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CHAPTER 4: MUSKOX MANAGEMENT REPORT

From: 1 July 2012
To: 30 June 2014[1]

LOCATION

GAME MANAGEMENT UNITS: 26B and 26C (26,000 mi^2)

GEOGRAPHIC DESCRIPTION: Central and Eastern Arctic Slope

BACKGROUND

Muskox populations in Alaska disappeared in the late 1800s or early 1900s (Lent 1998). The Territorial Legislature of Alaska urged Congress to appropriate money to reintroduce muskoxen from Greenland to Nunivak Island during 1935–1936 for the purposes of domestication or husbandry experiments (Paul 2009). During 1969 and 1970, 51 animals from Nunivak Island were released on Barter Island, and 13 were released at Kavik River on the eastern North Slope. The number of muskoxen in this area (Unit 26C) increased steadily during the 1970s and 1980s and expanded eastward into Yukon, Canada, and westward into Unit 26B and eastern Unit 26A during the late 1980s and early 1990s. The population was considered stable during the mid-1990s at around 500–600 muskoxen in Units 26B and 26C, with perhaps an additional 100 animals in Yukon, Canada. Beginning in 1999, calf production, yearling recruitment, and number of adults declined substantially in Unit 26C, and by 2003, only 29 muskoxen were observed in this unit. During 2004–2008, the number of muskoxen observed in Unit 26C ranged 1–44 (Reynolds 2008). Muskox numbers in Unit 26B appeared stable to slightly increasing from the mid-1990s through 2003 at approximately 302 muskoxen. The population declined to 216 by 2006, and since 2007, the population in Unit 26B stabilized at a reduced population size of approximately 190–198 muskoxen.

ADF&G first opened a hunting season in Unit 26C in 1982 and in Unit 26B in 1990. Several regulatory scenarios have been in effect since then (Lenart 2003). The *North Slope Muskox Harvest Plan* (1999, ADF&G files, Fairbanks) is the template for managing muskoxen in Unit 26B. Consistent with that plan, in March 1998, the Alaska Board of Game (board) determined that a harvest of no more than 20 muskoxen (Tier II hunt TX108) was necessary to provide a reasonable opportunity for subsistence use in Unit 26B west of the Dalton Highway. The board also decided that no more than 5 muskoxen were required to meet subsistence needs in Unit 26B east of the Dalton Highway. Tier I hunt RX110 replaced Tier II hunt TX110. Permits were made available in Nuiqsut and Kaktovik, and the season was announced by emergency order when snow conditions, weather, or other factors were suitable for hunting

[1] At the discretion of the reporting biologist, this unit report may contain data collected outside the reporting period.

muskoxen. A drawing permit hunt (DX112) was also established; 3 permits were issued annually for taking bull muskoxen in Unit 26B east of the Dalton Highway. The board determined that it was possible to have subsistence and drawing hunts in the same area because the population could be managed as 2 subpopulations: bulls and cows. The $25 resident muskox tag fee was waived for subsistence hunters in Units 26B and 26C. Hunters harvested small numbers of muskoxen annually in Units 26B and 26C when the seasons were open. Some season and boundary changes were made since 1998 (Lenart 2003).

MANAGEMENT DIRECTION

In April 1996, ADF&G initiated a management planning process on the North Slope to address concerns by North Slope residents about possible interactions between muskoxen and caribou and about the future management of muskoxen. Participants of the North Slope Muskox Working Group included representatives from local villages, ADF&G, the North Slope Borough, and affected federal agencies. The group developed the *North Slope Muskox Harvest Plan* (1999, ADF&G files, Fairbanks), and all agencies, including ADF&G, signed the plan in February 1999. During 1999–2006, hunt and harvest strategies were based on this plan.

Current management objectives were revised January 2012 and are listed below. These objectives were developed in response to results from research conducted during 2007–2011 and the Unit 26B muskox recovery program (Alaska Administrative Code, Title 5, regulation 92.126[b]), which authorized a predation control plan to reduce the effects of brown bear (also referred to as grizzly bear in Interior Alaska) predation on muskoxen. An operational plan titled *Operational Plan for Unit 26B Muskox Recovery, 2012–2018* was developed to provide guidance to staff to implement the recovery program (ADF&G 2012).

MANAGEMENT GOALS

1. Provide opportunities to harvest muskoxen while maintaining healthy, stable muskox populations.

2. Minimize any detrimental effects that muskoxen may have on caribou and caribou hunting.

3. Cooperate and share information about muskoxen among users (e.g., local and nonlocal residents and local, state, and federal agencies) to develop and implement harvest, management, and research programs.

4. Provide opportunities to view and photograph muskoxen.

MANAGEMENT OBJECTIVES AND ACTIVITIES

1. Increase the eastern Unit 26A, Unit 26B, and Unit 26C contiguous muskoxen population to 300 muskoxen by reducing brown bear predation on muskoxen in Unit 26B.
   - In April and May 2012 and 2013, department staff implemented a program to selectively and lethally remove individual brown bears in Unit 26B that are known to prey on muskoxen or are observed on muskoxen kill sites, pursuing muskoxen, or stalking muskoxen.
   - Conduct precalving surveys in early April to determine population size.
   - Conduct ground-based composition counts in April to determine herd composition.

- Maintain 15–20 radio collars on adult female muskoxen to assist in locating groups of muskoxen during precalving surveys and composition counts.
- Test for the presence of potentially population-regulating diseases including chlamydia, contagious ecthyma, trace mineral deficiencies, lungworm, and stomach worm.

2. When the population is at least 300 muskoxen and is considered growing, maintain a harvest rate of 1–3% per year of the spring precalving population in eastern Unit 26A and Unit 26B while the population in eastern Unit 26A, Unit 26B, and Unit 26C is less than 650 muskoxen.
   - Administer permit hunts and monitor results of the hunts.
   - Allow the population to grow to its historical high of 650 muskoxen distributed contiguously across eastern Unit 26A, Unit 26B, and Unit 26C.

METHODS

POPULATION SIZE AND COMPOSITION

Population Size

ADF&G, U.S. Fish and Wildlife Service, and Arctic National Wildlife Refuge (ANWR) biologists cooperated to collect population data. To obtain a minimum count of muskoxen, we conducted precalving surveys in late March or early April by flying systematic routes and drainages in Units 26B and 26C using a Cessna 185 or 206, or a Piper Super Cub. Bright, sunny days provided the best survey conditions. Surveys were flown at approximately 90 mph at 500–1,000 feet above ground level, depending on visibility. In addition to flying transects and drainages, we tracked radiocollared females to locate groups of muskoxen.

In Unit 26C, surveys began in 1978 when ANWR staff surveyed major drainages and smaller adjacent tributaries and bluffs. During 2002–2005, refuge staff annually flew approximately 1,400 miles along 50 north-south lines across the coastal plain from the Arctic Ocean to the mountains of the Brooks Range. Transects were spaced at 3-mile intervals from the Canning River to the Canadian border (Reynolds 2002, 2005, 2006, 2007, 2008).

In Unit 26B east of the Dalton Highway (eastern Unit 26B), we surveyed major drainages and some of the smaller adjacent tributaries and bluffs most years beginning in 1986. In Unit 26B west of the Dalton Highway (western Unit 26B), we initiated systematic surveys in March 1997. These systematic surveys were conducted by following transects spaced 6 miles apart, whereby we attempted to observe all muskoxen within 3 miles of either side of the transect. Six-mile wide transects were oriented north-south and extended from 70°N to 69°15′N. Beginning in April 1999, survey transects extended farther south to 69°N, and transects were also flown in the area approximately halfway between the Itkillik and Colville rivers. In April 2000 and 2003, the 6-mile wide systematic survey method also was applied to eastern Unit 26B. No surveys were conducted in 2001. In 2002, 2004, and 2005, we surveyed only major drainages and smaller adjacent tributaries and bluffs in all of Unit 26B and located groups by radiotracking.

