MUSKOX (*Ovibos moschatus*) DISTRIBUTION AND ABUNDANCE, MUSKOX MANAGEMENT UNITS MX-11 SUBDIVISION, KUGLUKTUK, SEPTEMBER 2013.

Lisa-Marie Leclerc[1]

Version: August 2015

[1]Wildlife Biologist Kitikmeot Region, Department of Environment

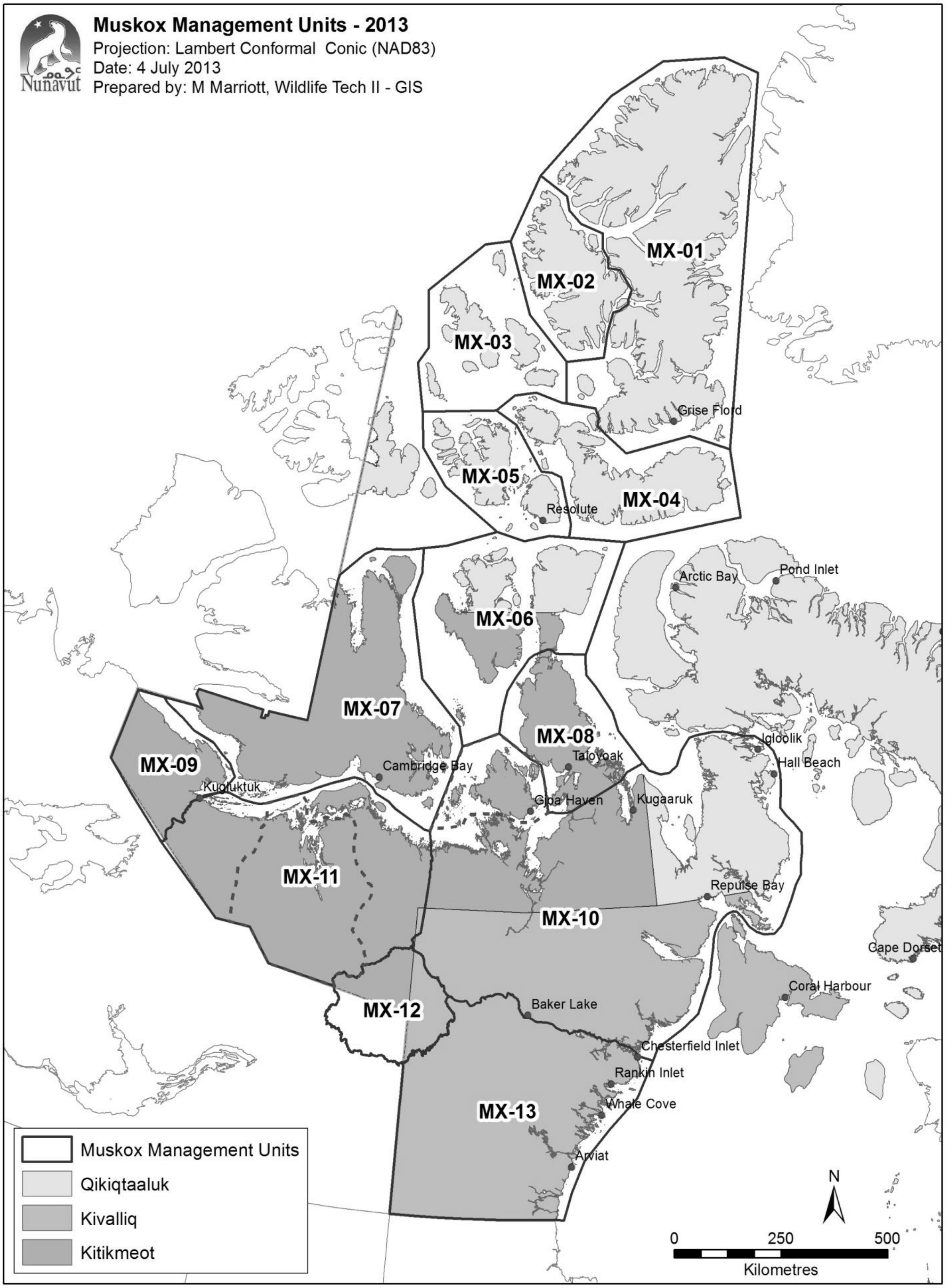
Wildlife Research Section, Government of Nunavut Box 377 Kugluktuk NU X0B 0E0

STATUS REPORT 2016-XX

NUNAVUT DEPARTMENT OF ENVIRONMENT

WILDLIFE RESEARCH SECTION

KUGLUKTUK, NU



Muskox Management Units - 2013
Projection: Lambert Conformal Conic (NAD83)
Date: 4 July 2013
Prepared by: M Marriott, Wildlife Tech II - GIS
Nunavut
MX-01
MX-02
MX-03
MX-04
MX-05
MX-06
MX-07
MX-08
MX-09
MX-10
MX-11
MX-12
MX-13
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
N
0
250
500
Kilometres

