and group size across the MX-07 muskox management zone.

Muskox Group Size

Muskox group dynamics is a fundamental part of the ecology and evolutionary process of the species, including mating and predator protection. Risk of predation in muskox, an open-land species, has been found to affect group size as it promotes fitness and protects offspring by decreasing the probability of capture (e.g. group formation) (Heard, 1992). Due to the importance that group size plays for this social ungulate, the variation in group sizes encountered was represented by a histogram. Group or cluster was defined by muskox occurring closely to each other, where the extent of the group could be well defined by the lack of animal in the surrounding. The number of lone muskoxen, assumed to be bulls, was also reported, but not included in the group size averaging. In the event that only one of the two observers detected the group that count was used, if both observers agreed on the same amount of muskox that count was used, and if both observers did not see the same amount of muskox an average of the two counts was done to determine the group size to keep the group size unbiased. The minimum and the maximum of group size were reported and the mean group size was calculated. The proportion of calves per adult muskox was provided for 2024 only.

Muskox Herd Distribution, Dispersion

The observed muskox locations, where all the muskox groups ("on" and "off" transects) were seen in 2023 and 2024, were at priory plotted on a map using ArcGIS Pro version 3.3 (ESRI, 2024) to determine the distribution (presence and absence) of muskox in MX-07. Since muskox dispersion on the landscape is usually influenced by the quality of the habitat and physiological needs (Wilkinson et al., 1976, Smith 1989, Gunn 1990), the spatial pattern of the group distribution was further investigated by using a spatial point-pattern analysis test, Moran's I. By determining the distance from one group relative to the others, it was possible to determine if the pattern expressed by the group dispersal on the landscape depicted a random or nonrandom pattern. If the pattern was not random, this pattern can be further described as clustered or dispersed (Oyana, 2020). The Moran's Index value was calculated, as well as the z-score and p-value.

Minimum Count of Muskoxen Observed

Since the number of observations on transect was low in all strata and in the study area (n = 43), there were not enough observations to parameterize an individual model for the muskox, as a sample size of at least 60 to 80 observations is necessary (Buckland et al., 2005). Therefore, it was assumed that all muskoxen were detected on transect, and the muskox total minimum count were reported as muskoxen observed within each stratum and in the management zone. Predators, grizzly bear (*Ursus arctos*), polar bear, and arctic wolf, were reported using the predator index

(Heard, 1992). The predator index reported all sighting against the total number hours of flying per 100 hrs on transect.

RESULTS

Survey Conditions

Since the 2023 survey condition and progress were described in Leclerc et al., 2024, emphasis was attributed to describe the 2024 survey condition on the remaining portion of MX-07. The Twin Otter departed on August 25th from Yellowknife to Cambridge Bay. The survey was completed between August 26th to September 1st, 2024, where Table 2 shows the survey progress and weather. The survey was performed in great weather. The visibility on transects was ideal, and no fog was encountered, except in the high hills along the west coast of Hadley Bay. On August 31st, the aircraft encountered some isolated showers, but the visibility was not impacted because of the minimal amount of precipitation (Table 2). Since there were weather delays, the northernmost four transects of Stratum 9 that were left unsurveyed in 2023 were flown (Leclerc et al., 2024). In sum, between 2023 and 2024, the entire management zone on Victoria Island was covered.

Since both surveys were completed in under 10 days, there is confidence that muskoxen did not move between strata during the survey periods nor between the two study areas, since muskox moved over a limited area in a year (Schmidt et al., 2016; Gunn and Fournier, 2000). Victoria Island terrain is open and relatively flat and dark brown muskoxen are easily detected, as they cannot hide under the tree canopy, or behind hills. Therefore, the availability bias was relatively low.

Table 2: Summary of the survey progress between August 25th to September 2nd, 2024, as well as the general weather encounter affecting visibility.

Date	Survey Progress	Weather
August 25th	Departure from Kugluktuk and Fuel Cache	Sunny, partially overcast
August 26th	Strata 4 and 1	Sunny
August 27th	Strata 3 and 2	Partially overcast, no fog
August 28th	Stratum 1- North	Sunny, fog in high coastal hills
August 29th	Stratum 2- North	Sunny, no fog
August 30th	Off	---
August 31st	Strata 1, and 2-North	Overcast, isolated showers, no fog
September 1st	Strata 9 and 2	Overcast, no fog
September 2nd	Departure from Cambridge Bay	Sunny, partially overcast