In April 2006 we conducted a systematic survey across the eastern North Slope in cooperation with ANWR, Gates of the Arctic National Park and Preserve, and Department of Environment,

Yukon Canada. The survey included the area on the coastal plain east of Judy Creek in eastern Unit 26A, all of Units 26B and 26C, and the western Yukon Territory as far east as the Babbage River. Transects, oriented approximately north-south and spaced 3 miles apart, were flown from the foothills of the Brooks Range mountains to the Arctic Ocean. The easternmost transect extended from 68.910°N, 138.384°W to 69.241°N, 138.503°W in Canada; the westernmost extended from 68.402°N, 149.995°W to 70.429°N, 150.260°W near the Itkillik Hills in Unit 26B. Additional transects beginning at 68.419°N, 150.115°W to 70.434°N, 150.379°W in the Itkillik Hills, were flown every 2–6 miles to just west of the Colville River at 69.432°N, 152.110°W to 70.418°N, 152.110°W. We assumed 90–100% coverage for transects that were spaced every 3 miles. The mountains were surveyed by flying suitable muskox habitat along the valleys of major drainages and parts of their tributaries from the Etivluk River to the Kongakut River. The survey area included approximately 33,000 mi^2 (85,470 km^2).

In April 2011, we conducted a systematic survey of the eastern North Slope in cooperation with ANWR and Department of Environment, Yukon Canada, similar to the 2006 effort, except the mountains were not searched. The survey included the area on the coastal plain on the north side of Teshekpuk Lake from just west of Ikpikpuk River (70.816°N 154.950°W) to Judy Creek in eastern Unit 26A, all of Units 26B and 26C (north of the mountains), and the western Yukon Territory as far east as the Babbage River extending into the British Mountains. The area from Ikpikpuk River to approximately Judy Creek was flown along the coast. Transects, oriented approximately north-south and spaced 3 miles (5 km) apart, were flown from the foothills of the Brooks Range mountains to the Arctic Ocean beginning at 70.833°N, 153.979°W extending to 70.696, 153.937 with transects flown between the mountains and the coast. We assumed 90–100% coverage for transects that were spaced every 3 miles.

During 2012–2015, no systematic surveys were conducted; however, during 2007–2010 and 2012–2015, research and management staff estimated a minimum April population size by counting muskox observed during radiotracking surveys to locate all known groups of muskoxen and by searching areas previously occupied by muskoxen (S. M. Arthur, E. A. Lenart, Wildlife Biologists, ADF&G files, Fairbanks).

We grouped population data as 1) Unit 26B and eastern Unit 26A, 2) Unit 26C, and 3) Units 26B, eastern 26A, and 26C combined. In previous reports, we further grouped population data as western Unit 26B (west of the Dalton Highway) including eastern Unit 26A, and eastern Unit 26B (east of the Dalton Highway). However, by 2004, this distinction was no longer useful, mainly because >50% of the muskoxen population resided along the dividing line between eastern and western Unit 26B as the population declined and redistributed.

Population Composition

To determine herd composition, we conducted ground-based composition surveys in Units 26B and 26C in late June or early July during 1990–2008. In 2007 and 2008, we also conducted composition surveys in April to determine if April was a better time period to conduct surveys. In general, muskoxen are in fewer and larger groups in April with almost all groups containing a radiocollared muskoxen. By June, muskoxen have dispersed into several smaller groups, and some groups do not have radio collars, making the groups difficult or unlikely to locate. Beginning in 2009, composition surveys were conducted in April only. We located groups of muskoxen by radiotracking from a fixed-wing aircraft or helicopter, and classified animals from

the ground as ≥4-years old, 3-years old, 2-years old, yearlings, or calves of the current year. Animals older than yearlings were also classified as male or female. In 2003 and 2005, some groups were classified from an R-44 or R-22 helicopter, but it proved difficult to classify animals from helicopters.

Radiocollaring

During 1999–2015, we monitored 9–30 radiocollared adult females each year to locate muskoxen in precalving surveys in April and composition counts in June and April. In April 1999, ADF&G deployed radio collars on 12 adult (≥3-years old) female muskoxen in 11 groups distributed between the Itkillik and Ivishak rivers in Unit 26B using methods described by Lenart (1999). During 1999–2006, adult female muskoxen were captured and radiocollared in June or July by darting with a CO_2 powered short-range projector pistol using the drug protocol described by Lenart (1999). The following numbers of radio collars were deployed on muskoxen in June: 2 in 2001, 1 in 2002, 2 in 2003, 5 in 2004, 2 in 2005, and 4 in 2006. During 2007–2012, muskoxen were darted using a Pneu-dart Model 389 cartridge-fired projector rifle. We deployed 21 radio collars on muskoxen in 2007 (9 in March, 2 in June, 10 in October), including 1 recapture in October. Six of these were captured using drug protocol described by Lenart (1999), and 15 were captured using various combinations of medetomidine hydrochloride, ketamine hydrochloride, tolazoline hydrochloride, and zolazepam (K. B. Beckmen, Wildlife Veterinarian, ADF&G files, Fairbanks). Due to inconsistent results, we discontinued use of the latter combination for muskox captures. No radio collars were deployed in 2008 or 2009. We captured and radiocollared 4 adult female muskoxen in July 2010, 2 in March 2011, 11 in 2012 (2 in April, 9 in September), and 3 in September 2014 using methods described by Lenart (1999). In 2014, we also administered 3 L/min oxygen and 15 cc oxytetracycline.

Annual survival rates of radiocollared adult female muskoxen were estimated using the Kaplan-Meier procedure (Pollock et al. 1989). During 1999 through 2005, the time period for estimating survival rates was 1 June through 31 May (e.g., 1 June 1999–31 May 2000). In 2006, the time period was 1 June 2006 through 31 March 2007. During 2007–2014, the time period was 1 April through 31 March (e.g., 1 April 2007–31 March 2008).

HARVEST

For Unit 26B, we monitored harvest and hunting effort through harvest reports submitted by hunters. Total harvest, residency, success rates, chronology of harvest, and methods of transportation were summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY10 = 1 July 2010–30 June 2011). We obtained harvest data from ANWR for Unit 26C.

Based on the *North Slope Muskox Harvest Plan* (1999, ADF&G files, Fairbanks), harvest data were grouped as 1) Units 26B and 26C combined; 2) Unit 26B; 3) Unit 26C; 4) western Unit 26B (west of the Dalton Highway); and 5) eastern Unit 26B (east of the Dalton Highway). Since 1998, western Unit 26B included the Tier II permit hunt TX108. In 2002, the eastern portion of Unit 26A (east of 153°W longitude) was included in TX108 because the population had expanded into eastern Unit 26A. Since 1998, eastern Unit 26B included registration Tier I (RX110) and drawing (DX112) permit hunts.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

Unit 26B and Eastern Unit 26A. In April 2015, we observed a precalving population of 198 muskoxen ≥1-year old in Unit 26B and along the Canning River in Unit 26C. All 26 radio collars (including 3 new mortalities) were located in 9 groups in Unit 26B and along the Canning River in Unit 26C.

In April 2014, we observed a precalving population of 177 muskoxen ≥1-year old in Unit 26B and along the Canning River in Unit 26C. This included locating all 25 radio collars in 9 groups and 1 lone 2-year-old female. We observed more muskoxen ≥1-year old during June surveys (181) and used the June numbers as our precalving population estimate for 2014.

