MUSKOXEN DISTRIBUTION AND ABUNDANCE IN THE AREA BETWEEN BATHURST INLET AND THE COPPERMINE RIVER, KITIKMEOT REGION, NUNAVUT (MX19 AND WEST OF MX14)

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2007

Status Report, No. 35

Dumond, M. 2007. Muskoxen distribution and abundance in the area between Bathurst Inlet and the Coppermine River, Kitikmeot Region, Nunavut (MX19 and west of MX14). Government of Nunavut, Department of Environment, Status report: 35, Iqaluit, 27 pp.

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File Report N°XXX

Summary

The population status of muskoxen (*Ovibos moschatus*) between Bathurst Inlet and the Coppermine River (Kitikmeot Region) has been a concern for residents of Kugluktuk and Kingaut. Although increasing muskoxen numbers have been observed in the western area, residents have also observed that the proportion of calves per groups and in the population has been lower in the past few years for the entire study area.

An aerial survey of muskoxen population was undertaken in August 2005. The overall muskox population estimate in MX19 is 2141 muskoxen (±586 S.E.). The results confirm good densities of muskoxen in the western part of the study area, indicating an increase in muskox abundance since the 1991 survey (Gunn *Draft report*). However, the muskox abundance has drastically declined (*P*=0.000) in the Eastern part of the study area compared to the 1986 survey (Gunn 1990). The estimate for the western part of MX14 is 434 ±168 (SE). Additionally, the overall proportion of calves in the population in the study area was low (6.1% in MX19 and 2.0% in the west part of MX14) Area specific data were also provided to Wolfden Inc. for their mining project baseline study. The distribution pattern is of concern as 81% of the muskox population was distributed in the Northwest corner (approx. 40%) of MX19. Management recommendations are provided to take the current muskox population distribution into account to avoid local extirpation.

Acknowledgements

Thanks to Jessica Elliott (Wildlife Technician) and Mike Hala (Kugluktuk Hunter) for their good work as observers. Thanks to Jim Brown (Pilot) for his patience and interest in the survey. Wolfden mining provided us with accommodation and fuel at Ulu camp. Special thanks for the crew at Ulu for their warm hospitality. Thank you to Luigi Torretti (Kitikmeot Wildlife Technician II) who provided constructive comments on an earlier version of this report. The project was funded by the Department of Environment (Government of Nunavut) and the Nunavut Wildlife Management Board (Project # 2-05-7).

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1.0. Introduction:

The management strategy of the muskox (*Ovibos moschatus*) population in the West Kitikmeot is based on dated information: MX 19 was partially surveyed in 1986 (Gunn 1990) and 1991 (Gunn draft report); and the west part of MX14 was last surveyed in 1986 (Gunn 1990). The management regime may be ineffective to ensure that current harvest opportunities are available and sustainable (Fournier and Gunn 1998) because current population trends may be substantially different from the baseline data used to develop the strategy. Muskox populations can also potentially be subject to over-harvest (Barr 1991).

Communities, through their respective HTOs, raised several concerns that required investigating the current muskox population trend. Kugluktuk HTO reported that hunters observed an apparent increase in muskoxen numbers in the west of MX19. Kingaut HTO reported that there was a low percentage in calves in muskox groups in MX14 and the east of MX19. Additionally, the area between the Coppermine River and Bathurst Inlet is also the current focus of many development projects and an update of the muskox population situation in the area was required.

2.0. Project Objectives:

1. To estimate muskox abundance between the Coppermine River and Bathurst Inlet and determine if the muskox numbers have significantly changed since the last surveys;

2. To provide a more comprehensive picture of the Muskox abundance and distribution in the West Kitikmeot;

3. To determine the proportion of muskox calves in the study area.

3.0. Study Area:

The study are is located in the West Kitikmeot region of Nunavut approximately between 65° and 67.75° North and 107° and 115.5° West. With the exception of a few areas along the Coppermine River, the study area is above the tree line.

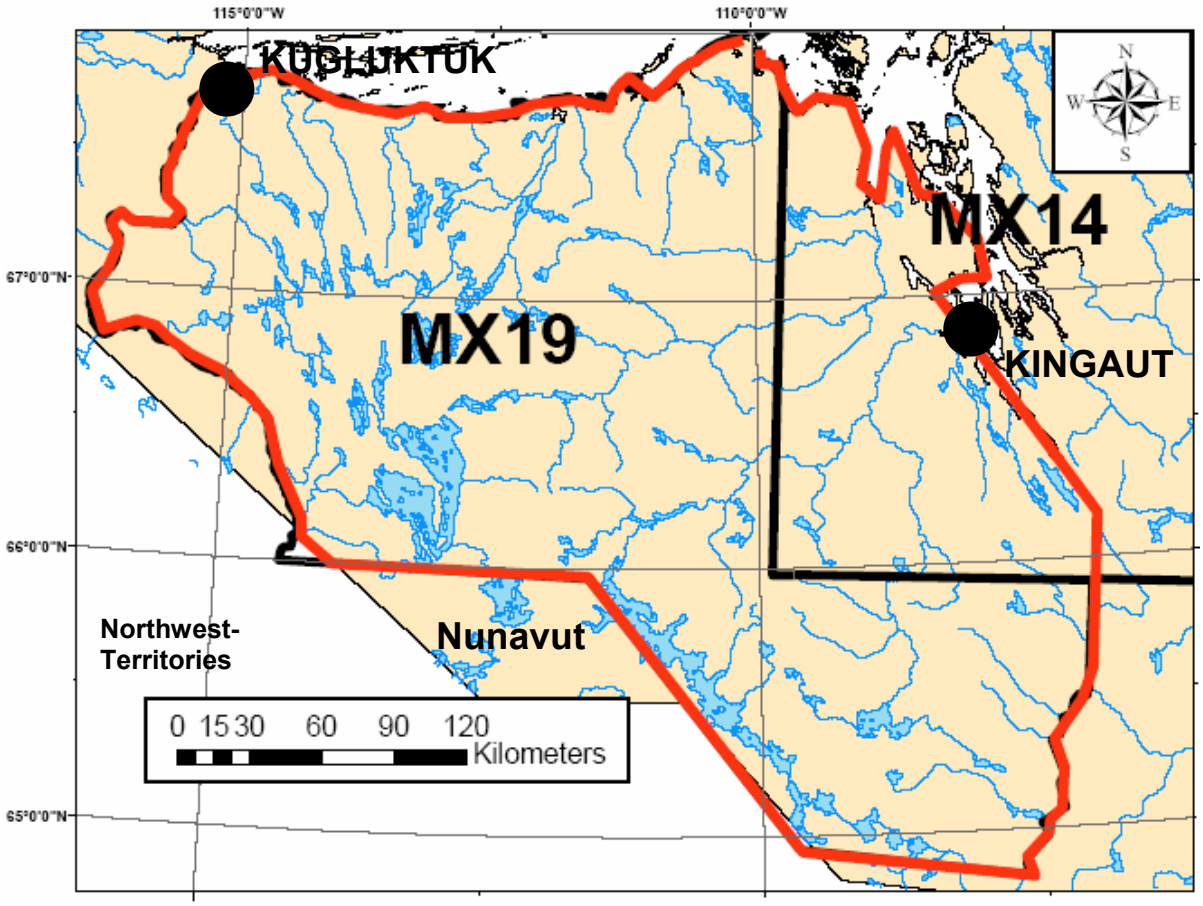

Figure 3.1: Study area (red) and current muskoxen management zones (MX14 and MX19) in the study area.