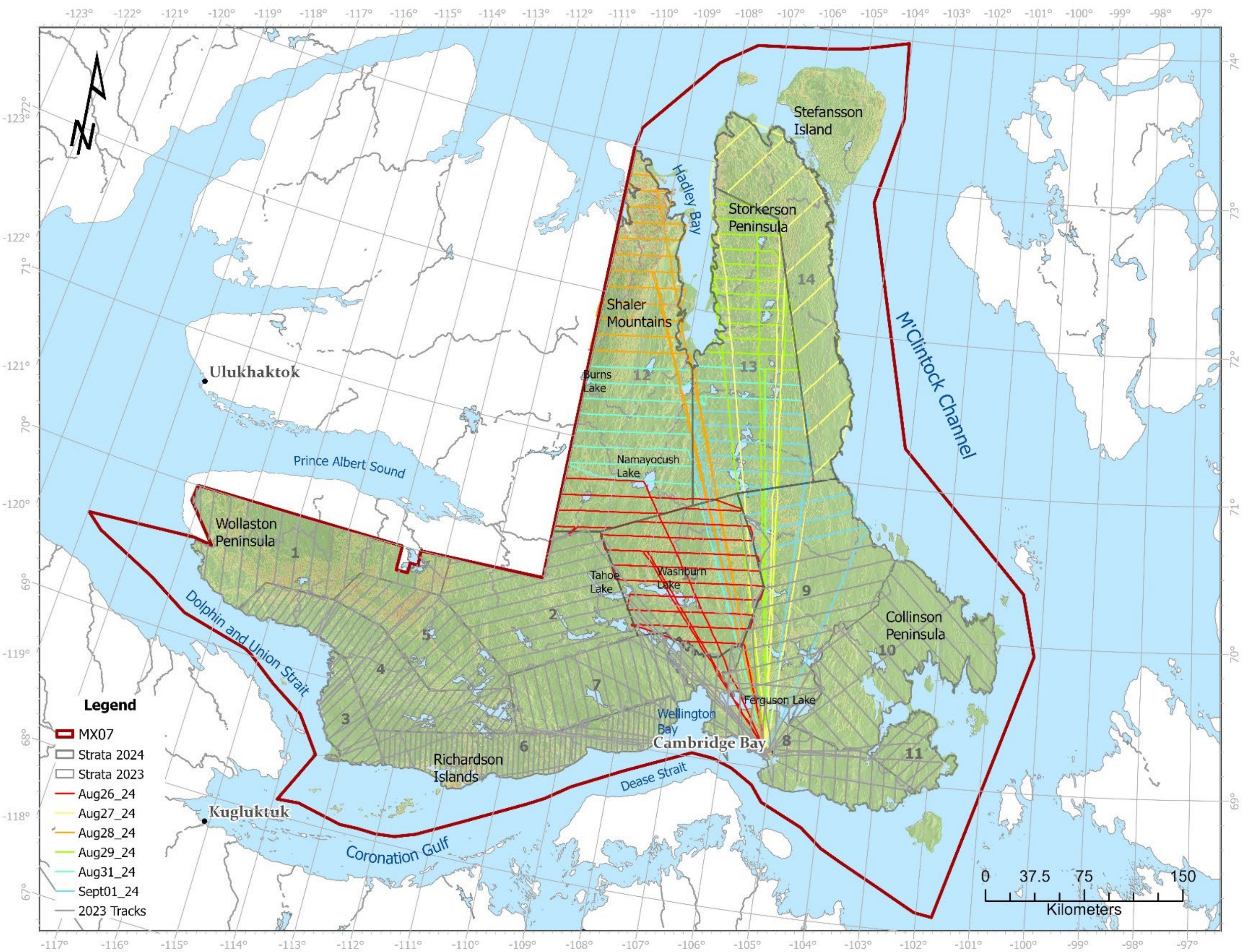

Figure 3: In the south section of MX-07, flight tracks (grey) done between October 23rd and November 1st, 2023. The 2024 flight tracks were represented by a different colour for each survey day between August 26th to September 1st, 2024.

Muskox Group Size

The largest group size observed was 18 muskoxen. Out of the 48 observations, 17 of them were single animals, most likely lone bulls since the surveys were performed during the rut (Figure 4). Without taking the single observations into account, the average group size was 6.13 (sd = 4.11) Groups with over 10 muskoxen were infrequent and accounted for less than 15% of the total number of the groups encountered. The calves to adults ratio was 5.3 calves: 100 adults including all number of calves and muskox seen.

