Trends in high arctic muskox (*Ovibos moschatus*) harvest, 1990-2015

Morgan Anderson[1]

[1] Department of Environment Wildlife Research Section, Government of Nunavut Box 209 Igloolik NU X0A 0L0, Canada (Corresponding author: Morgan.Anderson@gov.bc.ca).

Abstract: Harvest reporting has been in place for High Arctic muskoxen in Nunavut, Canada, since 1990-91. The communities of Resolute, Grise Fiord, and Arctic Bay harvest muskoxen in the region. Overall, muskox harvest has declined in Resolute and Grise Fiord since the 1990s. The recovery of Peary caribou populations on the Bathurst Island Complex, which provides an alternate preferred source of country food, may be a factor behind Resolute's decreased muskox harvest. The proportion of harvest for domestic use has also declined relative to sport hunts, which have remained relatively constant since the 1990s. We compared muskox harvest from tag records and reported harvest, i.e., the voluntary surveys to the Nunavut Wildlife Harvest Study for muskoxen. It is clear that voluntarily reported harvest underestimates actual harvest, but not consistently enough to predict the actual harvest. Muskox populations are at historic high levels on Bathurst Island, southern Ellesmere Island, and Devon Island and could support more harvest than is currently taken. Changes to Total Allowable Harvests and management unit boundaries in 2015, combined with a decline in the availability of Baffin Island caribou as country food, may result in increased harvest pressure on muskoxen in the High Arctic.

Key words: muskox; *Ovibos moschatus;* harvest; Nunavut.

Rangifer, 37, (1), 2017: 47-58
DOI 10.7557/2.37.1.4182

Introduction

Wildlife management agencies use harvest data to ensure sustainable use of wildlife. Harvest data can be used to track changes in populations (Lancia *et al.,* 1996; Bender & Spencer, 1999; Solberg *et al.,* 2000; Fryxell *et al.,* 2001), and harvest regimes can be used to alter (or preserve) demographic characteristics and population dynamics (Coltman *et al.,* 2003; Milner *et al.,* 2007; Allendorf *et al.,* 2008; Mysterud 2011; Schmidt & Gorn 2013).The utility of harvest data for addressing questions around population abundance and trend depends on the type and quality of data collected.

In Nunavut, Canada, muskoxen have been harvested by Inuit and their predecessors for millenia, and continue to be an important source of country food in the north. Overharvesting for the fur trade in the 1800s and 1900s led to a muskox decline that was only reversed with a 1924 total harvest ban (Barr, 1991). By 1969, muskox populations had recovered sufficiently to lift the harvest ban and implement a quota system, using Muskox Management

