Project # 2-17-05

Re-evaluation of The Northern Kivalliq Muskoxen (Ovibos moschatus) Distribution, Abundance and Quotas

Interim Report to the Nunavut Wildlife Management Board

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Introduction / Summary:

Prior to the enactment of protection in 1917 (Burch, 1977), muskox populations throughout the central arctic were hunted to near extirpation. Muskox populations throughout Nunavut are currently re-colonizing much of their historical range, but there remain gaps in information on the status of muskox populations in much of the eastern Mainland (Fournier and Gunn, 1998). At its greatest extent the distribution and abundance of muskox in the Kivalliq region of Nunavut has occurred within an area extending south of Latitude 66^0 north, west to the NWT/Thelon Game Sanctuary boundaries, east to the Hudson Bay coast line and south to the Manitoba border. Distribution and abundance of muskox within the Kivalliq reliably occurs within a slightly smaller geographic area that has been expanding for over 50 years (Figure 1). Kivalliq muskox subpopulations have been estimated using fixed-width line transect surveys in July of 1985, July 1986, July 1991, and July 1999. By 2010 concern was raised over the ten year lapse of information coupled with hunter's observations of muskox closer to communities. A re-evaluation of the central Kivalliq muskox status was conducted in July 2010, and July/August 2016, while a re-assessment of the Northern Kivalliq Muskox subpopulation was undertaken in July 2012 and most recently in July/August 2017. Based on these most recent survey results, central Kivalliq muskox numbers steadily increased up to July 2010, and then appeared to have stabilized between 2010 and 2016. The most recent survey of the northern Kivalliq subpopulation is still in the analysis stage, however, an increasing trend was documented between July 2000 and 2012.

To date there are no indications of health problems within the herd. A research program examining the distribution of the lungworm (*Omingmakstrongylus pallikuukensis)* amongst mainland muskox has been initiated in MX-10 but all tests have shown no indication of presence in the Kivalliq subpopulations. Future research should continue to examine the extent to which muskox have occupied range outside presently defined management areas.

Recently, hunters have been reporting increased observations of muskox closer to their communities both south and east of previously known distributions (Mulders and Bradley, 1991; Rankin Inlet HTO pers. comm.; Baker Lake HTO pers. comm.; Arviat HTO pers. comm.; Chesterfield Inlet HTO pers. comm.; Repulse Bay HTO pers. comm.; Coral Harbour HTO, pers. comm.; Whale Cove HTO, pers. comm. 2008). Ideally communities in the Kivalliq region would like to have easier access to healthy muskox populations. Both population estimates and distribution observations discussed herein will provide information that will enable regional wildlife organizations, local HTOs and biologists to determine the potential long-term effects of current harvest regimes on muskox populations in the Kivalliq while providing information on the continued expansion of muskox into their historical range.

Based on the results derived from strip transect quantitative methods, total allowable harvests for the 2 populations of muskox within the Kivalliq region (one north of the Thelon/Chesterfield Inlet waterways (Northern Kivalliq – MX-10) and the second south

(Central Kivalliq – MX-13) are currently based on 5% of the estimated adult muskox population (lower 95% confidence limit). At present within the Nunavut Wildlife Act and Regulations, a total allowable harvest (TAH) of 182 muskox is recommended for the central Kivalliq muskox population (MX-13) and 90 recommended for the northern Kivalliq muskox subpopulation (MX-10) (Figure 2).

At this time, and based on the 2016 population re-assessment of muskox in the central Kivalliq region, there is no new recommended change to the TAH of 182 and no new recommendations to the Nunavut Wildlife Management Board (NWMB). A full re-assessment is however planned for both the central and northern Kivalliq muskox subpopulations in 2018. Following this re-assessment any new developments will be discussed with all stakeholders prior to any recommended modifications to current management actions.

