MUSKOX (*Ovibos moschatus*) DISTRIBUTION AND ABUNDANCE, MUSKOX MANAGEMENT UNITS MX-08, BOOTHIA PENINSULA, AUGUST 2017.

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Version: February 2019

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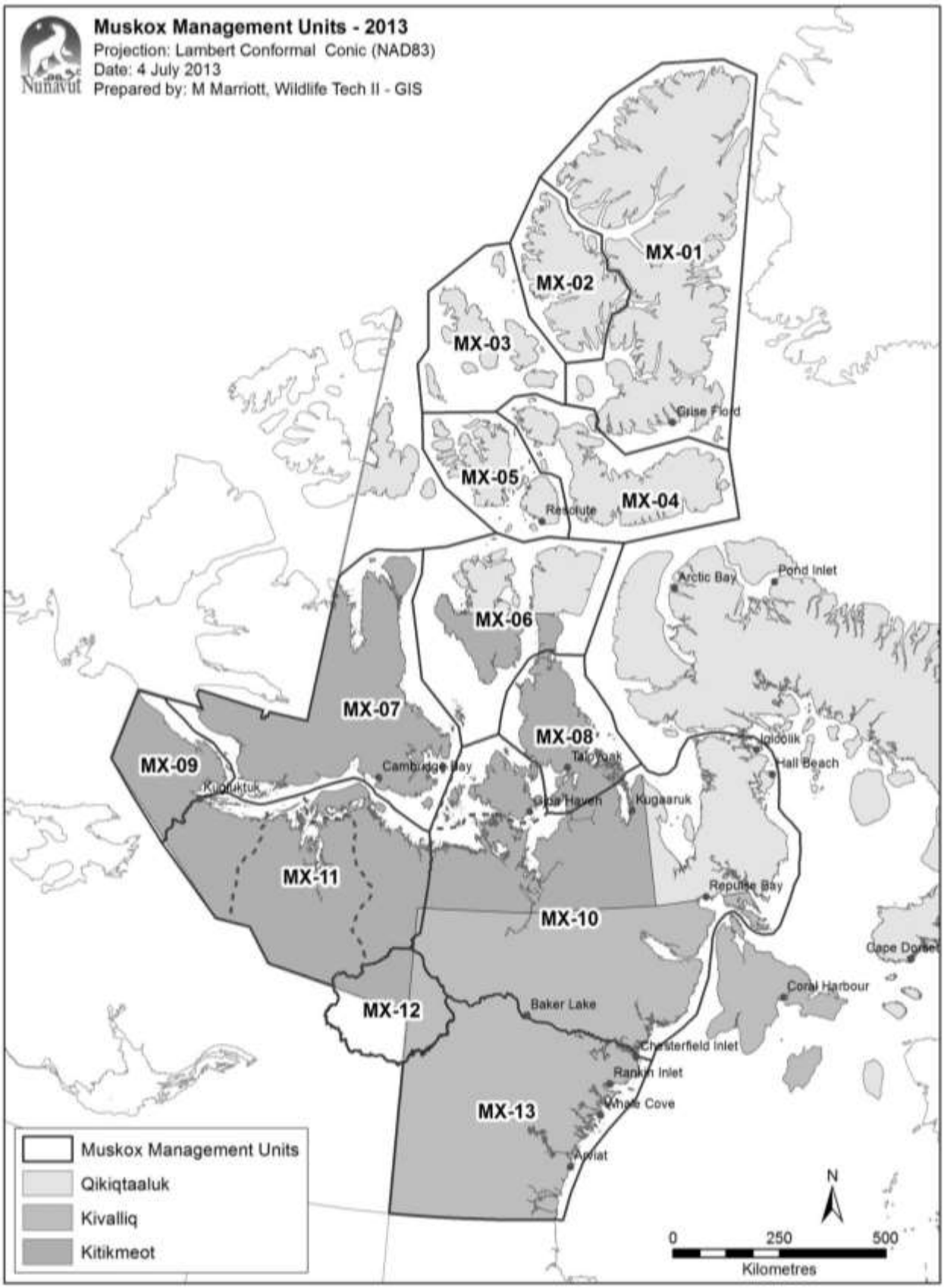
Muskox Management Units - 2013
Projection: Lambert Conformal Conic (NAD83)
Date: 4 July 2013
Prepared by: M Marriott, Wildlife Tech II - GIS
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Executive Summary

A systematic strip transect survey of the Boothia Peninsula was undertaken in summer 2017 to determine the abundance and distribution of muskox. The survey took place from August 07 to August 12. A total of 8,317.71 km^2 were flown, representing 20% coverage of the total study area (43,238 km^2). During the survey, 702 adult muskoxen were recorded on transect resulting in a population estimate of 3,649 ± 316 (S.E.). Calves represented 14% of the adult muskox seen and the average number of adults per group was small, 5 ± 4.45 (S.D.) The muskox density was of 0.084 muskox / km^2 in the management unit. This is an increase of muskoxen in MX-08 from what have been estimated previously, and it is consistent with the reported local knowledge. Thus, an increase in the current harvest rate could be supported by this current population estimate, as well as continuing the monitoring, harvest reports, and health monitoring program. A survey cycle of 5 years is advisable for this Muskox Management Unit or sooner if traditional knowledge indicates a significant change in the population trend, so harvest rate could be review.

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Introduction

The mechanism driving muskox population dynamics is not well understood. In the early part of the 1900s, hunting pressure drove muskox numbers close to extinction and reduced the distribution to a few limited pockets in the Canadian Arctic (Spencer 1976; Gunn 1984). To stimulate recovery, the existing muskox populations in Nunavut were managed to foster a continued colonization of the historic range (Gunn, 1983). While muskox are currently re-colonizing historical habitat in the central and eastern Canadian Arctic, most muskox populations have been increasing in the last few decades, inhibiting the monitoring of long-term population variation. Therefore, there is limited information available to determine how muskox populations naturally cycle.

