MUSKOX (*Ovibos moschatus*) DISTRIBUTION AND ABUNDANCE, MUSKOX MANAGEMENT UNITS MX09, WEST OF THE COPPERMINE RIVER, AUGUST 2017.

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For Nunavut Wildlife Research Trust

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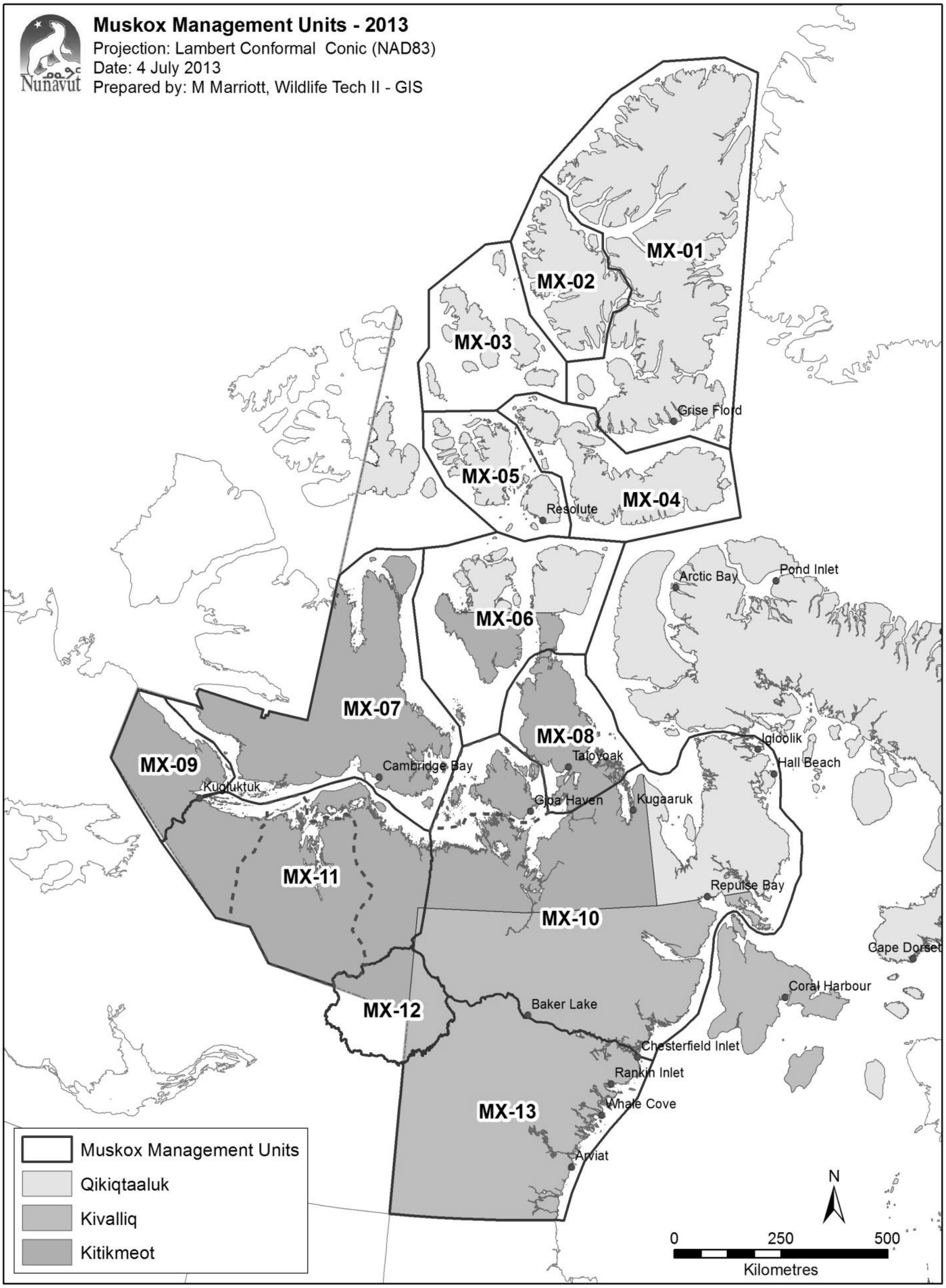
Muskox Management Units - 2013
Projection: Lambert Conformal Conic (NAD83)
Date: 4 July 2013
Prepared by: M Marriott, Wildlife Tech II - GIS
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Grise Fiord
Resolute
Arctic Bay
Pond Inlet
Igloolik
Hall Beach
Cambridge Bay
Taloyoak
Kugluktuk
Gjoa Haven
Kugaaruk
Repulse Bay
Cape Dorset
Coral Harbour
Baker Lake
Chesterfield Inlet
Rankin Inlet
Whale Cove
Arviat
Muskox Management Units
Qikiqtaaluk
Kivalliq
Kitikmeot
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Kilometres