4.0. Method:

I conducted an aerial survey using stratified random/systematic strip transects (the first transect was randomly placed and then each sequential line was evenly spaced at a set interval within each survey block). The stratification was based on local knowledge, previous surveys (Gunn 1990; Gunn *draft report*), habitat information, and aircraft capability rather than a reconnaissance survey to reduce study costs. Previous studies suggested that coverage lower than 15% resulted in coefficients of variation exceeding 30% (Gunn 1990, Fournier and Gunn 1998). Therefore, transects were planned and organized to obtain a coverage >15% in all surveyed block. We use the Cessna 337 at a speed of 180km/h, at 500 feet above ground level (154m), and set up markers to record muskoxen within 1500m on each side of the aircraft. The altitude was maintained visually. The survey was conducted from August 11 to 19, 2005. The study area was 61757 km^2 covered at 22% overall (after excluding Block 17 that was not fully surveyed). Post stratification to estimate muskox abundance in MX19 was established by dividing the study area into two areas with contrasting muskox densities. (High Density Area = HAD composed of block 1, 2, 3 and 7; and Low Density Area = LDA composed of block 4, 5, 8, 9, 13, 14 and 16). For the west part of MX14, I used blocks 6, 10, 11, 12 and 15 and adjusted the transect length to stop at the boundary of the zone. However for the calculation of the overall population estimate and for comparison with Gunn 1986, I used the full blocks. Barren-ground caribou (*Rangifer tarandus groenlandicus*) and grizzly bear (*Ursus arctos horribilis)* observations were also recorded during the survey, as well as anthropeginic structures or activity, and are presented in Figure 4.1. For all observations a way point was added on a GPS and the track of the airplane was recorded during the whole survey (Figure 4.1).

The field team consisted of the aircraft pilot, a navigator, and two observers (one on each side of the plane).

When muskoxen were observed, I recorded the number of individuals ≥1 year old (non-calves) and the number of observed calves. When necessary, I would ask the pilot to make a loop around a group in order to count calves and non-calves. The loop was made at a distance from the muskox group to avoid the formation of a defence circle that make the count difficult for adults and impossible for calves.

For the calculation of the estimate, I used only the individuals ≥1 year old observed within the 3km strip of the transects. Muskoxen observed outside the 3km strip were presented to illustrate the distribution and were used in LDA to adjust the lower limit of the confidence interval.

The muskox population estimate for each management zones and within each stratum (HAD and LDA) of MX19 was calculated using Jolly's Method 2 for unequal sample sizes (Jolly 1969 *In* Norton-Griffiths 1978). Only counts of non-calves were used for the final population estimates (Statistical analysis based on Campbell and Setterington 2001).

To determine if there was a significant trend in muskox numbers in the study area, comparisons of the 2005 population estimate to the 1986 and 1991 estimates were conducted using equation 5.3 of Thompson et al. (1998):

$$z = \frac{Y_{1991} - Y_{1999}}{\sqrt{Var(Y_{1991}) + Var(Y_{1999})}}$$

Where:

z = z statistic;

Y_x = population estimate for year x

$Var(Y_x)$ = variance of the population estimate.

The statistics were based on the hypothesis that the population estimate did not change between surveys and therefore I used the two tailed probability of the z statistic.

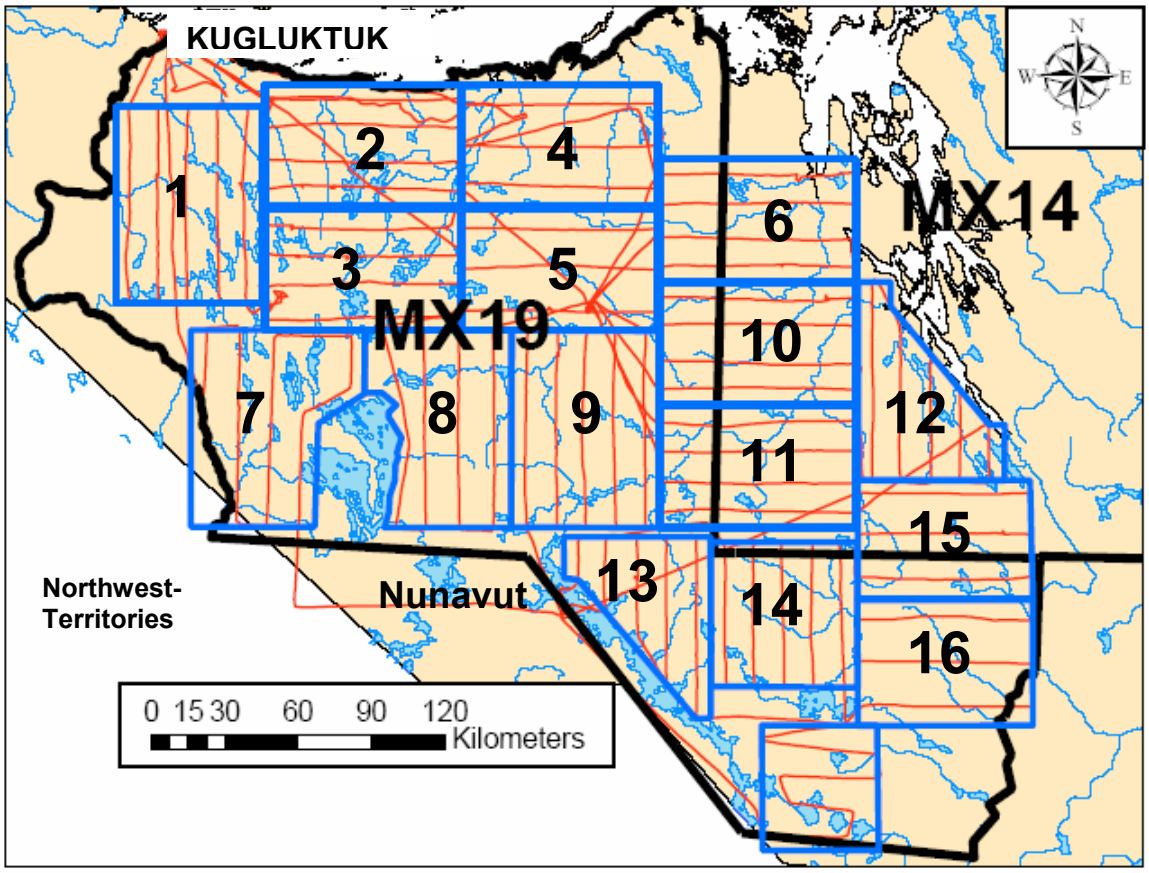

Figure 4.1: Muskox survey blocks with actual transects flown (aircraft track). The block ID number is indicated in each block.

5.0. Results:

The surveys was conducted on August 11, 15, 16, 17, 18 and 19, 2005 covering 4518 km of transects (after excluding lengths too foggy to observe), representing 13,555 km^2 of area. Three transects were re-sampled on August 19 (one in Block 2 and two in Block 4) because of foggy conditions that prevented good observation on August 15. The study area was 61757 km^2 covered at 22% overall after excluding block 17 that was not surveyed completely (Table 5.1).