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

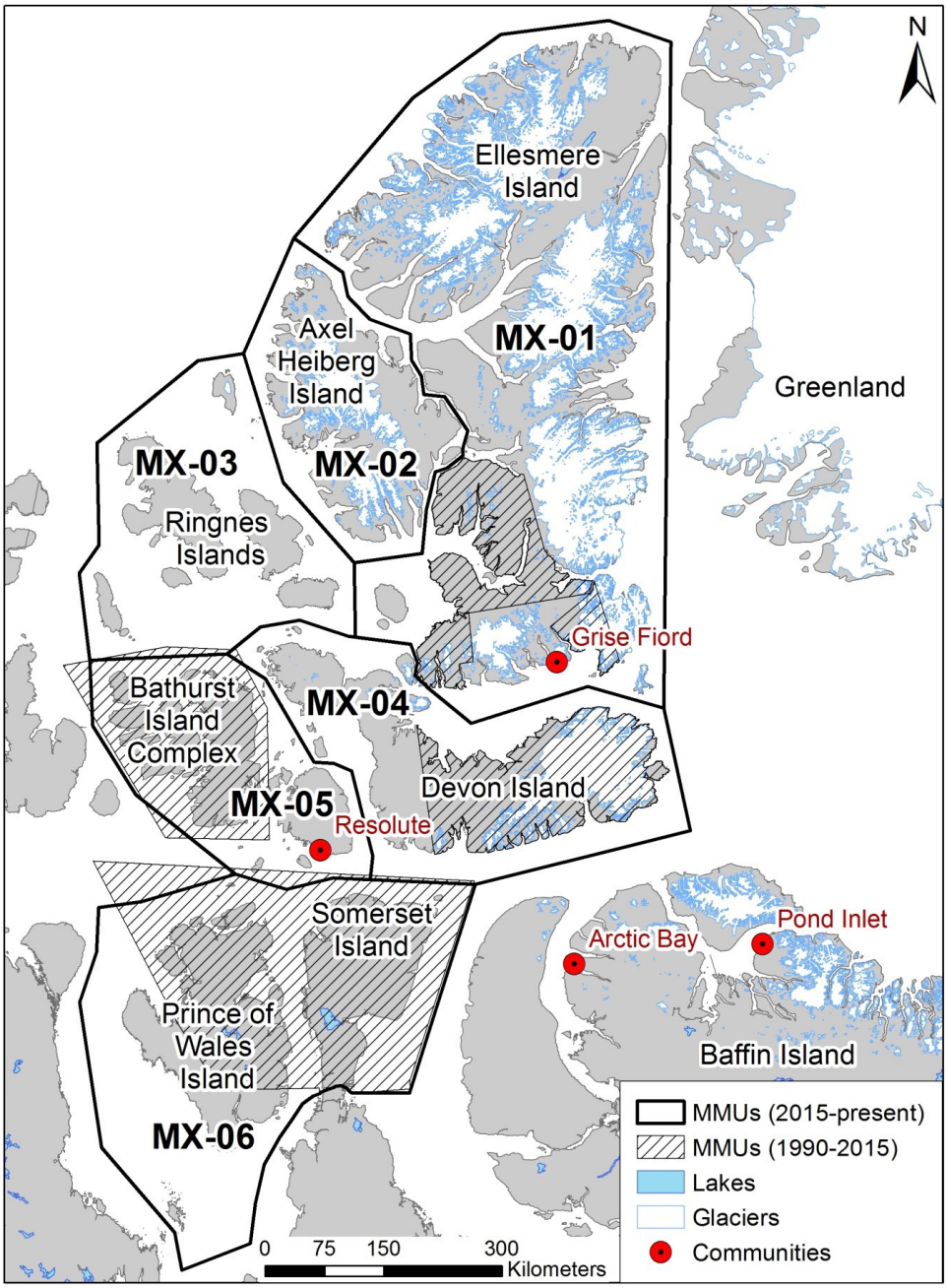

Figure 1. Current and historic muskox management units (MMUs) in the High Arctic region of Nunavut.

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

Units (MMUs) based on traditional harvest areas and knowledge of muskox populations (Figure 1, Gunn, 1984); muskoxen are only hunted in the established MMUs. Today's quotas, now called Total Allowable Harvest (TAH), and any Non-Quota Limitations (NQLs; e.g. seasonal restrictions, sex/age restrictions) are managed under the Nunavut Wildlife Act. The Nunavut Wildlife Management Board (NWMB), a co-management board established under the Nunavut Land Claims Agreement, establishes, modifies, and removes restrictions on Inuit harvest, with final approval by the territorial Minister of the Environment. TAHs and NQLs are established based on the best available knowledge, both traditional Inuit qaujimajatuqangit (IQ) and scientific information, with input from all co-management partners. The TAH is administered in the form of tags by the community Hunters and Trappers Organization/Association (HTO/HTA), which can assign tags to muskoxen harvested for domestic, commercial, or sport purposes. Commercial harvest in the high arctic has been generally small-scale, with hunters selling meat to the HTA and within the community, so it is considered here with domestic harvest.

Methods

Muskox mortality data sheets are completed by any hunter who harvests a muskox. Since 1990-91, there have been 579 tags issued for harvested muskoxen in the High Arctic (i.e., from the communities of Grise Fiord, Resolute, and Arctic Bay). Reporting the MMU and sex of the harvested animal are mandatory, but additional information is also collected including age class, body condition, pregnancy, and kill location. The boundaries of the MMUs have been modified since 1990-91, most recently in September 2015. We used the new 2015 management units (Figure 1). To facilitate future comparisons of harvest monitoring and to examine the proportion of the quotas available and used by each community, the previous MMUs and their associated quotas were combined to reflect these new MMUs. When the general kill location, MMU, or geographic coordinates provided were inconsistent (n = 36), these records were removed for our location-based analyses. There were also missing data where harvest sheets were either not completed or were lost when computers in remote offices failed. A harvest summary report (DOE 2011) recovered some of these records for 2009-10, however, data remains missing for Resolute for 2010-11 and 2011-12.