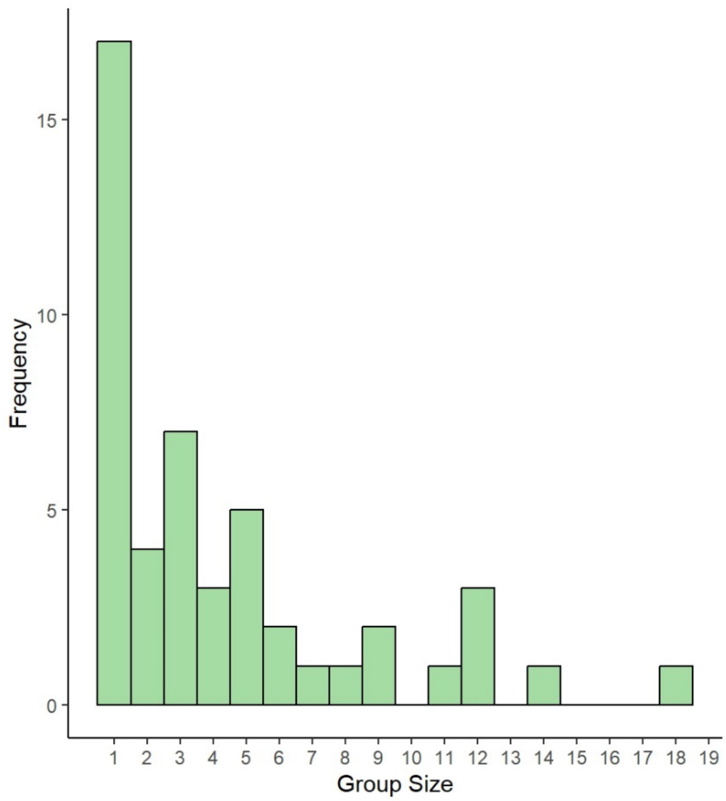

Figure 4: Frequency distribution of muskox group size (n = 48) observed during the 2023 and 2024 surveys combined, where the bins ranged from 1 to 19.

Muskox Herd Distribution, Dispersion

During the two surveys combined, 48 groups of muskoxen “on” and “off” transect were detected (Figure 5). No muskox was observed in Stratum 14 along the M’Clintock Channel and in Stratum 11 east of Cambridge Bay. Other than at these two locations, muskox groups were distributed continuously on the landscape. To shed light on the spatial pattern of the muskox groups, dispersion of the muskox on the landscape was further investigated by a spatial-point-pattern analysis. Such analysis revealed that muskoxen groups were clustered on the landscape and their pattern was not random (Moran’s Index = 0.315, z-score = 2.885, p-value = 0.0039).