Executive Summary

A systematic strip transect survey of the west side of the Coppermine River to north west of Contwoyto Lake, including the islands along the coast (MX-11, subdivision Kugluktuk) were conducted on September 9 and 17th, 2013 to determine the abundance and distribution of muskox at this location. A total of 35,564 km^2 were flown, in two separate strata, the south stratum (1) of 12,271 km^2 was survey at 20% and the northern stratum, of 23,292 km^2 was surveyed at 25%. Calves represented 10% of the adult muskoxen seen and the average adult per group was 23 ± 20 (S.D.). Muskoxen were aggregated in east and north of Kikerk Lake along the shoreline and 30 km south of the Coronation Gulf coast. During the survey, 1,331 adults muskoxen were recorded on transect resulting in an estimated population size of 6,746 ± 904.25 (S.E.) and Muskox densities were 0.1897 muskox/km^2 in the study area, where a higher density was seen in the northern stratum with 0.2466 muskox/ km^2. A recommended harvest rate of 3% is suggested to support steady growth of the group and a slow population increase. Recurring monitoring of the population at a five year interval, health and harvest (sex and location) should be implemented. The completion of MX-11 should be initiated no later than August 2016 and the Total Allowable Harvest should be reviewed in function of the entire population.

Table of Contents

List of Figures

List of Tables

Introduction

For thousands of years, Inuit survival was directly linked to the use of available animals, such as Muskox (*Ovibos moschatus*). Inuit developed traditional management strategies to assure their subsistence off the land was sustainable. However, in the wake of whalers, fur-traders, explorers and scientists, muskox were hunted for their meat and hides (Spencer 1976; Gunn 1984). This hunting pressure and others possible environmental factors contributed to reduce muskox numbers to near extinction levels and considerably changed their natural distribution and range, as some Arctic islands saw virtual extirpation (Spencer 1976; Gunn 1984).

Complete protection for close to 59 years in the area now defined as Nunavut, allowed the muskox to re-colonize their former habitats and its population dynamics are now more prone to respond to environmental factors. Fluctuation in population numbers has management concerns especially when muskox constitutes an important source of food for Inuit communities in the Kitikmeot Region.

From a cluster of muskox left in the south of Bathurst Inlet, in the Thelon Game Sanctuary, muskox appear to have recolonized the mainland moving outwards progressively (Tener, 1965; Dumond 2007). The environmental factors have a profound influence on the distribution, occurrence, survival, and increase of muskox. The north part of the Canadian mainland in the Kitikmeot region is characterized with lush vegetation, largely composed of sedge meadows and shrubs. Despite the rich flora, mainland muskox are also more prone to predators, wolf and grizzly bear compared to Victoria Island and King William Island which were mostly predator free up until recently.

After the 1917 moratorium, a conservative management harvest was maintained and adjusted in function of muskox distribution and the number of muskox estimate in the management units during aerial surveys (Gunn, 1984). Harvest zones were created to match the population expansion and re-colonization to historical range (Gunn, 1984). Resulting population oscillations bought different management strategies.

In July 2013, new muskox management units were established in Nunavut to represent the population boundaries based on genetic analysis, historic and present geographical distribution and community consultation. The management units MX-11 represents three old management zones; MX-13, MX-14, MX-15, part of MX-16 and MX-19. The prohibitive logistical costs, combined with remoteness of the muskox distributions have led to a proposed subdivision of MX-11 into three sub-management units. The creation of the MX-11, subdivision Kugluktuk, was originally proposed by the Government of Nunavut, Department of Environment and then supported by the Kugluktuk Hunter and Trapper Organization (HTO) and the community members in hope to manage at a smaller scale muskox in the vicinity of Kugluktuk and respond to the Kugluktuk HTO concern. Thus, it is up to the Regional Wildlife Organization (RWO) and HTOs to implement as a management zone.

This is the report on the muskox abundance and distribution of MX-11, subdivision Kugluktuk. The survey of this unit was requested by the Kugluktuk HTO after local hunters noticed an eruption of the number of muskox where the muskox group reached large number of animals, 40 to 70 animals (Barbara Adjun pers.com). Hunters wished to initiate a short-term increase in the harvest to reduce the growing population before a potential successive decline occurred. According the Reynolds, 1998, muskox populations undergo a sharp increase in numbers followed by a drastic decline and a very slow recovery.

This study aims to provide essential inventory information required to review existing management strategies and promote the conservation of the muskox group, so that future generations of Inuit may continue to harvest this resource. To do so, the relative muskox numbers, distribution, and calf crops will be assessed. Natural population oscillations may bring different management strategies, thus, conservative management harvest levels were maintained and the harvesting rate has been adjusted in function of the number of muskox estimate in the management units (Gunn, 1984).

Muskox population dynamics have an impact on management plan and decision making-related to harvest levels. The recommendations in this report are intended as short-term management options based on the 2013 survey results. From the scientific data, management recommendations included in this scientific report will be used with the community consultation report, as support documents to the Kitikmeot Muskox Management Plan.

Objectives

This project aims to address the concerns and requests of Inuit hunters, as well as to provide up to date scientific information. 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 information on their current abundance and distribution. Information on group structure, calf crop, group size and density, is essential to gain insight on the relation between these variables and population dynamic.

Materials and Methods

Study Area

The relief of the lower Coppermine River Valley and coast line is characterized by weather-worn plateaus and hill systems boarding the coast whereas eskers, rocky barrens, lakes and river valleys going through the landscape provide a physical uniqueness to this northern landscape. These topographic features along with the climate influence the biotic processes differently by location. At higher elevations and on dry exposed sites, plant cover becomes discontinuous.

