Wildlife Management (Muskoxen) in the Baffin and Nunavut Wildlife Act Draft Regulations and Orders

DRAFT

Document produced for the November 2006
NWMB meeting
on the
Nunavut Wildlife Act
Draft Regulations and Orders

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11 November 2006

Introduction

In January 2006, the Department of Environment (DoE) submitted a report to the Nunavut Wildlife Management Board (NWMB) outlining recommendations on the total allowable harvest[1] (TAHs) and non-quota limits (NQLs)for Nunavut's terrestrial species (DoE 2005). Subsequently, both NWMB and Nunavut Tunngavik Incorporated (NTI) have asked DoE for more information about the recommendations (www.nwmb.com/english/events/ae/meeting12). Those comments have provided DoE an opportunity to re-examine the recommendations on TAHs and NQLs for muskoxen and to incorporate updated information including aerial survey results, satellite location data, and Inuit Qaujimajatuqangit (IQ).

In the Baffin Region, muskoxen are only found on the High Arctic islands and not on Baffin Island or Melville Peninsula. Inuit from Resolute, Grise Fiord and Arctic Bay hunt muskoxen although caribou tends to be preferred (Taylor 2005). The Inuit have a long relationship with muskoxen. The Government recognizes that Inuit have been conserving muskoxen on the High Arctic islands for generations.

The first people to reach the Canadian Arctic, after the glaciers receded, traveled a pathway across the Arctic called the Muskox Way as they depended on hunting muskoxen. The earliest people (Independence I) reached Ellesmere and Devon islands some 4000 years ago (summarized in Lent 1999). Helmer (1991) excavated camp sites from 4500-3000 years before present on northeast Devon Island and suggested that the people had a pattern of using and abandoning areas as the muskox numbers increased

[1] "Total allowable harvest for a stock or population is defined as the number of individuals from a population of wildlife that may be lawfully harvested as established by the NWMB pursuant to Sections 5.6.16 to 5.6.18 of the NLCA."

and declined. Helmer (1991) refers to the ancient Inuit as monitoring where they hunted muskoxen before deciding to leave or return to those areas.

As the eastern Arctic climate cooled and warmed over the next two millennia, Inuit ancestors came, left and were replaced by other groups as Dorset gave way to Thule and then to the modern Inuit. In the early 1950s, the federal government relocated Inuit to establish the communities of Resolute and Grise Fiord. Similarly, the present town of Arctic Bay was developed as a result of government housing initiatives in the 1960's.

This document freely draws on Taylor's (2005) compilation of IQ. Taylor (2005) interviewed hunters from both communities to compile knowledge and experience with muskoxen and Peary caribou. She cautioned that her documentation and examination of Inuit knowledge in these areas was preliminary.

International, national and territorial conservation status: In 2003, the international conservation status of muskoxen was rated as G4 which is "Apparently Secure–Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread" (Association for Biodiversity Information 2001, www.abi.org, Natural Heritage Central Databases Association). At the Arctic Council's request, Circumpolar Arctic Flora and Fauna recently assessed circumpolar wildlife status and trends and identified muskoxen as a conservation success story (CAFF 2001). In the early 21st century, several thousand muskoxen occupied Greenland and Alaska.

In Canada, muskoxen were listed in 1960 as Endangered (Order-in-Council). More recently, COSEWIC has not rated muskoxen which would indicate no immediate concerns. In the NWT, muskoxen were listed in 2000 as "Secure".

In NWT and NU, the status of muskoxen on the mainland is still influenced by the massive unregulated commercial exploitation of muskoxen for their hides in the late 1800s. Indeed, exploitation had reduced muskoxen to a few isolated areas by the early 1900s. Subsequently, muskoxen have slowly re-colonized the mainland territories (Barr 1991, Fournier and Gunn 1998, Dumond In prep.).

For the most, muskoxen on the Arctic Islands were not subject to the commercial exploitation in the late 1800s. However, there is a suggestion that 133 hides were traded at Elipse Sound in 1916-18 (presumably from Somerset or Devon Island; Barr 1991) and that some expeditions locally over-hunted muskoxen (i.e. northern Ellesmere and Devon; Barr 1991, Dick 2001).

Information from archaeological sites, Inuit Qaujimajatuqangit and historical accounts reveal that characteristically, muskox abundance fluctuates over time sometimes with sharp declines and slow recoveries (Barr 1991, Lent 1999, Taylor 2005).

Muskox ecology and population dynamics: Muskoxen have the characteristics typical of other large-bodied herbivores (high adult survival, low fecundity, late onset of breeding, a single birth every 1-3 years, and females have a lifespan often exceeding 15 years; Gaillard et al. 1998, Gunn and Adamczewski 2003). The maximum rate of increase (r_m=1.30) is a doubling rate of about 3 years. However, the maximum rate of increase is rarely

reached. For the Baffin Region, there are only a few series of estimates to calculate rates of increase[2].