Executive Summary

The muskox in the West Kugluktuk management units (MX09) are the westernmost indigenous muskoxen in North American. Systematic strips transect survey took place in August 2017 to determine the muskox abundance and distribution in this area. A total of 8,591 km^2 were flown, representing 16% coverage of the study area of 53,215 km^2. During the survey, 87 adult muskoxen were recorded on transect resulting in an estimated number of 539 ± 150 (S.E.). The population in MX09 have been mostly stable since 1994, and it is consistent with local observations. Muskox distribution had not change from the historical one. Muskoxen have taken advantage of the wetter and lower-lying area in the Rae-Richardson River Valley that is within the proximity of uplands that provide them with suitable forage and a refugee from predators. The calf to adult ratio was 38% and the average number of adult per group was small, 6.21 ± 6.6. (S.D.). Muskox density was the lowest encounter within the Kitikmeot region with 0.010 muskox / km^2 since 2013. The next survey of this area should be effectuated no later than 2023, so harvest quota could be review.

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Introduction

During the last century, muskox on the upper Rae-Richardson River Valley were able to persist on the landscape while this species was getting nearly extirpated (Barr, 1991). This small pocket of muskox was known as the population of the North of Great Bear Lake. This population increased in numbers allowing for a small harvest quota to be establish for Kugluktuk (6 tags) and Paulatuk (8 tags) (Urquhart, 1980). The muskox population of the North of Great Bear Lake kept growing giving raise to the muskox population of the Rae-Richardson River watersheds, which was recently renamed the West Kugluktuk muskox management units, MX09.

The muskox of the West Kugluktuk management units are the westernmost indigenous muskoxen in North American, and represent the muskox population with the longest monitoring effort depicting over 80 years of monitoring (Kelsall *et al*., 1971). Based on comparable systematic population survey, this population peaked in 1988 before it plummeted and remained stable with around 550 animals between 1994 to 2007 (Gunn, 1995; Dumond, 2007). Even if this population is subject to year-round hunting by the community of Kugluktuk, the quota has been limited and enforced to 20 tags. It is known that harvesters do not fill this limit annually, since there is general local knowledge that these muskoxen are “sick” and found in few numbers (Kugluktuk HTO, pers. comm.). In the 1990s, the discovery of a lungworm parasite (*Umingmakstrongylus pallikuukensis*) was an attributable factor to the decline of the population (Gunn, 1995, Kutz, 2000). Although the effect of this parasite on the muskox population dynamic remains to be understood, this lungworm is known to decrease the respiratory capacity of the individual muskox thus making it more vulnerable at out running a predator.

The Rae-Richardson Rivers Valley area constitutes a rich habitat for predators, as it sustains wolf (*Canis lupus arctos)*, wolverine (*Gulo gulo*), and grizzly bear (*Ursus arctos horribilis*). Potential increase in grizzly bear could suggest that this predator is exercising a greater pressure in inhibiting the muskox population growth (Gun, 1995). However, recent study shows that the grizzly bear’s diet has great proportion of small tundra herbivores (e.i. ground squirrels). On the other hand, muskox accounted for an important prey for wolves and wolverines (L’Herault *et al*., 2016). People and the predators are depending on the same resources, muskox, and have always co-existed on the landscape. Under Inuit natural laws, all living forms should be respected as well as the roles they play in the ecosystem. This concept is referred by elders and hunters as *Maligaits* (L’Herault *et al*., 2016).

Since the caribou are declining in numbers and are becoming harder to harvest, harvesters are seeking alternative sources of meat, such as muskox, to help palliate food insecurity. Not only the conservation and the recovery of this small size population of muskox should be a priority, but the preservation of the harvesting rights should be maintained as a satisfactory long-term solution to food security in this northern community. This task is impossible without re-assessing the muskox population of MX-09, and revisiting the Total Allowable Harvest (TAH), and this project aims to provide an update of the muskox population, MX-09. Consistent with other muskox surveys, the Nunavut wide monitoring approach will be used. This scientific information will be provided in balance with Traditional Knowledge to review existing management strategies and promote a sustainable harvest of muskox.

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 : adult ratio 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-09. Information on group structure, calf production, group size and density, are essential to gain insight on the relation between these variables and population dynamic.

Materials and Methods

Study Area

The study area is the muskox management unit MX-09, also called West Kugluktuk management unit. The area has for boundary, to the west and south, the Nunavut boundary with the Northwest Territories and, to the north, the coast line of the Dolphin and Union Straight. The muskox management unit MX-09 is separated to the east from the adjacent muskox management unit MX-11 by the Coppermine River.