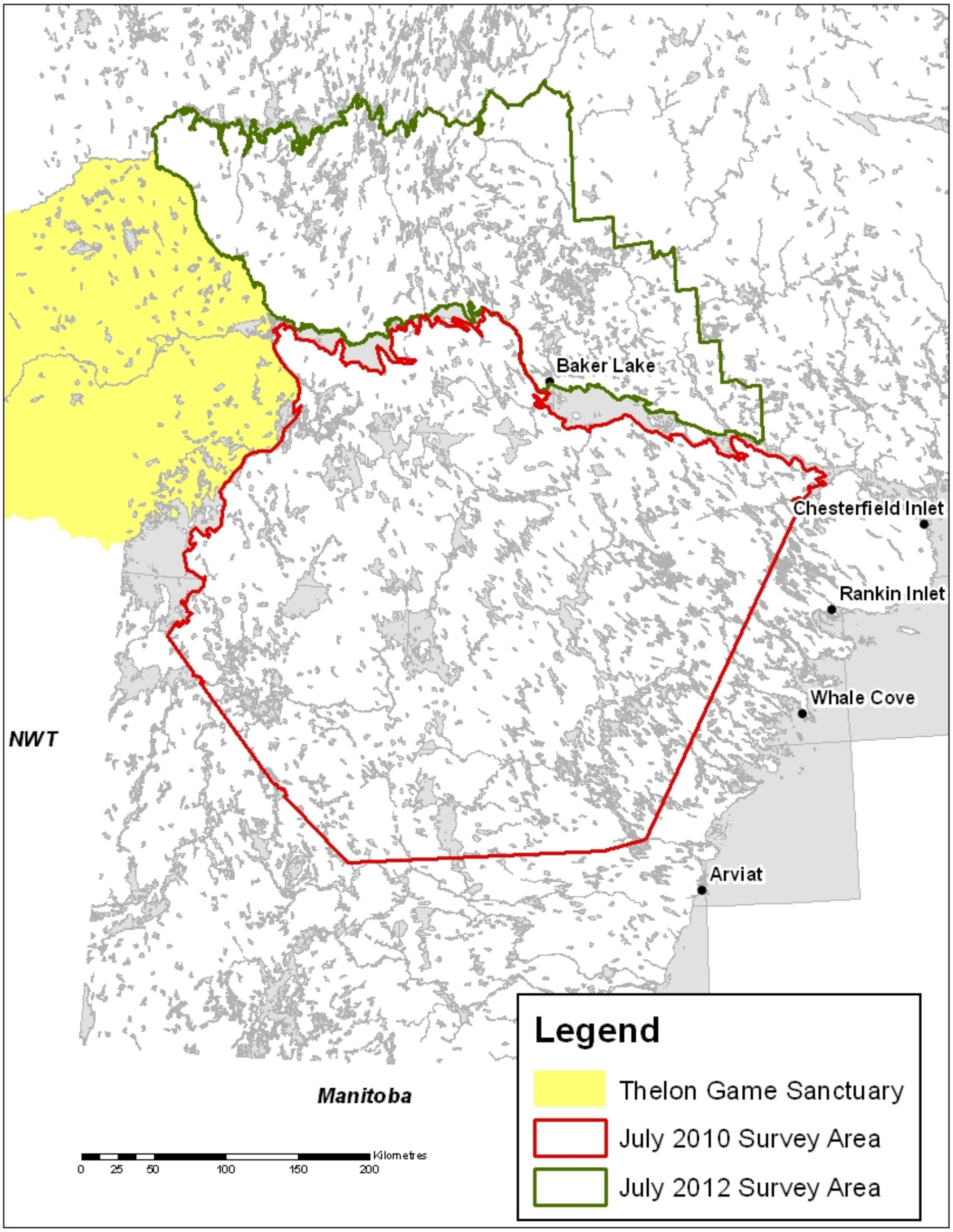

Figure 1. Survey study areas for the central (July 2010 &16) and northern (July 2012 & 2017) Kivalliq muskox subpopulations (MX-13 & MX-10).

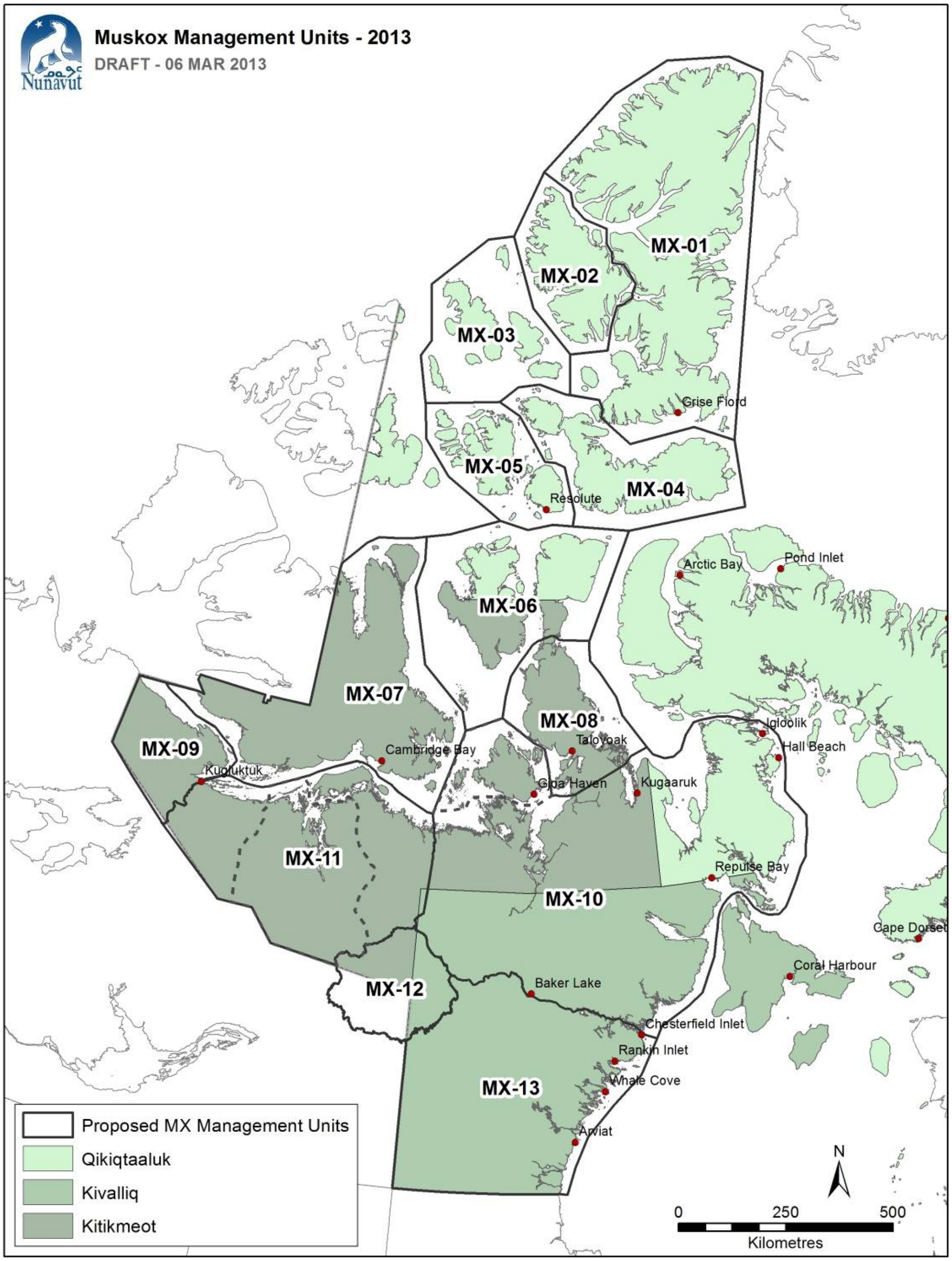

Figure 2. Nunavut's muskox management zones. The Northern Kivalliq muskox subpopulation extents are represented by MX-10, and the central Kivalliq muskox subpopulation extents are represented by MX-13.