Annual pregnancy rates usually range between 30 and 70% although directly measured pregnancy rates are rare (Gunn and Adamczewski 2003). More frequently, the proportion of calves seen during aerial surveys is used as an index to productivity although it compounds pregnancy rates and early calf survival. In populations increasing at or close to the maximum rate of increase, the proportion of calves can be as high as 23-29% of all muskoxen counted. On the eastern Arctic Islands, the proportion of calves to total muskoxen vary between <5% and 25%.

Mortality can be estimated for muskoxen up to 2 years of age as these age classes are recognizable in the field. The frequency of monitoring on the Arctic Islands is high on Banks Island, where calf survival varied annually (mean 55.5 ± 5.9% SE) and was lower after severe winters (Nagy et al. 2001). Toward the edge of their range, as in the High Arctic, annual variability in weather increasingly affects calf productivity and survival (Tener 1965, Hubert 1977, Miller et al. 1977).

Generally, calf and yearling survival contributes more variation in rates of population change and adult survival buffers the variation (Gaillard et al. 1998).We have relatively few measures of adult survival in muskoxen. An exception is adult survival estimated from radio-collared females. Survival was high (89%) in northern Alaska where muskoxen were re-colonizing historic ranges (Reynolds 1998).

[2] The exponential rate of increase is calculated and is converted to doubling time after Caughley (1977).

Causes of death include wolf and grizzly bear predation, hunting, accidents, disease and, sporadically, on the Arctic Islands, malnutrition during severe winters. Rates and effects of predation on muskoxen are unmeasured. Wolf predation on muskoxen is common (references in Gunn and Adamczewski 2005): for example, on northern Ellesmere Island, and northern and eastern Greenland, muskox occurrence in wolf scats ranged from 65-98% with lemmings and arctic hares as the next most frequent item (Marquard-Petersen 1998). Inuit hunters have commented that wolves may have more of an impact on muskoxen than they do on caribou (Taylor 2005: 103).

During severe winters (severe refers to a combination of snow depth, density and hardness sometimes with icing after rain), muskoxen are forced to expend more and more energy to obtain forage. As the muskoxen deplete their body reserves, their rumen microbes decline, and although the muskoxen continue to forage, they are less able to digest the forage. Additionally, the snow conditions force muskoxen to feed on less digestible forage such as willow twigs rather than more digestible grasses and sedges (Parker et al.1975). Severe and prolonged malnutrition eventually causes death. Smaller-bodied calves with proportionally lower body fat reserves and adult males with depleted reserves after the rut are usually the first to die (references in Gunn and Adamczewski 2005) but winters can be severe enough that muskoxen of both sexes and all ages die. Indeed losses can be significant. For example, on Bathurst Island during the winters of 1994-97, about 90% of the muskoxen disappeared. Notably, the rates of decline during severe winters are not necessarily matched by rates of carcass counts. Muskoxen may make desperation moves to find better foraging conditions. For example, during the muskox die-off in the mid-1990s, muskox carcasses were found on the sea-ice near Bathurst Island,.

Forage quality during August to October strongly affects whether muskoxen conceive and remain pregnant (references in Gunn and Adamczewski 2005). Less is known about how weather affects forage quality during the summer and fall. However, colder than usual temperatures and greater snow fall in August (and September) 1997 was followed by exceptionally low calf production on northern Ellesmere Island (Mech 2000).

Inuit hunters record that fluctuations in muskox (and caribou) abundance and changes in distribution were influenced by regular population cycles, weather and human disturbances (Taylor 2005:91). The weather includes rain in fall or winter which created ice lenses on the ground. Human disturbances refer to seismic surveys affecting distribution.

Approaches to setting Total Allowable Harvest: In theory, sustainable harvesting is deceptively simple as it is the removal of individuals at the rate at which they would otherwise increase (Caughley 1977). Enough individuals are removed to keep the population increasing (this assumes density-dependence meaning that removal of individuals increases forage for the survivors). An increasing population is resilient and may be able to recover from or 'buffer' the negative effects of environmental variation.

Theoretical approaches to harvesting are well-established although to implement them typically requires measured vital rates such as age and sex specific rates of fecundity and survival (for example, Milner and Gulland 1998 and Reynolds et al. 2001). The two references are books that present both theory of harvesting and then what happens in practice, drawing from a number of examples from around the world.

The approach used in NWT and NT for muskoxen aims to annually remove a fixed proportion of the most recent population estimate. The approach was derived from relatively simple deterministic modeling from the 1980s. The modeling was based on what was known then about muskox numbers, productivity and a guess at natural mortality. The fixed proportion was capped at 3-5% recognizing that muskoxen were are at an early stage of re-colonizing their former ranges. Where limited information exists, these methods are still applied in this document. However, to be closer to the underlying principle of sustainable harvesting, the fixed proportion is based when possible on the trend between the two most recent population estimates and related to the objectives for management.