In March 2013 we observed a precalving population of 197 muskoxen ≥1-year old in Unit 26B and along the Canning River in Unit 26C. All 28 radio collars were located in 11 groups, and an additional 2 unmarked bull groups were found. One of the radiocollared groups was located near Teshekpuk Lake in eastern Unit 26A. The 2 radiocollared muskoxen from this group were both on mortality mode, and no animals were observed. We waited until spring break-up to examine the dead muskoxen. Upon investigation in May, we found 20 dead muskoxen that we determined had drowned the previous November or December and were frozen in the small lake they were found in. This represented most or all of the muskoxen from the group.

Numbers of muskoxen observed in 2013, 2014, and 2015, were similar to those observed during 2007–2012. The precalving population in Unit 26B appeared stable at a reduced population size of approximately 192 muskoxen during 2007–2015. A small group of muskoxen that was often found on the Canning River on the boundary between Units 26B and 26C was included in the Unit 26B totals.

Numbers observed during 2007–2015 are slightly lower than the 216 muskoxen observed during 2006 surveys. During all surveys, some lone animals or small groups may have been present but not counted, and precision of these estimates is unknown. Thus, the significance of the apparent decline from 2006 (216 muskoxen) through 2015 (198 muskoxen) cannot be determined. However, the population was relatively stable at approximately 192 animals during 2007–2015. Muskoxen are long-lived, and some calves are being recruited into the population (See Population Composition section below), yet this population is not increasing. Thus, it is likely that mortality (particularly adult females) closely tracked or exceeded recruitment during 2003–2014. Observed causes of mortality included predation by brown bears, disease, drowning, starvation, and the combined effects of poor nutrition and winter weather (see Mortality section below). In addition to higher rates of mortality in particular years, some distributional changes probably occurred.

Unit 26C. In 2013, 2014, and 2015, we observed 17, 15, and 13 muskoxen on the Canning River. As noted previously, during 2007–2012, this Canning River group crossed back and forth between Unit 26B and Unit 26C, and these animals were included in the Unit 26B totals. Initially, emigration to Unit 26B and Yukon, Canada could have caused fewer muskoxen to be observed in Unit 26C. However, number of calves observed in early June and yearling

recruitment also were lower in Unit 26C beginning in 1999. Thus, Reynolds (2002, 2008) suggested factors other than emigration alone may have influenced the population including 1) effects of weather on quality, quantity, and availability of winter habitat (e.g., crust forming on snow and long winters with deep snow making foraging difficult and resulting in late green-up); 2) predation by brown bears; and 3) disease and mineral deficiencies making muskoxen more vulnerable to environmental conditions. These factors would likely affect calf recruitment, adult survival, and shifts in distribution.

Unit 26B and Eastern Unit 26A Combined with Unit 26C. The combined number of muskoxen observed during precalving surveys in eastern Unit 26A and Units 26B and 26C declined considerably; 491–651 were observed during 1995–2000, but only 331 muskoxen were observed in 2003, 217 in 2006, and 198 in 2015 (Table 1).

Eastern North Slope Including Northwestern Canada. In 2011, Environment Yukon staff observed 101 muskoxen between the Alaska-Canada border and the Babbage River in Yukon, Canada (M. Suitor, Environment Yukon files, Dawson City, Yukon, 2011). We estimate the total muskox population (eastern Unit 26A combined with Units 26B and 26C and northwestern Canada) at approximately 300 animals. This suggests that the population has declined substantially since the mid-1990s when the population was estimated at 700–800 muskoxen (Lenart 1999). The population likely remained stable at these reduced numbers during 2007–2014.

Population Composition

Units 26B and Eastern 26A. In April 2014 and 2015, the ratio of yearlings:100 females >2-years old was 17:100 and 22:100, considerably lower than the previous 5 years (Table 1). In April 2013, the ratio of yearlings:100 females >2-years old was 40:100 indicating very good recruitment of calves into the population (Table 1). Recruitment was also considered good the previous 4 years ranging 32–39 yearlings:100 females >2-years old. Although yearling recruitment was good during 2009–2013, population size remained stable.

In April 2013, 2014, and 2015, the ratios of bulls >3-years old:100 cows >2-years old were 46:100, 30:100, and 43:100 respectively (Table 1). Ratios of bulls >3-years old:100 cows >2-years old fluctuated annually with a low bull:cow ratio one year and a high bull:cow ratio the next year (Table 1). Variability in bull:cow ratios were likely affected by differences in search effort among years. Bulls are generally in smaller groups in spring and are therefore more difficult to locate, especially during June surveys. However, bull:cow ratios in April composition surveys were also variable (Table 1).

Calf Production, Summer Calf Survival and Timing of Calving — In 2014 and 2015, the maximum number of calves observed during 2 radiotracking surveys in June was 33 and 36 calves. These numbers were within the range observed at the end of June during the previous 6 years (2008–2013; range: 29–49; Table 1). Number of calves observed at the end of June in 2007 was very low (13).

The minimum number of calf births was estimated during 2007–2013, when data was collected through frequent radiotracking surveys from 1 April to 30 April (Table 1). The minimum number of calf births estimated ranged from 35 to 67, indicating that some years were particularly good

for calf production (Table 1; S. M. Arthur, E. A. Lenart, ADF&G files, Fairbanks). During the same time period, the number of female muskoxen >2-years old ranged from 71 to 88 muskoxen (Table 1). Calves were born as early as 18 April and as late as 27 June (S. M. Arthur, E. A. Lenart, ADF&G files, Fairbanks).

In 2014, the number of calves observed at the end of September was 26 (Table 1). In 2015, the number of calves observed in early to mid-October was 27–29, similar to 2014 (Table 1). In some years, the number of calves observed in the fall was low with 13 observed in 2007 and 17 in 2013. We also observed years when the number of calves observed was high with 40 in 2012 and 45 in 2009 (Table 1). During 2007–2015, calf survival from the end of June through October ranged 57–100% (Table 1; S. M. Arthur, E. A. Lenart, ADF&G files, Fairbanks).

In Unit 26C, the number of calves observed in June or July during 2000–2002 was very low (1 and 7; Table 1). Yearling recruitment also was low during 1999–2000 (range = 0–17:100 females >2-years old; Table 1). Annual bull (>3-years):cow (>2-years) ratios during 1999–2000 ranged 40–60:100 (Table 1). No data were available to determine yearling:cow and bull:cow ratios for 2002–2015 because too few muskoxen were located.

Distribution and Movements

Muskoxen tend to form larger groups of 6–60 during winter and remain in one location for most or all of the winter. During summer, they form smaller groups of 5–20 and move more frequently.

During 2006–2015, muskoxen were found primarily near the Kachemach River, the mouth of the Itkillik River, Beechy Point, the Kuparuk River Delta, Deadhorse, and along the Sagavanirktok, Ribdon and Ivishak rivers in Unit 26B. One group (<25) was found near Point Lonely in eastern Unit 26A and would occasionally return to the Colville Delta (until its demise in early winter 2012 (see Mortality section below). Another small group (<15) was found on either the Kavik River or, more frequently, the Canning River.

Considerable shifts in distribution have occurred since 2003 (Lenart 2007, Reynolds 2007). Long range movements (≥50 miles) of groups and individual radiocollared animals have also been noted (Lenart 1999, 2003, 2005, 2007). In 2007 a group of muskoxen that had been residing between Fish Creek and the Kachemach River moved to Teshekpuk Lake (approximately 100 miles). During 2007–2012, this group was observed at Point Lonely and Kogru River, moved to the Colville Delta, and then returned to Teshekpuk Lake.