The Boothia Peninsula is an example of a location where muskox is re-colonizing their historical range. Previous surveys on the Boothia Peninsula were conducted in 1985, 1995, and 2006. In 1985, the Boothia Peninsula was known to be devoid of muskox (Spencer Bay HTO pers. Comm; Gunn and Ashevak 1990). A decade later, 61 muskoxen were seen on transect providing an estimate of 554 ± 205 (SE) animals (Gunn and Dragon, 1998). According to hunter observations, muskox numbers around Taloyoak have been increasing since 1995. During the latest population survey, in 2006, muskox abundance for Boothia Peninsula was estimated at 1,100 ± 253 animals from the 562 adult muskoxen seen on transect (Dumond, 2007). Based on the location of sightings between the 1995 and 2006 surveys and local knowledge, muskox appear to occupy the Boothia Peninsula from Somerset Island, north of Amittaryouak Lake, moving southward reaching a southern limit at Cape Cambridge (Gunn and Dragon, 1998; Dumond, 2007). In 2006, areas of higher muskox density were found in the vicinity of Murchison Promontory and Pasley Bay. Thus, the environmental conditions on the Boothia Peninsula seem to be optimal to promote muskox population growth.

Taloyoak Hunters have commented on the higher numbers of muskoxen sightings. They fear that muskox will start impacting negatively the caribou calving grounds on the Boothia Peninsula. It is part of Inuit traditional knowledge that muskoxen displace caribou from their habitat. Muskox feeding pits or the destruction they cause to ground cover might prevent caribou from feeding in the area or the strong muskox musk might deter caribou. However, muskox and caribou have been co-habiting in the Arctic for thousands of years, where their ranges overlap temporally and spatially. Even today, there is no clear scientific evidence determining an negative impacts related to the muskox-caribou relationship, as this inter-species relationship is difficult to isolate from confounded variables in the wild. Thus,

traditional knowledge might be a more powerful tool to understand in inter-species relationship.

In 1995, there was no muskox quota in the area that was previously part of MX-09 due to the very low number of muskoxen on the Boothia Peninsula. However, a quota of 20 tags for Prince of Wales Island and 12 tags for Somerset Island were assigned to these two harvest zones (Gunn and Dragon 1998). After the 2006 population survey was completed, a Total Allowable Harvest (TAH) of 20 was set. Assuming that this quota was filled on a yearly basis, a harvesting rate of 6% would have led to a slow decline, as the harvesting rate will be higher that the population yield. (Tener, 1965). Despite this risky management approach taken with limited knowledge on the population demographics, recent local knowledge has indicated that the muskox numbers have still continued to increase.

Based on local knowledge, there is a need to re-evaluate the existing TAH relative to the management goal. Taloyoak hunters are requesting an increase in harvesting opportunities to keep the muskox population relatively low so they can preserve the caribou calving grounds. A reassessment of the muskox population in MX-08 is necessary to revisit the TAH. It is also important to make sure that there is enough incentive in place to reach the harvesting rate in order to achieve the goal of keeping the muskox population relatively low. Thus, this project aims to first provide an update of the current muskox population in the muskox management unit MX08. Consistent with other muskox surveys, the Nunavut wide monitoring approach will be used. This scientific information will be provided and paired with traditional knowledge to review existing management strategies and promote a sustainable harvest of muskox for future generations of Inuit allowing for the co-habitation of caribou and muskox on the Boothia Peninsula.

Objectives

This project aims to address the concerns and requests of Inuit hunters, as well as to provide up to date scientific information for management purposes. Therefore, the main objectives of this study are:

1. Determine the estimated number of muskox;
2. Determine muskox distribution and density;
3. Determine calf crop and group size.

By doing so, it will be possible to have better information on current muskox abundance and distribution in the muskox management unit MX-08. Information on group structure, calf

production, group size, and density is essential to gain insight on the relation between these variables and population dynamics.

Materials and Methods

Study Area

The study area is the muskox management unit MX-08, which includes the Boothia Peninsula and a portion of the mainland. The area lies between M'Clintock Channel to the west and the Gulf of Boothia to the east, and is separated from MX-06 to the north by Bellot Straight and the southern boundary is shared with muskox management unit MX-11. The Boothia Peninsula is the northernmost extension of the Canadian mainland and the North American Continent. The area is rich in topography with plains, lowlands, plateaus, and rolling bedrock hills (Dyke, 1984).

This management unit is part of the Northern Arctic Ecozone, which has two Northern Arctic Ecoregions. The southeast and the north part are characterized by Boothia Peninsula Plateau and a small portion of the southwest by the Victoria Island lowlands (Environment Canada, 1995). Due to the spatial heterogeneity of the area, the Arctic tundra vegetation cover is influenced by the soil moisture, nutrient availability, snow cover, wind exposure, and microclimate differences defining dwarf-shrub health or moist to wet sedge meadows (Laidler *et al.,* 2008).

Vegetation covers in the Victoria Island Lowlands are dominated by *Saxifraga oppositifolia, Dryas integrifolia*, and *Sali*x spp., and the wet areas are characterized by sedges, cottongrass, saxifrage, and moss (Walker, 2000; Environment, 1995). Remaining upland areas are part of the Boothia Peninsula plateau, which have a mid-arctic eco-climate. In the upland the vegetation is discontinuous, and dominated with tundra species (Environment, 1995). Vascular plants are found in bedrock cracks and depressions where it is well irrigated by runoff and protected from winds (Walker, 2000).