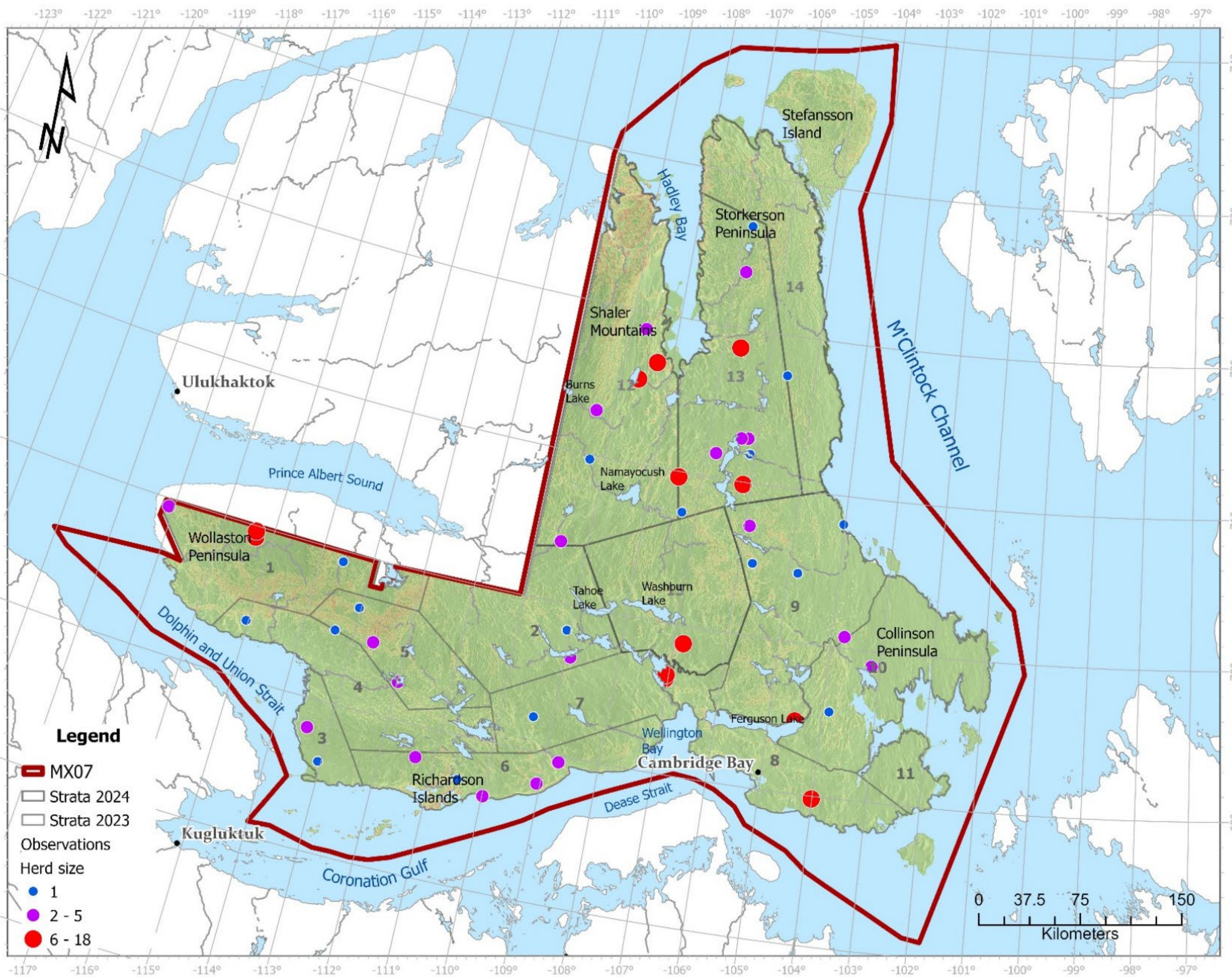

Figure 5: Geo-referenced locations of muskox herd seen "on" and "off" transects between October 23rd and November 1st, 2023 (Strata 2023) and between August 26th to September 1st, 2024 (Strata 2024).

Minimum Count of Muskoxen Observed

All the muskox observations made "on" and "off" transect were considered. Among the 15 Strata in MX-07, the number of muskox group varied from 0 to a maximum of 11 groups. The average number of groups per stratum was 3.69 (sd = 2.83). Over the entire muskox management zone MX-07, we identified a minimum count of 207 muskoxen; 124 in 2023 and 83 in 2024. Stratum 13 had the highest number of muskoxen observed, with 47 muskoxen. If we removed the observation "off" transect, 43 groups were "on" transects for a minimum count of 180 muskox in 60,384 km^2 of survey area for a total density of 0.003 muskox/km^2. The scarcity of muskox across the entire MX-07 management zone prohibited us from doing any further analysis, such as Distance Sampling, and from deriving an abundance estimate with adequate confidence, even for rough management decision (CV = 25.5%) (Pollock et al., 1990; Skalski et al., 2005).

Table 3: Summary of the minimum count of muskox in each surveyed stratum based as to whether the observations off the transect strip were included or not.

Year	Stratum	Area (km^2)	Number of Group	Number of Muskox (on and off transect)	Number of Muskox (on transect)
2023	1	9,328	4	25	25
	2	9,787	2	3	3
	3	2,375	2	5	1
	4	8,101	1	1	1
	5	5,622	4	9	9
	6	6,972	5	15	15
	7	6,581	1	1	1
	8	7,577	3	34	20
	9	13,297	6	25	23
	10	11,064	2	6	5
	11	2,151	0	0	0
2024	12	18,340	6	24	24
	13	10,415	11	47	41
	14	10,871	0	0	0
	15	13.950	1	12	12
		136,430	**48**	**207**	**180**

Although the observers were tasked to record predators, no grizzly bears or wolves were observed during the 2023 nor the 2024 survey. Nonetheless, in the southern part of the management zone (2023 Strata) 15 groups of polar bears were observed for a total of 30 individuals, while in the north (2024 Strata) three individual polar bears were detected.