Persistence of populations depends more on their rate of change than their absolute size (examples in Caughley and Gunn 1996). However, very small populations are vulnerable to bad luck (natural disasters, demographic, environmental and genetic stochastisity). Such populations are at an even greater risk of extinction when harvested.

There are many examples when harvesting has driven a population or species to or close to extinction and economic factors are uppermost. However, uncertainty and environmental variation can also contribute to the loss of species or populations. Uncertainty includes biases, errors in data collection and data gaps. Recently, techniques have been developed for dealing with uncertainty (risk analyses , information theory, probability theory and fuzzy logic: Reynolds et al. 2001). However, those techniques have not yet been applied to muskox harvesting. Currently, the only approach to incorporating uncertainty is conventional parametric statistics (for example, using the lower confidence interval for estimates).

Muskoxen live where the season of plant growth (high diet quality), is short and annually variable. Nutrition, especially during late summer and fall, is the key to whether cows reproduce (references in Gunn and Adamczewski 2005). The winters are long with snow conditions dictating the availability of relatively low-quality forage which can affect survival and condition. Long-term data (Maxwell 1981?) indicates that the least and greatest snow cover depth can vary by 75% on either side of the average and the earliest and latest dates of snow cover bracket the average by 2-4 weeks. Thus environmental variability is an important factor in the population dynamics of muskoxen. The evidence for this includes low to no calf production and die-offs that correlate with a measurable change in weather .

Rationale for Proposed Muskox Units: Muskox hunting under a quota system started from the late 1960s when quotas were applied to relatively arbitrary areas meant to encompass local hunting interests where muskoxen had either been seen or counted during aerial surveys. Through community consultations, application of IQ, aerial survey results, movements of radio-collared muskoxen and known geographical barriers, changes to the original muskox units are now being recommended (DoE 2005).

In theory, the boundaries of muskox units should coincide with muskox population boundaries. Typically, 'population' can be defined as groups of individuals that are demographically, genetically, or spatially disjunct from other groups of individuals (Wells and Richmond 1995). This definition has elements in common with DoE's (2005) definition (population is defined as a demographic unit for which birth and death rates are believed to contribute more to population trajectory than rates of immigration and emigration).

Demographic changes are usually based on aerial surveys and the survey areas were typically either islands or multiple muskox units for larger islands. Surveys have some limitations when identifying demographic populations. As well, the question of genetic distinction of populations is incomplete. Within the arctic islands, muskoxen from Greenland genetically group more closely with muskoxen from Ellesmere than with those from the southern arctic islands (van Coeverden de Groot 2000). However, more genetic analyses will be required to define whether there is finer scale genetic variation (population level) as not all areas of muskox distribution have been sampled and muskoxen have extremely low genetic variation.

In the absence of demographic and genetic information, 'population' can be defined as a group of individuals spatially disjunct from other groups (Wells and Richmond 1995). In the designation of conservation units Green (2005) has also advanced this approach. Green (2005) recommends using, in order of preference, established taxonomy, direct or inferred genetic evidence, range disjunction, and biogeographic distinction.

Range disjunction at the scale of all except the largest islands reflects what we know about muskox movements and probability of dispersal. Limited information from marked muskoxen does not reveal inter-island movements. Except during environmentally forced dispersal (i.e. severe winters), there are few observations of muskoxen crossing sea ice (Taylor 2005) which suggests muskox ranges are disjunct between islands. Range disjunction between islands supports the designation of muskox units MX/01 (Bathurst Island) and MX/02 (Cornwallis Island), MX-08 (Somerset) and MX/09 (Prince of Wales Island).

In cases where one or more muskox units are adjacent to each other (i.e. MX/05, MX/06, MX/07), there is some uncertain whether distinct populations are represented. However, in the High Arctic, range disjunction imposed by terrain, glaciers and mountains is likely; it is unusual for muskoxen to cross these features. Indeed, there are only rare observations of bull muskoxen crossing glaciers (Taylor 2005). Instead, muskoxen demonstrate fidelity to relatively small discrete patches of suitable habitat; lowlands and slopes with sedges, grasses and willows typically characterize their range on arctic islands (Gunn and Adamczewski 2003).

A dominating influence on biogeography is climate and arctic climate is strongly regionalized (Maxwell 1981). Western Devon (M/07-WD) is in a separate region (I, Northwestern Region) from north and south Devon (MX/05-ND and MX/06-SD). As well, the two management areas on Ellesmere (MX/04-SE and MX/03-CE) largely correspond to the two climate regions IV and V. In the absence of information to the contrary, it is prudent to accept the range disjunction and biogeographic areas as affecting muskox population structuring.