Survey Area

Prior to survey, no reconnaissance survey was undertaken to maximize the coverage area investigated. Instead, anticipated muskox distribution patterns were obtained from past ground surveys, hunter observations, and Inuit Traditional Knowledge/*Inuit Qaujimajatuqangit* (IQ). According to *IQ,* muskox has increased in numbers and they are now uniformly distributed over the entire Boothia Peninsula with no specific aggregation. Based on this change in distribution,

the whole management unit MX-08 was surveyed at 20% coverage with no strata of different effort allocation (Figure 1).

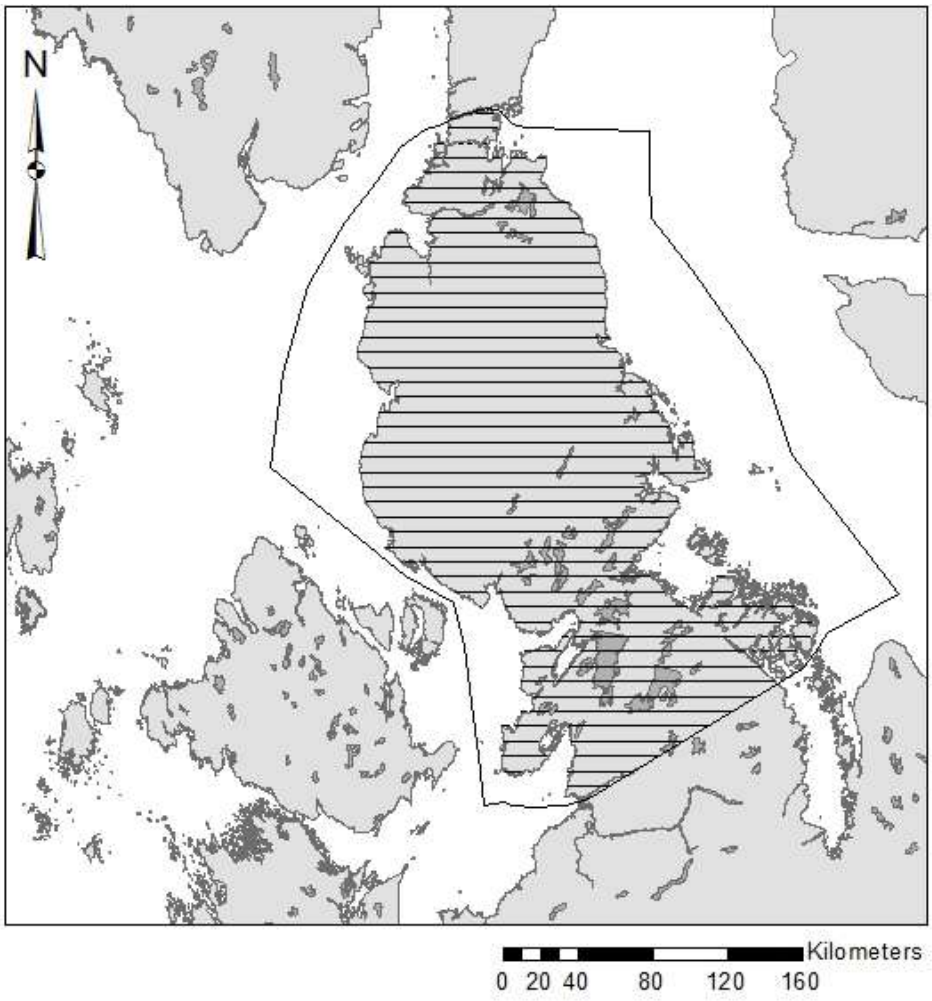

Figure 1: Transect lines representing 20% coverage of the muskox management unit MX-08.

To increase the precision of the survey areas, ESRI'S ArcGIS software with an adapted survey design tool was used to randomly plot the transect lines until the desired percentage of coverage was achieved. The tool allows the user to determine the precise number of transects and the distance between each transect line required in function of the transect strip width and the total area of the management unit. Orientation of the transect lines within the stratum was determined in function to have the most homogeneous and shorter transect line length under the assumption that muskox are randomly and uniformly distributed on the landscape (Figure 1).

Table 1, below, summarizes the total area, the percentage of cover, the total number of kms of transects of different length, the number of lines, the resulting distance between each transect line and the orientation of the transect lines. In sum, the management unit, MX-08, of 43,238 km^2 was surveyed with a total of 5,198 km of transect lines, which represented 46 transect lines of different length at a spacing of 8 km (Table 1).

Table 1 Characteristic of the study area and the transect lines per stratum in the Management Unit MX-08.

Stratum	Total area (km^2)	Percentages (%)	Total transect lines (km)	Number of lines	Distance between transect line (km)	Orientation
1	43,238	20	5,198	46	8	East-West
MX-08	43,238	----	5,198	46	----	----

Aircraft configuration

A systematic transects line survey was flown with a fixed-wing single engine turbine aircraft, a grand caravan. The transect lines were surveyed at a speed of 160 km/hr and the survey altitude of about 152 meters, which was mostly maintained following the relief of the study area using a radar altimeter. The pilot responsibilities were to monitor this air speed and altitude while following the pre-programmed transect on a Geographic positioning system (GPS). The strip transect was 800 meters on each side of the aircraft, for a total transect width of 1.6 kilometers. The pre-determined transect width of 400 meters was set on each wing based on calculation using the formula of Norton-Griffiths (1978) and others (Gunn and Patterson 2000; Howard 2011).