The study area is part of the Southern Arctic Ecozone, transiting from the boreal forest around Great Slave Lake to the tundra along the latitudinal gradient. 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, taiga forest restricted to locally warm and dry place and scattered stand of spruce are present. This vegetation 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 west side boundary of the study area subdivision is characterized with vegetated rock outcrops that are common on the Canadian Shield (Environment Canada, 1995).

Survey Area

The new management unit MX-11, located in the Kitikmeot region, includes from the east side of the Coppermine River to the Perry River in the Queen Maud Gulf Sanctuary. To the south it follows the Nunavut border and extends to include bordering islands to the north, including the Kent Peninsula. The subdivision is defined by the one third of this management unit, from the western border to North West of Contwoyto Lake (Figure 1). The two other potential subdivisions are Bathurst Inlet and Ellice River.

No reconnaissance survey was undertaken prior to maximize the coverage area investigated. Instead, anticipated muskox distribution patterns were obtained from past surveys, hunter observations from early fall distribution, and *Inuit Qaujimajatuqangit* (IQ). Base on this information, the management unit MX-11, subdivision Kugluktuk was divided into two stratums, south (1) and north (2), where the north stratum also includes the islands offshore (Figure 1). The percentage of area covered for each stratum was determined based upon previous knowledge of muskox distribution and the land use, such as human activity and infrastructure. The southern stratum at 20% (stratum 1) and northern stratum was flown at 25% (stratum 2).

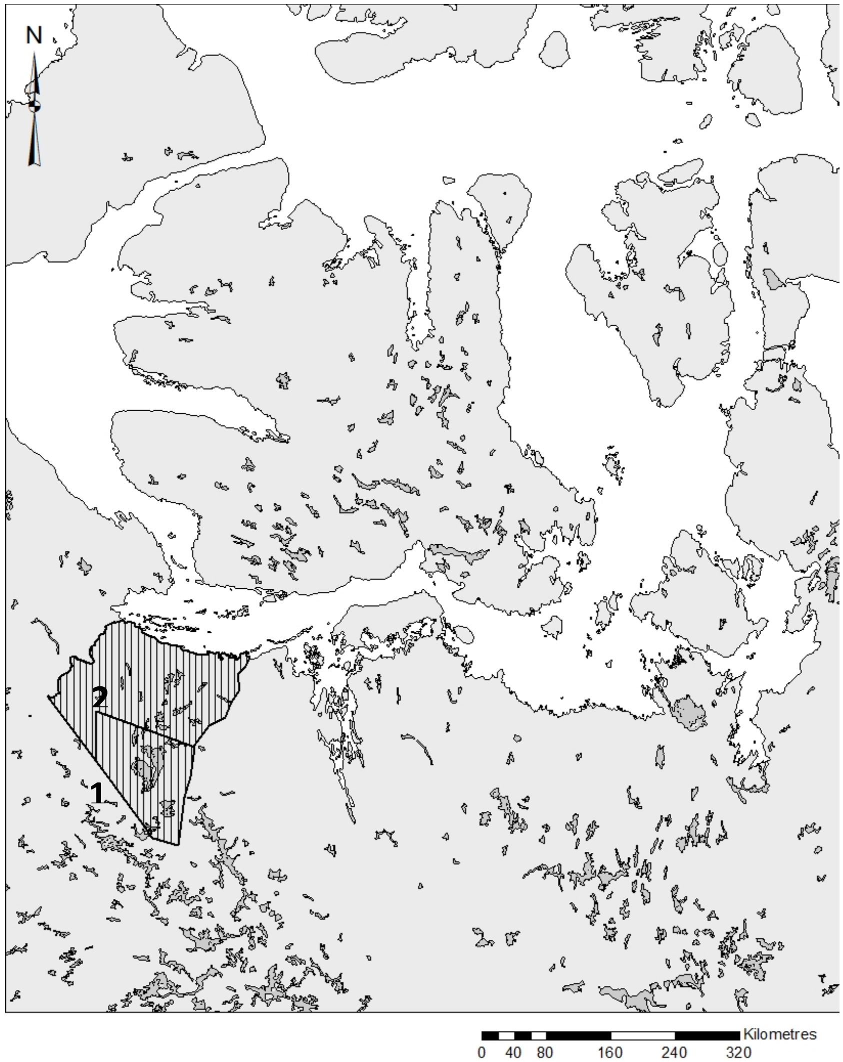


Figure 1:Transect lines and the two strata boundaries (1 and 2) of the muskox management unit MX-11 during a muskox survey on the east side of the Coppermine River, Nunavut, September 2013.

A tool within ESRI'S ArcGIS software was created to increase the precision of the survey areas. The tool allows to determine the precise number of transects and the distance between each transect line required to reach the predetermined percentage of cover in function of the transect strip width and the total area of each stratum within the management unit or subdivision. Orientation of the transect lines within the stratum was determined in function to have the most homogeneous and shortest transect line length (Figure 1).

The south stratum (1) of 12,271 km^2 was survey at 20% with 1,479 kms of transects, which represented 15 transect lines of different length (Table1). The northern stratum, of 23,292 km^2 was survey at 25% with 2,907kms of transects, which represented 31 transect lines of different length (Table1). The resulting distance between each transect was 8.73km and 7.95 km for the south and north stratum respectively. Muskox aggregate along the coast during the summer to take advantage of the cooler temperatures than experienced inland. Therefore, for both stratum, the orientation of the transect lines was North-South, perpendicular to the coast, with the aim of avoiding sampling bias and have relatively an equal number of muskox per transect line.