Support for the use of climate regions comes from Inuit hunters. Their knowledge indicates that muskox numbers fluctuate less on Ellesmere and Devon islands than on Prince of Wales, Somerset and Bathurst Islands (Taylor 2005). Ellesmere and Devon Islands are largely in climate regions that are colder and drier and less subject to incursions of maritime air masses (Maxwell 1981) which can be associated with rain in winter and heavier snowfall.

Rationale for Proposed Non-quota Limitations:

Sex specific harvesting : DoE is not recommending Sex specific harvesting at this time. Although sex selective harvesting was previously part of muskox

harvest restrictions, DoE believes that it is unwarranted given more recent information and the status of Nunavut muskox.

The rationale for harvesting males rather than females was initially considered to be a conservative step (leaving more cows to have calves). However, unintended effects from male selective harvesting in other species has been documented, especially in smaller populations or where the harvesting rate is high (references in Gordon et al. 2005).

Saiga antelope are one example of unintended effects of promoting the sex selective harvesting of males. Saiga males have horns that are valued in traditional medicine. By initially encouraging harvesting of male saiga antelope, a strong market was developed which drove the harvest until breeding systems collapsed and the populations crashed (down from 1,250,000 in the mid-1970s to approximately 50,000: Milner-Gulland et al 2003).

For muskoxen, unintended effects may be to expose herds to greater risk of predation. Inuit from Grise Fiord in 1967 suggested that if sports hunters killed larger bulls, the herds would be at more risk from wolves in winter (Lent 1999??).

As well, the selective harvesting of males could potentially influence dispersal. One breeding strategy is that bulls disperse to find breeding opportunities which likely plays a role in re-colonization (Forchhammer and Boomsma. 1998). Such dispersive breeding may be important not only at re-colonizing edges of muskox distribution on the arctic mainland but also on islands after die-offs. After a weather-induced decline or die-off, the sex ratio

of the surviving muskoxen will likely be skewed toward females as males die at a higher rate (Gunn et al. 1989).

Sex-selective harvesting also has to consider the preferences of the hunters.

Seasons: In the 1980s, the impetus for seasons was to balance the need to promote guided non-resident harvesting with the protection of muskoxen groups during calving and summer. Muskox herds with newborn calves often stampede and the calves are left behind . Abandoned calves can lead to controversy over their fate. Muskoxen usually calve from mid-April to early June (Tener 1965), although calving dates vary geographically. Additionally, there is justification to minimize disturbance during late summer and fall as nutrition is the key to whether cows reproduce (references in Gunn and Adamczewski 2005).

Total Allowable Harvest by muskox unit

The goals for muskox management in the Baffin are:

- Maintain a natural ecological balance within the High Arctic in which both muskoxen, their habitats and Inuit are part of that balance;
- Maintain muskox populations capable of sustaining the harvesting needs of beneficiaries.

The specific objectives to meet the goal for each muskox unit are included in the text on the individual units. The goals will be interpreted and applied giving full regard to the broader principles and objectives of the NLCA.

MX/01 –BI Bathurst Island Complex

Designation of muskox unit: The designation of Bathurst and its satellite islands is based on IQ (Taylor 2005), survey results and movements of radio-collared muskoxen. Muskox seasonal movements remain within Bathurst Island (for example; preliminary location data for 4 muskoxen fitted with satellite-collars in 2003 indicates that movements are limited to Bathurst Island). Only during severe winters have Inuit hunters and biologists reported occasional desperation movements on to the sea ice (Taylor 2005, Gray 1987, Miller 1998).

Population trend information: IQ identifies the muskox abundance as fluctuating (Taylor 2005). Based on aerial surveys, since 1961, muskoxen on Bathurst Island have been through two declines and one recovery, although a second recovery may be underway. In 1961, muskox numbers were relatively high – Tener (1963) estimated 1136 muskoxen. When the population was next estimated in 1973, it had declined 59% (Miller et al. 1977). Inuit hunters from Resolute had reported heavy snowfall during the 1967-68 winter and movements of muskoxen across the sea-ice (in Gray 1987, Taylor 2005). Gray (1987) did not see calves, yearlings and 2-years old muskoxen or rutting behavior in 1968 and did not see calves until 1971. In September 1973, heavy wet snow was reported and the total winter snowfall was above the long term average. Between April 1973 and August 1974, a 75% decline had reduced the estimated number of muskoxen to 164 ± 70 SE (Miller et al. 1977). The muskox carcasses examined in 1974 had signs of malnutrition (Parker et al. 1975).

Muskox numbers recovered and increased between 1974 and 1993, to an estimated 1200 (Ferguson 1987, Miller 1987, Miller 1995, 1998). The annual rate of increase was r = 0.109 (a doubling rate of about 6 years).