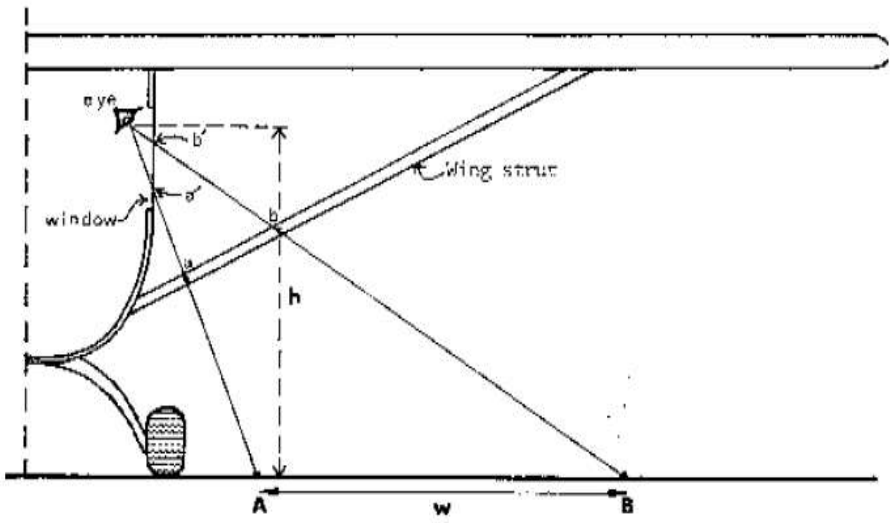

Figure 2: Schematic diagram of aircraft configuration for strip width sampling North-Griffiths (19878). W is marked out on the tarmac, and the two lines of sight a'-a-A and b'-b-B establish, whereas a'- and b' are the window marks.

$$w = W*h/H$$

Where, W= the required strip width; h= the height of the observer's eye from the tarmac; and H= the required flying height.

The entire survey was set up with an observer/recorder crew: two recorders, one left side observer and one right side observer. Each left and right observer and a recorder were divided into a team. Observers were responsible to continuously searched for and counted muskox; the number of calves (5-6 months old) were counted when they were conspicuous while on transect. No sex and age classification count were systematically attempted. The data recorded included the number of muskox and GPS locations. Only counts of adults were used in the final population estimate. Even if this survey focused on muskox, additional sightings of other species were also recoded, such as caribou, polar bear, and wolf.

Analyses

As this survey focused mainly on obtaining an estimated number, only unambiguous classification criteria were used to determine the number of calves and adults. The group was then broken down into adults (female/male) and calves (Howard 2011). The flying height and speed did not allow for accurately distinguishing male from female muskox from horn size and shape. Therefore, the proportion of calves per female cow was not determined, and no information on the recruitment or productivity was generated. The group structure was

however described such as calf:adult ratio, mean group size, and the number of single lone bulls encounter.

To determine the number of muskoxen in the study area, only the adult muskoxen sightings recorded on transect were analyzed using Jolly's Method 2 for unequal sample sizes (Jolly 1969) using a coefficient limit of 95%. Such methodology was previously used for the survey of Boothia Peninsula in 2006. The population estimates for fixed-width strip sampling using Jolly's Method 2 for uneven sample sizes (Jolly 1969; summarized in Caughley 1977) are derived from the following equation:

$$\hat{Y} = RZ = Z\frac{\sum_i y_i}{\sum_i z_i}$$

Where $\hat{Y}$ is the estimated number of animals in the population, R is the observed density of animals (sum of animals seen on all transects $\sum_i y_i$ divided by the total area surveyed$\sum_i z_i$), and Z is the total study area. The variance is given by:

$$Var(\hat{Y}) = \frac{N(N-n)}{n}\left(s_y^2 - 2Rs_{zy} + R^2 s_z^2\right)$$

Where N is the total number of transects required to completely cover study area Z, and n is the number of transects sampled in the survey. s_y^2 is the variance in counts, s_z^2 is the variance in areas surveyed on transects, and s_{zy} is the covariance. The estimate $\hat{Y}$ and variance $Var(\hat{Y})$ are calculated for each stratum and summed. The Coefficient of Variation (CV = σ/$\hat{Y}$) was calculated as a measure of precision.

Density, the number of muskoxen per unit area (muskox/km^2), will be determined using the number of adult muskoxen seen on transect divided by the total area of the study area. Lakes and stream areas will be not subtracted from the total area calculations used in muskox density (Statistical analysis based on Campbell and Setterington (2001)).

The area occupied by muskox and the time of the survey within the study area was determined. Thus, the distribution of muskox was illustrated by plotting each muskox sighting on and off transect, based on their precise geospatial position captured with GPS. In addition, the number of animals composing each group was highlighted using an increasing size of circles to represent groups of 0-1, 2-7, 8-11, 12-15, and 16-19 animals.

Given the importance of predators, Polar bear (*Ursus maritimus*) and Arctic Wolf (*Canis lupus arctos*), we collected standardized information of predator sightings in the management units

using the predator index (Heard, 1992). The predator index reports all predator sightings per species against the total number hours flown, also including the ferry time in this case. It is then possible to have a yearly trend, as the number of predators observed is expressed per 100 hours for this particular time of the year.

Results

The survey was conducted out of the community of Taloyoak from August 07th to August 12th, 2017. The management unit was surveyed in 40 hours, including on transect and ferrying flights from Taloyoak airport to the start of the transect lines. Low ceiling and fog prohibited the ability to survey continuously from the North to the South of the study area. Therefore, some sections were left to be completed at a later time, when the weather was permitting. The sedentary muskox behavior (Adamczewski *et al*., 1997) reduces the probability that an individual will move any great distance within the short survey time frame.