Results

Use of quota

Regardless of community or MMU, since 1990 muskox harvest has generally fallen below the quotas allocated. On average, from 1990-2015, Grise Fiord used 17.0% of the 74 muskox tags annually available for MX-01 and 56% of the 4 tags for MX-04. Resolute averaged 4.0% use of their 7 MX-04 tags, 5.3% use of their 40 MX-05 tags, and 22.2% use of their 20 MX-06 tags. Arctic Bay used an average 18.0% of their 4 MX-04 tags. Exceptions to the administration of tags are common. Although they originally had no tags, Arctic Bay hunters harvested four muskoxen from Somerset Island in both 2004-05 and 2006-07 by transferring tags from Resolute. Tags have also been issued for areas that were not included in previous MMUs. In 1995-96, Resolute received a special permit to hunt seven muskoxen on Cornwallis Island, which was outside an established MMU at the time. In 1998-99, Resolute received another permit to hunt three muskoxen on Griffith Island, also not included in an MMU. In both cases, tags from neighboring Bathurst Island were used. All three islands are now amalgamated into the same MMU, MX-05.

Domestic and sport harvesting has been ongoing since the 1990s by both Resolute and Grise Fiord, although harvest has declined in

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

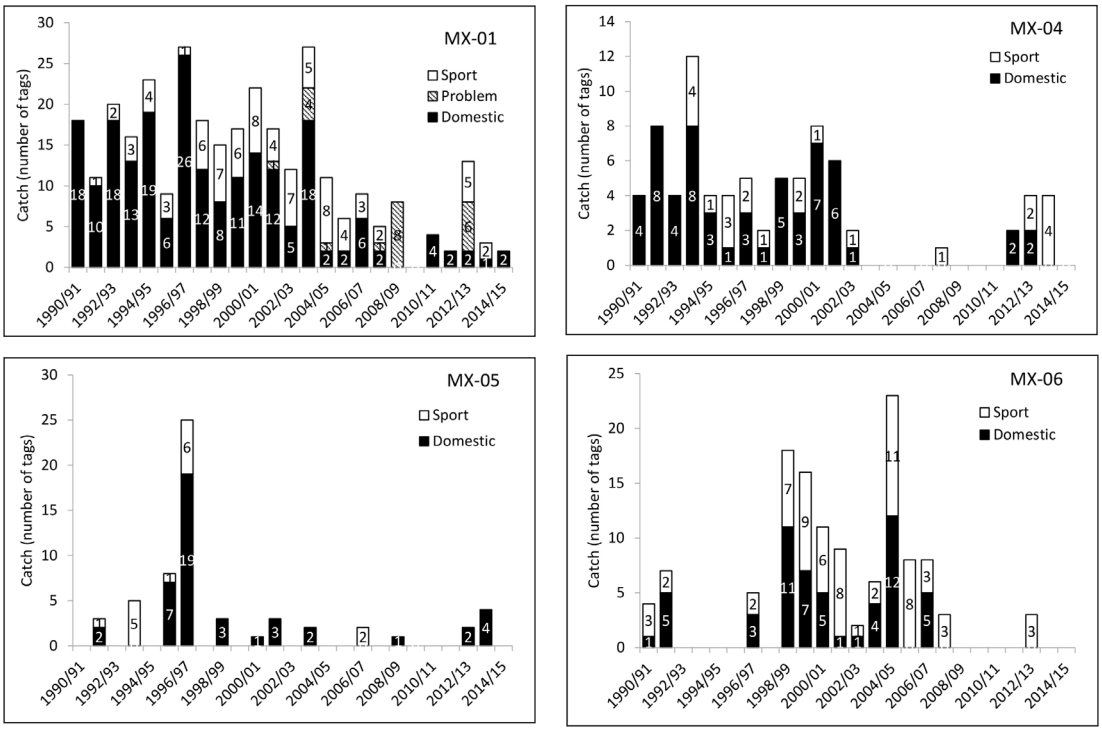

Figure 2. Use of muskox tags by harvest type and management unit. Black bars are domestic harvest, white bars are sport harvest, and hatched bars are problem muskoxen that had to be removed from communities. Data is incomplete for 2010-11 and 2011-12 from Resolute, which harvests mostly from MX-05 but also MX-04 and MX-06.