This area is part of the Southern Arctic Ecozone, transiting following the latitudinal gradient from the boreal forest around Great Slave Lake to the tundra. In this subdivision, two terrestrial ecoregions are found, the Takijuq Lake Upland and Coronation Hills regions (Environment Canada, 1995). In the south of the subdivision, it includes; the edge of the tree line, eskers, rocky barrens, with lakes going through the landscape to provide a physical uniqueness. The taiga forest is present, but restricted to a locally warm and dry place with scattered stands of spruce. The taiga gives place to northward vegetation covers, which are dominated by sedge meadows and shrubs, such as dwarf birch, willow mixed with various herbs, lichens, and mosses. The entire east side boundary of the study area is characterized by vegetated rock outcrops that are common on the Canadian Shield (Environment Canada, 1995). To the North, the Coronation Hill region prevails. The relief of the lower Coppermine River valley and coast line is characterized by weather-worn plateaus and south facing hill systems. These topographic features along with the climate, influence the biotic processes differently. Plant cover becomes discontinuous to null at higher elevations, on dry exposed sites, and on the low profile sand dunes boarding the coastline north of the Bluenose Lake.

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). Since it was reported that muskox groups are still found in low number across MX-09, the whole management unit was surveyed at 16% coverage with not strata of different effort allocation (Figure 1).

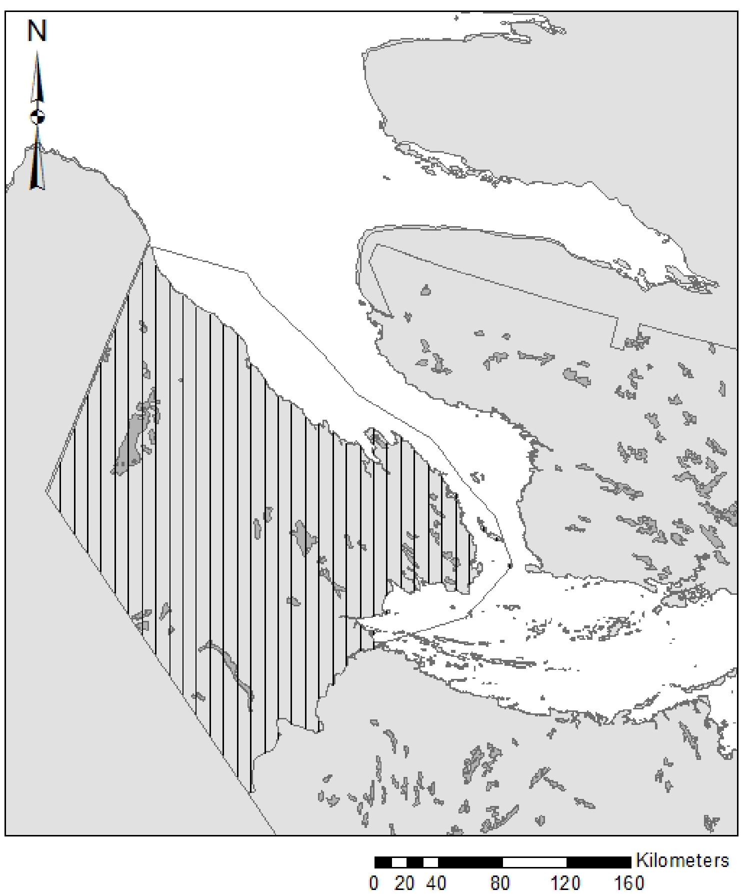

Figure 1: Transect lines of the muskox management units MX-09 representing 16% coverage of the area.

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 desired percentage of coverage was archived. 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 groups 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 km of transects of different length, the number of lines, the resulting distance between each transect line and the orientation of the transect line. In sum, the management unit, MX-09, of 53,215 km^2 was surveyed with a total of 5,237 km of transect lines, which represented 31 transect lines of different length at a spacing of 8.5 km (Table 1).

Table 1 Characteristic of the study area and the transect lines per stratum in the Management Unit MX-09.

Stratum	Total area (km^2)	Percentages (%)	Total transect lines (km)	Number of lines	Distance between transect line (km)	Orientation
MX-09	53,215	16	5,237	31	8.5	North-South

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 121 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 800 meters was set on each wing based on calculation using the formula of Norton-Griffiths (1978) and others (Gunn and Patterson 2000; Howard 2011).