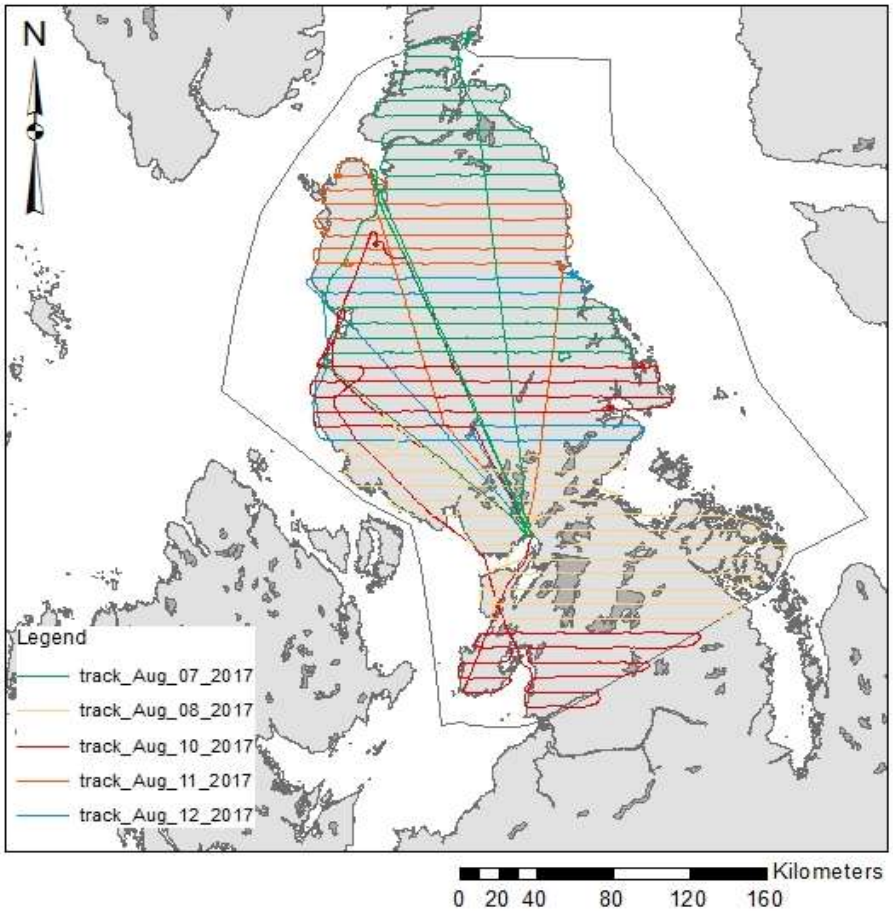

Figure 3: Daily tracks completed to cover 20% of the muskox management units MX-08 from August 7th to 12th.

Distribution

The adult muskox distribution in the management unit is represented in Figure 5 below. During the survey, 170 groups of muskox were seen on and off transect. The large groups of muskox, 16-19 adult animals, were distributed from Cape Farrand to Abernethy Bay within 40 km from coast. Additional muskox aggregations were found around the Wrottlesley River valley in the small portion of the southwest by the Victoria Island lowlands. Very few groups were located at high elevation (594 meters) in the central north part of the Peninsula, as muskoxen appeared to avoid the Boothia Peninsula Plateau. It was the first time that muskox observations was recorded south of Cape Cambridge, now reaching close to Acland Point at their southernmost distribution.

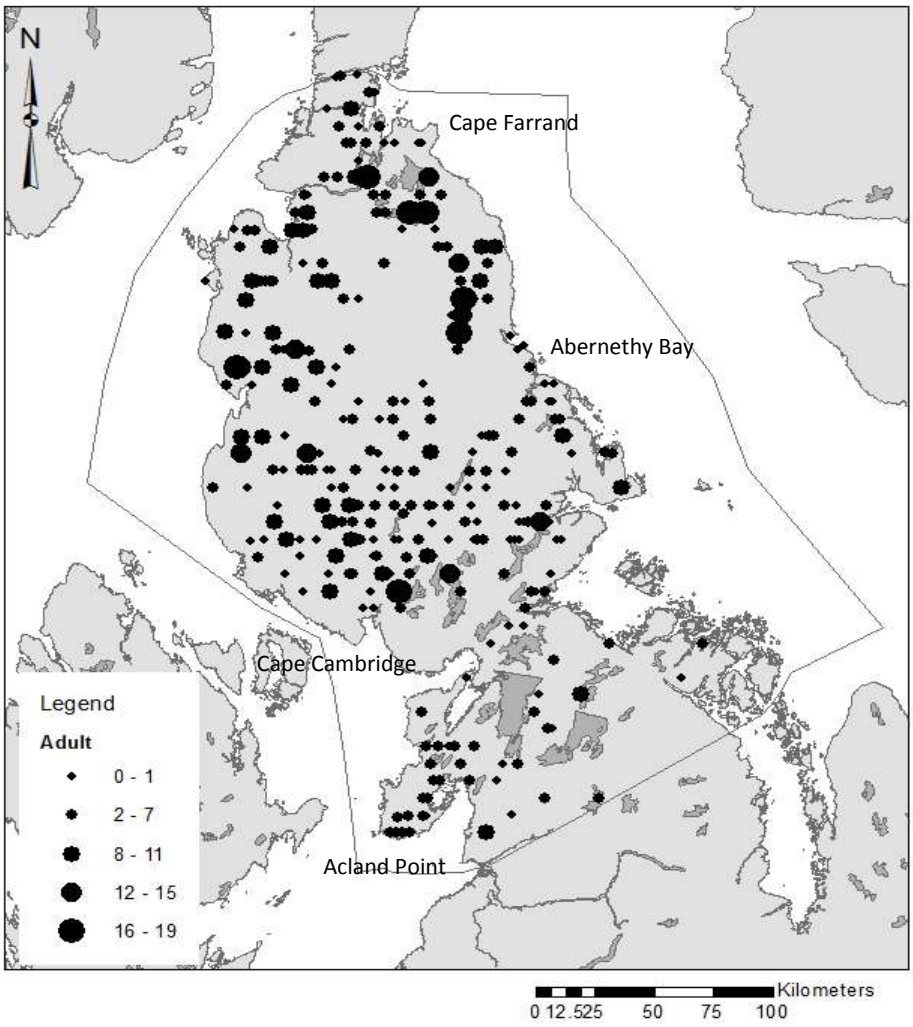

Figure 4: Muskox distribution on and off transect in the management unit MX-08 during the survey where the number of animals per group was grouped as 0-1, 2-7, 8-11, 12-15, and 16-19.