A total of 732 adult muskoxen were observed, including 170 individuals observed outside the transect width or during taxi. Muskoxen were clustered with the highest densities observed in the north-western portion of the study area (Figure 5.1, Table 5.1). The population estimate for the entire study area was 2560 muskoxen (±604 S.E.). In the high density area of MX19 (HDA) (17071 km^2), we counted 384 adult muskoxen and 25 calves on transects. The population estimate for that area is 1732 adult muskoxen (±471 S.E.) with 6.5% of calves in the population. In the low density area (LDA) of MX19 (26086 km^2), we counted 77 adult muskoxen and 3 calves on transects. The population estimate for that area is 365 adult muskoxen (±209 S.E.) with 3.9% of calves in the population. In the west part of MX14 (13645 km^2), we counted 101 adult muskoxen and 2 calves on transects. The population estimate for that area is 434 adult muskoxen (±168 S.E.) with 2.0% of calves in the population.

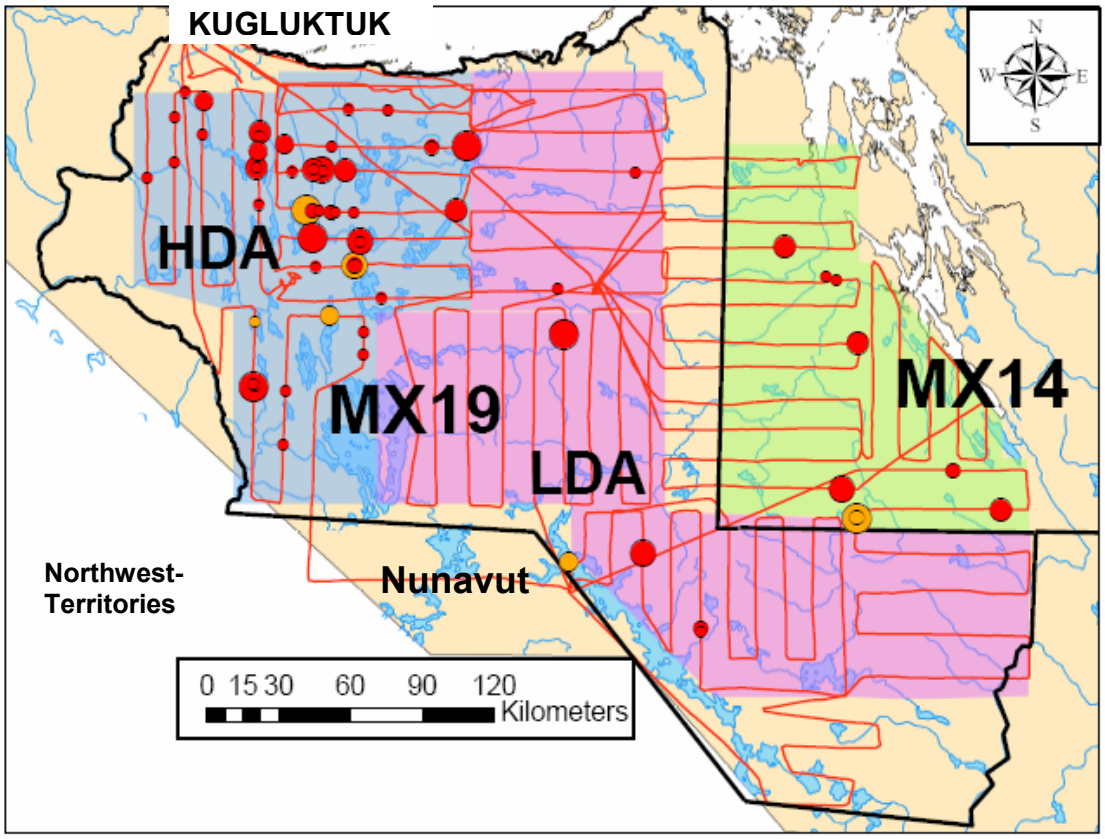

Figure 5.1: Distribution and relative density of muskoxen (circles are proportional to muskox group size), observed on (red) and off (orange) transects during an aerial survey in the West Kitikmeot, August 2005.

Table 5.1: Number of adult muskoxen observed and estimated density for each survey block, August 2005.

BLOCK	AREA TOTAL km^2	COVERAGE (%)	MUSKOXEN ADULTS (on transect)	MUSKOXEN CALVES (on transect)
1	4800	25%	67	5
2	4000	22%	147	11
3	4000	24%	109	9
4	3840	18%	1	0
5	3840	18%	2	0
6	4000	24%	21	0
7	4271	19%	61	0
8	3904	20%	0	0
9	4800	25%	42	0
10	4000	24%	30	0
11	4000	24%	32	0
12	3030	24%	0	0
13	2712	23%	32	3
14	3420	25%	0	0
15	3570	18%	18	2
16	3570	18%	0	0
TOTAL	61757	22%	562	30

Using blocks representing approximately the study area of previous surveys, I compared previous muskox population estimates with the one calculated from this survey (Table 5.2).

Table 5.2: Comparison between the survey results from August 2005 and the previous surveys in the study area.

ZONES 1986 and 1991	Approximate corresponding Blocks	SURFACE TOTAL (2005) (km^2)	PREVIOUS ESTIMATE (±SE)	2005 ESTIMATE (±SE)	*Z* VALUE	*P* VALUE
Northwest Contwoyto Lake	1, 2, 3, 4, 5, 7, 8, 9, 13	36167	1403±379[1]	2152±577	-1.085	0.278
Northeast Contwoyto Lake	6, 10, 11, 12, 13, 14, 15, 16	30746	3408±464[2]	604±225	5.437	0.000

[1] Survey conducted in July-August 1991 (Gunn *Draft report*)
[2] Survey conducted in August-September 1986 (Gunn 1990)