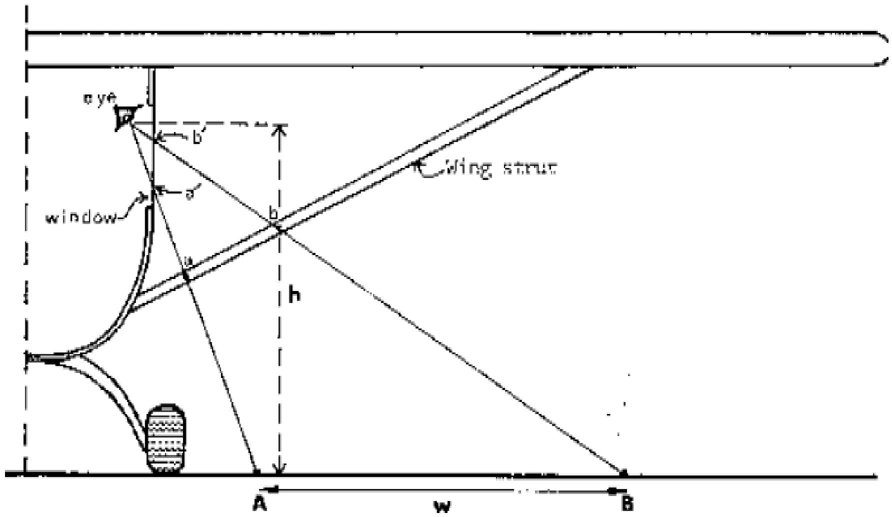

Figure 2: Schematic diagram of aircraft configuration for strip width sampling North-Griffiths (1978). W is marked out on the tarmac, and the two lines of sight a'-a-A and b'-b-B establish, whereas a'- and b' are the window marks.

$$w = W*h/H$$

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 side observers and the recorders were divided into a team. Observers were responsible to continuously search for and count 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 include the number of muskox and GPS location. 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, grizzly bear, wolverine, 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 in a group from horn size. 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 crop, mean group size, and the number of single lone bull encounter.

To determine the number of muskox in the study area, only adult muskox 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 is commonly used in calculating the muskox estimate in other management units in Nunavut. 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 muskox per unit area (muskox/km^2), will be determined using the number of adult muskox 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 was illustrated by plotting each muskox sighting on 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, Arctic wolf, wolverine, and grizzly bears, we collected standardized information of predator sightings in the management units using the predator index (Heard, 1992). The predator index reports all predator sighting per species against the total number hours flown, in this case also including the ferry time. It is then possible do have a yearly trend, as the number of predators observed is expressed per 100 hours.

Results

The survey was conducted out of the community of Kugluktuk from August 25th to August 30th, 2017. The management unit was surveyed at 16% coverage, which was surveyed in 51 hours, including on transect and ferry flight from Kugluktuk airport to the start of the transect lines. Low ceiling and fog prohibited to survey continuously from the west side to the east on the management unit. Therefore, some sections of the coast line were left to be completed at a later time, when weather was permitting. The sedentary muskox behavior (Adamczewski *et al.*, 1997) reduces the probability that an individual moves a significant distance within the short survey time frame.

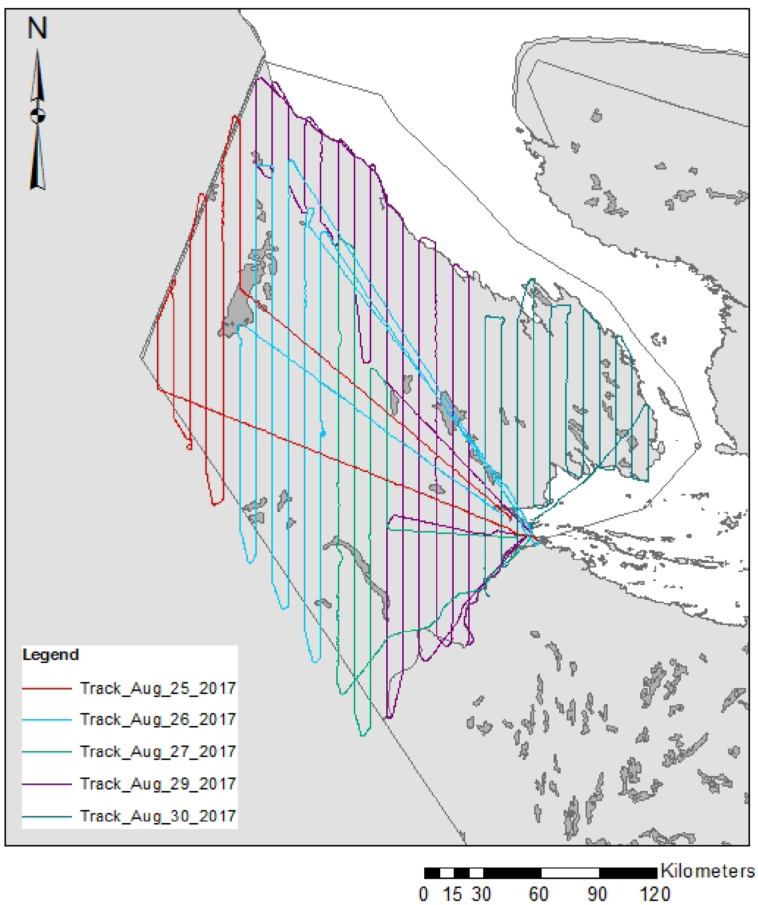

Figure 3: Daily track effectuated to cover 16% of the muskox management units MX-09 from August 25th to 30th.