Objectives:

The objectives of the project were to utilize *Inuit Qaujimajatuqangit* and aerial survey methods to determine the subpopulation status of muskox in the Central (MX-13) and Northern (MX-10) Kivalliq Region of Nunavut. The results are currently being used to address requests by Kivalliq HTOs to sustainably harvest more muskox closer to their communities. The results of the surveys have provided recommendations for harvest levels (TAH) and population boundaries as well as the adjustment to non quota limitations (NQL). The information from these surveys has been used to determine the numbers of muskoxen within MX-10 and MX-13 as part of the requirement outlined in the Central Kivalliq Muskox Management plan developed by the Kivalliq Regional Wildlife Board in partnership with the Department of Environment, Government of Nunavut, and Nunavut Tunngavik Inc.. Muskox populations in the Kivalliq must be estimated regularly in order to provide recommendations on sustainable harvest.

Another objective of this research program was to determine the number of muskoxen on the periphery of previously delineated distributions. A comprehensive estimation of the muskoxen population outside known and historic distributions needs to be updated. Observations made by hunters suggest that there has been an increase in the number of muskox and that muskox have occupied a much larger range than reported in July 1999 and 2010. The expansion of muskox beyond previously delineated boundaries is confirmed in this report. The shorter growing season and thicker snow cover reported for the eastern arctic could make muskox expansion into historic range more sensitive to harvesting (Gunn, 1983; Forchammer and Boertmann, 1993). In order to develop harvest management recommendations, effort was put into determining the present status of the periphery of muskox populations relative to previous management zones.

Study Area:

The July 2010 and 2016, and 2012 and 2017 central and northern Kivalliq Muskox surveys incorporated an area stretching from the Hudson Bay coast to the Kivalliq Regional Boundary in the West, and North from the Manitoba Boundary to latitude 66^0 north. The study area exists primarily within tundra habitats characterized by continuous permafrost, while a smaller portion extends along the fringe of the forest ecotone (Taiga) (Figure 1).

The central and northern study areas included portions of the Maguse River Upland, Dubawnt Lake Plain/Upland, Back River Plain, and the Garry Lake Lowland ecoregions of the Southern Arctic ecozone, and the Wager Bay Plateau ecoregion of the Northern Arctic ecozone (Environment Canada 2001; Table 1). These ecoregions are characterized by a cover of shrub vegetation consisting of dwarf birch (*Betula glandulosa*), willow (*Salix* spp.), and alder on warm, dry sites.

Poorly drained sites are dominated by willow, sphagnum moss, and sedge. The region is associated with areas of continuous permafrost and Turbic Cryosolic soils, but unfrozen organic (Mesisol and Regosolic) soils also occur. Bedrock forms broad, sloping uplands and lowlands. Hummocky bedrock outcrops covered with till are dominant, and prominent esker ridges occur in some parts of the area. Twenty-five to 50% of the Maguse River Upland ecoregion is wetlands that are characteristically lowland low- and high-centered polygon fens (Environment Canada 2001). Sandy flats sparsely covered with vegetation characterize the Dubawnt Lake Plain/Upland ecoregion, and the southwestern portion is characterized by rolling terrain forming broad sloping uplands and lowlands where small and medium sized lakes are common. Soils in most of the southern study area are Turbic and Static Cryosols on level to undulating discontinuous veneers of sandy morainal and fluvioglacial deposits. The small portion of the central study area that falls within the northern Arctic ecozone is characterized by discontinuous cover of tundra vegetation including dwarf birch, willow, Labrador tea, *Dryas* spp., and *Vaccinium* spp. Lichen-covered rock outcroppings are common (Environment Canada 2001).

Table 1. Ecoregions of the central (MX-13) and northern (MX-10) muskox survey study areas in the Kivalliq and northeast Kitikmeot region of Nunavut.

<table>
<tr><th>Study Area</th><th>Ecozone</th><th>Ecoregion</th></tr>
<tr><td rowspan="2">Central
(MX-13)</td><td>Southern Arctic</td><td>Maguse River Upland
Dubawnt Lake Plain/Upland
Back River Plain
Garry Lake Lowland</td></tr>
<tr><td>Northern Arctic</td><td>Wager Bay Plateau</td></tr>
<tr><td rowspan="2">Northern
(MX-10)</td><td>Southern Arctic</td><td>Chantrey Inlet Lowland
Queen Maud Gulf Lowland</td></tr>
<tr><td>Northern Arctic</td><td>Wager Bay Plateau
Victoria Island Lowlands
Boothia Peninsula Plateau</td></tr>
</table>

Methods:

Survey Area

Two methods were used to meet the stated objectives. The first was a collection of *Inuit Qaujimajatuqangit* and local knowledge to determine currently known distributions of muskox. Information was collected and compiled during consultation visits with the communities of Rankin Inlet, Baker Lake, Whale Cove, Chesterfield Inlet and Arviat. The information collected was then used to help determine the survey study area extents. Once the survey study area was designated, systematic transects, drawn with a random starting point, were placed throughout the survey study area at a spacing of 7.0 km which when flown at an altitude of 152 meters (500 ft.) provided a maximum strip width of 2000 meters. All surveys were flown using an independent double observer pair (sight-resight) distance sampling method. The 2000 meter strip width provided 29.2 percent coverage of the entire survey area (Figure 3). Due largely to the exceptional sightability of muskox in July, visual transect survey methods are widely accepted as being the most cost effective means of estimating muskox populations while still providing an acceptable level of precision (Case and Graf, 1986; Graf and Case, 1989; Graf *et al*, 1989; Gunn, 1995; Mulders and Bradley, 1991).