the last ten years (Figure 2). Concurrently, the harvest by Arctic Bay has been modest and sporadic. The Resolute and Grise Fiord domestic harvests also include hunting trips whose purpose is education and training in traditional skills and knowledge. This information has only been noted incidentally, so we do not differentiate these two types of domestic harvest. Small scale commercial use (meat sold to the HTA) which occurred in the 1990s, has been almost nonexistent over the past decade despite relatively high densities of muskoxen, but is also considered under domestic harvest since meat is generally used by the community for local sustenance. Sport hunts comprise a relatively small number of tags that has not changed dramatically, but an increasing proportion of the total harvest due to reduced domestic harvest. In April 2013, three Resolute sport tags for MX-06 were transferred from Resolute to Arctic Bay. Otherwise, recent sport hunts are typically conducted from Grise Fiord or Resolute.

Since 1991, the majority of muskoxen for all harvest types have been taken on Ellesmere Island (MX-01), followed by Bathurst Island (MX-05) and Somerset Island (MX-06) (Figure 2). Since 2010, most of the reported harvesting occurred out of Grise Fiord, even considering missing harvest reports from Resolute (Table 1, Table 2). Domestic harvest appears to have declined in all MMUs (Figure 2), particularly MX-05 and MX-06, where Resolute normally harvests.

The occurrence of problem muskoxen (animals that act aggressively toward people or dogs, or cannot be driven away from the community) is sporadic, although the tags used for problem animals may represent a large

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

proportion of tags in a given year and MMU, e.g. 46% in MX-01 in 2012-13. Perhaps these events have been more common in the last 10-15 years, or they may not have been reported as problem animals previously. Further, animals are sometimes harvested near communities before they can become a problem, and may not be recorded as problem wildlife (Iviq HTA, pers. comm.).

The primary period of harvest has been in the late winter and spring, generally February to May. Sport hunts are almost all (99.4%) conducted in March, April, and May, when daylight and temperatures are more hospitable. Most (72.0%) domestic and commercial harvest also occurs February to May, although there is a second small peak in October accounting for 8.1% of harvest. Domestic harvest was year-round with the exception of June and July when no harvest was reported.

Sex, age, and condition of harvested muskoxen

There were 579 tags used by the communities of Resolute, Grise Fiord and Arctic Bay for domestic or sport muskox harvest from 1990-2015. For 465 tags (80.3%) an age class (adult, sub-adult, yearling, calf) was specified. Sub-adults were generally considered as bulls less than 4 years old and females less than 3 years old (Smith, 1976; Lent, 1999), but exact ages of harvested muskoxen were not known. The majority of harvested animals were adults (78.5%), followed by sub-adults (17.4%), yearlings (3.7%) and calves (0.4%, n = 2 taken in August and October). Of the yearlings, two were problem animals and another was starving. For the 139 tags distributed for sport hunting, where age class was reported the majority were adult muskoxen. Only three sub-adults (2.2%) were recorded by the sport harvest.

Of the 554 muskox harvest reports where the sex was recorded, 425 (76.7%) were male. Sport harvests were highly male-biased, but six cows (3.2% of the sport harvest) were also taken. One of the latter was a sub-adult in poor condition.

Where the body condition of harvested muskoxen was reported (n = 476 tags), this was generally good (66.4%) with classification terms being fat, healthy, excellent and very fat – body condition is judged subjectively by the hunter. Another 21.4% were termed fair or average, and 12.2% were considered skinny or in poor condition.

Linking harvest and abundance

Aerial surveys for abundance have been infrequent and sporadic, providing basically only snapshots in time. Still, for island groups where muskoxen have been harvested, recent surveys of those same islands permit comparisons of harvest records with population estimates. Devon Island (MX-04) in spring 2008 was estimated to have 302-864 muskoxen (95% CI, Jenkins *et al.,* 2011). This suggests that the 2007-08 harvest (n = 1, taken by Grise Fiord) accounted for 0.1-0.3% of the total island population. Similarly, for MX-06 in April 2004, there were 1582-2747 muskoxen (95% CI) on Russell, Pandora and Prince of Wales islands, and a further 962-3792 (95% CI) on Somerset Island (Jenkins *et al.,* 2011). The 2003-04 muskox harvest from MX-06 by the Resolute community represented about 0.1-0.2% of the estimated population. When surveyed in May 2005, southern Ellesmere and Graham islands evidenced few muskoxen (312-670, 95% CI) and severe winter conditions in the preceding years were thought responsible (Jenkins *et al.,* 2011). At that time, Grise Fiord hunters harvested 9 muskoxen, which represented 1.3-2.9% of the estimated population. The same area surveyed in 2015 estimated muskox abundance at 3200 ± 602 SE (Anderson & Kingsley, 2015), which would make the Grise Fiord harvest (n = 4 for 2014-15) only 0.2% of the estimated population.