DISCUSSION

Victoria Island offers a rich landscape diversity. Stefansson Island and the Storkerson Peninsula are known for their bare vegetation and a rock outcrop dominated flat landscape where semi-aquatic sedge and grasses have a tendency to concentrate around ponds, lakes, and in the drainage system. As herbivore, muskox rely strongly on the distribution of plant communities they feed upon. Muskox are not likely to adopt a random dispersion pattern on this heterogeneous landscape. Indeed, the dispersion pattern of muskox in the management zone was clustered. The highest number of muskoxen was found in Stratum 13 (n = 47), which may indicate a more optimal muskox habitat at this location, although some muskoxen were found distributed across the management zone (excepted Strata 11 and 14).

During the 2023 Dolphin and Union caribou survey, a considerable southern section of MX-07 was flown at very high coverage, 30% to 70%, and the number of muskox groups observed was minimal, only accounting for 30 groups. For comparison, over 210 groups were observed in the same area in August 2013-2014 (Leclerc, 2015). Local knowledge from Cambridge Bay corroborates this observation, as hunters have seen fewer groups and they have to travel longer distances between groups in their traditional hunting areas (EHTA pers.com).

Muskox group size seems to vary independently of the muskox population trend. During the declining trend, 2000 to now (Tomaselli et al., 2018), two surveys performed revealed that the number of muskoxen per group is small, with a mean of 5.7 (sd = 4.32) in 2013-2014 (Leclerc, 2015) and 6.13 (sd = 4.11) in 2023-2024 (Figure 4). A majority of small groups were still encountered at a time where the muskox number was found to be increasing. When the muskox number was increasing, from 1960 to 1990 (Tomaselli et al., 2018), the mean group size ranged from 9.9 (SE = 1.4) (Gunn and Lee, 1990) to 5.1 (SE = 0.2) (Gunn and Patterson, 2012) depending on the survey year and survey area. However, the range in groups size seems to contract in a declining phase. The largest group size was 18 in this study and 25 in 2013-2014 (Leclerc, 2015). Local knowledge affirmed that groups larger than 20 individuals were seen before the decline. In fact, group up to 37 muskoxen were reported during the increasing phase (Gunn and Patterson, 2012).

The muskox defense mechanism is characterized by the adult's behavior to form a tight circle facing outward, protecting the calves in the centre (Heard 1992). Forming large group can be a dissuasive and be used as an intimidating tactic to deter predators. When the group is small, muskoxen are more likely to form a line and individuals, especially calves, might become an easier target. Since the first sighting of grizzly bears at Rymer Point around 1978, their sightings on Victoria Island continue to increase as the years progressed (KAA pers. com.). Local knowledge suggests that muskox calves are an easy target for the grizzly that seems to kill, and leave most of the carcasses untouched (KAA and EHTA pers.com). Some hunters have followed grizzly bear tracks and found seven muskox carcasses (EHTA pers.com). However, no grizzly bears or wolves were observed during the survey of MX-07, while a total of 18 groups of polar bear were observed for a total 33 individuals. Their absence in the management zone seems reasonable based on the low number of prey.

Victoria Island had the largest endemic muskox number in the circumpolar Arctic at its peak in the 1990s (Cuyler et al., 2019). The results from this survey can be compared with the 2013-2014 survey results, as the same area was surveyed. In 2013-2014, 1,296 muskoxen were counted on transect, which resulted in an estimate of 10,026 ± 597 (SE) (CV = 6%) muskoxen and a density of 0.0743 muskox / km^2 (Leclerc, 2015a) In 2023-2024, a minimum zone of 180 muskoxen resulted from our effort, but the observations were too scarce to have confidence in an abundance estimate for the management zone. Results suggest that between these two MX-07 surveys, a continuous decline has occurred, with 86% less on transect observations then in 2013-2014, even with a higher survey effort in 2023-2024. In May 2023, a survey on the Northwest Territories portion of Victoria Island resulted in 380 adults and 25 calves observed on transect, with preliminary estimates showing that the muskox at this location also continued to decline (Davison et al., 2023). Due to the length of time between estimates, it is impossible to determine a more detailed picture of the trajectory of the trend within these 10 years. For example, to determine if the decline has stabilized over the last two to three years. Therefore, an increase in the monitoring frequency is warranted for this management zone, as well as the development of indices that can be used in between costly surveys to monitor trends more closely.

Muskox population cycles are not well understood. This species faced extinction in the early 1900s, because of an overexploitation of this resource by explorers during the fur trade (Barr, 1991). Since then, small pockets of muskox were recovering and recolonized their habitat. Such a pattern has been monitored on King Williams Island and the Boothia Peninsula, locations previously characterized and documented by the absence of muskox, where muskoxen are now thriving and increasing (Leclerc, 2015b; Leclerc, 2019). On the west side of the Canadian Arctic, on Banks and Victoria Islands, muskox reached their peak in abundance between 1990 and 2000, but underwent a rapid, drastic decline (Tomaselli et al., 2018; Leclerc, 2015; Davison and Baryluk, 2021). These examples might support that the muskox cycle is characterized by periods of boom and bust across its range.