Aircraft Configuration

All surveys were flown using a Cessna 206 Grand Caravan high wing single engine turbine aircraft based out of Rankin Inlet and Baker Lake. Strip widths of 0 to 250 meters, 250 to 500 meters, 500 to 750 meters and 750 to 1000 meters were established on the wing struts on both sides of the aircraft using streamers to mark off the 0 meter, 500 meter and 1000 meter markers and tape to delineate the remaining 250 and 750 meter segments (Figure 4). Strip width (w) was calculated using the formula of Norton-Griffiths (1978):

$$w = W * h/H$$

where:

W = the required strip width;

h = the height of the observer's eye from the tarmac; and

H = the required flying height

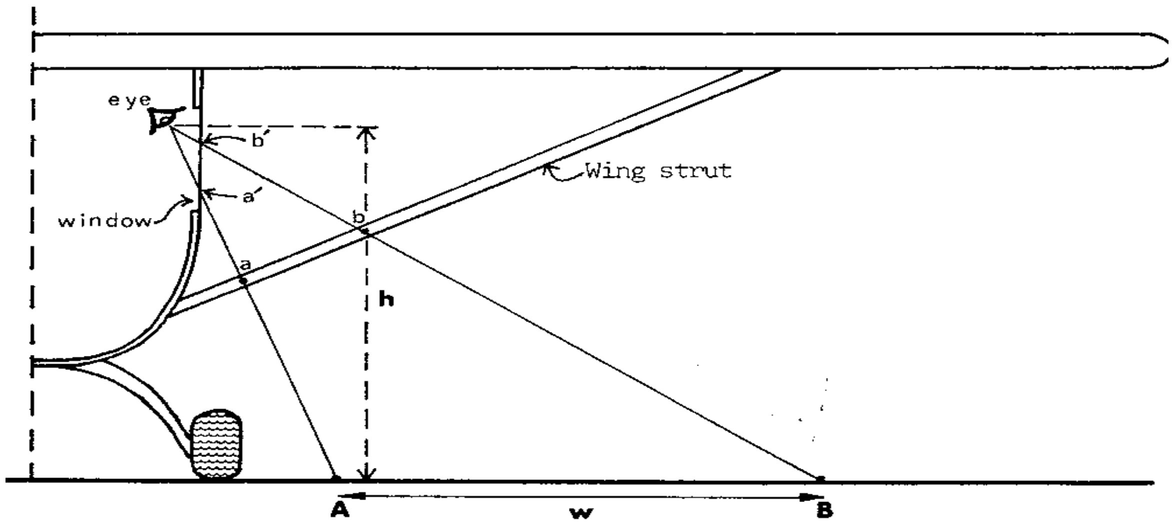

Figure 4. Schematic diagram of aircraft configuration for strip width sampling (Norton-Griffiths, 1978). W is marked out on the tarmac, and the two lines of sight a' – a – A and b' – b – B established. The streamers are attached to the struts at a and b. a' and b' are the window marks.

The strip width area for density calculations was 1000 meters out each side of the aircraft, for a total of 2000 m along each transect. The further division of the 1000 meter markers into 250 meter segments was to facilitate estimates using distance sampling techniques. Due to the size of the study area, the relatively limited data on muskox densities within much of the study area, and time and other logistic limitations, it was decided to allocate all of the survey effort into one systematic random transect survey over both survey years. Survey altitude was maintained as close as possible to 185 m above ground level (agl) using a radar altimeter. Ground speed was maintained between 175 and 195 kilometers per hour. The 2010 central Kivalliq muskox survey was initiated July 10, and completed July 22, 2010, while the 2016 central Kivalliq muskox survey was initiated July 24, and completed August 24. The 2012 northern Kivalliq muskox survey was initiated July 6th, and completed July 11th, while the 2017 northern Kivalliq muskox survey was initiated July 21 and completed July 29.

The entire survey was set up as an independent double observer sight-resight (capture/mark-recapture) distance sampling platform utilizing a survey crew of 7; two data recorders/navigators, two left side observers, two right side observers and the pilot (Figure 5). Two of the selected observers, one for each side of the aircraft, had experience surveying wildlife visually from aircraft. The two remaining observers were selected by the local HTO pertinent to each of the survey areas (Rankin Inlet, Baker Lake, and Arviat). The observers were further divided into front and rear teams, each isolated from the other using visual barriers between the seats as well as isolated through the use of two independent intercom systems monitored by each of a front data recorder/navigator and a rear data recorder/navigator. The pilot's responsibilities were to monitor air speed and altitude while following transects pre-programmed on a Garmin GPS 176 and 650t geographic positioning system devices (GPS). The data recorder/navigators were responsible for monitoring a second and third identically programmed GPS unit for the purposes of double-checking the position as well as to record the waypoints and numbers of observed muskox groups composed of adults and calves on data sheets. The responsibilities of the observers were to monitor their 1,000 meter segmented strips and call out numbers of muskox, separated by adults and calves observed within each designated 250 meter wide sub-strip (distance sampling). The rear right and front left observers, the pilot and the two data collector/navigators remained consistent throughout the 2010, 2012, 2016 and 2017 surveys while the observers varied depending on survey. All experienced observers remained consistent across each individual survey period. The 2012, 2016 and 2017 survey observers switched positions half way through the day (front to rear and rear to front) to provide data with which to asses changes in sightability between the front and rear positions. Only counts of adults and yearlings were used in the population estimate.

Statistical Analyses

Survey data collected within all pre-stratified strata were analyzed using Jolly's Method 2 for unequal sample sizes (Jolly 1969 in Norton-Griffiths 1978). Only counts of adults were used for the final population estimates. Lake areas were not subtracted from the total area calculations used in density calculations.