Unlike the other MMUs, the Bathurst Is-

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

land Complex (MX-05) was regularly surveyed in the 1990s to track the population trends of Peary caribou. The winters of 1993-94, 1994-95, and 1996-97 were characterized by ground-fast ice that caused widespread movement and mortality for both Peary caribou and muskoxen on the Bathurst Island Complex (Miller & Gunn, 2003). Several unsystematic surveys during this period produced population estimates, or at least minimum counts, for muskoxen. When muskox harvest is compared to abundance on the Bathurst Island Complex, they do not change proportionally to each other (linear regression slope = -13.0076, R^2 = 0.0313; Figure 3). Hunter choices may explain this discrepancy. Peary caribou numbers have increased since their die-offs of the mid-1990s. Given the alternative of taking a muskox or a Peary caribou, hunters typically choose the caribou (Resolute Bay HTA and Iviq HTA, pers. comm.).

Voluntary harvest estimates and mandatory reporting

A large-scale harvest study, which relied on hunter interviews and voluntary reporting, took place in the High Arctic during the same time that mandatory reporting for muskox harvest was in effect. The 5-year, 1996-2001, Nunavut Wildlife Harvest Study (NWHS, Priest and Usher 2004) conducted by the Nunavut Wildlife Management Board, collected hunter information to assess monthly catch on all harvested species in Nunavut. Sometimes, both data sources (harvest reported in the NWHS and harvest confirmed by tags used) were nearly identical. For example, in 1996, Resolute reported to the NWHS twelve muskoxen harvested in October, two in November, and three in December. Tag records for harvested muskoxen indicate one additional muskox harvested in December, but otherwise reflect the information provided to the NWHS. Typically