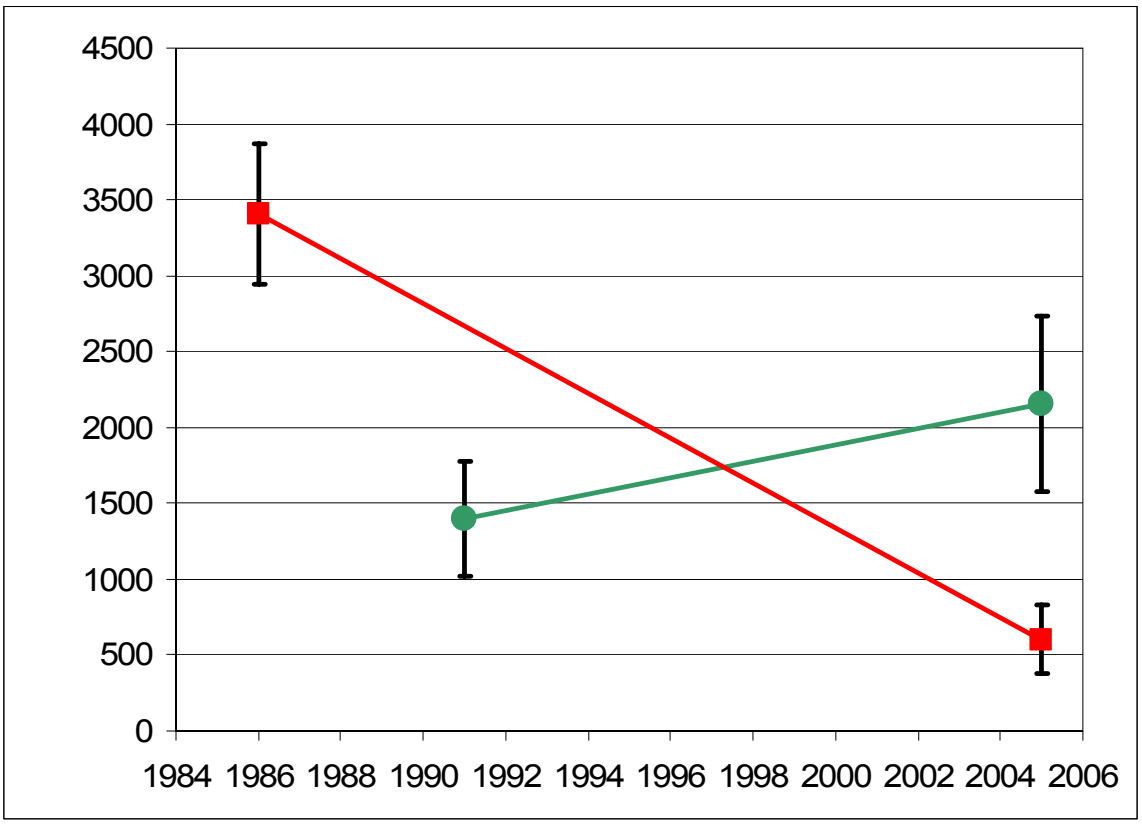

Figure 5.2: Trend in the Muskox population in the West Kitikmeot. West area is in green, East area is in red. Standard error is shown for each estimate.

The proportion of observed calves was low for the entire study area (5.3%; Table 5.3). Calves were observed, within transects, in only 5 of 12 blocks where muskoxen were observed. In the West of MX19 (HAD), calves represented 6.1% of the population, while in the East of MX19 (LDA) they were only representing 2.0%. The proportion of calves in groups with calves was respectively 11.2% ($N_{MX19HDA}$=9) and 10.7% ($N_{MX19LDA}$=1), and was 11.3% for the overall surveyed area (N=11 groups). In the surveyed part of MX14, the calf proportion in groups with calves was 14.3% (N_{MX14}=1).

Table 5.3: Observed proportion of calves in the muskox population and in groups with calves (GWC) during an aerial survey (August 2005). West is the area Northwest of Contwoyto Lake and East is the area Northeast of Contwoyto Lake.

	Total number of Adult	Total number of Calves	Proportion of Calves (%)	Total Adults in GWC	Number of Groups	Proportion of Calves in GWC
Study Area	562	30	5.3	266	11	11.3
MX19 HDA	384	25	6.1	252	9	11.2
MX19 LDA	77	3	2.0	28	1	10.7
MX14 West	101	2	2.0	14	1	14.3

Group size averaged 9.7 overall (when including lone animals) in the entire study area. Group size was 19.7 in average when excluding lone animals. In $MX19_{HDA}$, group size averaged 8.5 and 19.8 with and without including lone animals respectively. In $MX19_{LDA}$, group size averaged 12.8 and 18.8 with and without including lone animals respectively. In MX14, group size averaged 14.4 and 19.8 with and without including lone animals respectively.

Group size distribution (Figure 5.3) did not vary significantly between $MX19_{HDA}$, $MX19_{LDA}$ and $MX14_{west}$ (G-test, *df*=10, *P*=0.3854).

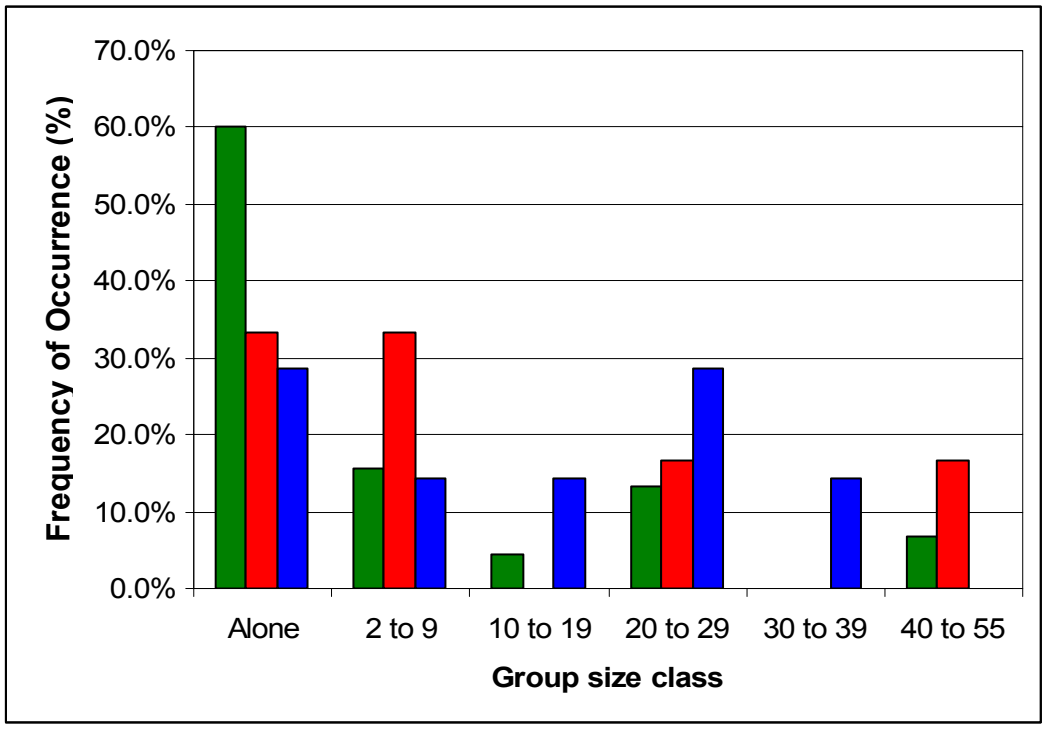

Figure 5.3: Distribution (%) of muskoxen Group size (adults) in $MX19_{HDA}$ (Green) $MX19_{LDA}$ (Red) and $MX14_{West}$ (Blue) Areas during the August 2005 aerial survey (West Kitikmeot, Nunavut).

In the blocks 1 and 7 that would represent newly colonized areas (compared to the 1991 survey (Gunn *Draft report*), the proportion of lone bulls was approximately 2 times the proportion in Blocks 2 and 3 (more established population, Table 5.4).

Table 5.4: Percentage of lone animals among observed muskoxen for each survey block (West Kitikmeot, August 2005)

Block	1	2	3	4	5	6	7	9	10	11	13	15
N	11	12	14	1	1	1	8	1	3	1	3	2
Lone adult	10.5	4.1	6.4	100	0	0	11.5	0	6.7	0	3.1	0
≥ 2 adults	89.5	95.9	93.6	0	100	100	88.5	100	93.3	100	96.9	100

During the survey we also recorded caribou, grizzly bears and human activity (Figure 5.4). We observed 175 caribou distributed in two main areas (Figure 5.4). We observed a total of 13 Grizzly bears among which were 6 lone Grizzly bears and 3 family groups ranging from 2 to 3 individuals (likely a female with 1 to 2 youngs).

Recorded human activity into 5 categories:

- Cabin: one or more recreational cottage or outpost camps
- Camp: Outfitting or exploration/mining camps including several buildings,
- Community: Kugluktuk and Bathurst Inlet,
- Fuel caches: Old or new fuel caches
- Anthropic: Various other human activities or structure such as lumber, trails, markers, etc…

During the survey we recorded 5 cabins, 22 camps, 2 communities, 9 Fuel caches, and 10 miscellaneous human activities or structures.