Sight-resight and Distance sampling analysis are ongoing and will appear in their entirety following the completion of a fully reviewed GN DOE file report. The completion of the file report is expected in the fall of 2018 and will replace any and all previous reports produced for co-managers including the present work. As other analyses are ongoing, the authors of this report and the GN DoE would like to ensure the reader understands that the results presented herein may change following further more comprehensive analysis and to this end reserve the right to update the results presented in this report within the final GN DOE File Report. Any and all GN DOE research projects are required to produce a comprehensive thoroughly peer reviewed File Report following the completion of the research program. The GN File Reports represent the most comprehensive and complete reporting format and as a result will be the main documents used to make management recommendations.

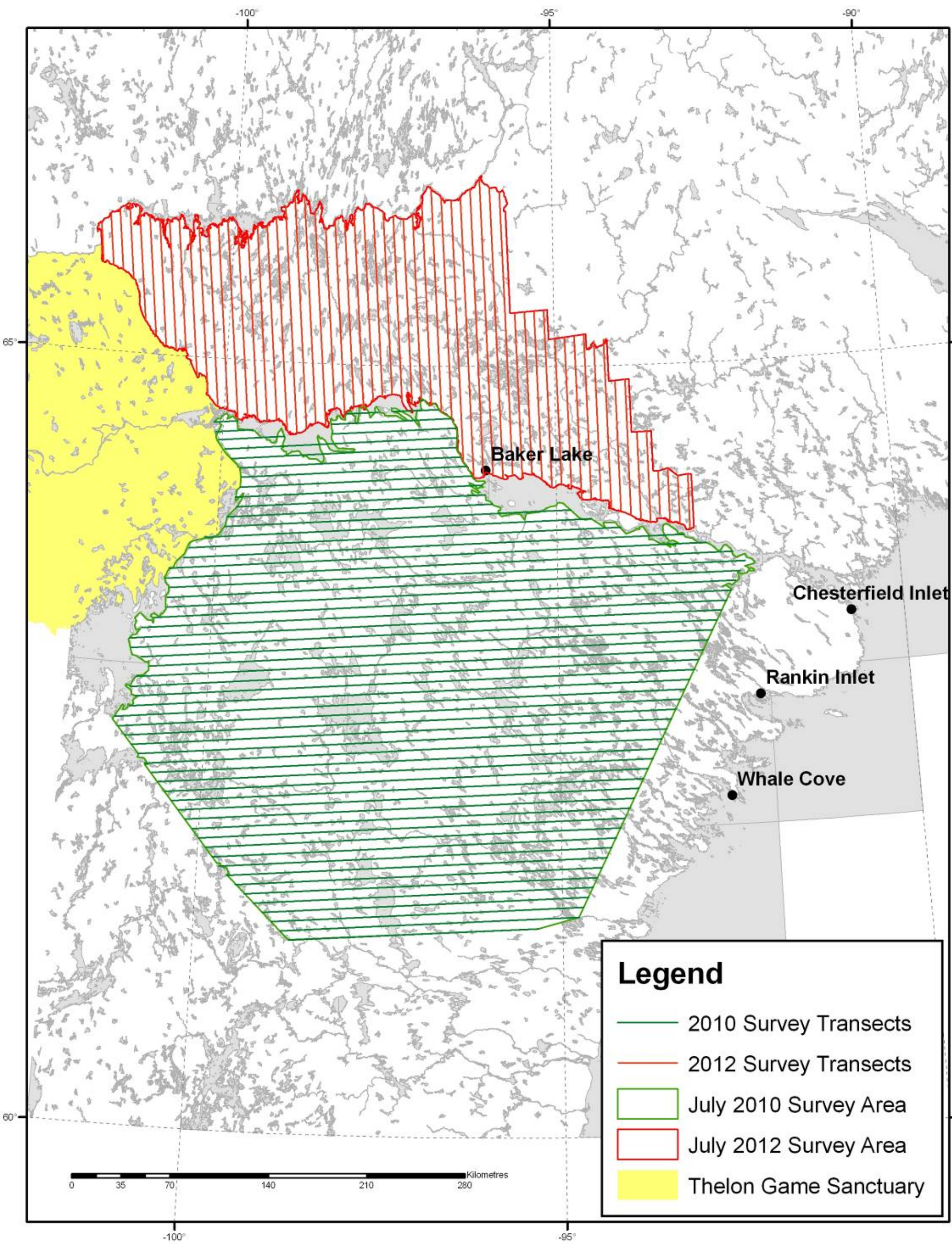

Figure 3. Study area and transects of the July 2010, 2016 (Central), and 2012, 2017 (Northern) Kivalliq Muskox surveys. Study area in 2010 & 2016 was divided into a western and eastern stratum based on estimated densities from IQ studies and past survey results.