Since 1980, lone bulls and small groups of muskoxen have also been reported south of the Brooks Range in Unit 25A near Arctic Village. In 1999, 3 muskoxen were illegally harvested from a group of 10 muskoxen located north of Arctic Village. Of the 3 harvested animals, 2 were cows. This was the first documentation of a mixed-sex group south of the Brooks Range in northeastern Alaska. There also was a sighting of a lone bull on the Yukon River in Unit 25B near Eagle. In March 2004, we observed a group of 3 bull muskoxen in the Wind river drainage in Unit 25A. A mixed group of 15 muskoxen was reported on the Coleen River in 2005 (H. Korth, local resident, personal communication, 2005). In August 2006, ADF&G staff observed a mixed-sex group of 13 muskoxen on the East Fork Chandalar River. Two groups of 6 were reported on the Sheenjek and Chandalar rivers in June 2006 (P. E. Reynolds, Wildlife

Biologist, U.S. Fish and Wildlife Service, Fairbanks, personal communication, 2006). Moose hunters have also reported lone muskoxen on the Porcupine and Coleen rivers. In addition, a lone bull was sighted near Coldfoot in summer 2004, and lone bulls have been sighted in Atigun Pass and on Chandalar Shelf since 2004. We suspect the animals found on the south side of the Brooks Range originated from Units 26B and 26C.

A few bull muskoxen and some small groups have been sighted at the Gisasa, Kateel, and Hogatza rivers in Units 21D and 24C beginning in 1999. In April 2012, a mixed-sex group of 16 muskoxen were observed by a brown bear hunting guide in the headwaters of the Gisasa River, and 2 bulls were observed on the ridges between the South Fork Nulato and Gisasa rivers. Other reports of lone bulls have occurred in Nulato, Ruby, and on the Yukon River across from Galena. These animals likely originated from the Seward Peninsula.

MORTALITY

Harvest

Seasons and Bag Limits. The summary below lists seasons and bag limits for the various muskox hunts in Units 26B and 26C beginning in RY90. Seasons and bag limits for the Tier II (TX108) hunt in western Unit 26B and eastern Unit 26A remained the same during RY00–RY05, with a season of 1 August–31 March and a bag limit of 1 muskox. The season was closed in RY06. Seasons and bag limits for the Tier I (RX110) and the drawing (DX112) hunts in eastern Unit 26B remained the same during RY98–RY04. The Tier I hunt season opening was announced by emergency order when conditions were good for traveling, and the season closed no later than 31 March with a harvest quota of 4 muskoxen. The DX112 season was 20 September–10 October and 10–30 March with a bag limit of 1 bull muskox. No permits were issued for the drawing hunt (DX112) and the Tier I hunt (RX110) in RY05. No permits were issued for any of the 3 hunts (Tier II hunt–TX108, DX112, RX110) in RY06, RY07, or RY08. No federal permits were issued in Unit 26C during RY03–RY07; however, 1 permit was issued in RY08. No permits were issued during RY09–RY12. All hunts remain in regulation.

Location/Regulatory year[a]	Permits; Hunt type; Bag limit	Resident Open Season	Nonresident Open Season
Unit 26B			
1990–1994	2; Tier II; 1 bull	1–31 Oct; 1–31 Mar	No open season
Unit 26B, west of Dalton Hwy			
1995	3; Tier II; 1 bull	1–31 Oct; 1–31 Mar	No open season
1996–1997	3; Tier II; 1 bull	15 Sep–15 Nov; 1–31 Mar	No open season
1998–1999	9; Tier II; 1 muskox	15 Sep–31 Mar	No open season
2000–2005	9[b]; Tier II; 1 muskox	1 Aug–31 Mar	No open season
2006–2008	0; Tier II; 1 muskox	No open season	No open season
Unit 26B, east of Dalton Hwy			
1995	2; Tier II; 1 bull	1–31 Oct; 1–31 Mar	No open season
1996–1997	2; Tier II; 1 bull	15 Sep–15 Nov; 1–31 Mar	No open season
1998–2004	∞ (harvest quota of 4); Tier I; 1 muskox and 3; Drawing; 1 bull	To be announced; season closed no later than 31 Mar and 20 Sep–10 Oct; 10–30 Mar	No open season and No open season

Location/Regulatory year[a]	Permits; Hunt type; Bag limit	Resident Open Season	Nonresident Open Season
2005–2013	0; Tier I; 1 muskox and 0; Drawing; 1 bull	No open season and No open season	No open season and No open season
Unit 26C			
1990–1991	9; Tier II/Federal; 1 bull	1–31 Oct; 1–31 Mar	No open season
1992–1993	10; Federal; 1 bull	1–31 Oct; 1–31 Mar	No open season
1994–1995	10; Federal; 1 bull	1 Oct–15 Nov; 1–31 Mar	No open season
1996–1997	15; Federal; 1 bull	15 Sep–15 Mar	No open season
1998–2001	15; Federal; 1 bull (3 permits for females)	15 Sep–31 Mar	No open season
2002	2; Federal; 1 bull	15 Sep–31 Mar	No open season
2003–2007	0; Federal; 1 bull	No open season	No open season
2008	1; Federal; 1 bull	15 Sep–31 Mar	No open season

[a] Regulatory year (RY) begins 1 July and ends 30 June (e.g., RY90 = 1 July 1990–30 June 1991).
[b] For RY00 in Unit 26B west of Dalton Hwy, 10 Tier II permits were issued because of a discrepancy in scoring.

Alaska Board of Game Actions and Emergency Orders. During the March 2004 meeting, the Alaska Board of Game (board) rescinded several regulations established in RY02 related to bow hunting along the Dalton Highway. The North Slope Closed Area was eliminated along with the requirement that hunters mark their arrows. In addition, limiting the use of licensed highway vehicles in the Dalton Highway Corridor Management Area to publicly maintained roads was more clearly defined to allow "no motorized vehicles, except licensed highway vehicles on the following designated roads: 1) Dalton Highway; 2) Bettles Winter Trail during periods when Bureau of Land Management and the City of Bettles announce that the trail is open to winter travel; 3) Galbraith Lake road from the Dalton Highway to the Bureau of Land Management campground at Galbraith Lake, including the gravel pit access road when it is open; 4) Toolik Lake road, excluding the driveway to Toolik Lake Research Facility; 5) the Sagavanirktok River access road 2 miles north of Pump Station 2; 6) any constructed roadway or gravel pit within ¼ mile of the Dalton Highway."

During the March 2006, 2008, and 2010 meetings, the board did not make any regulatory changes for muskoxen seasons. However, brown bear seasons were liberalized in Unit 26B during the August and October 2010 emergency meetings in an effort to reduce the effects of brown bear predation on muskoxen.

During the January 2012 meeting, the board adopted a Unit 26B muskox recovery program which authorized a predation control plan to reduce the effects of brown bear predation on muskoxen (Alaska Administrative Code Title 5, regulation 92.126[b]).

Federal Subsistence Board Actions — Beginning in RY03, the Federal Subsistence Board agreed that no permits would be issued until a minimum of 36 animals were observed in Unit 26C during April surveys. The number of permits that can be issued is 3% of the estimated muskox population in Unit 26C, and permits are for bulls only.

Harvest by Hunters. Hunting for muskoxen in the eastern North Slope has only been allowed by permit. The number of permits available and weather conditions such as cold, snow, and fog influenced the harvest. The total reported harvest in Units 26B and 26C was 3–20 since RY90, when both units were opened to hunting, and was <5% of the estimated total population observed

during precalving surveys (Lenart 2003; Tables 1 and 2). In eastern Unit 26A and all of Unit 26B, reported harvest was 0–14 during RY90–RY05 for the Tier I, Tier II, and drawing hunts combined and was <5% of the Unit 26B segment of the population (Lenart 2003; Tables 1 and 2). No permits have been issued for hunts (Tier I and drawing) in eastern Unit 26B since RY05, and no permits have been issued for the Tier II hunt in eastern Unit 26A and western Unit 26B since RY06. In March 2011, 3 muskoxen were harvested illegally near Nuiqsut in Unit 26A.