Table 1 Characteristic of the study area and the transect lines in the Management Unit MX-11, subdivision Kugluktuk.

Stratum	Total area (km^2)	Percentages (%)	Total transect lines (km)	Number of lines	Distance between transect line (km)	Orientation
1	12,271	20	1,479	15	8.73	North-South
2	23,292	25	2,907	31	7.95	North-South
MX-11, subdivision	35,564	____	4,386	46	____	____

Aircraft configuration

Turbo Beaver. The transect lines were surveyed at a speed of 160 km/hr and at an altitude of about 150 meters which was consistently maintained due the flat relief of the study area. Pre-determined transect width of 800 meters was set on the window based on calculation using the formula of Norton-Griffiths (1978) and others (Gunn and Patterson 2000; Howard 2011).

$$w = W*h/H$$

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

The strip transect was 800 meters on each side of the aircraft, for a total transect width of 1.6 kilometers. The strip width calculations were confirmed by flying perpendicular over a known distance marked at 800 meters. Two observers in the rear continuously searched for and counted muskox, either as on or off-transect; the number of calves (5-6 months old) were counted when they were conspicuous. No sex and age classification count were systematically attempted. Photographs were taken of large groups (> 20 muskoxen). The data keeper recorded the number of muskox, GPS location. Even if this survey focused on muskox, additional sightings of other species were recoded, such as caribou, grizzly bear, 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 in a group from the sexual dimorphism of the horn. 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 bulls encounter was also recorded.

To determine the number of muskox in the study area, only the adults muskox sightings recorded on transect were analyzed using Jolly's Method 2 for unequal sample sizes (Jolly 1969) using a coefficient limit of 95%. The count was automated by a script in ESRI'S ArcGIS software.

Density, the number of muskox per unit area (muskox/km^2), was determined using the number of adult muskox seen on transect divided by the total area of the study area. Lakes and streams areas were not subtracted from the total area calculations used in muskox density.

The area occupied by the muskox during this specific season within the study area was determined. Thus, the distribution was illustrated by plotting each muskox sighting on transect base on their precise geospatial position captured with a Global Positioning System (GPS) during the survey. In addition, the number of animal composing each group was highlighted using an increasing size of symbol to represent group of 1-5, 6-12, 13-20, 21-30, 31-45 and 46 to 91 animals.

We collected standardized information of predator sightings Grizzly Bear (*Ursus arctos horribilis*) and Arctic Wolf (*Canis lupus arctos*) in the study area using the predator index (Heard, 1992). The predator index reports predator sightings per species expressed per 100 hours.

Results

The survey was conducted from September 9 to September 17, 2013. Weather days were encounter on September 9, 12, 15 and 16. During these days, the celling was too low to reach part of the survey area located over the plateau. The area was surveyed in 46 hours, including time to fly the 4,386kms of transect lines and ferry from the Kugluktuk airport to the transect lines.

Group Characteristic

During the survey, 81 groups of muskox were recorded on transect, with 25 being single lone bulls. Whereas the lone bulls accounted for 2% of the total number of muskox observed, the calves represented a minimum of 10% (141 calves and 1472 muskoxen). The average adult per group was 17 ± 20.03 (S.D.) excluding the lone bulls. The highest number of adults counted in one group was 91. The majority of the groups sighted (25%) were grouped in 21 to 30 animals (Figure 2). Across all group classification, there was little variation of frequency of occurrence where the distribution is somewhat uniform.

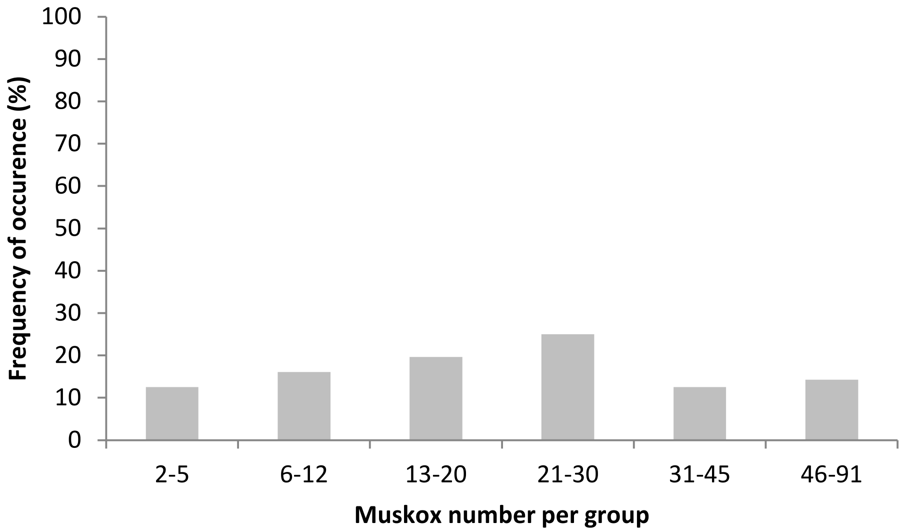


Figure 2:Frequency of occurrence (%) of the different muskox number per group, grouped as follow 2-5, 6-12, 13-20, 21-30, 31-45, and 46-91, during the survey of the management unit MX-11, subdivision Kugluktuk.