Distribution

The adult muskox distribution in the management units is represented in the Figure 5 below. During the survey, 18 groups of muskox were seen on and off transect. The large groups of muskox, 16-19 adult animals, were distributed mostly north of Dismal Lake, and 25 km from the coast south of Stapylton Bay. Most muskox sighting were found between Emagyok Lake and Dismal Lake in the Rae-Richardson River Valley. No muskoxen were seen on the west side of the management unit, or around Bluenose Lake.

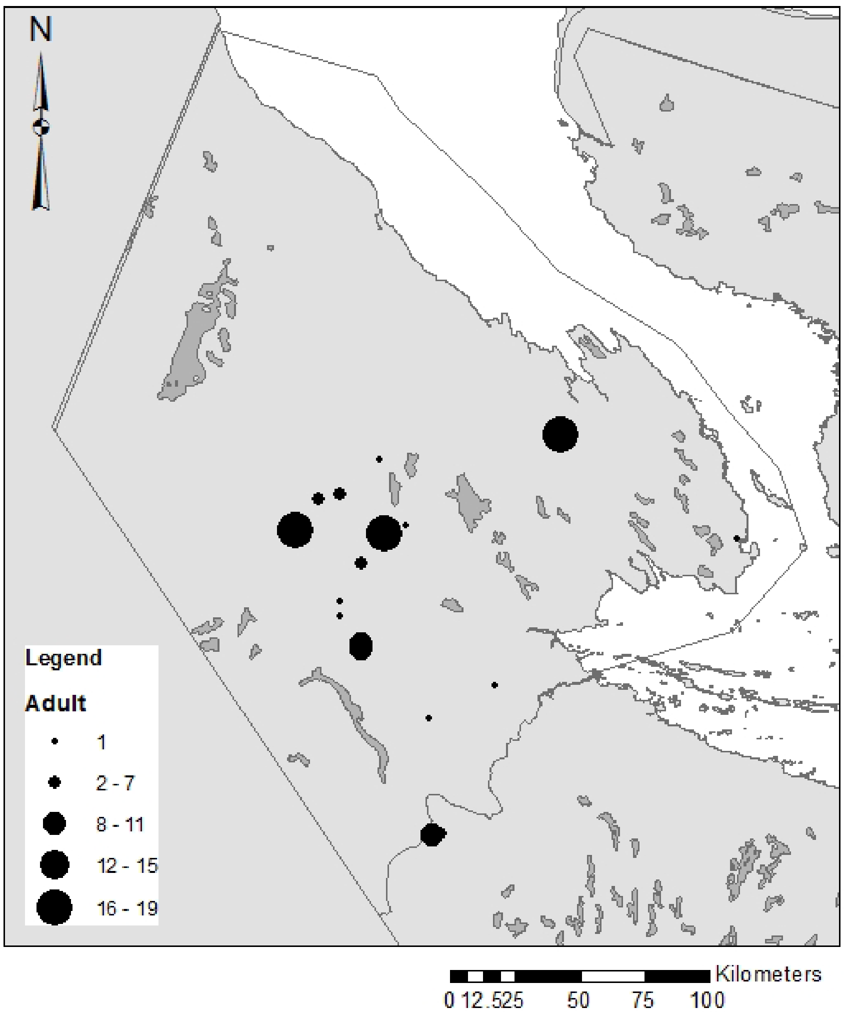

Figure 4: Muskox distribution on and off transect in the management unit MX-09 during the survey where the number of animal per group was grouped as 0-1, 2-7, 8-11, 12-15, and 16-19.

Group Characteristic

During the survey, 14 groups of muskox were recorded on transect, and seven groups were single muskox, mostly lone bulls. The majority of the groups (58%) were small groups of 2 to 11 adults (Figure 5). The average number of adults (+1 year and older) per group was 6.21 ± 6.6 (S.D.). The highest number of adults counted in one group was 18. Calves were not including in the group size, but in the calf to adult ratio.