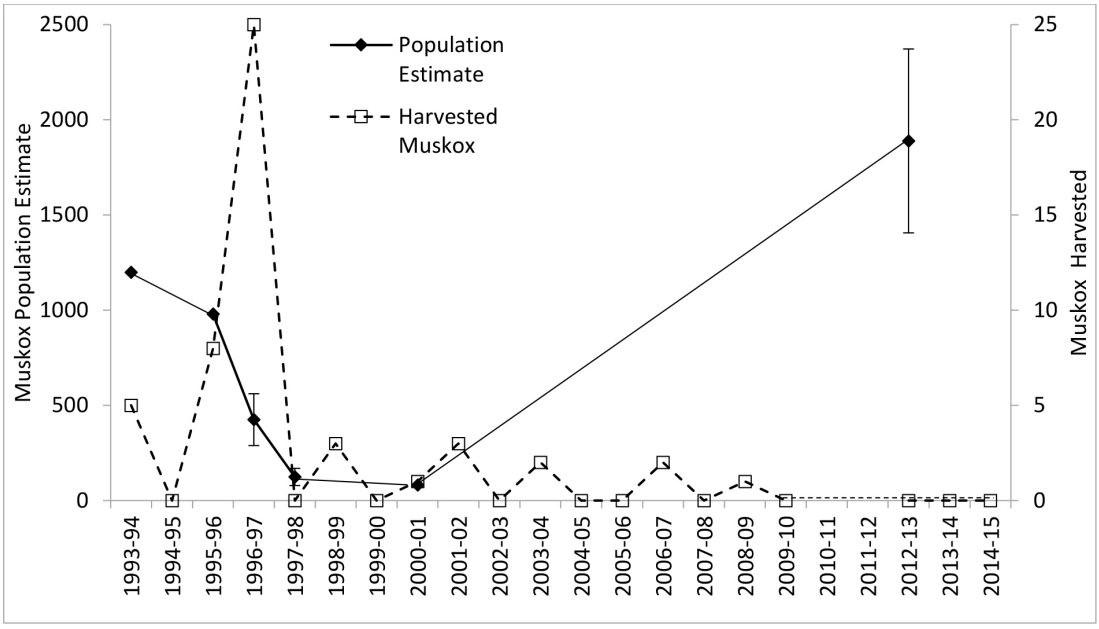

Figure 3. Muskox harvest rates for MX-05 (Bathurst Island Complex), compared to the total population estimate of muskoxen (error bars represent standard error, where available). Population estimates were available for 1993 (Miller, 1995), 1995 and 1996 (Miller, 1998), 1997 (Gunn & Dragon, 2002), 2001 (Jenkins *et al.,* 2011), and 2013 (Anderson, 2014). Harvest data was missing for the 2010-11 and 2011-12 harvest years.

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

however, the NWHS reported fewer muskoxen harvested than tags issued. For example, in spring 1997, the NWHS harvest estimate was two muskoxen, but tag records indicate that 13 muskoxen were harvested over the same period. Regardless of the year, both Grise Fiord's and Resolute's reported harvest was below the tag harvest (Table 1, Table 2). The exception was 1997-98 in Resolute, where one muskox was reported in the NWHS when no tags had been issued. The discrepancy between voluntarily reported harvest and tag harvest may have been due in part to sport harvests not being included in the NWHS. Therefore, we also compared the NWHS estimates to just tags issued for domestic harvest. We found that the voluntary harvest reported for the year was a better predictor of the annual domestic harvest (linear regression slope = 0.9888, R^2 = 0.6293) than the total annual harvest (linear regression slope = 0.9408, R^2 = 0.4636), but still underestimated the actual tag harvest.

Discussion

Mandatory harvest reporting for muskoxen in the High Arctic has allowed co-management partners to track harvest patterns over time, although not muskox abundance or population trend. The changes in MMUs complicate long-term analysis of harvest data, since altering MMU boundaries changes where people can harvest. New regulations and MMUs introduced for the 2015-16 harvest year may encourage harvest in areas that were previously not available for hunting. Harvest of muskoxen in all management zones has been low, and has declined since the 1990s, despite recent surveys and local observations of increasing muskox populations, which indicate that higher harvest levels could be sustained. Disproportionate changes in population size and demographic parameters with increased or selective harvest rates have been noted elsewhere (Coltman *et al.,* 2003; Milner *et al.,* 2007; Schmidt & Gorn 2013), so increased harvest should be carefully monitored.

Over the last 5 years, sport hunts have accounted for an increasing proportion of the muskox harvest compared to domestic harvest activities. This is a marked shift from the late 1990s, when harvests were predominantly for domestic use. Muskox sport hunts are often combined with polar bear sport hunts, since hunters making a trip as far as to Resolute or Grise Fiord usually want to take full advantage of the available harvest opportunities. Sport hunts take place primarily from March to May. Domestic hunts occur year-round, but usually between February and May. In June and July, harvest areas can be more difficult to access, but traditionally this time period is also set aside to allow muskox and caribou to raise their young and gain weight during the brief summer (Resolute Bay HTA and Iviq HTA, pers. comm).

The NWHS was a massive project, involving a territorial coordinator, regional liaison officers, community fieldworkers, and monthly harvest reporting by over 6,000 Inuit hunters across Nunavut, including 75 hunters in Resolute and 73 hunters in Grise Fiord (Priest & Usher, 2004). Priest and Usher (2004) estimated that 19% of hunters were missed in Grise Fiord and none in Resolute (Priest & Usher, 2004), but they also note that only one hunter in Grise Fiord and two in Resolute consistently refused to participate in the study. Regardless of the scope of the NWHS project, the harvest records associated with tags and mandatory reporting were a more reliable source of harvest information than voluntary harvest estimates, even when estimates were collected regularly from experienced hunters. The NWHS provides a comprehensive review of errors that commonly occur with harvest data, including non-response bias, recall time, survey coverage (missed hunters), strategic response bias, and measurement issues (Priest & Usher, 2004). Voluntary and anecdotal information on har-

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

Table 1. Comparison of muskox harvest estimates from the NWHS (Priest & Usher, 2004) and the tag records in the muskox harvest database for Grise Fiord.