During the next three winters (1994-97), fall temperatures were warmer than usual, and snowfall was above average. Inuit hunters reported rain during Ukiuq [winter] (Taylor 2005:79). Hunters from Resolute were concerned about dead muskoxen found on Cornwallis Island which prompted Miller (1997) to investigate. Miller (1997) estimated 980 live muskoxen and counted 50 carcasses in 1995. The following summer the decline had continued as Miller (1998) estimated that 625 ± 241 SE muskoxen had died during the 1995/96 winter leaving an estimated 425 ± 136 SE muskoxen alive. By 1997, only an estimated 124 ± 45 SE 1+ yr-old muskoxen were alive which indicated a 90% decline since 1994 (Gunn and Dragon 2002). In 2001, only 3 clusters of muskoxen were observed on A transects during aerial surveys and no population estimate could be derived. In total, however, 94 muskoxen were reported across the study area, including animals counted during ferrying and while on and off the A transects.

Current trend: Unknown since 2001 when a low rate of recovery was probably underway.

Vital rates: The pregnancy rates, calf and adult survival underlying the two known periods of increase are unknown except for the proportion of calves determined during aerial surveys.

Previous Harvests:

Resolute hunters on average annually take a total of 13 muskoxen (1998-2006; range is 8-23). From Bathurst Island, MX/01, the harvest has not exceeded 3 muskoxen (1998-2006). No trend is apparent in either the total harvest or the harvest from MX/01.

Recommended TAH: The objective is to encourage an increasing population trend until the population is about half the peak sizes (1961, 1994) when the TAH should be re-examined.

The population is relatively small (based on 2001 observations) and could be vulnerable to environmental variation. The sex and age structure is unknown. A TAH of 3 or 3% of the current minimum count is recommended.

Effect of TAH on population trend:

A TAH of 3 is recommended for this unit which is unlikely to measurably reduce the rate of increase.

Non-quota Limitations

Sex-selective harvest is not recommended.

Seasons: The DoE Wildlife Research group in consultation with the available literature and other northern ungulate biologists believe implementing a harvest season to protect against the disruption of musk ox groups during summer is a valid conservation strategy that allows the maximization of harvesting opportunities while maintaining healthy musk ox populations and, to this end, a harvest season from 01 October–15 April for all populations is recommended.

MX/02 –CI Cornwallis Island

Designation of muskox unit: The designation of Cornwallis as a muskox unit is new and is based on IQ (Taylor 2005), survey results, and movements of radio-collared animals. The unit is an island large enough to encompass seasonal home ranges although the amount of suitable habitat is low (Tener 1965). The 2 muskoxen radio-collared on Cornwallis Island demonstrate no inter-island migration during their yearly cycle. Some movements from Bathurst Island have occurred during exceptionally severe winters (1973 and 1994) when Inuit hunters reported more muskoxen on Cornwallis (Taylor 2005:70).

Population trend information: Historically, few muskoxen were recorded for Cornwallis Island varying from 3 to 4-50 between 1952 and 1980 (Barr 1991). Inuit hunters report low numbers of muskoxen in the 1970s and in the 1990s (Taylor 2005, page 78). Only 1 cluster, representing 2 individuals was observed on A transects during aerial survey of Cornwallis Island in 2002. Because of the low density, represented by few observations, a population estimate could not be derived. Notably, a total of 18 animals were counted on the island during 2002; this represents all animals observed while flying, including ferrying, and on and off A transects.

Current trend: Unknown.

Vital rates: Unknown.

Previous Harvests:

Resolute hunters on average annually take a total of 12.8 muskoxen (range is 2-23) but not, since at least 1998, from Cornwallis Island.

Recommended TAH: The objective is to encourage an increasing population trend until the population is at least 25 muskoxen (half the known peak) when the TAH should be re-examined. The population is extremely small and could be vulnerable to environmental variation. A quota of 0 is recommended.

Effect of TAH on population trend:
A TAH of 0 is recommended for this unit which will not threaten the existence or recovery of this population.

MX/03 –CE and MX/04-SE central and southern Ellesmere Island

Designation of muskox units: Ellesmere is one of the largest High Arctic Islands with high mountains, glaciers and fiords creating likely barriers to movements. The original units are being recommended for change at the request of the Grise Fiord HTO.

The climate is strongly regionalized (Maxwell 1981) and the two muskox areas on Ellesmere (MX/03 and MX/04) largely correspond to the two climate regions IV and V. The regional climate is considered to influence biogeographic zoning which likely affects muskox demography through local climate and its effects on vegetation. The regular hunting area is south Ellesmere although hunters occasionally charter planes for hunting beyond this area (Taylor 2005, pg. 60). There is no information that suggests that muskoxen migrate from north to south.

Population trend information: Historically, European and American explorers often depended on hunting muskoxen (Barr 1991). For example Barr (1991) estimates that the various explorers and Inuit from Greenland

harvested 1252 muskoxen from Ellesmere and Axel Heiberg islands between 1875 and 1917.