Estimate

During the survey, 1,331 adults muskoxen on transect were recorded on the 7,017.57 km^2 of transect area surveyed. The estimated number of muskox in the management unit MX-11, subdivision of Kugluktuk (35,564 km^2), totalized then 6,746 ± 904.25 (S.E.) ($p<0.005$, $t = 2.048$, $N = 185$ and $n = 46$). For this estimate, the total number of transects at 100% coverage was 185 (N) and 46 (n) transect lines were surveyed (20% of the entire study area) (Table 2). Individually, the estimate number for the south stratum (1) is 955 ± 246.29 (S.E.) ($p<0.005$, $t = 2.145$, $N = 61$ and $n = 15$) and 5,744 ± 870.06 (S.E.) ($p<0.005$, $t = 2.042$, $N = 124$ and $n = 31$) for the north stratum (2).

Table 2: Muskox estimate in the Muskox management Unit MX-11, subdivision Kugluktuk.

Stratum	Area Survey (km^2)	Total area (km^2)	Muskox on Transect	Estimate	Standard error (S.E.)	95% CL (±)	CV
1	2,366.54	12,271.52	184	955	246.29	528.29	0.258
2	4,651.03	23,292.52	1,147	5,744	870.06	1,776.67	0.151
MX-11 Subdivision	7,017.57	35,564	1,331	6,746	904.25	1,851.0	0.134

* $p<0.005$, $t = 2.145$, $N = 61$ and $n = 15$
** $p<0.005$, $t = 2.042$, $N = 124$ and $n = 31$
*** $p<0.005$, $t = 2.048$, $N = 185$ and $n = 46$

Distribution

At the time of the survey, adult muskoxen, on transect, were concentrated in two locations (Figure 3). Muskox aggregation was observed from north of Napaktulik Lake to the shoreline. Along the coast, numerous groups of about 31 to 45 animals were observed. The second aggregation was located 30 km south of the Coronation Gulf coast were groups of 46 to 91 were on graminoid vegetation is abundant. Local hunters had reported muskox on the Island north of Kugluktuk, indeed two groups of muskox, (one of one animals and the other one of five animals) were observed on Lawford Islands. No muskox were present 25 km from the south and east boundaries of the management unit.

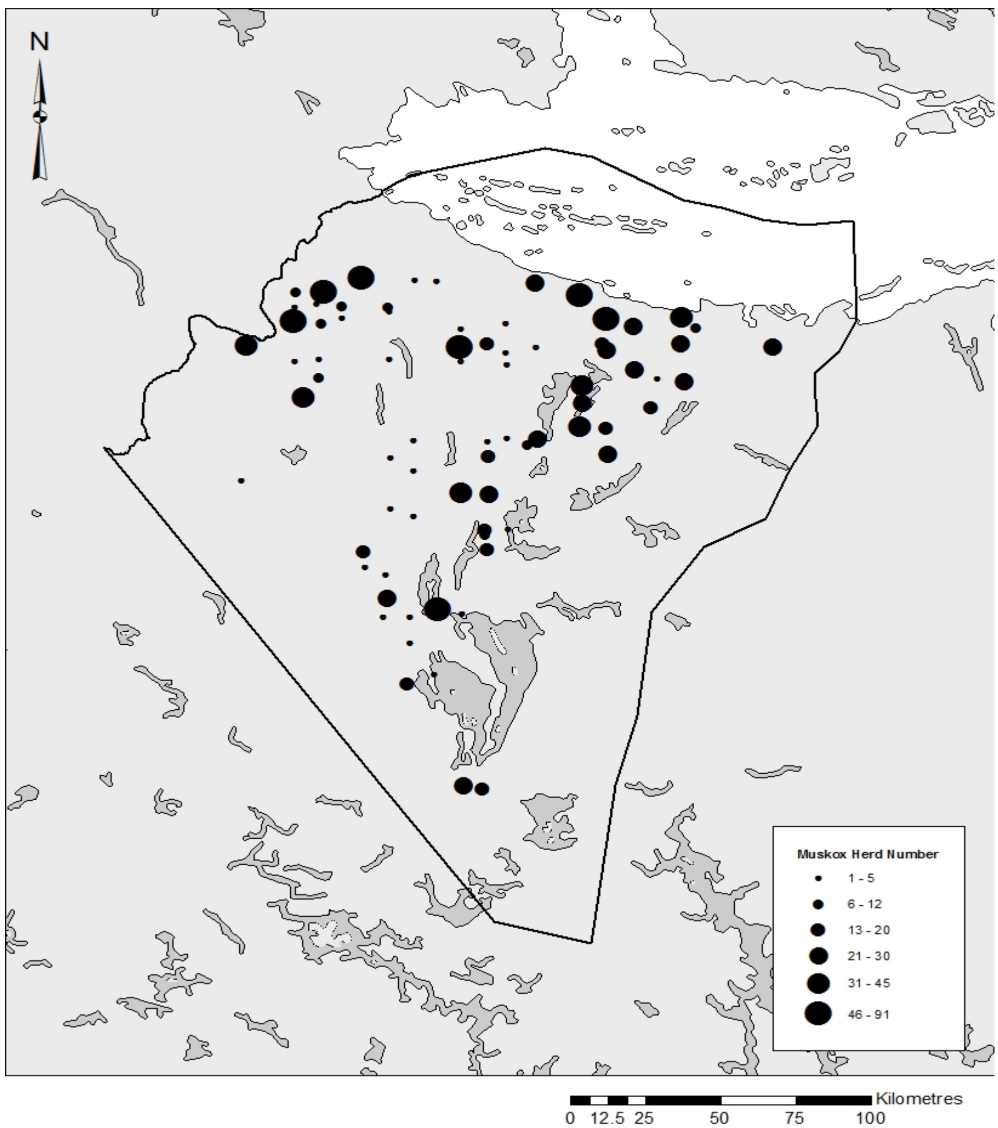


Figure **3:** Muskox distribution and abundance recorded in the management unit MX-11, subdivision Kugluktuk, during the survey taking place between September 9 to 17, 2013, where the number of animal per group was grouped as 1-5, 6-12, 13-20, 21-30, 31-45, and 46-91.