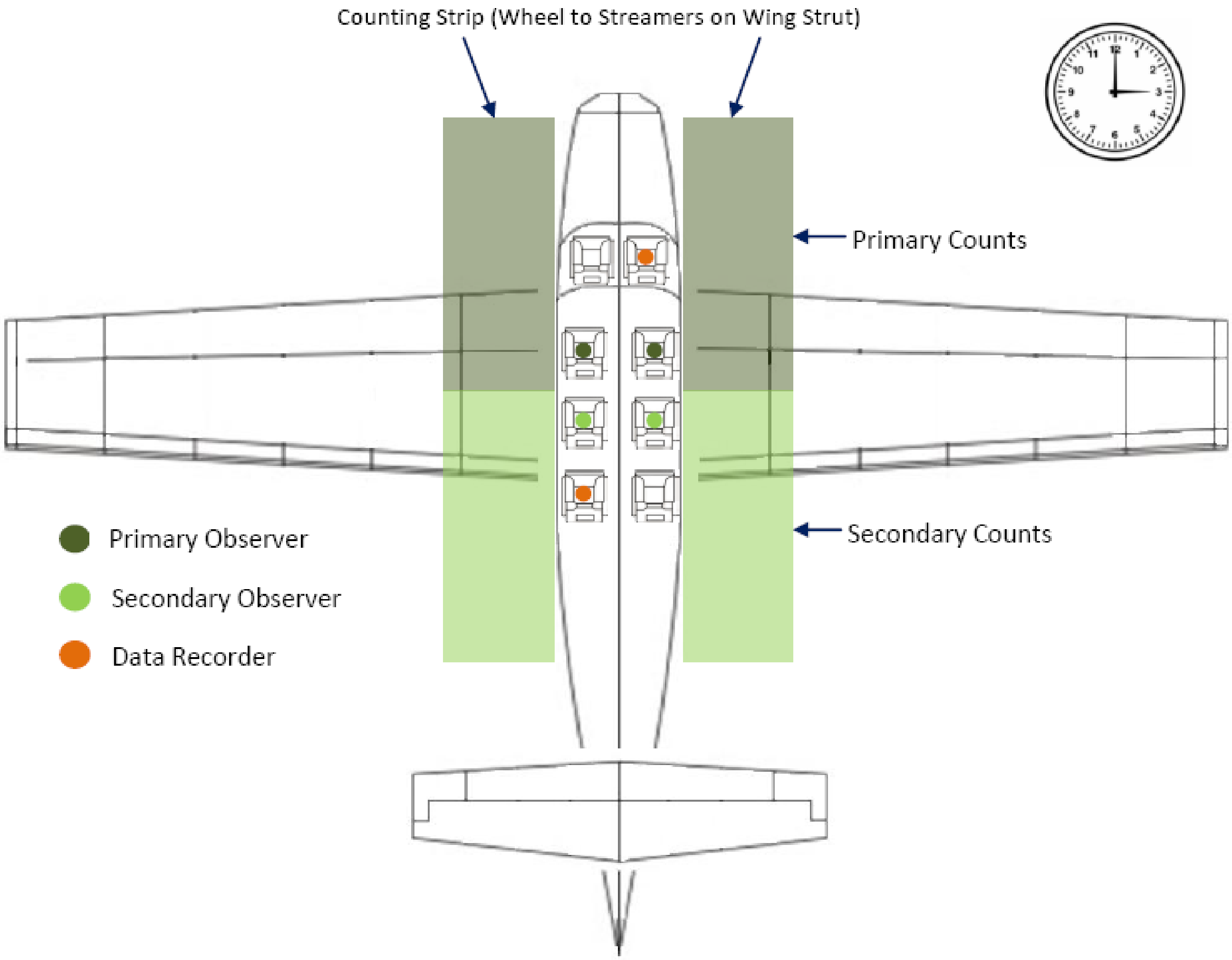

Figure 5. Observer position for the double observer method employed on this survey. The secondary observer calls muskox not seen by the primary observer after the muskox have passed the main field of vision of the primary observer. The small hand on a clock is used to reference relative locations of muskox groups (e.g. "muskox group at 3 o'clock" would suggest a muskox group 90° to the right of the aircrafts longitudinal axis.).

Project Schedule:

Output or step	Start date (dd/mm/yyyy)	End date (dd/mm/yyyy)
Systematic Double observer pair Abundance Survey	July 25, (2017)	August 15th, (2017)
Data Analysis	August (2017)	September (2017)
Report (Final Report)	July. (2017)	March (2018)

Preliminary Results and Discussion:

Central Kivalliq Muskox Survey

The Central Kivalliq muskox subpopulation had been steadily increasing between July 1986 and July 2010 (Figure 6). The most recent July 2016 estimate, however, suggests a stabilization in abundance across the central Kivalliq. Central Kivalliq muskox abundance estimates of 838 (+/- 362, 95% CI) in July 1986 steadily increased to 1,203 (+/-284, 95% CI) in July 1991, 2,143 (+/- 396, 95% CI) in July 1999, and finally 4,506 (+/- 948, 95% CI) by July 2010. An estimate of 4,437 muskox (+/- 1,054, 95% CI) in July 2016 indicates a stabilization in growth with no statistically validated change detected (Figure 6, Table 2). Of note was the survey flown in July 1991 which found muskox in a much smaller area than the July 1999 survey over the same general survey extents. Despite this discrepancy in area occupancy, similar relative densities were recorded. The 2010 survey results did indicate an increase in abundance but for the first time since 1985 showed a dramatic decline in muskox density within the survey area. This same general trend in relative density continued into 2016. This could be an artifact of the much larger survey area or it could suggest a punctuated/accelerated range expansion since the July 1999 survey. Further research and analysis is necessary before making any conclusions as to the mechanisms behind these changes in relative density.

Limitations to comparisons made with pre-1999 muskox surveys in the central Kivalliq were noted above. The primary limitation relates to variations in survey study areas, where the 1999, 2010 and 2016 central Kivalliq survey extents included a broader area designed to encompass all muskox within the central Kivalliq region and as a result were overlapping. Overall, central Kivalliq muskox were found over a much broader area in both 2010 and 2016 than previously recorded, suggesting not only an increase in abundance but an expansion of their range as well. During the July 1999 survey, muskox were more concentrated within smaller geographic areas than observed in July 2010 and

2016. One of the most surprising observations was the presence of numerous carnivores, and most specifically grizzly bears. A total of 21 grizzly bears (of all ages and sexes) were observed within both the July 2010 and July 2016 survey areas. All were observed in very good to exceptional body condition (Figure 9). This represents a considerably higher number than the 6 observed during the July 1999 survey though the survey area in July 1999 was considerably smaller. Additionally, wolf relative densities appeared to be higher in more recent years. In July 1999, 16 wolves were observed on transect while in July 2010, 39 wolves were observed. In July 2016, 30 wolves of all ages and sexes were observed on transect.