Inuit hunters identify many locations with muskoxen and report that on southern Ellesmere, muskoxen have increased since 1970s. As well, changes in muskoxen diistribution in the 1970s was associated with movement away from seismic surveys (Taylor 2005:83-90).

Tener (1963) surveyed most of Ellesmere but at a very low coverage (3%) and estimated 4000 muskoxen based on counting 605 muskoxen. Subsequently, southern Ellesmere (Jones Sound coastal areas) was covered during surveys in the early 1970s when 670-1350 muskoxen were recorded (Barr 1991). In 1989, Case and Ellsworth (1991) surveyed southern Ellesmere and estimated 2020 +/- 285 (SE) muskoxen. Gauthier (1996) counted 1147 muskoxen over south and central Ellesmere during military patrols.

Recent aerial and ground surveys of Ellesmere Island (2005-06) reported the greatest abundance of muskoxen on the Fosheim Peninsula. This area has previously been described as a "refugium" for muskoxen dating back to at least 1961 (Thomas et al. 1981). The 2005 portion of the survey covered southern Ellesmere Island from the west coast, including Graham Island, east to the Manson Ice Field, and areas south of Svendsen Penninsula. The Sydkap Ice Cap was not included. A density estimate of 14 muskoxen per 1000 km^2 was estimated for the area. In 2006, the north-central and northern portion of Ellesmere was surveyed where muskoxen occur at a much higher density: 63 muskoxen per 1000 km^2 was estimated. Noteably, all age classes of muskoxen observed during aerial surveys in May 2005 were in extremely poor condition. Animals unable to

stand or run were observed frequently and over 40 emaciated recently dead carcasses were observed throughout the study area (Campbell 2006).

Current trend: In general muskoxen are thought to be increasing (Taylor 2005:110). However, low densities of muskoxen south of the Fosheim Peninsula (2005-06 survey) suggest that populations have declined relative to previous surveys.

Vital rates: Unknown

Previous Harvests: Between 1998 and 2006, Inuit from Grise Fiord annually harvested an average of 24 muskoxen (13-31). The majority of muskoxen were harvested from the existing MX-02 (annual average 16; southcentral Ellesmere), with smaller numbers from existing MX-03 and MX-04 (average 2 and 3 per year, respectively).

Recommended TAH: The objective is to maintain the population at a level to sustain current levels of Inuit needs.

MX/03 – CE (Central Ellesmere) A recent aerial and ground survey of Ellesmere Island demonstrated that the majority of muskoxen were distributed north of the designated muskoxen units (Fosheim Peninsula). The density estimate from the 2005 survey is applied to this muskoxen unit, and a population estimate of 276 (95%CI 197-393) is derived. Given that the northern portion of this unit is within the low density 2006 survey area, but that muskoxen of good condition were observed, 5% of the upper confidence interval of the estimate is applied and a TAH of 20 is recommended.

MX/04 – SE (South Ellesmere) If the density estimate from the 2005 survey of southern Ellesmere Island is applied to proposed MX-04, which is contained entirely within the survey area, a population estimate of 138 (95%CI 98-196) is derived. Given the poor condition of muskoxen observed in 2005 a harvest of 4 is recommended or 3% of the mean abundance estimate until information on trends/recovery is available.

Effect of TAH on population trend:

TAHs of 20 and 4 for MX/03-CE and MX /04-SE, respectively are recommended which will not threaten the existence or recovery of this population.

Non-quota Limitations

Sex-selective harvest is not recommended.

Seasons: The DoE Wildlife Research group in consultation with the available literature and other northern ungulate biologists believe implementing a harvest season to protect against the disruption of musk ox groups during summer is a valid conservation strategy that allows the maximization of harvesting opportunities while maintaining healthy musk ox populations and, to this end, a harvest season from 01 October–15 April for all populations is recommended.

MX/05 – ND, MX/06 - SD and MX/07 – WD, Devon Island

Designation of muskox units: North Devon (MX/05) is within a separate climate region from the rest of the island (Maxwell 1981) and is also separated by rugged terrain from the other two muskox units. The other

two units are a string of small lowlands along the north and south coast, respectively. The two areas are also separated by rugged terrain and glaciers. The three areas are a rationalization of the previous two units which owed more to historical patterns. The previous unit MX/05 included the central and eastern portion of Devon Island and is now divided into MX/05 (north Devon) and MX/06 (south Devon). MX/07 is a new unit for western Devon. Six muskoxen were radio-collared in 2003 and preliminary analysis of location data indicates fidelity to the island and no movement from western Devon island to the east.

Population trend information: Information on trends for the northeast coast (1908-1960; 1970-73; and 1978-1987) reveal fluctuations in numbers and calf survival (summarized in Pattie 1990). The other areas are less known although the island has been covered in a single survey – Tener (1965) reported about 200, Freeman (1971) reported 450 muskoxen in 1967 and Case (1992) estimated 370 in 1990. Inuit hunters report that for the 1950s-90s, muskoxen occurred around the coasts of Devon and large herds around Cape Sparbo and Trulove Lowlands on the north coast (Taylor 2005:80-82).