Density

The southern portion of the management unit (12,271.52 km^2) had few muskox, 955 ± 246.29 (S.E.), comparatively with the northern portion (23,292.52km^2) with 5,744 ± 870.06.29 (S.E.) muskoxen. Since 85% of the muskoxen are located in the northern stratum, this is reflected in the higher density 0.2466 muskox / km^2 versus 0.0778 muskox / km^2 in the southern stratum. Overall, the muskox density of the entire management unit (35,564 km^2) was 0.1897 muskox / km^2.

Predator sighting (wolves and grizzly bear)

During the 46 hours of flying within the study area, 5 wolf and 4 grizzly bear sightings were recorded. Wolf numbers varied from 1 to 3 per sighing for a total of nine individuals. Grizzly bear sightings were either a traveling individual (2 sightings) or were a female with a cub of the year (2 sightings). Thus, 4 mature animals and 2 cubs were encountered. Predator sightings in the management unit, MX-11 using the predator index (Heard, 1992) revealed 20 wolves / 100 hours and 13 grizzly bears / 100 hours.

Discussion

Group Characteristic

The 1991 calf crop was low with only 8% and seems to have increased in 2005 with a calf crop of 11.3 % (Gunn, unpublished report; Dumond, 2007). The calf crop of 2013, 10%, might suggest that the population is now most likely stable. As has been previously established, a 10.5% calf crop is necessary to keep muskox populations stable (Freeman, 1971). As calf crops vary largely in between years, it is essential to establish yearly monitoring in order to use the calf crop as a relative index of population trend in between survey years.

The average adult per group was 23 ± 20 (S.D) where the majority of the groups (25%) were of 21 to 30 animals. Prior surveys of the area accounted for group sizes with a mean size of 13 ± 7.8 (S.D.) and 12.8 in average in 1991 and 2005 respectively (Gunn, unpublished report; Dumond, 2007). Group size is now larger to what has been previously observed in the area, although it is consistent to what has been observed on the mainland in the Thelon Sanctuary and in the Queen Maud Gulf area (Tener, 1965; Gunn, 1992).

It has been established that group sizes are not uniform and vary geographically upon a latitudinal gradient (Tener, 1965). The northern extent of the Canadian mainland is characterized with large patches of rich foraging plants and a potential number of predators greater than on the Arctic Canadian Archipelago. The combination of forage and the predator might shape the response of muskox in forming larger group sizes (Tener, 1965; Gunn, 1992). Indeed, the muskox groups on the mainland have been larger than what have been reported on Victoria Island or the higher Arctic (Gunn, 1995; Tener, 1965; Leclerc, pers. comm; Anderson, unpublished report).

During the survey, 81 groups of muskox were recorded on transect, where 25 were single lone bulls. A high number of bulls were found at the west side of the management unit in 2005, as in 1991 very few muskoxen were actually found at the same location (Dumond, 2007; Gunn, unpublished report). Still, a high percentage of single bulls, representing 46% of the 41 social units in 1991, were observed in the study area (Gunn, unpublished report).

This supports the hypothesis that during the rut, more single bulls would occur because the large groups do not favor the opportunities for herd bulls. Also, lone bulls are more likely to be able to defend themselves against predators and subsequently be the first in the re-colonization process. These assumptions remain however, untested.

Abundance Estimate

After the extensive hunting period, muskox was assumed to be eliminated from the northern part of the mainland and Great Slave Lake. However, small remnant of the population found refuge on the rough country of Bathurst Inlet region and along the Thelon River (Tener, 1965). With the moratorium of 1917, the population started to reoccupy its former range. The mainland population was estimated to be 500 animals (Anderson, 1930).

In 1975 in Northeast of Contwoyto Lake around the west side of Bathurst inlet, muskox numbers was estimated by Parks Canada between 400 to 500 muskoxen. In the 1980s, more report of sightings came from the area of Contwoyto Lake. The first systematic surveys in 1986 confirmed an estimate of 3,400 muskoxen. In 1991, in response of the Burnside and Coppermine HTOs request, the northwest of Contwoyto Lake to the Coppermine River was estimated for the first time. Fewer muskox were found on the west side of Contwoyto Lake with 1,400 muskoxen, suggesting that they were slowly recolonizing the west part of the mainland.

Their slow expansion and reoccupation of the area was progressive. From the 1,400 muskoxen in 1991, 2,141 muskoxen in 2005 were estimated (Gunn, unpublished report; Dumond 2007). Since the early 1990s, the residents are consistently reporting an increase in muskox sightings in the area. In 2012, the community members and the Kugluktuk HTO started to express some concerns, as very large and numerous groups of muskox have being reported. This observation initiated the need to assess the number of muskox in the area. The estimated numbers of muskox totaled 6,746 ± 904.25 (S.E.) in fall 2013. Although direct comparison with the two previous systematic surveys is difficult due to the change in the area surveys and the technique employed, we can nonetheless say that muskox numbers have increased.