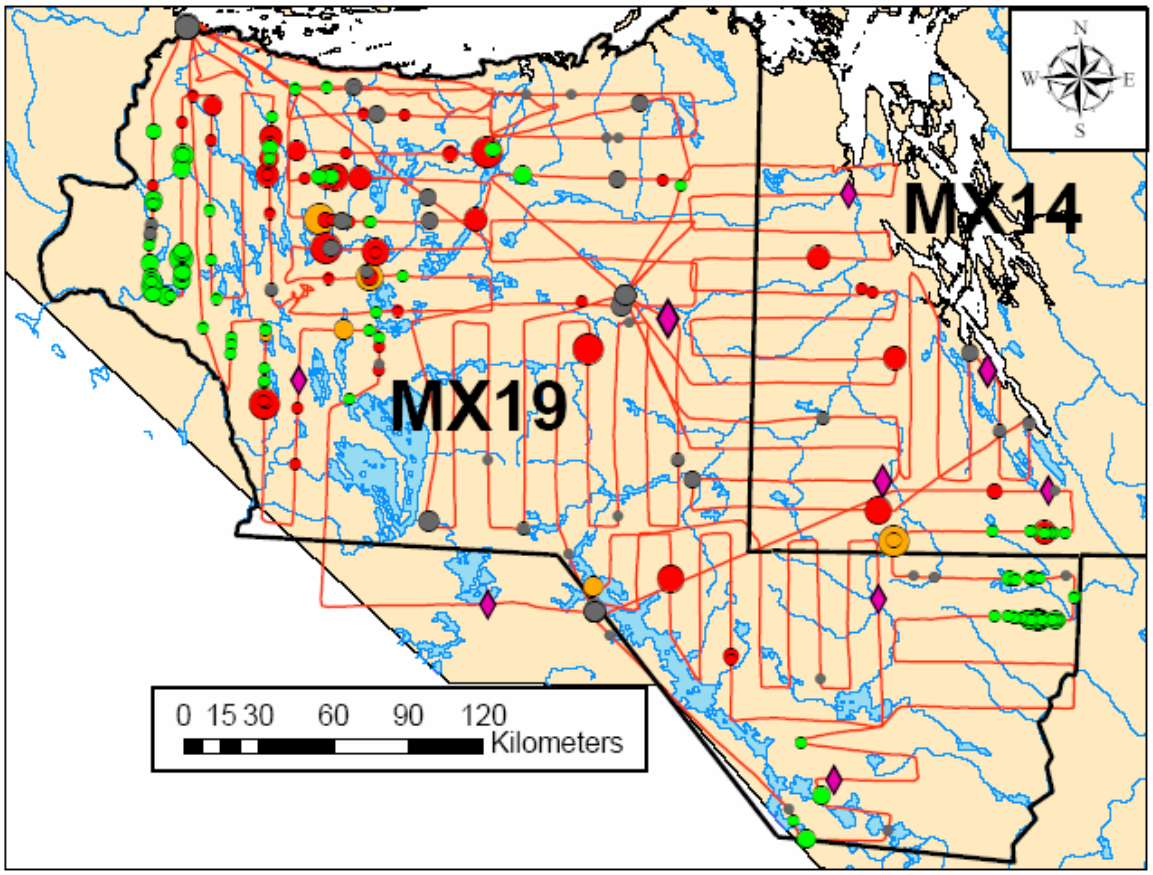

Figure 5.4: Caribou (green dots), Grizzly bear (purple diamond), Anthropic (grey dots), and Muskox (red and orange dots) observations during August 2005 aerial survey in the West Kitikmeot. Symbols are proportional to group size for wildlife or foot print for anthropic activities.

6.0. Discussion:

The aerial survey observations were consistent with local knowledge observations in terms of muskox population trends and low abundance of calves. Hunters from Kugluktuk were observing a local increase in muskoxen but also reported that there were not many calves. Hunters from Kingaut (Bathurst Inlet – Contwoyto area) were reporting a decline in muskoxen numbers over the past few years and were also observing very few calves.

The coefficient of variation is relatively high and the resulting confidence intervals (95%) are fairly wide. Despite this, in the eastern part of the study area, the decline in muskox abundance was significant (P=0.000). This result confirms also local hunters' observations. In the west part of MX19, although not statistically significant, the apparent trend seems to be consistent with local knowledge.

The distribution of muskoxen changed mainly in the West because muskoxen re-colonized the western and north-western part of the area. In the East, the distribution did not change dramatically and, even with the drastic decline in abundance, Muskoxen have remained in the 1986 core areas.

It is difficult to interpret whether the change in distribution and the trend in muskox population in the two areas are linked. In the West, the increase in the population can be linked to the colonization of new areas. Bulls are usually the first to colonize new areas (Smith 1989). In the blocks 1 and 7 that would represent the newly colonized areas, the proportion of lone bulls was approximately 2 times the proportion in Blocks 2 and 3 (more established population).

Because our study area was previously surveyed as two areas surveyed 5 years apart, it is difficult to establish what the influence of demography is and what the influence of population shift or movements is.

It is interesting to note that very few muskoxen were observed in the central section of the study area. This area has been a hub of anthropogenic activity with 2 active mines, intensive mineral exploration, and relatively heavy aerial traffic. Muskoxen were more abundant in the area in 1991, prior to the big exploration rush. The scientific data collected for this study cannot demonstrate a cause-and-effect relationship between low density of muskoxen and anthropogenic activities. However, I would strongly suggest that it would be worth monitoring muskox distribution in relation to habitat and human activities to detect potential negative effects on muskox distribution on the Nunavut mainland. Surveys conducted by exploration project in the area at different time of year showed a higher muskox density in the area. Season is an important variable in assessing muskox distribution and range use.

7.0. Management Implications:

Overall, muskox abundance has increased in MX19 between 1991 and 2005. The current estimate for MX19 is 2100 ($MX19_{HDA}$ + $MX19_{LDA}$) is approximately 2100 muskoxen (non-calves). Nevertheless, the trend in muskox abundance is not homogeneous with MX19. This brings some concerns regarding the distribution of the harvest within this management zone in order to avoid local depletion and a potentially long re-colonization process. The estimate for the west part of MX14 is 434±168 (SE).

Due to the differences in densities and trends, the 2 areas of MX19 (HDA and LDA) may deserve different management strategies. However, it is not evident at this point that the two clusters are different populations. The minimum distance between observed muskox was less than 85km, which is the average seasonal movement of mainland muskoxen (Gunn and Fournier 2000). Therefore, seasonal migrations are, in the absence of a movement barrier, sufficient to suggest genetic exchange between the two groups of muskox. The gap between the two muskox clusters: (1) coincides with intensive exploration and mining activities, including at times intensive aerial traffic and may potentially act as a barrier; and/or (2) can due to poorer habitat quality or other ecological factors. Either hypothesis would need further investigation.

Muskox populations seem to go through fluctuations independent of the harvest, but harvest can increase the rate and amplitude of a population fluctuations. Harvest was an important factor in the near extirpation of muskoxen a century ago (Barr 1991).

In the Kivalliq, muskox harvest is set at 3% of the lower limit of the confidence interval in order to promote the recovery of the population in its historic range. As presented by Campbell and Setterington (2001), this rate of harvest seems to have been successful to achieve management goals when calf proportion in the population is around 15% (see Campbell and Setterington 2001 for detailed explaination).