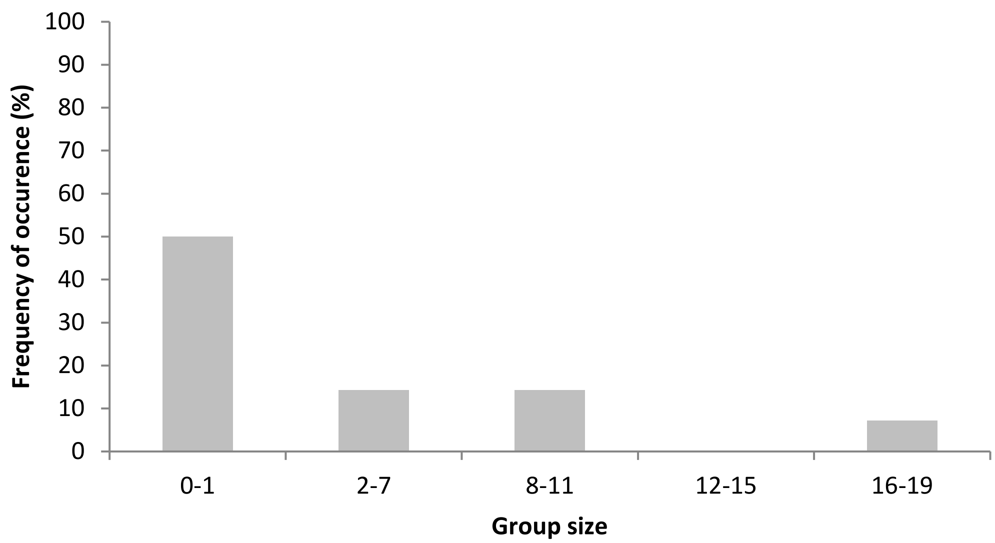

Figure 5: Frequency of occurrence (%) of adult muskox number per group size, grouped as follow 0-1, 2-7, 8-11, 12-15, and 16-19.

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 with certainty the sex of the adult or the group age based on the horn shape and length. A little more than one third of the group seen (36%) had calf. For the group that had calf, most of them had at least one calf, but some larger groups had 12 and where distributed mostly in the Rae-Richardson River Valley (Figure 6). Thus, the calf to adult muskox ratio was 38%.

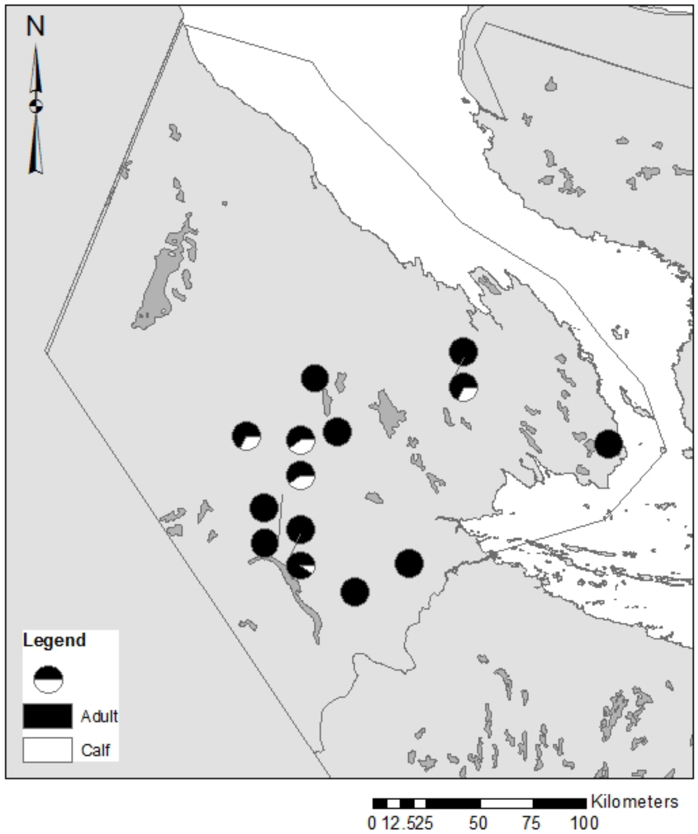

Figure 6: Proportion of calf per adult muskox in each group observed on transect in the Muskox Management Unit MX-09.

Estimate

The percentage of the overall cover of the management unit surveyed with 8,591 km^2 represented 16% of the total study area (53,215 km^2). During the survey, 87 adult muskoxen on transect were recorded. The estimated number of muskox in the management unit MX-09, totalized then 539 ± 150 (S.E.) ($p<0.005$, $t = 1.696$, $N = 132$ and $n = 31$). For this estimate, the total number of transect at 100% coverage was 132 (N) and 31 (n) transect lines were surveyed (Table 2). Overall, the muskox density of the management unit was 0.010 muskox / km^2.

Table 2 Muskox estimate in the Muskox management Unit MX-09

Stratum	Area Survey (km^2)	Total area (km^2)	Muskox on Transect	Estimate	Standard error (S.E.)	95% CL (±)	CV
MX-08	8,591	53,215	87	539	150	255	0.28

* $p<0.005$, $t = 1{,}696$, $N = 132$ and $n = 21$

Predator sighting (wolf, wolverine, and grizzly bear)

In 2017 during the 51 hours of flying within the management units, 6 wolves, 2 wolverines, and 26 adult grizzly bear sightings were recorded (Figure7). The wolves (blue dots) were found on the southern part of the study area, south of Dismal Lake, meanwhile the wolverines (yellow dots) were along the coast or between Bluenose Lake and Emagyok Lake. Grizzly bears (red square) were found dispersed in the study area in 24 different locations. Among them, one group were composed of a female and cubs and two other groups were composed of a female and two cubs. Predator sightings, using the predator index, (Heard, 1992) reveled 12 wolves / 100 hours, 4 wolverines / 100 hours, and 51 grizzly bears / 100 hours.