Distribution

All three surveys occurred relatively at the same time of the year, where the 2013 survey was undertaken at the beginning of the rut but before the fall displacement to winter area. In September, the muskox did not start moving into their winter range and forming larger aggregations. Therefore, there is possibility to compare the distribution of the muskox in the study area between the years, which varied from 1986 to 2013.

In 1986, the area surveyed also included the north part of Contwoyto Lake. It was between Napaktulik Lake and Contwoyto that most muskox group where observed. The other clusters of muskox were along Tree River and only two herds of muskox were seen west of Napaktulik Lake (Gunn, unpublished report). The distribution of muskox in 2005 was different. There were very few muskox found between Napatulik Lake and Contwoyto Lake and north of the Contwoyto Lake. The muskox was mostly aggregated north of Napuatulik Lake from Tree River to the east of the Coppermine River. What generated a change in the distribution of muskox remains untested, but speculation could lead to an increase in predators south, along the Northwest Territories border that contributed to driving the muskox further north along the coast.

Very similar distributions between 2005 and 2013 distribution were observed, and therefore might describe a post recolonization of muskox distribution in the study area, where the balance between predator avoidance and best available foraging patches is established. The diverse feature of the landscape and resulting vegetation distribution do not allow for muskox to be randomly distributed in the study area. Following surveys should take into consideration this information and modify stratification as a consequence. Consistently in 2005 and 2013, few muskox are distributed on the entire west side boundary of the 2013 survey area. This location is characterized with vegetated deprived outcrops rock and hilly topography that are common of the Canadian Shield.

Although this natural geographical barrier might constrain the presence of muskox and prohibit muskox movement during the summer, groups of muskox were observed at this location in 1986. The increase in the anthropogenic activity with active mine camps, intensive mineral exploration, and the relatively heavy aerial traffic might be a likely cause for the absence of muskox at this location. Muskoxen are found to be very sensitive to disturbance, where their distributions are known to shift (White, 2002; McLaren and Green, 1985). It is imperative to study more in depth the effect of muskox distribution in relation to human pressures.

Density

In 1991, muskox densities were only 0.03 muskoxen / km^2. Overall, the muskox density of the entire management unit (35,564 km^2) was 0.1897 muskox / km^2 which constitute a relative increase as compared to 1995. In 2005 and 2013, two distinct areas with differences of densities were observed. Comparatively in 2013, since 85% of the muskoxen were located in the northern stratum, a higher density 0.2466 muskox / km^2 versus 0.0778 muskox / km^2 in the southern stratum were observed. The muskox density in this study area is consistent and within range of what has been seen elsewhere in the Canadian Arctic and in Greenland (Anderson, unpublished; Campbell and Setterington, 2001; Ferns, 1997).

The difference in densities encountered within the management units should be taken into consideration for harvest management and stratifying following surveys. Muskox has a seasonal range fidelity that might affect their distribution and density. Their winter distribution on the landscape, when they are more accessible by snowmobile, remains unknown.

Predator sighting (wolves and grizzly)

The high number of predators observed during the survey, 20 wolfs / 100 hours and 13 grizzly bears / 100 hours, coincides with the observations made by local community members (Kugluktuk HTO, per. comm.). Wolves and Grizzly bear predation on muskox have been reported by local hunters and in the literature and are not unusual in the study area. The community members are however more concerned about the predation effect of an alternative species in the area, caribou, than the effect of these predator on the muskox. The number of predators in the area might impacts the population dynamics, group structure and distribution on the landscape.

Management Recommendations

Although, some muskox harvest management units were established west of Bathurst Inlet in the early 1980s, the first muskox management unit around Kugluktuk was established in 1990s following the first systematical survey of the area including east of the Coppermine River to the Northwest of Contwoyto Lake. The harvest management unit created, MX-19, had an original quota of 20 muskoxen (Dumond, 2006).

The increase in muskox sightings allowed for an increase in quota from 20 to 60 between 1991 and 2002. The 2005 survey recommended a harvest rate of 2.8%, which translated into 69 tags. The management strategy was put forward to allow the immigration from high density areas to the lower density areas and an increase in muskox numbers. This quota was maintained until the 2013 survey.

The previous management strategy was effective in increasing the population size from 2,141 to 6,746 ± 904.25 (S.E.) muskoxen relatively in the same area. However, the density and the distribution of muskox observed in 2013 failed to detect immigration from the high density areas to the low density areas. In fact, relatively similar distribution and density were found in 2005 and 2013. Therefore, the same concern in the distribution of the harvest pressure in the management unit should also apply here (Dumond, 2007). Most likely, a high harvest pressure in the same area over time will lead to local extirpation, such as encountered on Victoria Island during the commercial harvest. However, as muskox are not uniformly distributed on the landscape like on Victoria Island, the recolonisation process will be slow, seemingly nonexistent due to the very low number of muskox in the periphery.

For the Management unit MX-11, with the previous surveys result taking into account that that there is about 750 muskoxen in the eastern half of the population distribution, this brings the population estimate of MX-11 to 7 500 muskoxen. Therefore, a Total Allowable Harvest of 225 is recommended, which constitutes a conservative harvest rate of 3%. Such management regimes are believed to foster growth according to Tener's (1965) long-term empirical data of muskox harvest.