MX/05 – ND (North Devon:) This area includes small patches of lowland where muskoxen have persisted although their abundance and calf survival varies. Numbers varied between 26 and 176 (0.3 to 2.5/km^2) on the Cape Sparbo-Hardy and Truelove lowlands (70 km^2) between 1973 and 1986 (Pattie 1990). During Case's (1992) survey 178 muskoxen were observed in the Cape Sparbo-Hardy and Truelove lowlands and 281 along the entire north coast. Inuit hunters report groups of muskoxen along the north coast lowlands in the 1960s into the 1980s (Taylor 2005:80-82).

MX/06 – SD (South Devon): Historic sightings of muskoxen along the south coast are few (Barr 1991) and although Inuit travel less along the south coast, there are scattered sightings (Taylor 2005:82). In total, 72 muskoxen were observed on the south coast during the 1990 survey (Case 1992).

MX/07 – WD (West Devon) Inuit hunters reported large numbers of muskoxen on the Grinnell Peninsula in the mid-1980s (Taylor 2005:83). During the 1990 survey of Devon Island only 13 muskoxen were observed in the west. The DoE survey of west Devon Island (2002-03) identified 95 individuals.

Current trend: Unmeasured and in general muskoxen are not recorded as declining on Devon (Taylor 2005).

Vital rates: Currently unknown: calf productivity is annually variable between 0% to 22% (Pattie 1990). Calf survival was low over winter 1984/85 as only 1 of 33 calves counted in 1984 survived. In 1990, Case (1992) recorded the proportion of calves as 13%, yearlings 8.2%, and 2-year olds as 3.3%. The adult sex ratio was 39.5 bulls: 100 2+ year old cows.

Previous Harvests: Between 1998 and 2006, Inuit from Resolute annually hunt an average of 13 muskoxen (2-23), primarily from the existing MX/06 (Prince of Wales and Somerset Islands). Only 1 animal was taken from Devon Island during this eight year period. In contrast, hunters from Grise Fiord annually hunted an average of 23 muskoxen (13-29), primarily from Ellesmere Island (existing MX-02/03/04). An average of 2 muskoxen were harvested annually from Devon. Arctic Bay hunters generally take 0-5 animals from Devon Island.

Recommended TAH:

MX/05 – ND (North Devon): The most recent estimate was 17 years ago and was for a small population with a record of fluctuating in size. The objective is to maintain the population at a level to sustain current levels of Inuit needs. The IQ suggests the muskoxen are increasing which leads to the recommendation of a TAH of 14 or 5% of the 1990 count.

MX/06 – SD (South Devon) The most recent estimate was 17 years ago and was for a relatively small population (72 muskoxen, Case 1992). The trend is unknown. The objective is to maintain the population at a level to sustain current levels of Inuit needs. A TAH of 2 which is 3% of 1990 count is recommended.

MX/07 – WD (West Devon) During the 1990 survey of Devon Island only 13 muskoxen were observed in the west while the DoE survey of west Devon Island (2002-03) counted 95 muskoxen. The objective is to maintain the population. A TAH of 5 or c. 5% of the 2002/03 estimate is recommended.

Effect of TAH on population trend: The TAH's will not threaten either the existence or recovery of this muskoxen in the three areas unless calf productivity is not sustained or adult mortality changes significantly.

Non-quota Limitations

Sex-selective harvest is not recommended.

Seasons: The DoE Wildlife Research group in consultation with the available literature and other northern ungulate biologists believe implementing a harvest season to protect against the disruption of musk ox groups during summer is a valid conservation strategy that allows the maximization of harvesting

opportunities while maintaining healthy musk ox populations and, to this end, a harvest season from 01 October–15 April for all populations is recommended.

MX/08 – SI SOMERSET ISLAND

Designation of muskoxen unit: Somerset is designated as MX/08 with the TAH allocated to Resolute. For the most part, the population on this island is disjunct from Prince of Wales although in the 1970s, a few muskoxen from Prince of Wales likely colonized Somerset Island. Inuit hunters report that some muskoxen have moved from Prince of Wales to Somerset and possibly more northern islands (Taylor 2005). However, in the mid to late 1970s, during extensive surveys in late winter-spring, muskoxen or their tracks were not seen on the sea ice (Miller et al 1982).

Population trend information: IQ reports that early on muskoxen were known to be on Somerset Island and that many died 1928-30. Low numbers persisted through the 1950s -1970s as muskoxen were occasionally seen.