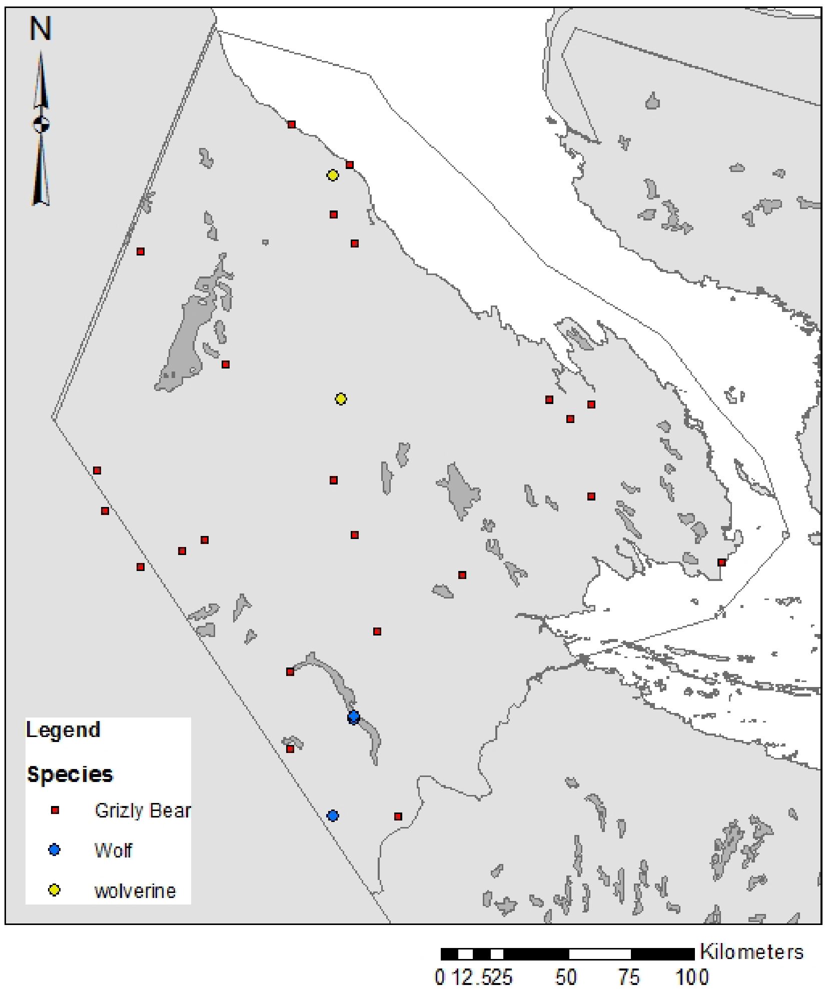

Figure 7: Locations where Wolf, Wolverine, and Grizzly Bear were observed in the Muskox Management Unit MX-09.

Discussion

Distribution

Historically muskoxen were abundant in the area of Dismal Lake, and in the 50s-60s few muskoxen were seen in the Bluenose Lake area (Kelsall *et al*., 1971). No muskoxen were observed around Bluenose Lake in 2017. In 2007, the majority of the muskox observations on and off transect were north of Emagyok Lake (Dumond, 2007), whereas in 2017 most of the muskoxen were distributed south of the same lake in the Rae-Richardson River Valley, which is typical of muskox suitable summer habitat characterized by a wetter and lower-lying area within the proximity of uplands (Danks and Klein, 2002). Thus, the difference between the 2007 and the 2017 muskox distribution suggest a summer movement away from the coastal plain. Such change in distribution could be explained by the specific time that the survey was effectuated, June versus late August. Muskox have potentially moved their main distribution slightly to the south and this might be due to a change in the aridity of the sols that influenced the foraging conditions and to the proximity the upland serves as an escape terrain from predators. The use of summer areas may vary from year to year and within the season.

Group Characteristic

The small group size encounter, 6.21 ± 6.6 (S.D.), during the survey is attributable to the timing in which the work was effectuated. After the peak of the rut, in mid-August, the herds are still small and do not start to merge into the larger wintering herds. They are then easier to count. The small herd are the result of competition within herds to access the rich forage of the Rae-Richardson River Valley. Bulls tend to be solitary, which explains the number of solitary muskox seen during the survey (7) (Gunn, 1990). During mating season, one strategy suggests that the bull disperse in hopes for less contested breeding opportunity, reducing the cost of combat between adult bulls.

The calf to adult muskox ratio was 38%. This ratio is normally associated with a population that would be increasing, since it has been established that 10.5% of calf adult ratio is necessary to keep the muskox population stable (Freeman, 1971). Since the calf ratio have known to vary greatly between years, longer series of data is needed to determine a trend (Reynolds, 1998).