Observations of muskox in what was previously considered marginal habitat raised several questions, while at the same time densities in what was previously considered better quality habitat dropped substantially. All these observations raise questions as to whether muskox populations are poised to increase further or are reacting to change in environmental conditions, predator-prey dynamics, or anthropogenic changes within the environment. Further analysis is ongoing in attempts to explain the changes observed in both July 2010 and 2016.

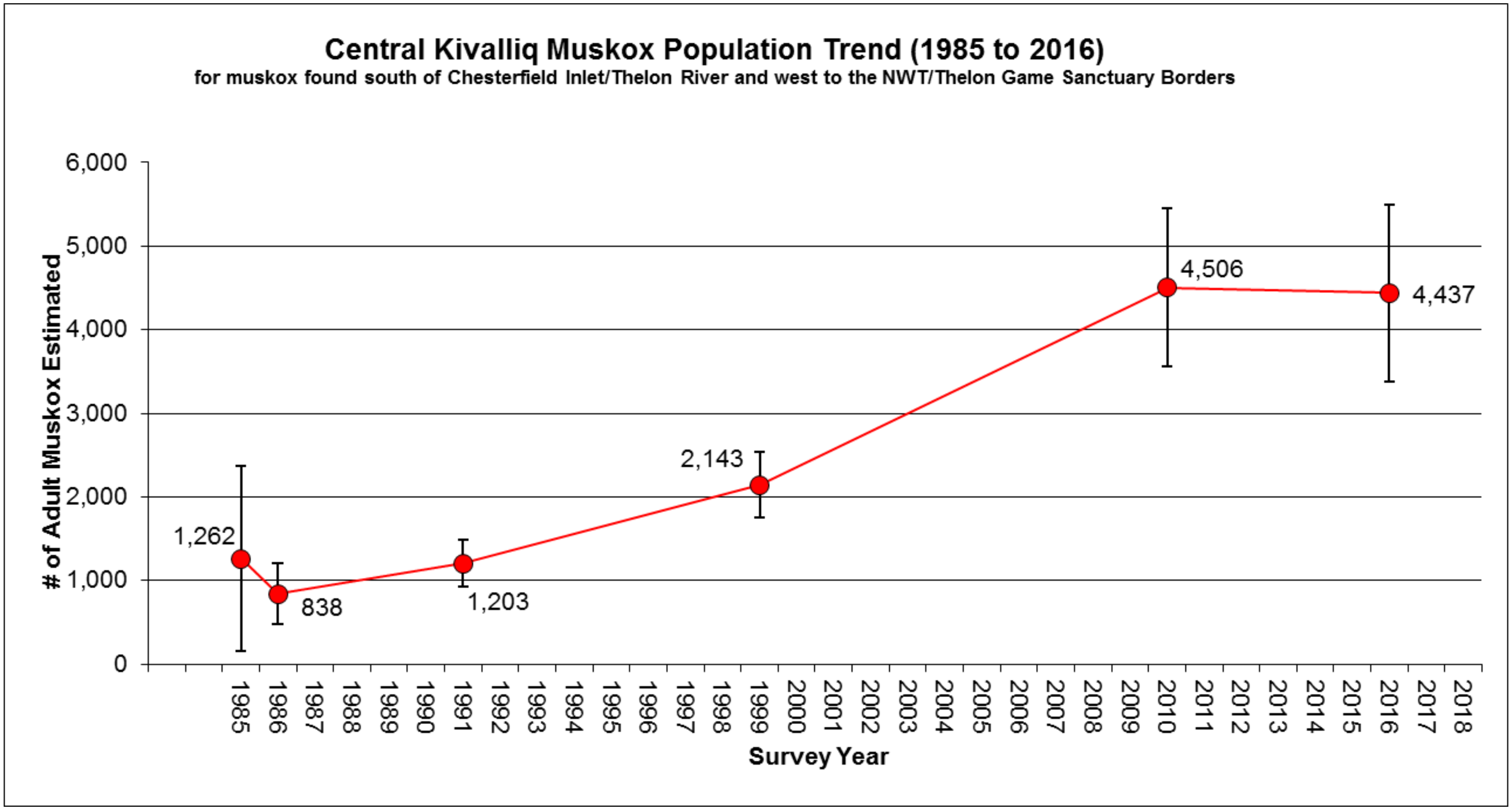

Figure 6. The trend of the central Kivalliq Muskox Population from 1985 through July 2016.

Table 2. A summary Central Kivalliq muskox survey results south of Chesterfield Inlet/Thelon River and west to the NWT/Thelon Game Sanctuary boundaries (1985–2010).

Year	*Total stratum area (km^2)*	*Population estimate*	*Standard error*	*CV*	*Lower 95% CI*	*Upper 95% CI*	*% calves*	*Authors*
1985 (Nov)	19,706	**1,262**	563	0.45	159	2,365	17.9	Case & Graf 1986
1986 (July)	8,261	**838**	176	0.21	476	1,200	11.5	Case et al. 1986
1991 (July)	12,555	**1,203**[1]	145	0.13	919	1,487	15.9	Mulders & Bradley 1991
1999 (July)	19,475	**2,143**	199	0.09	1,747	2,539	18.4	Campbell & Setterington, 2001
2010 (July)	114,618	**4,506**	478	0.11	3,558	5,455	15.4	Campbell & Lee, 2015.
2016 (July)	129,074	**4,437**	531	0.12	3,383	5,491	22.6	This Study
2017 (July)	In Process	In Process	In Process	In Process	In Process	In Process	In Process	This Study

[1] The calculation of lake areas were subtracted from the Mulders and Bradley (1991) estimate.