Annual reported harvest in Unit 26C ranged 5–15 during RY90–RY02 (<4%; Lenart 2005). No permits were issued in Unit 26C since RY02. Restrictions in regulations ensured a low harvest. Some hunters may not have reported their harvests despite the permit systems.

Hunter Residency and Success. Before RY90, muskoxen were harvested under a registration permit system in which both residents and nonresidents could participate (Golden 1989, Lenart 1999). From RY90–RY97, state Tier II or federal subsistence permits were issued only to local residents of Unit 26 (Lenart 1999; Table 2). Beginning in RY98, nonlocal residents could participate in the registration and drawing hunts east of the Dalton Highway in Unit 26B; residency and success data for these hunts are in Tables 3 and 4. Success rates in Unit 26B were high for all years (Table 2). Success rates for Unit 26C were not available, but we suspect success rates were good (>50%) in all hunts. Hunters were predominantly local residents (Tables 3 and 4).

Transport Methods and Harvest Chronology. In most years, hunters relied primarily on snowmachines to hunt muskoxen. However, hunters also used aircraft in some fall hunts during the early 1990s. Hunters with drawing permits primarily used highway vehicles, and hunters with Tier II permits primarily used boats (Table 5).

Chronology of harvest depends mostly on weather (e.g., snow, fog, temperature, and rivers freezing). During RY95–RY05, approximately 50% of the harvest occurred in March for Units 26B and 26C combined. The remaining 50% was distributed between September, October, November, January, and in April after the hunting season was closed.

Natural and Other Mortality

Brown bears kill both calf and adult muskoxen and have been a more important predator than wolves in Unit 26B and Unit 26C (P. E. Reynolds, personal communication). Reynolds et al. (2002) concluded that brown bear predation on muskoxen began to increase during the late 1990s. Multiple mortalities of muskoxen suspected to be caused by predation in Unit 26B were reported since 2000 (Reynolds et al. 2002). During 2007–2011, ADF&G research staff determined that brown bear predation on adult and calf muskoxen was the primary cause of mortality in Unit 26B. Data indicated that 67% of the documented adult cow mortality (n = 45) was caused by brown bear predation (Arthur 2007, 2008; Arthur and Del Vecchio 2009; S. M. Arthur, ADF&G files, Fairbanks). This represented an average of 6 adult cows annually. Fifty-six percent of the documented adult bull mortality was caused by brown bears (n = 16), an average of 2 adult bulls annually. Total documented adult muskoxen mortality caused by brown bear predation was 62% (n = 73), an average of 9 adult muskoxen annually. The remaining documented causes of death for adults included unknown cause (11%), starvation/other nonpredation (8%), vehicle collision/shot (11%), disease (3%), and drowning (1%). Also during

2007–2011, 58% (n = 45) of documented calf mortality was caused by brown bear predation. This resulted in an average of 5 calves annually. The remaining documented causes of death for calves included perinatal (18%), abandoned (11%; often due to a brown bear scattering the group), disease (7%), starvation (2%), vehicle collision (2%), and gored (2%). Over the 5 years, a total 74 calves were classified as "missing"; their fates were unknown and not included in the above calculations. We suspect that all of these calves died, and most deaths were likely related to brown bears either directly via predation or indirectly via abandonment because the bear was preying on the group of muskoxen.

Late winter storms contribute to mortality of calves, yearlings, and adults, but these losses are generally low. However, during breakup in May 2004, the Colville River flooded and killed at least 13 muskoxen in 2 groups (6 adults, 2 yearlings, and 5 calves). In early June 2006, 1 adult radiocollared female muskox, 1 yearling female muskox, and 1 calf were reported stranded on the sea ice off Northstar and Endicott islands and likely died of starvation. During 2007 and 2008, a total of 6 calves were observed to have died during or immediately after birth. As noted previously, in spring 2013, we found 20 muskoxen frozen in a small lake southeast of Teshekpuk Lake. We determined that they were likely on thin ice in early winter 2012, broke through the ice, and drowned. Other observed causes of death include disease, winter malnutrition, and individuals falling through thin ice on lakes and rivers.

Some human-caused mortality occurs as a result of capture activities, and some muskoxen are killed by vehicles on the Dalton Highway. In 2011, 2 muskoxen were illegally shot, and it appeared the event caused another radiocollared muskox to die. Causes of some of the mortalities are unknown.

Survival rates for radiocollared adult females ranged 0.60–1.0 during 1999–2014 ($\bar{x}$ = 0.85; Table 6), indicating that in some years, mortality of adult females was high. No notable trends were detected, but sample sizes were small (range = 9–26; Table 6).

Disease

Zarnke et al. (2002) tested sera from 104 muskoxen from Alaska for evidence of exposure to malignant catarrhal fever viruses (MCFV), and determined that these muskoxen had a high serum antibody prevalence rate of 96%. However, there was no evidence that muskoxen were experiencing clinical signs of MCFV.

Fifty-six sera collected during 1980–2004 from muskoxen in Units 26B and 26C (ANWR population) were tested for the presence of chlamydia. Four percent of the samples tested positive. The 2 samples that tested positive were collected in 2000, suggesting that this organism may have recently appeared in the population. However, antibodies to chlamydia were present in muskoxen populations at Nunivak Island, Seward Peninsula, and Cape Thompson, Alaska that are not declining (K. B. Beckmen, ADF&G files, 2009). Occurrence rates in sera from these 3 populations averaged 22% (n = 41; range: 17–25%).

HABITAT

Various studies of the status of muskox habitat (O'Brien 1988) indicated forage abundance was not limiting muskox population growth in Units 26B and 26C during the 1980s. Little is known about many factors that influence forage quality for muskoxen, particularly with respect to trace

nutrients, such as copper and other minerals. Reynolds (2002) speculated that changes in forage quality and quantity on winter ranges in Unit 26C may have affected reproduction and survival. These changes may have been related to annual variability in weather, snow depth, length of snow season, and icing conditions (Reynolds 2002).

NONREGULATORY AND MANAGEMENT NEEDS/PROBLEMS

Unit 26B Muskox Recovery Program

ADF&G prepared the *Operational Plan for Unit 26B Muskox Recovery 2012–2018* (ADF&G 2012) to provide supporting information and guidance to implement the muskox recovery program (5 AAC 92.126).

Results of the 2012 and 2013 muskoxen recovery fieldwork are summarized by Lenart and Caikoski (Wildlife Biologists, ADF&G, memorandum [Unit 26B Muskox Recovery Program–Field Activities Summary 2012], 16 November 2012, Fairbanks; ADF&G, memorandum [ADF&G Fairbanks and Unit 26B Muskox Recovery Program–Field Activities Summary 2013], 19 December 2013, Fairbanks). Three male brown bears were lethally removed from Unit 26B in April and May 2012 and another 3 male brown bears in 2013 because they had either killed muskoxen or muskoxen were in imminent threat from the bears.

Three adult female muskoxen ≥1-year old (including 1 radiocollared muskox) were killed by brown bears during April–June 2012. One radiocollared adult female muskoxen ≥1-year old was killed by a brown bear in 2013. These numbers (3 and 1) compare to a 5-year mean of 9 adult muskoxen ≥1-year old killed by bears annually observed during 2007–2011, which were years prior to predator control. No adult muskoxen deaths unrelated to bear predation were documented during April–June 2012, but 20 muskoxen died by drowning during November 2012–March 2013, compared to a 5-year mean of 4 adult muskoxen ≥1-year old annually observed during 2007–2011.