The management objective in the study area is to maintain a stable muskox population to sustain current subsistence and sport hunting. Although is it probably difficult to influence muskox population trends only through harvest management, it is important that the harvest level does not amplify unwanted trends. The proportion of calves observed was very low for this study. Calf proportion has intuitively an important influence on muskox population trends. Harvested animals need to be replaced individuals in younger age classes. Calves and yearling muskoxen are probably more vulnerable to predation than older individuals. Subsistence hunters usually also harvest younger age classes (calves, yearling, 2-3 years old), whereas sport hunters select mature, prime bulls.

Recommendations:

MX19

Option 1: Management for recovery in the east ($MX19_{LDA}$) and stability in the west ($MX19_{HDA}$):

I recommend harvesting the west portion of MX19 at 4% of the estimate (TAH = 69) and the east portion at 3% or less of the estimate (TAH ≤ 11). Within MX19, it will be the responsibility to the Kitikmeot Hunters and Trappers Association (KHTA) to create sub-management zones or distribute the tags among users so harvest patterns reflect muskox distribution and relative densities.

Option 2: Management for stability overall

I would recommend a harvest rate of 3.5% of the population to allow immigrant from high density areas to replenish low density areas while limiting the sink effect of a harvest to high in the low density area (TAH = 75).

$MX14_{west}$

Option 1: Management for recovery

I recommend harvesting the west portion of MX14 at 3% or less of the estimate (TAH ≤ 13). Because the east half of MX14 was not surveyed, I would suggest to use local knowledge to establish the best harvesting strategy. If the east side has also witness a decline, I would suggest reducing the overall TAH for this zone. If local knowledge indicates that muskox abundance has increased on the east side of MX14, TAH could probably remain at its current level provided that harvest patterns reflect muskox distribution and relative densities.

Option 2: Management for stability

I would recommend a harvest rate of 4% of the population in the west part of MX14. Currently, the TAH is 20 for Bathurst Inlet that harvest mainly in the west part of MX14. When TAH is filled, harvest rate is 4.6% based on the estimate in this report. This harvest rate may be too high to stabilize a declining population.

For all areas: With the low proportion of calves, I recommend to maintain harvesting season that should continue to be set to reduce impact during late spring and summer to reduce stress on new born calves, allow females to accumulate fat reserves (important for lactation and pregnancy), and to reduce social disturbance during the rut.

I also would strongly recommend monitoring on the relationship between habitat, human activities, land use and availability, and muskox dynamics and distribution.

8.0. Reporting to Communities/Resource Users:

The preliminary results were discussed with impacted HTO's Chairmen and KHTA Chairman. Area specific data were provided to WolfDen Resources Inc. for their environmental baseline data. The preliminary results were also communicated to ENR-GNWT and the EMAB. When final results are available (this report), they will be presented to the impacted communities and co-management partners.

9.0. Literature Cited:

Barr, W. 1991. Back from the brink: The road to muskox conservation in the Northwest Territories. The Arctic Institute of North America of the University of Calgary, Alberta, Canada. *Kamotik Series* No. 3. 127pp.

Campbell, M. and M. Setterington. 2001. The re-evaluation of Kivalliq and Northeast Kitikmeot Muskox (Ovibos moschatus) populations, management zones and quotas. Technical Report Series 2001 – No. 1-02. Nunavut Wildlife Division, Department of Environment, Arviat, Nunavut. 97pp.

Fournier, B. and Gunn, A. 1998. Muskox numbers and distribution in the Northwest Territories, 1997. DRWED Yellowknife NWT, File Report No. 121. 55pp.

Gunn, A. 1990. Distribution and abundance of muskoxen between Bathurst Inlet and Contwoyto lake, NWT, 1986. NWT DRR File Report No.100. 28pp

Gunn, A. ***Draft report.*** Distribution and abundance of muskoxen Northwest of Contwoyto Lake, NWT, 1991. GNWT ENR Manuscript Report No.##. ##pp

Gunn, A. and B. Fournier. 2000. Calf survival and seasonal migrations of a mainland muskox population. File Report No.124. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. Yellowknife.

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

Norton-Griffiths, M. 1978. Counting animals. Serengetti ecological monitoring programme Handbook No. 1. Afropress Ltd., Nairobi Kenya. 139 pp.

Smith, T.E. 1989. The role of bulls in pioneering new habitats in an expanding muskox population on the Seward Peninsula, Alaska. Canadian Journal of Zoology 67:1096-1101.

Thompson, W.L., G.C. White and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press Inc. San Diego. 365 pp.

APPENDICES

Appendix 1: Survey history of Muskox Population in the study area

3.1. April 3-6, 1970, (Monaghan 1970) transects 5 miles apart were flown south of the Burnside river and transects 10 miles apart were flown north or the Burnside river (West of MX14). The coverage was estimated to be 100% and 50% respectively. The author estimated 108 adult muskoxen. The proportion of calves was probably in the order of 5% to 10%. It is important to note that in early April the calves were close to become yearling. The density estimate would be around 2 muskoxen/km^2 (M. Dumond personal estimate from available information).

Monaghan, H.J. 1970. Preliminary report – Muskox survey Bathurst Inlet area 1970. Preliminary report, G.N.W.T. 5pp.

3.2. July 18-20, 1976, (Spencer 1976) transects were flown in the area of Bathurst Inlet (exact location unknown) and 91 adult muskoxen were counted and the proportion of calves (2-3 month old) was estimated to be 17.2%.

Spence, W. 1976. Musk-oxen (Ovibos moschatus) survey Central Western Arctic, July 15 - July 24, 1976. Area Fish and Wildlife Office, Cambridge Bay, N.W.T. Manuscript report, 10pp.

3.3. February 26 – March 1, 1979, (Kingsley 1979) 81 muskoxen were counted and the author estimated a density of 2.45 muskoxen per 100km^2 in the west part of MX14. This would give a rough estimate of 400 muskoxen in the west part of MX14.

Kingsley M.C.S. 1979. Winter Muskox Survey, Bathust Inlet, N.W.T. Canadian Wildlife Service. Edmonton, Alberta. 15pp.

August 28 – September 8, 1986, (Gunn 1990) was the first systematic survey of the area. Gunn (1990) counted 641 muskoxen and 79 calves on 4,547 km^2 of strip transects. She estimated, for the Northeast of Contwoyto Lake and the west part of MX14, a muskox population of 3,400±460 (Standard Error). The density estimate would be 13.1 adult muskoxen per 100km^2. The proportion of calves in the population was 12.3%.

Gunn, A. 1990. Distribution and abundance of muskoxen between Bathurst Inlet and Contwoyto lake, NWT, 1986. NWT DRR File Report No.100. 28pp

July 30 – August 1, 1991. (Gunn 2005) was the first systematic survey in the area northwest of Contwoyto Lake. Gunn (2005) counted 141 muskoxen and 11 calves on 5,276 km^2 of strip transects. She estimated, for the area from the Northwest of Contwoyto Lake to the Coppermine River, a muskox population of 1403±379 (Standard Error). The density estimate was 2.7 adult muskoxen per 100km^2. The proportion of calves in the population was 8%.

Gunn, A. In prep. Distribution and abundance of muskoxen Northwest of Contwoyto Lake, NWT, 1991. GNWT ENR Manuscript Report No.##. ##pp

August 11 – 19, 2005, (This report)
Dumond, M. In prep. Muskoxen distribution and abundance in the area between Bathurst Inlet and the Coppermine River, Kitikmeot Region, Nunavut (MX19 and West of MX14) – August 2005. Nunavut Wildlife Division, Department of Environment. Technical Report ##, ##pp.