Group Characteristic

During the survey, 139 groups of muskox were recorded on transect, where 26 were single lone bulls. The majority of the groups (41%) were very small groups of 2 to 7 adults (Figure 5). The average number of adults (+1 year and older) per group was 5 ± 4.45 (S.D.) where calves were not included in the group size. The highest number of adults counted in one group was 19.

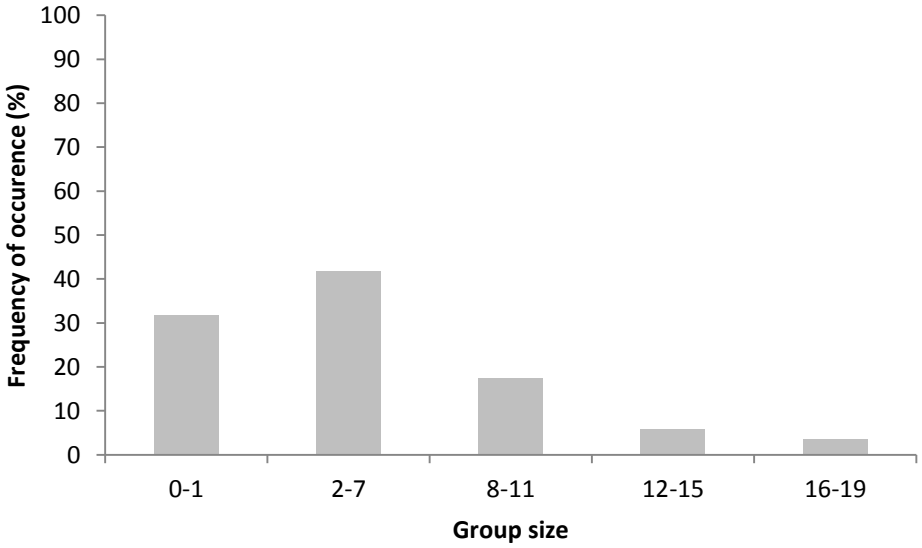

Figure 5: Frequency of occurrence (%) of adult muskox number per group size, grouped as follow 0-1, 2-7, 8-11, 12-15, and 16-19.

Nonetheless, the calf to adult ratio was determined for each group of muskox seen on transect. Since the identification was done from a fixed-wing, it was impossible to distinguish the sex of the adult or yearling based on the horn shape and length. Close to half the group seen (45%) did not have any calves. For the group that had calves, most of them had at least one calf, but some larger groups had up to 4. Most of the groups that had a larger proportion of calves were located north of the Boothia Peninsula, south of Murchison Promontory and west of Cape Farrand, and in the Wrottlesley River valley (Figure 6). The overall proportion of calves to adults was 14%.

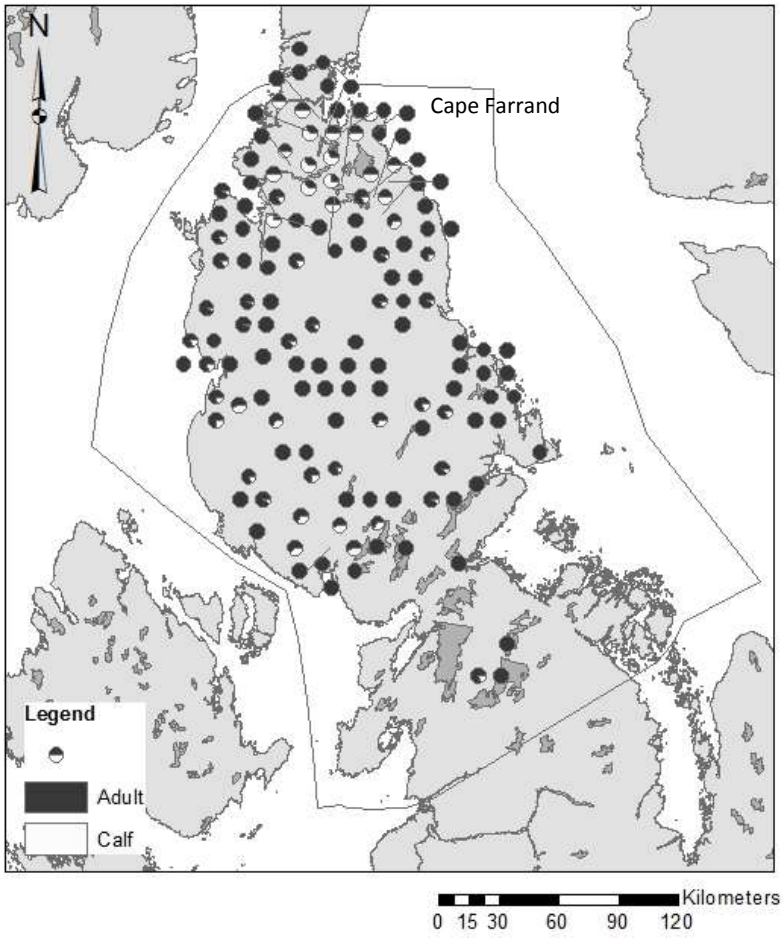

Figure 6: Proportion of calves per adult muskox in each group observed on transect in the Muskox Management Unit MX-08.