There was some potential that removing brown bears in 2012 would result in a population increase. During the calving period in June 2012, at least 82% of the cows had a calf with 66% of the calves surviving to October. These data indicated the potential for an increase in the population by the following spring 2013. However, during early winter (late October–November), 20 muskoxen drowned in a small lake. If these animals had not drowned, the population would have increased by approximately 14%.

The population remained stable in 2013, and calf production was lower with only 58% of the cows having a calf, and survival to October was considerably lower at 41% (Table 1). Calf survival to the end of June was good (73%), so a substantial proportion of the mortality on calves occurred post-June after our monitoring surveys were suspended. We do not know the causes of calf mortality during July through October. By the following spring in 2014, the population estimate was slightly lower than observed in previous years (181 compared to approximately 193 during 2007–2013; Table 1); however, we suspected we were missing 1 or 2 bull groups.

The Muskox Recovery Program did not receive funding for fiscal years 2014 and 2015; therefore we were unable to intensively monitor the population during 1 April–30 June to determine minimum number of calves born, determine summer calf survival, capture most mortality events, and lethally remove brown bears threatening or killing muskoxen. We did not suspend the

program entirely, but we would lethally remove brown bears threatening or killing muskoxen when we were conducting other fieldwork, particularly during the end of April. We continued to conduct the survey and inventory work on Unit 26B muskox, which included a precalving population estimate and composition survey in April and 2 radiotracking flights in June to provide an index to calf production and maintain an adequate sample size of radio collars on adult female muskoxen. In 2014 no brown bears were lethally removed. Two radiocollared muskoxen were found dead in April 2014 of unknown causes. In 2015, 1 brown bear was lethally removed. Three radiocollared muskoxen were found dead in April of unknown causes, and 1 radiocollared muskoxen was killed by a brown bear in June 2015.

CONCLUSIONS AND RECOMMENDATIONS

The overall population size in Units 26B and 26C declined considerably during 2001–2007, but the population dynamics differed between the 2 units. Abundance of calves, yearlings, and adults began declining in Unit 26C in 1999. Reynolds (2002) hypothesized at that time that the major factors influencing the decline in Unit 26C likely included weather (and its effects on female body condition, reproductive success, and winter foraging) and predation by brown bears. In Unit 26B, abundance of calves and yearlings was stable during 1999–2006, but numbers of muskoxen declined during 2003–2006. Thus, mortality rates likely exceeded recruitment. The Unit 26B population declined through 2007 but has remained stable since then at just below 200 muskoxen.

During 2007–2011, ADF&G research staff documented that brown bear predation on muskoxen was a primary source of mortality for muskoxen in Unit 26B. In April 2012, ADF&G implemented a Unit 26B muskox recovery program that authorized a predation control plan to reduce the effects of brown bear predation on muskoxen by selectively removing brown bears threatening or killing muskoxen. Although there may have been some evidence in 2012 that removing brown bears would ultimately result in a population increase, no such effect occurred because 20 muskoxen drowned in early winter 2012. The population has remained stable following 2 years of intensive monitoring of muskoxen groups to lethally remove those brown bears threatening or killing muskoxen.

Harvest rates of muskoxen during 1996–2005 were below 5% of the entire population (Units 26B and 26C combined) and within each unit (Unit 26B and Unit 26C) during growth and decline of the herd. Although it is unlikely that this low harvest rate exacerbated the decline; it may have contributed to the decline. Additionally, most of the harvest was comprised of males (>80%), and it is possible that removal of the large bulls that protect herds may have had some effect on the survival of females, calves, and younger bulls.

We did not meet our first goal to provide opportunities to harvest muskoxen while maintaining healthy, stable muskox populations. No permits were issued for muskoxen hunting during the report period (RY12–RY14) because the population was fewer than 200 animals.

We met Goal 2 to minimize detrimental effects that muskoxen may have on caribou and caribou hunting. No such effects were noted during RY12–RY14.

We partially met Goal 3 to cooperate and share information about muskoxen among users (e.g., local and nonlocal residents and local, state, and federal agencies) to develop and implement

harvest, management, and research programs. We provided information at state and federal advisory committee meetings.

We met Goal 4 of providing opportunities to view and photograph muskoxen. Viewing and photography were possible, particularly near the Dalton Highway, where small groups congregated during summer and where much of the muskoxen population resided during RY12–RY14. Improvements to the Dalton Highway have increased public use and resulted in increased traffic and greater interest in muskoxen by both hunters and nonhunters.

We did not meet our first objective to increase the eastern Unit 26A, Unit 26B, and Unit 26C contiguous muskoxen population to 300 muskoxen ≥1-year old by reducing brown bear predation on muskoxen in Unit 26B, partially because funding was not provided after 2013. We did not make any progress toward this objective; the population remained stable at 198 muskoxen in 2015. Estimating population growth rate as a result of the selective removal treatment is difficult. However, during 1987–1995, the annual rate of increase for the population was 7%. This growth rate may reasonably represent the population growth potential if reducing bear predation resulted in higher survival, and habitat is not limiting under this scenario, it would take approximately 7 years for the muskoxen population to increase from 190 ≥1-year old (the 2011 estimated population size) to 300 ≥1-year old. We are currently into the program 3 years with no increase in the population.

Because the population was not at least 300 muskoxen, we were unable to achieve objective 2 to maintain a harvest rate of 1–3% of the population.

RECOMMENDATIONS

To better clarify goals and objectives, I recommend changing the management goals, objectives, and activities to the following:

Management Goals

1. Allow for growth and expansion of Northeast Alaska muskoxen into historic ranges.
2. Provide opportunities to harvest Northeast Alaska muskoxen on a sustained yield basis.
3. Provide opportunities to view and photograph muskoxen.
4. Minimize any detrimental effects that muskoxen may have on caribou and caribou hunting.

Management Objectives and Activities

1. Maintain a population of at least 300 muskoxen in the eastern Unit 26A, Unit 26B, and Unit 26C contiguous muskoxen population.
   - Conduct precalving surveys in early April to determine population size.
   - Conduct ground-based composition counts in April to determine herd composition.
   - Maintain 20–30 radio collars on adult female muskoxen to assist in locating groups of muskoxen during precalving surveys and composition counts.

- Reduce brown bear predation on muskoxen in Unit 26B when we determine it would be effective and funding is available.

2. Maintain a harvest rate of 1–3% per year of the spring precalving population in eastern Unit 26A and Unit 26B, when the population is at least 300 muskoxen and is considered to be growing.
   - Administer permit hunts and monitor results of the hunts.
   - Allow the population to grow to its historical high of 650 muskoxen distributed contiguously across eastern Unit 26A, Unit 26B, and Unit 26C.

REFERENCES CITED

Alaska Administrative Code. 2015. State of Alaska, Legislative Affairs Agency, Juneau. http://www.legis.state.ak.us/basis/folio.asp (Accessed 14 January 2016).

Alaska Department of Fish and Game. 2012. Operational plan for Unit 26B muskox recovery, 2012–2018. Division of Wildlife Conservation, Juneau. http://www.adfg.alaska.gov/index.cfm?adfg=intensivemanagement.unit26b#anchor (Accessed 14 January 2016).

Arthur, S. M. 2007. Distribution, movements, and survival of muskoxen in northeastern Alaska. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid Research Annual Performance Report 1 July 2006–30 June 2007, Federal Aid in Wildlife Restoration Project 16.10, Juneau. http://www.adfg.alaska.gov/static-f/home/library/pdfs/wildlife/research_pdfs/muskox-dist-move07.pdf (Accessed 14 January 2016).