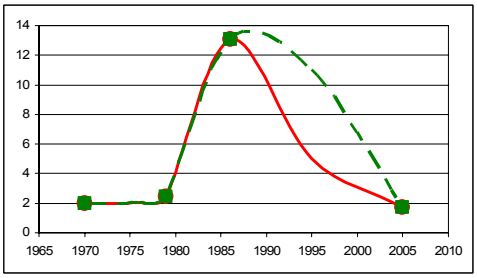

Figure A1.1: Graphical representation of the possible muskox population density fluctuations on the west side of Bathurst Inlet (1970 – 2005).

Appendix 2: Muskox population estimates calculations

Management Zone:	**MX/19**
Location:	**WEST KITIKMEOT**
Area of strata (km^2) (Z):	**43157**
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**640.9110573**
Transects sampled (n)	**46**
Total transects (N)	**213.6370191**
t-value for n-1 (95%CL):	**2.014**

				z	y_1	y_2					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	**z^2**	y_1^2	y_2^2	$z*y_1$	$z*y_2$
MX19	1	80.0	3.0	240.0	1	0	57600.00	1	0	240	0
MX19	2	80.0	3.0	240.0	2	0	57600.00	4	0	480	0
MX19	3	80.0	3.0	240.0	8	1	57600.00	64	1	1920	240
MX19	4	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	5	80.0	3.0	240.0	56	4	57600.00	3136	16	13440	960
MX19	6	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	7	55.0	3.0	165.0	2	0	27225.00	4	0	330	0
MX19	8	78.5	3.0	235.5	65	7	55460.25	4225	49	15307.5	1648.5
MX19	9	80.0	3.0	240.0	80	4	57600.00	6400	16	19200	960
MX19	10	76.0	3.0	228.0	31	0	51984.00	961	0	7068	0
MX19	11	80.0	3.0	240.0	68	9	57600.00	4624	81	16320	2160
MX19	12	80.0	3.0	240.0	8	0	57600.00	64	0	1920	0
MX19	13	80.0	3.0	240.0	2	0	57600.00	4	0	480	0
MX19	14	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	15	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	16	79.0	3.0	237.0	1	0	56169.00	1	0	237	0
MX19	17	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	18	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	19	80.0	3.0	240.0	2	0	57600.00	4	0	480	0
MX19	20	48.0	3.0	144.0	0	0	20736.00	0	0	0	0

MX19	21	20.0	3.0	60.0	2	0	3600.00	4	0	120	0
MX19	22	78.0	3.0	234.0	2	0	54756.00	4	0	468	0
MX19	23	78.0	3.0	234.0	57	0	54756.00	3249	0	13338	0
MX19	24	28.0	3.0	84.0	0	0	7056.00	0	0	0	0
MX19	25	55.0	3.0	165.0	0	0	27225.00	0	0	0	0
MX19	26	78.5	3.0	235.5	0	0	55460.25	0	0	0	0
MX19	27	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	28	76.0	3.0	228.0	0	0	51984.00	0	0	0	0
MX19	29	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	30	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	31	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	32	78.0	3.0	234.0	42	0	54756.00	1764	0	9828	0
MX19	33	20.0	3.0	60.0	0	0	3600.00	0	0	0	0
MX19	34	17.0	3.0	51.0	0	0	2601.00	0	0	0	0
MX19	35	28.0	3.0	84.0	0	0	7056.00	0	0	0	0
MX19	36	39.0	3.0	117.0	28	3	13689.00	784	9	3276	351
MX19	37	57.0	3.0	171.0	0	0	29241.00	0	0	0	0
MX19	38	73.0	3.0	219.0	4	0	47961.00	16	0	876	0
MX19	39	58.0	3.0	174.0	0	0	30276.00	0	0	0	0
MX19	40	57.0	3.0	171.0	0	0	29241.00	0	0	0	0
MX19	41	58.0	3.0	174.0	0	0	30276.00	0	0	0	0
MX19	42	58.0	3.0	174.0	0	0	30276.00	0	0	0	0
MX19	43	74.0	3.0	222.0	0	0	49284.00	0	0	0	0
MX19	44	70.5	3.0	211.5	0	0	44732.25	0	0	0	0
MX19	45	70.0	3.0	210.0	0	0	44100.00	0	0	0	0
MX19	46	70.0	3.0	210.0	0	0	44100.00	0	0	0	0

Totals	**3097.50**	**3.00**	**9292.50**	**461**	**28**	2022000.75	25313	172	105329	6319.5

Statistical Calculations

	Area	**Adults(y_1)**	**Calves(y_2)**
SUM(z)	**9292.50**		

SUM(y)		**461**	**28**
SUM(z^2) and/or SUM(y^2)	**2022000.75**	**25313**	**172**
SUM(z * y)		**105328.5**	**6319.5**
R = SUM(y) / SUM(z)		**0.0496**	**0.0030**
s_y^2		**459.84**	**3.44**
s_z^2	**3218.11**		
s_{zy}		**265.25**	**14.42**
Y = R x Z		**2141.01**	**130.04**
Var(**Y**)		**343689.56**	**2636.04**
SE(**Y**)		**586.25**	**51.34**
95% Confidence Limits of Y (+/-)		**1180.71**	**103.40**
95% Confidence Limits of Y (%)		**55.15**	**79.52**
Coefficient of Variation		**0.27**	**0.39**
% area coverage			21.53

Management Zone:	**MX19HDA**
Location:	**East Kugluktuk**
Area of strata (km^2) (Z):	**17071**
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**243.5814507**
Transects sampled (n)	**18**
Total transects (N)	**81.19381688**
t-value for n-1 (95%CL):	**2.11**

				z	**y_1**	**y_2**					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	**z^2**	y_1^2	y_2^2	$z*y_1$	$z*y_2$
MX19	1	80.0	3.0	240.0	1	0	57600.00	1	0	240	0
MX19	2	80.0	3.0	240.0	2	0	57600.00	4	0	480	0
MX19	3	80.0	3.0	240.0	8	1	57600.00	64	1	1920	240
MX19	4	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	5	80.0	3.0	240.0	56	4	57600.00	3136	16	13440	960
MX19	6	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	7	55.0	3.0	165.0	2	0	27225.00	4	0	330	0
MX19	8	78.5	3.0	235.5	65	7	55460.25	4225	49	15307.5	1648.5
MX19	9	80.0	3.0	240.0	80	4	57600.00	6400	16	19200	960
MX19	10	76.0	3.0	228.0	31	0	51984.00	961	0	7068	0
MX19	11	80.0	3.0	240.0	68	9	57600.00	4624	81	16320	2160
MX19	12	80.0	3.0	240.0	8	0	57600.00	64	0	1920	0
MX19	13	80.0	3.0	240.0	2	0	57600.00	4	0	480	0
MX19	14	48.0	3.0	144.0	0	0	20736.00	0	0	0	0
MX19	15	20.0	3.0	60.0	2	0	3600.00	4	0	120	0
MX19	16	78.0	3.0	234.0	2	0	54756.00	4	0	468	0
MX19	17	78.0	3.0	234.0	57	0	54756.00	3249	0	13338	0
MX19	18	28.0	3.0	84.0	0	0	7056.00	0	0	0	0
Totals		**1261.50**	**3.00**	**3784.50**	**384**	**25**	851573.25	22744	163	90631.5	5968.5