This conservative management approach goes against the proactive management strategy proposed by the Kugluktuk HTOs (Leclerc, 2015). Despite the fact that a consistent harvest rate of 3% is maintained and there is a subsequent increase in the number of tags available, this management action does not call for stabilizing the population or decreasing it as requested by the community. The community of Kugluktuk is concerned that a high number of muskox observed with the numerous large groups in one area will lead to increases in disease and overgrazing resulting in population crash (Kugluktuk HTO, pers. comm). However, the current distribution and great variation of muskox densities in the study area, the high number of predators and the unknown numbers of muskox to the east of the management units call for a conservative harvest rate. In addition, it is strongly recommended that the remaining portion of MX-11 should be survey no later than 2016 and the TAH for MX-11 be review subsequently.

Following the near extirpation of the species, there is no long-term monitoring data available to visualize muskox population cycles similar to caribou. In the absence of fully understanding muskox ecology, interactions between muskoxen, their forage, plant growth and understanding of how carnivores limit muskox numbers, a conservative approach should be maintained as muskox seem to respond to various undefined environmental factors independent of harvest levels. Environmental factors may negatively affect muskox population dynamics and directly impact management planning and decision-making related to harvest levels. Increase in efforts to collect harvest information on which sex and age classes are harvested and where they are taken will be needed.

Acknowledgements

I wish to thank the pilot Samantha Merritt for her dedication and in making it possible to fly the surveys. I am grateful to the Kugluktuk HTO for assistance in providing observers, Eric Hitkolok, Dennis Kokak and Gordon Kokak that assisted during parts of 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 Management Board under the Research Permit 2013-060.

References:

Anderson, R.M. 1930. Notes on the muskox and the caribou. In Hoare (1930). pp. 49-53.

Anderson M. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyii*) and muskox (*Ovibos moschatus*) on Southern Ellesmere Island, March 2015. Status report, April 16 2015 draft. 41 pp.

Campbell M. and Setterington M. 2001. The re-evaluation of Kivalliq and northeast Kitikmeot muskox (*Ovibos moschatus*) population, management zones, and quotas. Technical Report Series 2001- No 1-02.97 pp.

Dumond, M. 2006. Review of Muskox Populations Status in the Kitikmeot Region of Nunavut. Government of Nunavut, Working DRAFT- May 2006. 29 pp.

Dumond, M. 2007. Muskoxen Distribution and Abundance in the Area Between Bathurst Inlet, and the Coppermine River, Kitikmeot Region, Nunavut (MX19 and West MX14). Gov. of Nunavut, Unpubl. Rep., 27 pp.

Environment Canada 1995. Ecological Framework of Canada. http://ecozones.ca/english/. Accessed September 1 2014.

Ferns, P.N. 1977. Muskox abundance in the southern part of the range in East Greenland. Arctic 30(1): 52-60.

Freeman M.M. 1971. Population characteristics of muskoxen in the Jones Sound region of the Northwest Territories. Journal of Wildlife Management 35(1) 103-108.

Gunn, A.R. Decher and T. W. Barry. 1984. Possible causes and consequences of an expanding muskox population, Queen Maud Gulf area, Northwest Territories. Bio. Pap. Univ. Alaska. Spec. Rep. 4: 41-61.

Gunn, A. Distrubution and Abundance of Muskoxen Northwest of Contwoyto Lake, NWT, 1991. Department of Environment and Natural Resources, Government of the Northwest Territories, 2005. Unpublished report.

Gunn, A. 1992. Differences in the sex and age composition of two muskox populations and implications for male breeding strategies. Rangifer 12(1): 17-19.
Gunn, A., and Patterson, B.R. 2000. Distribution and Abundance of Muskoxen on Southeastern Victoria Island, Nunavut. Gov. of the N.W.T., Unpubl. Rep.

Heard, D.C. 1992. The effect of wolf predation and snow cover on musk-ox group size. American Naturalist 139: 190-204.

Howard, F., 2011. Aerial Wildlife Survey Manual. Aerial Procedure Manual v. 0.9 (Uganda). Wildlife Conservation Society. 81 pp.

Jolly, G.M. 1969. Sampling methods for aerial census of wildlife populations. East. Afr. Agric. For. J. 34:46-49.

Leclerc, L.-M..2015. West Kitikmeot Muskox Workshop Report. Cambridge Bay, October 14-15, 2014. Government of Nunavut, Department of Environment.

McLaren, M.A. and Green, J.E. 1985. The reactions of muskoxen to snowmobile harassment. Arctic 38 (3): 188-193.

Norton-Griffiths, M. 1978. Counting Animals. Serengetti Ecological Monitoring Programme Handbook No.1. Afropress Ltd., Nairobi Kenya. 139 pp.

Reynolds, P.E. 1998. Dynamics and range expansion of a re-established muskox population- J. Wildlfe. Manage. 62:734-744.

Spencer, W., 1976. Muskox (*Ovibos moschatus*) surveys, central western Arctic. N.W.T. Wildl. Serv. Unpubl. Rep., 11pp.

Tener, J.S. 1965. Muskoxen in Canada; a biological and taxonomic review. Canadian Wildlife Service. Queens Printer and Controller of Stationary. Ottawa.

White. D., 2002. Muskoxen Density and Distribution on King William Island, Nunavut. Gov. of Nunavut, Unpubl. Rep., 22pp.