Estimate

The percentage of the overall cover of the management unit surveyed with 8,317 km^2 represented 20% of the total study area (43,238km^2). During the survey, 702 adult muskoxen on transect were recorded. The estimated number of muskox in the management unit MX-08, totaled 3,649 ± 316 (S.E.) ($p<0.005$, $t = 1.676$, $N = 184$ and $n = 46$). For this estimate, the total number of transect at 100% coverage was 184 (N) and 46 (n) transect lines were surveyed (Table 2). Overall, the muskox density of the management unit was 0.084 muskox/km^2.

Table 2 Muskox estimate in the Muskox management Unit MX-08

Stratum	Area Survey (km^2)	Total area (km^2)	Muskox on Transect	Estimate	Standard error (S.E.)	95% CL (±)	CV
MX-08	8,317	43,238	702	3,649	316	530	0.09

* $p<0.005$, $t = 1,676$, $N = 184$ and $n = 46$

Predator sighting (wolves, polar bear and grizzly bear)

In 2017, during the 40 hours of flying within the management unit, 2 wolf and 7 polar bear sightings were recorded. The wolves were found on the southern part of the study area; 1 wolf west of Josephine River and south of Netsilik Lake where four wolves constituted the pack. These two locations were overlapping with caribou sightings (Figure7). Being located between two polar bear management units, the M'Clintock Channel and the Gulf of Boothia, it was probable to observe polar bears. Indeed, 1 female and two cubs were observed on the Cape Hobson and a lone adult was seen a few kilometers inland off the shore of M'Clintock Channel. The remainder of the sightings were on the Gulf of Boothia, with seven polar bears and a female with a pair of cubs observed between Abernethy Bay and Mary Jones Bay. No grizzly bears were seen during the survey. Predator sightings, using the predator index, (Heard, 1992) reveled 13 wolves/100 hours and 25 polar bears/100 hours.

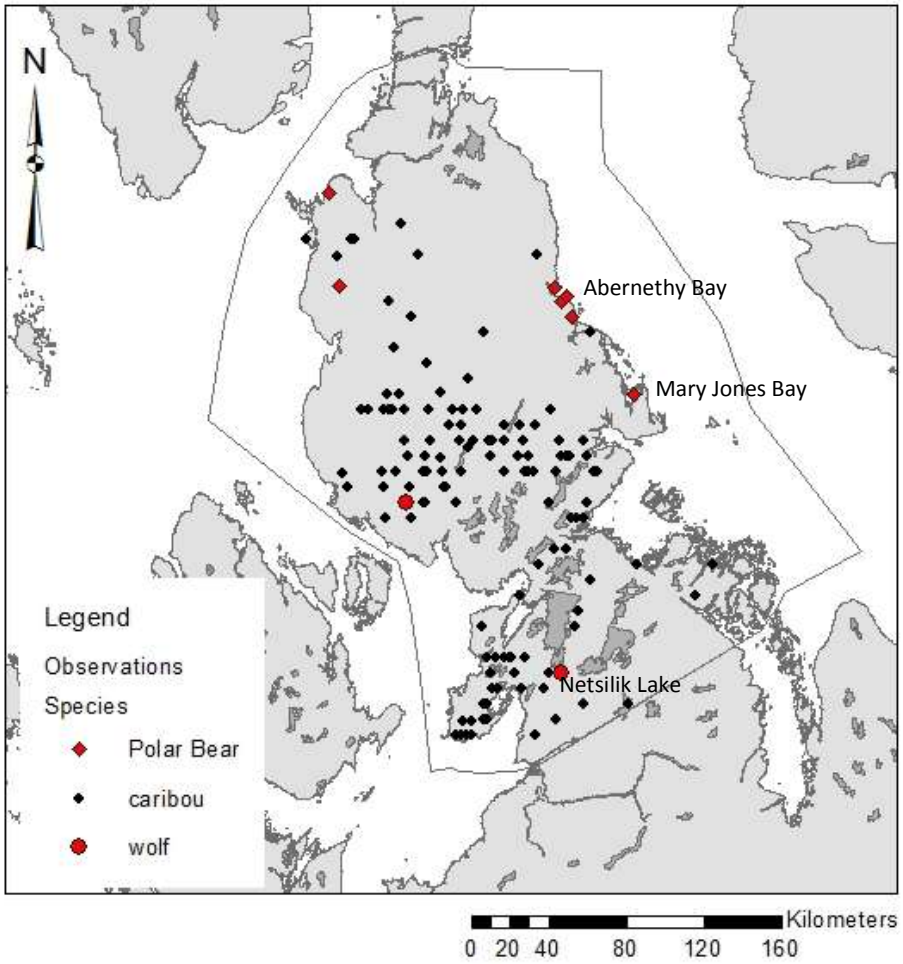

Figure 7: Locations where Polar Bears and Wolves were observed in the Muskox Management Unit MX-08 in relation to caribou distribution.

Discussion

Distribution

Despite the fact that traditional knowledge indicates that muskox inhabited the Boothia Peninsula long ago, it is common knowledge that muskox were not found in this management unit in the 1980s (Gunn & Dragon, 1998). Early in the 1990s, muskox started to move south of Somerset Island colonizing the northern part of the Peninsula, where their distribution remained consistent for a decade (Dumond, 2007). In 2017, although the majority of the muskox were still located north, they re-colonized most of the Peninsula reaching a new southern limit. Favorable environmental conditions and adequate forage, low number of predator (no grizzly bear) would have either contributed to increase the immigration rate or herd productivity. Muskox are now found in close proximity to the community of Taloyoak, as far south of Arcland Point, which can provide new harvesting opportunities. If these muskoxen are from the Arctic Archipelago, a subspecies genetically and morphologically distinct from the mainland muskox, it will be interesting to track their expansion and monitor the exchange between these two subspecies once their ranges overlap.