Statistical Calculations

	Area	Adults(y_1)	Calves(y_2)
SUM(z)	**3784.50**		
SUM(y)		**384**	**25**
SUM(z^2) and/or SUM(y^2)	**851573.25**	**22744**	**163**
SUM(z * y)		**90631.5**	**5968.5**
R = SUM(y) / SUM(z)		**0.1015**	**0.0066**
s_y^2		**856.00**	**7.55**
s_z^2	**3287.18**		
s_{zy}		**549.75**	**39.57**
Y = R x Z		**1732.13**	**112.77**
Var(**Y**)		**221850.93**	**2042.81**
SE(**Y**)		**471.01**	**45.20**
95% Confidence Limits of Y (+/-)		**993.83**	**95.37**
95% Confidence Limits of Y (%)		**57.38**	**84.57**
Coefficient of Variation		**0.27**	**0.40**
% area coverage			22.17

Management Zone:	**MX/19LDA**
Location:	**WEST KITIKMEOT**
Area of strata (km^2) (Z):	**26086**
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**397.8257081**
Transects sampled (n)	**28**
Total transects (N)	**132.6085694**
t-value for n-1 (95%CL):	**2.052**

				z	y_1	y_2					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	**z^2**	y_1^2	y_2^2	$z*y_1$	$z*y_2$
MX19	1	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	2	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	3	79.0	3.0	237.0	1	0	56169.00	1	0	237	0
MX19	4	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	5	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	6	80.0	3.0	240.0	2	0	57600.00	4	0	480	0
MX19	7	55.0	3.0	165.0	0	0	27225.00	0	0	0	0
MX19	8	78.5	3.0	235.5	0	0	55460.25	0	0	0	0
MX19	9	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	10	76.0	3.0	228.0	0	0	51984.00	0	0	0	0
MX19	11	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	12	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	13	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX19	14	78.0	3.0	234.0	42	0	54756.00	1764	0	9828	0
MX19	15	20.0	3.0	60.0	0	0	3600.00	0	0	0	0
MX19	16	17.0	3.0	51.0	0	0	2601.00	0	0	0	0
MX19	17	28.0	3.0	84.0	0	0	7056.00	0	0	0	0
MX19	18	39.0	3.0	117.0	28	3	13689.00	784	9	3276	351
MX19	19	57.0	3.0	171.0	0	0	29241.00	0	0	0	0
MX19	20	73.0	3.0	219.0	4	0	47961.00	16	0	876	0

MX19	21	58.0	3.0	174.0	0	0	30276.00	0	0	0	0
MX19	22	57.0	3.0	171.0	0	0	29241.00	0	0	0	0
MX19	23	58.0	3.0	174.0	0	0	30276.00	0	0	0	0
MX19	24	58.0	3.0	174.0	0	0	30276.00	0	0	0	0
MX19	25	74.0	3.0	222.0	0	0	49284.00	0	0	0	0
MX19	26	70.5	3.0	211.5	0	0	44732.25	0	0	0	0
MX19	27	70.0	3.0	210.0	0	0	44100.00	0	0	0	0
MX19	28	70.0	3.0	210.0	0	0	44100.00	0	0	0	0
Totals		**1836.00**	**3.00**	**5508.00**	**77**	**3**	1170427.50	2569	9	14697	351

Statistical Calculations

	Area	Adults(y_1)	Calves(y_2)
SUM(z)	**5508.00**		
SUM(y)		**77**	**3**
SUM(z^2) and/or SUM(y^2)	**1170427.50**	**2569**	**9**
SUM(z * y)		**14697**	**351**
R = SUM(y) / SUM(z)		**0.0140**	**0.0005**
s_y^2		**87.31**	**0.32**
s_z^2	**3219.45**		
s_{zy}		**-16.07**	**-8.54**
Y = R x Z		**364.67**	**14.21**
Var(**Y**)		**43787.98**	**164.33**
SE(**Y**)		**209.26**	**12.82**
95% Confidence Limits of Y (+/-)		**429.39**	**26.30**
95% Confidence Limits of Y (%)		**117.75**	**185.14**
Coefficient of Variation		**0.57**	**0.90**
% area coverage			21.11

Management Zone:	**MX/14West**
Location:	**WEST KITIKMEOT**
Area of strata (km^2) (Z):	**13645**
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**244.9499244**
Transects sampled (n)	**19**
Total transects (N)	**81.6499748**
t-value for n-1 (95%CL):	**2.101**

				z	y_1	y_2					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	**z^2**	y_1^2	y_2^2	$z*y_1$	$z*y_2$
MX14	1	54.9	3.0	164.7	0	0	27126.09	0	0	0	0
MX14	2	54.6	3.0	163.8	0	0	26830.44	0	0	0	0
MX14	3	52.2	3.0	156.6	0	0	24523.56	0	0	0	0
MX14	4	53.9	3.0	161.7	21	0	26146.89	441	0	3396	0
MX14	5	56.1	3.0	168.3	2	0	28324.89	4	0	336.6	0
MX14	6	55.4	3.0	166.2	0	0	27622.44	0	0	0	0
MX14	7	57.3	3.0	171.9	28	0	29549.61	784	0	4813	0
MX14	8	56.1	3.0	168.3	0	0	28324.89	0	0	0	0
MX14	9	57.5	3.0	172.5	0	0	29756.25	0	0	0	0
MX14	10	57.1	3.0	171.3	0	0	29343.69	0	0	0	0
MX14	11	56.6	3.0	169.8	0	0	28832.04	0	0	0	0
MX14	12	57.7	3.0	173.1	32	0	29963.61	1024	0	5539	0
MX14	13	80.0	3.0	240.0	0	0	57600.00	0	0	0	0
MX14	14	62.0	3.0	186.0	0	0	34596.00	0	0	0	0
MX14	15	49.0	3.0	147.0	0	0	21609.00	0	0	0	0
MX14	16	37.0	3.0	111.0	0	0	12321.00	0	0	0	0
MX14	17	21.0	3.0	63.0	0	0	3969.00	0	0	0	0
MX14	18	70.0	3.0	210.0	4	0	44100.00	16	0	840	0
MX14	19	70.0	3.0	210.0	14	2	44100.00	196	4	2940	420

Totals	**1058.40**	**3.00**	**3175.20**	**101**	**2**	554639.40	2465	4	17865	420

Statistical Calculations

	Area	Adults(y_1)	Calves(y_2)
SUM(z)	**3175.20**		
SUM(y)		**101**	**2**
SUM(z^2) and/or SUM(y^2)	**554639.40**	**2465**	**4**
SUM(z * y)		**17864.7**	**420**
R = SUM(y) / SUM(z)		**0.0318**	**0.0006**
s_y^2		**107.12**	**0.21**
s_z^2	**1334.07**		
s_{zy}		**51.90**	**4.51**
Y = R x Z		**434.03**	**8.59**
Var(**Y**)		**28313.66**	**55.29**
SE(**Y**)		**168.27**	**7.44**
95% Confidence Limits of Y (+/-)		**353.53**	**15.62**
95% Confidence Limits of Y (%)		**81.45**	**181.77**
Coefficient of Variation		**0.39**	**0.87**
% area coverage			23.27

Appendix 3: Budget Summary

Expense type	Amount ($)
Fixed wing aircraft and fuel	68.7K
Casual (1 observer) (6 days)	1.5K
Field accommodation and landing fees	1.2K
Freight (air, ground and maritime)	9.7K
Instruments and supplies, safety equipment	2.4K
Service Contract	0.2K
Community Consultations (Travel & Accommodation)	2.2K
TOTAL	**85.9K**