Historically, there are few records in the 1880s (Barr 1991). However in 1925, two Inuit families from Arctic Bay traveled to Somerset Island and on the northern end of the island, being faced with starvation, killed 14 muskoxen (Barr 1991). In the early 1950s, Inuit reported many muskoxen although by the early 1970s, none were seen during aerial surveys (Barr 1991). In 1980, only 29 muskoxen were counted on Somerset Island during an island-wide aerial survey. The muskoxen increased as in 1995, the estimate was 1140 +/- 260 on Somerset Island (Gunn and Dragon 2005). By 2004, the muskoxen on Somerset had further increased to 1959 (95% CI :

). Between 1995 and 2004 the muskoxen were slowly increasing at r = 0.06, doubling time 12 years.

Current trend: For Somerset Island, the trend is **i**ncreasing 1980 – 2004. IQ supports the growing abundance of muskoxen on the island and acknowledges significant fluctuations over approximately 80 years (1920 to 2003; Taylor 2005).

Vital rates: Unknown

Previous Harvests: From 1998 – 2006, hunters from Resolute harvested an average of 9 muskoxen (range 0-18) from Prince of Wales and Somerset Islands.

Recommended TAH: The objective is to encourage sustainable harvesting of muskoxen and foster the recovery of caribou. The average annual rate of increase (6%) is recommended as the TAH (117 muskoxen).

Effect of TAH on population trend:

For Somerset, the recommended TAH will halt the average annual rate of increase.

Non-quota Limitations

Sex-selective harvest is not recommended.

Seasons: The DoE Wildlife Research group in consultation with the available literature and other northern ungulate biologists believe implementing a harvest season to protect against the disruption of musk ox groups during summer is a valid conservation strategy that allows the maximization of harvesting opportunities while maintaining healthy musk ox populations and, to this end, a harvest season from 01 October–15 April for all populations is recommended.

MX-09 - PW PRINCE OF WALES

Designation of muskoxen unit: Prince of Wales is designated as MX/09 with the TAH allocated to Taloyoak. For the most part, the population on this island is disjunct from Somerset Island although in the 1970s, a few muskoxen from Prince of Wales likely colonized Somerset Island. Inuit hunters report that some muskoxen have moved from Prince of Wales to Somerset and possibly more northern islands (Taylor 2005). However, in the mid to late 1970s, during extensive surveys in late winter-spring, muskoxen or their tracks were not seen on the sea ice (Miller et al 1982).

Population trend information: Inuit hunters report that muskoxen abundance on Prince of Wales and Somerset islands has fluctuated over the last 80 years (Taylor 2005:74-77). Inuit report for Prince of Wales Island, that muskoxen were present in the 1850s (Barr 1991) and also in the 1930s and 1950s (Barr 1991, Taylor 2005:76-77). The first island-wide aerial surveys were in 1974-75 and led to an estimate of 600 muskoxen. By 1980, the estimate was 1126 +/- 276 (Standard Error) and by 1995, muskoxen had increased to 5259 +/- 414 (Gunn and Dragon 2005). Between 1980 and 1995, the rate of increase was r = 0.103 (doubling rate 7 years) for muskoxen on Prince of Wales. Inuit hunters were concerned about the increasing muskox abundance in areas previously used by caribou (Taylor 2005). Views on the relationship between caribou and muskoxen vary among the Inuit (Taylor 2005) and among biologists (Gunn and Dragon 2005, Gunn and Adamczewski 2003).

In the early 1990s, muskox carcasses were found on both Somerset and Prince of Wales islands after freezing rain in Ukiaq [fall] (Taylor 2005: 77). By 2004, the number of muskoxen on Prince of Wales Island had declined to 1934 muskoxen (95% CI 1433-2600)

Current trend: Between 1995 and 2004, the muskoxen on Prince of Wales declined by an annual average rate of about 5%.

Vital rates: Unknown

Previous Harvests: From 1998 – 2006, hunters from Resolute harvested an average of 9 muskoxen (range 0-18) from Prince of Wales and Somerset Islands.

Recommended TAH: The objective is to encourage sustainable harvesting of muskoxen and foster the recovery of caribou. Since 1995 muskox abundance has declined although the reasons are uncertain. The recommended TAH (20 muskoxen) is a balance between allowing the muskoxen to decline further (possibly foster caribou recovery) without accelerating the decline to the point of jeopardizing sustainable harvesting. The TAH should be re-considered if Inuit report finding carcasses or in 5 years.

Effect of TAH on population trend:

The recommended TAH will slightly accelerate the current rate of decline.

Non-quota Limitations

Sex-selective harvest is not recommended.

Seasons: The DoE Wildlife Research group in consultation with the available literature and other northern ungulate biologists believe implementing a harvest

season to protect against the disruption of musk ox groups during summer is a valid conservation strategy that allows the maximization of harvesting opportunities while maintaining healthy musk ox populations and, to this end, a harvest season from 01 October–15 April for all populations is recommended.

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