Density

The mechanism driving muskox density is not fully understood. Heard (1992) noted that group size is not generally related to muskox density. In this management unit, a vast area to the west of the management unit does not seem to be utilized by muskox that, at low muskox number, drive the overall density down- 0.010 muskox / km^2. The muskox density in the management unit MX-09 is the lowest muskox density recorded in the Kitikmeot Region since intensive survey work started in 2013.

Abundance Estimate

The extent of this area remained relatively the same even after all the muskox management units were re-delineated across Nunavut in 2015. For this management unit, small changes included extending the delineation to reach the Northwest jurisdiction boarder to the west and south. This relative similitude between the old and new delineation allows to compare previous population estimates with recent survey one.

During the muskox moratorium, the small number of muskox remaining on the upper Rae-Richardson River Valley were able to increase in number on the north part of Great Bear Lake. In 1980, the muskox population in the area was estimated to 869±279 (S.E.) and the successive survey done three years later record a continuous increase in the muskox population of the Rae-Richardson Rivers watersheds with an estimate of 1,295 ± 300 (S.E.) animals (Gunn 1995; Fournier and Gunn, 1998). The peak of the muskox population in the area was recorded in 1988, with 1,805 ± 289 (S.E.). From the tree consecutive surveys, in 1980; 1983; and 1988, the number of tags increased respectively from 12, 35, to 50. In 1994, muskox abundance in this area plummeted to 540 ± 139 (S.E.) muskoxen and remained relatively stable based on the subsequent survey conducted in 2007 with a population estimate of 589 ± 121 (S.E.) muskoxen (Gunn 1995; Dumond, 2007). The latest estimate of 2017 with 539 ± 150 muskoxen show that this population has remained stable. This current status is supported by the observations of hunters.

Since 1994, the muskox population have been maintained relatively stable and the number of tags has also remained consistent with 20. Environmental factors such as predator, forage quality and quantity, diseases and harvesting might have contributed to the stabilization of the muskox population in this management unit. Ongoing and more frequent population monitoring effectuated every 5 years, might allow to detect early signs of recovery of the herd, indicator of population growth. Information provide in this report should guide future muskox survey in allocating the survey effort proportionally with the distribution of muskox. This will help to reach a more precise estimate.

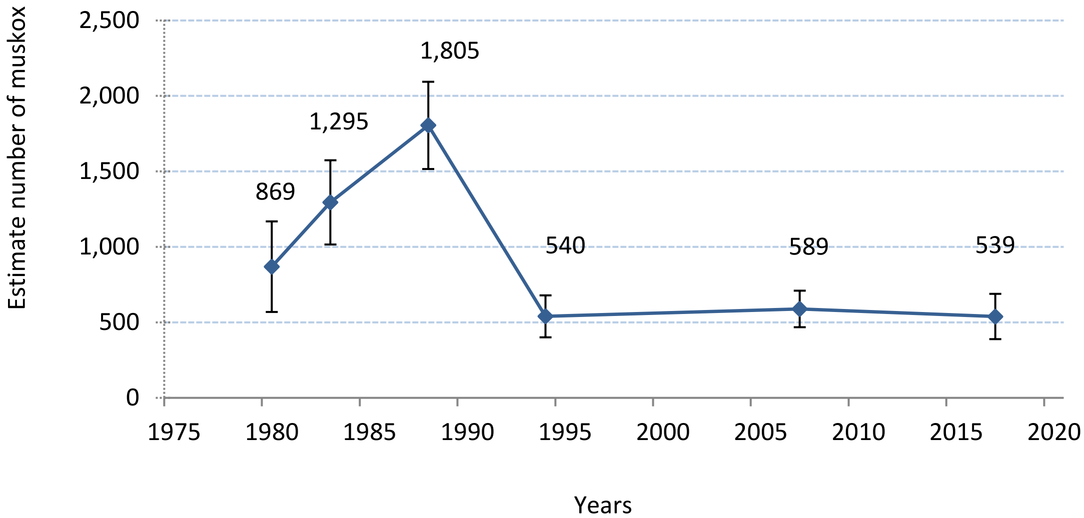

Figure 8: Muskox population estimate for MX-09.

Predator sighting (wolves, wolverine, grizzly bear)

Wolves and wolverines are muskox predators and are found in the study area and pose an additional cause of mortality that might affect the muskox population to a greater extent in the future. Although the number of grizzly bear sightings (51/ 100 hours) is greater than for the other two predators (12 wolves / 100 hrs and 4 wolverines/ hours), their impact on influencing the muskox dynamics might be disproportional of their number, since their diet is constituted mostly of small tundra herbivores (e.i. ground squirrels) (L'Herault *et al*., 2016). However, the grizzly bear has adapted to their tundra environment to maximize food source. Local community members have observed new grizzly bear's hunting strategy that involves chasing the herd to break the calf-cow pair and then sit there to attract the lost muskox calf, as the muskox calf is attracted by the darker silhouette. The community members are however more concerned about the predation effect on caribou, than the effect of these predators on the muskox.

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