During the bust, the concern goes beyond the decline in abundance, as the very few individual lefts are imperiled by a loss of genetic diversity making them less resilient to diseases and brings additional concern on their capacity to adapt to accelerated rapid warming in the Arctic (Lok et al., 2024). This is a concern because muskox genetic diversity is naturally very low and, in some cases, even lower than a species which have bene identified a risk. For example, muskox have lower diversity than the Tasmanian devil (*Sarcophilus harrisii*), a species that recently experienced a population bottleneck (Lok et al., 2024, Morris et al., 2012). The very low number of muskoxen left on Victoria Island increases the conservation concern for the fate of muskox as a species. A recent genetic study of the whole muskox genome showed that muskox underwent repeated population bottlenecks (Prewer et al., 2022). This suggests their past ability to survive “the climate crash” and glaciation events (Bartoli et al., 2005), as well as their ability to survive the hypothesis of the boom-bust muskox population dynamics.

The boom-bust dynamics are characterized by a period of almost exponential growth that overshoots the species carrying capacity, which leads to a subsequent population crash (Doebeli et al*.*, 2021; Haller-Bull and Bode, 2021). Such eruptive dynamics are common for species that are free of limiting factors (predators) in the new colonized environment. Understanding the cause of muskox population fluctuations such as primary exogenous (environment stochastic with weak density dependance) or endogenous (over-compensatory dependence) could help manage muskox population to minimize boom-bust dynamics, so the species can reach a stable equilibrium dynamic and to lessen the extinction risk (Boor et al., 2017).

Many contributing factors, acting in concert, might have played a role in causing this drastic decline of muskox on Victoria Island. Wildlife populations are regulated by different mechanisms; either density-dependent or independent. The risk of diseases can increase with the host population density. The community-based health surveillance program allowed us to monitor the diseases infection rate in muskox as the population grew. In 2008-2013, an increase in morbidity and mortality were documented, as hunters found muskox carcasses on the land. The post-mortem investigation of dead muskoxen resulted in the carcasses testing positive for *Erysipelothrix rhusiopathiae*. In addition, a fecal sample collection also confirmed the northward spread of the muskox lungworm, *Umingmakstrongylus pallikuukensis,* and finally*,* in more recent years, Orf and Brucellosis were also detected (Tomaselli et al., 2014; Dalton et al., 2024; Aguilar et al., 2024). These observations allow to detect change in population trend earlier, acting as surveillance warning system. However, these increases in outbreaks could be because of an alteration of the environment from anthropogenic climate changes (Lok et al., 2024).

The northern part of Victoria Island, an arctic desert, receives less than 250 mm of precipitation annually. Climate change is occurring at an unprecedented rate (Rantanen et al., 2022). Shift in the precipitation regime, such as an increase in the phase of liquid over solid precipitation and potential increase in evaporation rate would drive complex ecological changes in the arctic terrestrial ecosystem affecting plant diversity, abundance, and distribution. These major changes can impact and disrupt muskox habitat. Recently, hunters have seen an influx of muskox on the sea ice migrating to the mainland (KAA and EHTA pers.com), perhaps seeking a more optimal habitat. Although these changes in the muskox habitat remain highly speculative, additional effort should be allocated to investigate if change in the environment occurred during the decline.

The Victoria Island management zone, MX-07, has been managed for a harvested population since the muskox numbers were large and the probability of extinction in the short term was negligible. Now, with such a small number remaining, the management regime should shift from focusing on harvest potential to minimizing the risk of extirpation and promoting timely recovery. Such models should take into consideration the possible immigration/emigration factors from the neighboring population from surrounding islands, such as Banks Island, King William Island, or Prince of Wales Island, and including other sources of variation (i.e. genetic effect, environment stochasticity). Since the muskox on Victoria Island has been subjected to no or low harvest pressure for over the past 5 years, attention should be geared to the threats currently affecting reproduction rates by preserving calves. Co-management partners' discussion should focus on developing management strategies with long-term goals. To assure species persistence, the establishment of management strategies to promote the long-term maintenance of the species on the landscape and minimizing extinction threat is primordial. It is also important to continue gathering information on muskox population dynamics.

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