	1996-97		1997-98		1998-99		1999-00		2000-01	
Month	**NWHS**	**Tags**	**NWHS**	**Tags**	**NWHS**	**Tags**	**NWHS**	**Tags**	**NWHS**	**Tags**
June										
July										
August		1			1	1			1	2
September										
October	2	4	1	2				1		
November							1			1
December						1				
January										
February	9	12		1			1	3		4
March	8	10		2	3	10		1		3
April		1	1	8	1	6	3	12		12
May		3	2	6		2	1	3		4
Total	**19**	**31**	**4**	**19**	**5**	**20**	**6**	**20**	**1**	**26**
Tags used for domestic harvest		29		12		13		14		17
Percent of total tags reported in NWHS		61.3		21.1		25.0		30.0		3.8
Percent domestic tags reported in NWHS		65.5		33.3		38.5		42.9		5.9

vest is often limited to relative terms like 'some,' 'few,' or 'many,' which vary depending on the experience of the observer, the local conditions, season, population cycle, and area and period of observation. This further complicates interpretation of what little information is available. The occurrence of NWHS harvest reports for months when no tags were used may have resulted when harvested muskoxen were not assigned a tag, or could represent harvest assigned to a different time period – for hunts spanning two different months, the harvest may have been assigned to one month in the NWHS report and the other on the mandatory muskox harvest report.

Given our results, the use of harvest information to track changes in muskox population size should be approached with caution. In the case of MX-05, currently the only high arctic MMU with enough data on harvest and muskox abundance to examine these trends, muskox harvest did not track muskox abun-

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

Table 2. Comparison of muskox harvest estimates from the NWHS (Priest & Usher, 2004) and the tag records in the muskox harvest database for Resolute.

	1996-97		1997-98		1998-99		1999-00		2000-01	
Month	**NWHS**	**Tags**	**NWHS**	**Tags**	**NWHS**	**Tags**	**NWHS**	**Tags**	**NWHS**	**Tags**
June										
July										
August										
September										
October	12	12								
November	2	2								
December	3	4								
January										
February										
March		3				5	1	5	1	
April	2	4	1		3	5		10		
May		6			5	8	2	3	5	1
Unknown						3				11
Total	**19**	**31**	**1**	**0**	**8**	**21**	**3**	**18**	**6**	**12**
Tags used for domestic harvest		22		0		14		7		6
Percent of total tags reported in NWHS		61.3		na		38.1		16.7		50.0
Percent domestic tags reported in NWHS		86.4		na		57.1		42.9		100

dance. Instead, this example highlights the importance of examining other factors influencing harvest, e.g., hunter bias in species selected for harvest. Since harvest on Bathurst Island has generally been low, an increase from one to three muskoxen taken may not indicate a true increasing harvest trend. Also, hunters travel to Bathurst Island primarily to take Peary caribou. Although both caribou and muskoxen are abundant on the island, hunters preferentially harvest the caribou. Since there is no mandatory harvest reporting for Peary caribou, we were unable to examine whether caribou harvest tracks population changes on the island.

The High Arctic is a relatively simple harvest region, where few (1-3) communities harvest from a given management unit and where mandatory reporting was (until 2015-16) required for all muskoxen in all MMUs. Communities are small, HTAs are engaged and active, and

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

capable Wildlife Officers have been present in communities over much of the time period reported here. The situation is more complicated in other regions in Nunavut. On Baffin Island, overlapping harvest areas and harvest pressure from ten communities, including the capital, makes coordinating and monitoring harvest difficult. In the mainland Kivalliq region, online sales and discounted shipment of caribou have exerted pressure on mainland caribou herds beyond the sustenance requirements of Kivalliq communities, and no mandatory reporting is in place. The challenges presented here concerning the collection, interpretation, and implementation of harvest data in management and policy will only be magnified for regions where these other complicating factors are at play.

References

Allendorf, F. W., England, P. R., Luikart, G., Ritchie, P. A. & Ryman, N. 2008. Genetic effects of harvest on wild animal populations. – *Trends in Ecology and Evolution* 23: 327-337. https://doi.org/10.1016/j.tree.2008.02.008

Anderson, M. 2014. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on the Bathurst Island Group, May 2013. – Status Report, Nunavut Department of Environment, Wildlife Research Section, Igloolik, Nunavut. 39pp.

Anderson, M. & Kingsley, M. C. S. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on southern Ellesmere Island, March 2015. – Status Report 2015-01, Nunavut Department of Environment, Wildlife Research Section, Igloolik, Nunavut. 49pp.