Arthur, S. M. 2008. Distribution, movements, and survival of muskoxen in northeastern Alaska. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid Research Annual Performance Report 1 July 2007–30 June 2008, Federal Aid in Wildlife Restoration Project 16.10, Juneau. http://www.adfg.alaska.gov/static-f/home/library/pdfs/wildlife/research_pdfs/muskox-dist-move08.pdf (Accessed 14 January 2016).

Arthur, S. M., and P. A. Del Vecchio. 2009. Distribution, movements, and survival of muskoxen in northeastern Alaska. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid Research Annual Performance Report 1 July 2008–30 June 2009, Federal Aid in Wildlife Restoration Project 16.10, Juneau. http://www.adfg.alaska.gov/static-f/home/library/pdfs/wildlife/research_pdfs/16.10_09.pdf (Accessed 14 January 2016).

Golden, H. N. 1989. Units 26B and 26C muskox. Pages 23–37 [*In*] S. O. Morgan, editor. Muskox management report of survey and inventory activities 1 July 1987–30 June 1988. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Study 16.0, Juneau.

Lenart, E. A. 1999. Units 26B and 26C muskox. Pages 30–43 [*In*] M. V. Hicks, editor. Muskox management report of survey–inventory activities 1 July 1996–30 June 1998. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Study 16.0, Juneau.

Lenart, E. A. 2003. Units 26B and 26C muskox. Pages 54–71 [*In*] C. Healy, editor. Muskox management report of survey and inventory activities 1 July 2000–30 June 2002. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Project 16.0, Juneau.

Lenart, E. A. 2005. Units 26B and 26C muskox. Pages 49–68 [*In*] C. Brown, editor. Muskox management report of survey and inventory activities 1 July 2002–30 June 2004. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Project 16.0, Juneau.

Lenart, E. A. 2007. Units 26B and 26C muskox. Pages 49–69 [*In*] P. Harper, editor. Muskox management report of survey and inventory activities 1 July 2004–30 June 2006. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Project 16.0, Juneau.

Lent, P. C. 1998. Alaska's indigenous muskoxen: A history. Rangifer 18(3-4):133–144.

O'Brien, C. M. 1988. Characterization of muskox habitat in northeastern Alaska. Thesis, University of Alaska Fairbanks.

Paul, T. W. 2009. Game transplants in Alaska. Alaska Department of Fish and Game, Division of Wildlife Conservation, Technical Bulletin 4, 2nd edition, Juneau.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: The staggered entry design. Journal of Wildlife Management 53(1):7–15. doi:10.2307/3801296

Reynolds, P. E. 2002. Muskoxen in the Arctic National Wildlife Refuge, Game Management Unit 26C, 2001–2002. U.S. Fish and Wildlife Service. Arctic National Wildlife Refuge. Fairbanks, Alaska.

Reynolds, P. E. 2005. Muskoxen in the Arctic National Wildlife Refuge, Game Management Unit 26C, 2004–2005. U.S. Fish and Wildlife Service. Arctic National Wildlife Refuge. Fairbanks, Alaska.

Reynolds, P. E. 2006. Muskoxen in the Arctic National Wildlife Refuge, Game Management Unit 26C, 2005–2006. U.S. Fish and Wildlife Service. Arctic National Wildlife Refuge. Fairbanks, Alaska.

Reynolds, P. E. 2007. Muskoxen in the Arctic National Wildlife Refuge, Game Management Unit 26C, 2006–2007. U.S. Fish and Wildlife Service. Arctic National Wildlife Refuge. Fairbanks, Alaska.

Reynolds, P. E. 2008. Muskoxen in the Arctic National Wildlife Refuge, Game Management Unit 26C, 2007–2008. U.S. Fish and Wildlife Service. Arctic National Wildlife Refuge. Fairbanks, Alaska.

Reynolds, P. E., H. V. Reynolds, and R. T. Shideler. 2002. Predation and multiple kills of muskoxen by grizzly bears. Ursus 13:79–84.

Zarnke, R. L., Hong, Li, and T. B. Crawford. 2002. Serum antibody prevalence of malignant catarrhal fever viruses in seven wildlife species from Alaska. Journal of Wildlife Diseases 38:500–504.

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Table 1. Units 26B (and eastern 26A) and 26C muskox precalving population estimates and composition counts, Alaska, 1990–2014[a]

Location[c]/ Year	Precalving population estimate[d] Muskoxen observed	June and April composition[b] Date	Muskoxen classified (excluding calves)	No. cows >2-yr	Bulls >3-yr: 100 cows >2-yr (no. bulls >3-yr)	Yearling: 100 cows>2-yr (no. yearling)	No. calves[e]
Unit 26B, eastern Unit 26A							
1990	122		83 (69)	34	41 (14)	32 (11)	n/a, 14, n/a
1991	156		98 (75)	35	69 (24)	26 (9)	n/a, 23, n/a
1992	224		193 (162)	77	43 (33)	40 (31)	n/a, 31, n/a
1993	237		131 (103)	51	41 (21)	20 (10)	n/a, 28, n/a
1994	166		91 (76)	28	46 (13)	68 (19)	n/a, 15, n/a
1995	330		145 (123)	53	55 (29)	36 (15)	n/a, 22, n/a
1996	266		44 (41)	23	35 (8)	22 (5)	n/a, 3, n/a
1997	279	30 Jun	123 (107)	47	49 (23)	51 (24)	n/a, 16, n/a
1998	207	26–27 Jun	97 (78)	42	24 (10)	24 (10)	n/a, 19, n/a
1999	237	22–23 Jun	194 (162)	71	62 (44)	32 (23)	n/a, 32, n/a
2000	277	7 Jun	172 (131)	68	31[f] (21)	25 (17)	n/a, 41, n/a
2001		10–11 Jun	286 (239)	99	64[f] (63)	39 (39)	n/a, 47, n/a
2002	284	8–9 Jun	241 (203)	103	27[f] (28)	23 (24)	n/a, 38, n/a
2003	302	26–28 Jun	162 (134)	53	87[f] (46)	15 (8)	n/a, 28, n/a
2004	198	7–8 Jun	153 (123)	66	44 (29)	17 (11)	n/a, 30, n/a
2005	186	5–7 Jun	119 (89)	46	39 (18)	28 (13)	n/a, 30, n/a
2006	216	4–5 Jun	133 (119)	56	29 (16)	41 (23)	n/a, 14, n/a
2007	196	13 Apr	153 (n/a)	73	41 (30)	16 (12)	35, 13, 13
2007		4–6 Jun	131 (120)	54	35 (19)	33 (18)	11
2008	192	21 Apr	162 (n/a)	79	28 (22)	18 (14)	67, 41, 34
2008		19–20 Jun	200 (163)	88	40 (35)	14 (12)	37
2009	196	14–15 Apr	174 (n/a)	82	52 (43)	39 (32)	63, 45, 45
2010	187	15–16 Apr	187 (n/a)	88	25 (22)	35 (31)	52, 35, 32
2011	190	14–15 Apr	186 (n/a)	84	31 (26)	39 (33)	55, 29, 29
2012	191	18–22 Apr	175 (n/a)	74	42 (31)	32 (24)	61, 49, 40
2013	197	20 Mar	190 (n/a)	85	46 (39)	40 (34)	41, 30, 17
2014	181[g]	23 Jun	177 (n/a)	82	30 (25)	17 (14)	n/a, 33, 26
2015	198	23 Apr	159 (n/a)	74	43 (32)	22 (16)	n/a, 36, 27–29