Northern Kivalliq Muskox Survey

Results of the 2012 northern Kivalliq muskox survey confirm an increase from the July 1999 abundance estimates (Figure 7). Initial estimates show the northern Kivalliq muskox population to have increased from an estimated 1,522 (SE = 331; CV = 0.22) in July 1999 to 2,341 (SE = 275; CV = 0.12) in July 2012. As with the central Kivalliq population, survey observations also suggest an expansion in the subpopulations geographic distribution eastward. Once again, these results should be used with caution as more extensive statistical analysis of the July 2012 results are being conducted along with the July 2017 northern Kivalliq Muskox survey results. The complete reassessment of the July 1999, 2010, and 2016 central Kivalliq muskox surveys and the July 1999, 2000, 2012 and 2017 northern Kivalliq muskox surveys utilizing the double observer pair sight-resight and distance sampling analysis procedure is nearing completion and will be provided to all stake holders in the form of a GN File Report on or about April 2018.

The GN DOE has met as recently as October 2017 to discuss all preliminary results and draft estimates with the Kivalliq Wildlife Board and its representatives from the communities of Arviat, Whale Cove, Rankin Inlet, Baker Lake, Chesterfield Inlet, Repulse Bay, and Coral Harbour. During this meeting it was agreed that until the northern Kivalliq muskox survey results are ready, no decision will be made concerning the adjustment of either the subpopulations TAH and/or the addition of any NQLs.

Community consultation:

All seven Kivalliq communities (Arviat, Whale Cove, Rankin Inlet, Chesterfield Inlet, Baker Lake, Repulse Bay and Coral Harbour) and the Kivalliq Wildlife Board (KWB) have been informed of the projects preliminary results and are in agreement with the management recommendations presented in this report. All Kivalliq community HTOs agreed that the preliminary results are consistent with local IQ. All parties agree that the TAH should be re-assessed following the production of the Departmental File Report. To this end, validated results from the 2010 and 2012 surveys were used to apply an exemption permit for the 2012/2013 harvesting season. Northern Kivalliq muskox survey results are still in the analysis stage and will be discussed further at the next KWB meeting expected in late January or early February, 2018. Presently, HTO members, local Conservation officers and local hunters are taking part in the continued collection of local knowledge concerning the location of muskox groups across the central and northern Kivalliq, and incorporating IQ in the possible mechanisms surrounding their continued range expansion into marginal habitats and observed lower relative densities.

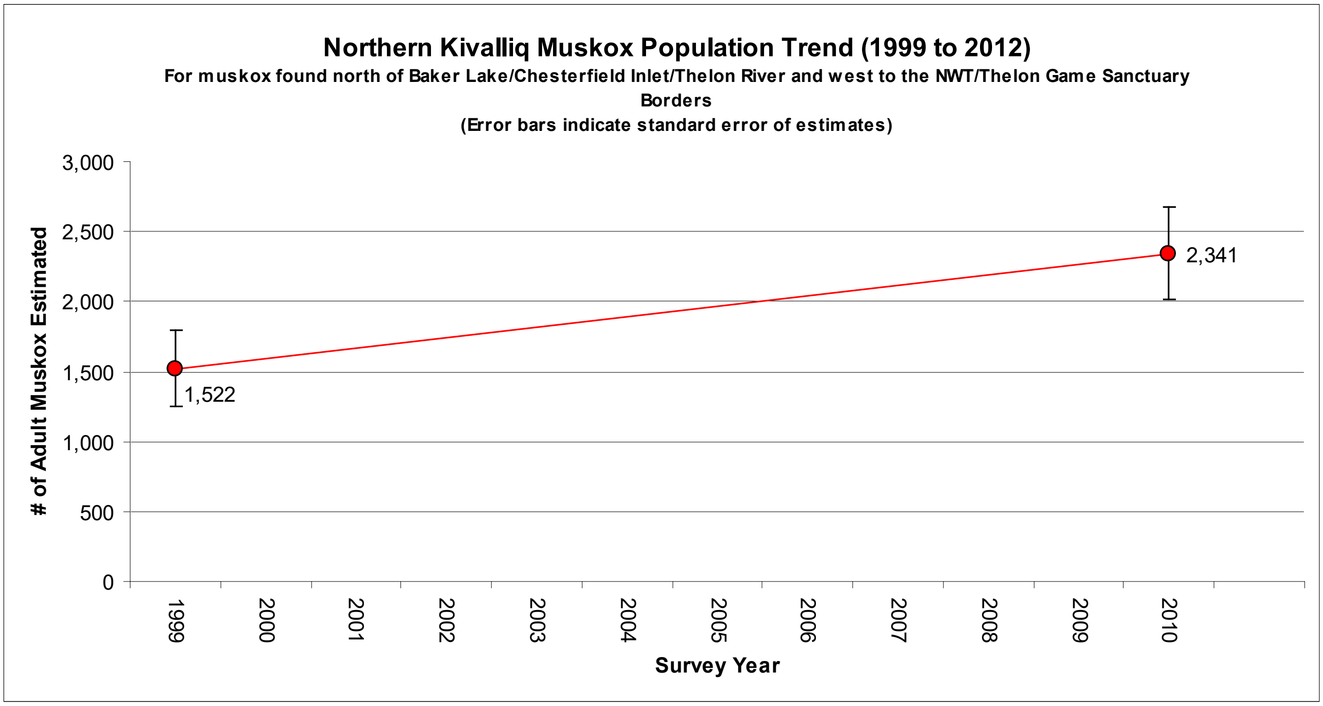

Figure 7. Trends of muskox abundance within the northern kivalliq subpopulation, July 2012.

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