Group Characteristic

The number calves represented 14% of the total number of adult muskox observed on transect. This ratio is normally associated with a population that would be increasing, since it has been establish that a calf recruitment rate of 10.5% is necessary to keep the muskox population stable (Freeman, 1971). Since the calf ratios have known to vary greatly between years, long term data is needed in order to determine a trend (Reynolds, 1998).

Small groups of muskoxen was characteristic of the Boothia Peninsula, with an average group number of 5 ± 4.45 (S.D.), which is consistent with the mean group size of 6 established in 2007 (Dumond, 2007). Comparatively to King Williams Island where the muskoxen are known to increase in number rapidly, larger groups, 13 ± 8.40 (S.D.), were observed at the same period of the year (Leclerc, 2015).

Abundance Estimate

The extent of the harvest zone MX-09 remained relatively the same after the creation of MX-08 when each muskox management unit in Nunavut was reviewed in 2015. The major change, is that the new unit, now called MX-08, did not include the southern portion of Somerset Island, but starts at the northernmost coastline. This similarity allowed the 2017 study to be compared with previous population estimates.

Surveys of the Boothia Peninsula have occurred sparsely since the 1980s. In 1985, during a survey, no muskoxen were seen. Local knowledge has indicated that the presence of disease or parasites caused an abrupt decline in the muskox number. It is only in 1995 that muskox started to re-colonize the area and resulted in an initial population estimate of 554 ± 205 SE. The community members of Taloyoak mentioned a consistent increase in the muskox number. This observation triggered a second survey, in 2007. This survey confirmed the local knowledge and the muskox numbers were then estimated at 1,058 ± 198 SE. Recently, with this continuous increase, muskox have been recorded to be close to the community of Taloyoak and they would like to re-adjust the Total Allowable Harvest. In 2017, the estimated number of muskox reached 3,649 ± 316 SE, which is the highest number to date. There will likely be a recommendation for the NWMB to consider an increase to the current harvesting rate after consultation and discussion with the Hunter and Trapper Organization in the affected community of Taloyoak.

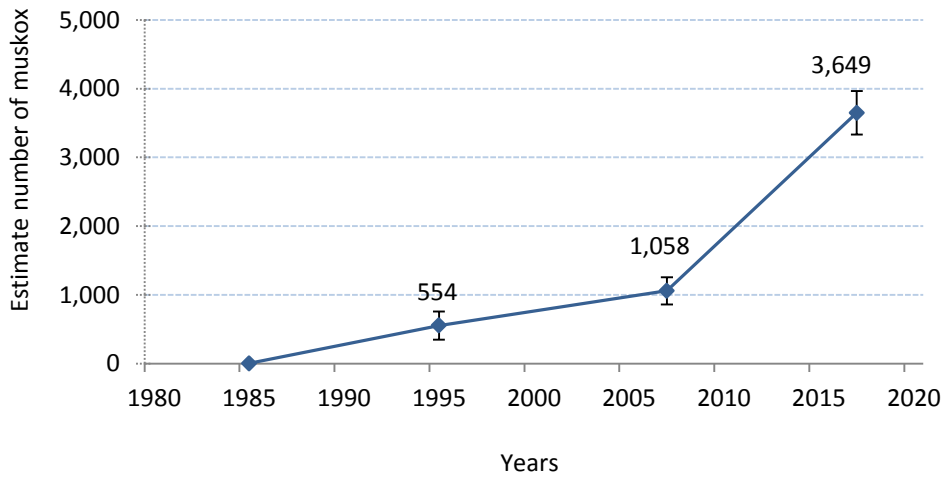

Figure 8: Muskox population estimate for MX-08.

Density

Muskox density was 0.084 muskoxen / km^2 on the Boothia Peninsula. In this management unit, the muskox has a density higher to the overall density on Victoria Island, 0.074 muskox / km^2, but is lower to that of King William Island where the muskox population has also increased (0.1123 muskox/km^2) (Leclerc, 2015). The mechanism driving muskox density is still not fully understood. Heard (1992) noted that group size in not generally related to muskox density. These qualitative comparisons between areas, highlight that density might fluctuate spatially and temporally.

Predator sighting (wolves, polar bear)

The number of known muskox predators was minimal. Only two wolves were observed, and at close proximity of caribou, their main prey. Wolf predation on muskoxen is common, with packs

or single wolves observed following and killing muskox. No Grizzly bears were found on the Boothia Peninsula. The relatively low abundance of predators would benefit calf recruitment and female survival, promoting an increase in the population. 25 polar bears 100 hours were seen, but polar bear are known to feed on a mainly marine based diet and are not known to predate on muskox and should not contribute to regulate muskox population.

Acknowledgements

I wish to thank the pilot, Brent Abercromby, for his dedication and in making the survey possible. A special acknowledgement goes to Thomas Bolt and Darien Evyagotailak for their logistical support and their enthusiasm and participation. I am grateful to the Taloyoak HTO for assistance in providing meaningful insight essential to the planning of this survey and the selection of observers. Karen Ikavalloq, Stevenson Kaviatok, Robert Quqqiaqand Jonah Aryout's involvement need to be acknowledge as they assisted as observers during the aerial survey. I also want to acknowledge the precious time that Tristan Brewer gave as technical support for the data analysis. This project was funded by the Department of Environment (Government of Nunavut) and the Nunavut Wildlife Research Trust Fund under the Research Permit 2017-12.

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