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

Bender, L. C. & Spencer, R. D. 1999. Estimating elk population size by reconstruction from harvest data and herd ratios. – *Wildlife Society Bulletin* 27: 636-645.

Coltman, D. W., O'Donoghue, P., Jorgenson, J. T., Hogg, J. T., Strobeck, C. & Fest-Bianchet, M. 2003. Undesirable evolutionary consequences of trophy hunting. – *Nature* 426: 655-658. https://doi.org/10.1038/nature02177

Department of Environment (DOE). 2011. Muskoxen and Peary caribou harvest database summary report. – Summary Report, Nunavut Department of Environment, Pond Inlet, Nunavut. 24pp.

Fryxell, J., Falls, J. B., Falls, E. A., Brooks, R. J., Dix, L. & Strickland, M. 2001.Harvest dynamics of mustelid carnivores in Ontario, Canada. – *Wildlife Biology* 7:151-159.

Gunn, A. 1984. Aspects of the management of muskoxen in the Northwest Territories. – Biological Paper, University of Alaska Special Report 4: 33-40.

Gunn, A. & Dragon, J. 2002. Peary caribou and muskox abundance and distribution on the Western Queen Elizabeth Islands, Northwest Territories and Nunavut (June-July 1997). – File Report No. 130, Northwest Territories Department of Resources, Wildlife and Economic Development, Yellowknife, NT. 79pp.

Jenkins, D., Campbell, M., Hope, G., Goorts, J. & McLoughlin, P. 2011. Recent trends in abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. – Wildlife Report No. 1, Nunavut Department of Environment, Pond Inlet, Nunavut. 184pp.

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

Lancia, R. A., Bishir, J. W., Conner, M. C. & Rosenberry, C. S. 1996. Use of catch-effort to estimate population size. – *Wildlife Society Bulletin* 24: 731-737.

Lent, P. C. 1999. Muskoxen and their hunters: a history. University of Oklahoma Press, Norman, Oklahoma, USA. 324pp.

Miller, F. L. 1995. Peary caribou conservation studies, Bathurst Island complex, Northwest Territories, July-August 1993. – Technical Report Series No. 230, Canadian Wildlife Service, Prairie & Northern Region, Edmonton, Alberta. 76pp.

Miller, F. L. 1998. Status of Peary caribou and muskox populations within the Bathurst Island Complex, south-central Queen Elizabeth Islands, Northwest Territories, July 1996. – Technical Report Series No. 317, Canadian Wildlife Service, Prairie & Northern Region, Edmonton, Alberta. 147pp.

Miller, F. L. & Gunn, A. 2003. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands Canadian High Arctic. – *Arctic* 56: 381–390. https://doi.org/10.14430/arctic635

Milner, J. M., Nilsen, E. B. & Andreassen, H. P. 2007. Demographic side effects of selective hunting in ungulates and carnivores. – *Conservation Biology* 21: 36-47. https://doi.org/10.1111/j.1523-1739.2006.00591.x

Mysterud, A. 2011. Selective harvesting of large mammals: how often does it result in directional selection? – *Journal of Applied Ecology* 48: 827-834. https://doi.org/10.1111/j.1365-2664.2011.02006.x

Priest, H. & Usher, P. J. 2004. The Nunavut Wildlife Harvest Study. Report to the Nunavut Wildlife Management Board, Iqaluit, Nunavut. 822pp.

Schmidt, J. H. & Gorn, T. S. 2013. Possible secondary population-level effects of selective harvest of adult male muskoxen. – *PLOS One* 8: e67493. https://doi.org/10.1371/journal.pone.0067493

Smith, T. E. 1976. Reproductive behavior and related social organization of the muskox on Nunivak Island. – M.S. Thesis. University of Alaska Fairbanks, Fairbanks, Alaska, USA.

Solberg, E. J., Loison, A., Sæther, B.-E. & Strand, O. 2000. Age-specific harvest mortality in a Norwegian moose *Alces alces* population. – *Wildlife Biology* 6: 41-52.

Manuscript recieved 23 December 2016
revision accepted 15 June 2017
manuscript published 27 July 2017

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com

This journal is published under the terms of the Creative Commons Attribution 3.0 Unported License
Editor in Chief: Birgitta Åhman, Technical Editor: Eva Wiklund and Graphic Design: H-G Olofsson, www.rangiferjournal.com