Location[c]/ Year	Precalving population estimate[d] Muskoxen observed	June and April composition[b] Date	Muskoxen classified (excluding calves)	No. cows >2-yr	Bulls >3-yr: 100 cows >2-yr (no. bulls >3-yr)	Yearling: 100 cows>2-yr (no. yearling)	No. calves[e]
Unit 26C							
1990	332		286 (242)	101	42 (42)	46 (46)	44
1991	282		377 (305)	144	36 (52)	31 (45)	72
1992	283		324 (273)	114	56 (64)	45 (51)	51
1993	326		404 (323)	143	43 (62)	36 (51)	81
1994	318		341 (285)	120	53 (63)	42 (51)	56
1995	321		240 (215)	88	58 (51)	36 (32)	25
1996	332		195 (157)	75	41 (31)	23 (17)	38
1997	324		362 (324)	146	48 (70)	32 (46)	38
1998	331		211 (186)	90	42 (38)	22 (20)	25
1999	254		272 (257)	127	60 (76)	16 (21)	15
2000	246		184 (183)	97	40 (39)	17 (17)	1
2001	168		47 (46)	27	48 (13)	0 (0)	1
2002	35		71 (64)				7
2003	29						
2004	30						
2005	9						
2006	1						
2007[h]	0						
2008[h]	37						
2009–2015[h]	0						

[a] Data source for Unit 26C (all years) and Unit 26B (1990–1997); P. E. Reynolds, U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, Fairbanks.
[b] Composition classification was conducted during the second week of June through early July during 1990–2008 and during mid-April 2007–2011.
[c] Unit 26B surveys occurred east of the Sagavanirktok River until 1996 when the entire subunit from the Colville to the Canning rivers was surveyed. Unit 26C surveys encompassed the Canning to Clarence rivers. Beginning in 2007 a group on the Canning River (Units 26B and 26C boundary) was included in the Unit 26B population estimate and not reported in Unit 26C.
[d] Precalving estimates were determined in late March or April based on total muskoxen observed during systematic transect surveys or radiotracking flights.
[e] During 1990–2008, the number of calves includes calves observed on the ground during the June composition survey. During 2007–2013, in Unit 26B the first number in the column is the minimum number of calves observed born during 1 April–30 June; the second number in the column is the number of calves observed at the end of June and the third number in the column is the number of calves observed at the end of September or in October. In 2014 and 2015 the second number is the maximum number of calves observed during either an early or late June survey. The notation "n/a" indicates data not available.
[f] During 2000–2004, some or all 3-year-old bulls were included in the "Bulls >3-yr" category for Unit 26B. In 2001 all 3-year-old bulls were included.
[g] In 2014 we observed more muskoxen (excluding newborn calves) during June surveys compared to the precalving survey in April. We used the value derived in June as the precalving population estimate.
[h] During 2007–2015, a group on the Canning River (Unit 26B–26C boundary) was included in the Unit 26B population estimate and not reported in Unit 26C.

Table 2. Units 26B and 26C muskox harvest data by permit hunt, Alaska, regulatory years[a] 1996–2005.

Regulatory year	Hunt/ area[b]	Unit	Permits available[c]	Returned reports	Total hunters	Successful hunters[d]	Bulls	Cows	Total harvest
1996	TX108	26B (West)	3	3	3	2	2	0	2
	TX110	26B (East)	2	2	1	1	1	0	1
	RX113 (F)	26C	15	n/a	n/a	15	12	3[e]	15
1997	TX108	26B (West)	3	3	3	2	2	0	2
	TX110	26B (East)	2	2	1	1	1	0	1
	RX113 (F)	26C	15	n/a	n/a	10	9	1[e]	10
1998	TX108	26B (West)	9	9	4	4	3	1	4
	RX110	26B (East)	unlimited	9	5	3	3	0	3
	DX112	26B (East)	3	3	3	3	3	0	3
	RX113 (F)	26C	15	n/a	n/a	8	8	0	8
1999	TX108	26B (West)	9	9	5	1	1	0	1
	RX110	26B (East)	unlimited	3	0	0	0	0	0
	DX112	26B (East)	3	3	2	2	2	0	2
	RX113 (F)	26C	15	n/a	n/a	8	8	0	8
2000	TX108	26B (West)	10[f]	10	6	5	4	1	5
	RX110	26B (East)	unlimited	6	6	6	6	0	6
	DX112	26B (East)	3	3	3	3	3	0	3
	RX113 (F)	26C	15	n/a	n/a	6	5	1	6
2001	TX108	26B (West)	9	9	3	3	3	0	3
	RX110	26B (East)	unlimited	5	4	4	4	0	4
	DX112	26B (East)	3	2	2	2	2	0	2
	RX113 (F)	26C	15	n/a	n/a	2	2	0	2
2002	TX108	26B (West)	9	7	6	5	unk	unk	5
	RX110	26B (East)	unlimited	2	1	1	1	0	1
	DX112	26B (East)	3	3	3	3	3	0	3
	RX113 (F)	26C	2	n/a	n/a	n/a	0	0	0
2003	TX108	26B (West)	9	9	5	2	2	0	2
	RX110	26B (East)	unlimited	0	0	0	0	0	0
	DX112	26B (East)	3	3	1	1	1	0	1
	RX113 (F)	26C	0	0	0	0	0	0	0
2004	TX108	26B (West)	9	5	4	4	3	1	4
	RX110	26B (East)	unlimited	5	3	1	1	0	1
	DX112	26B (East)	3	3	3	3	3	0	3
	RX113 (F)	26C	0	0	0	0	0	0	0
2005	TX108	26B (West)	9	9	7	4	2	2	4
	RX110	26B (East)	unlimited	0	0	0	0	0	0
	DX112	26B (East)	0	0	0	0	0	0	0
	RX113 (F)	26C	0	0	0	0	0	0	0

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 1996 = 1 July 1996–30 June 1997).
[b] Hunt areas: RX = registration; TX = Tier II; DX = drawing; F = federal hunt; 1007, 1013, 113 = Unit 26C; 1010, 110, and 112 = east of Dalton Highway and since regulatory year 1999 = east of Dalton Highway Management Corridor; 108 = west of Dalton Highway; 1012 = east of Jago River; 1014 = west of Jago River; Hunts RX1013(F) and RX113(F) are not registration hunts–they are lottery. Beginning in 2002, TX108 also included Unit 26A, east of 153°West longitude.
[c] Permits available may not equal permits issued in federal hunts because unused permits were reissued. In hunt RX110 unlimited number of permits available; harvest quota = 4.
[d] Determined from returned reports.
[e] Illegal animal(s).
[f] Only 9 permits were supposed to be issued, but 10 permits were issued due to a mistake in scoring. This was not considered a biological problem.

Table 3. Unit 26B East muskox hunter residency and success, Alaska, regulatory years[a] 1998–2004.

Hunt[b]/ Regulatory year	Successful			Unsuccessful			Total hunters
	Local[c] resident	Nonlocal resident	Total (%)	Local[c] resident	Nonlocal resident	Total (%)	
RX110							
1998	2	1	3 (60)	1	1	2 (40)	5
1999	0	0	0 (0)	0	0	0 (0)	0
2000	4	2	6 (100)	0	0	0 (0)	6
2001	4	0	4 (100)	0	0	0 (0)	4
2002	1	0	1 (100)	0	0	0 (0)	1
2003	0	0	0 (0)	0	0	0 (0)	0
2004	0	1	1 (33)	0	2	2 (67)	3
DX112							
1998	0	3	3 (100)	0	0	0 (0)	3
1999	0	2	2 (100)	0	0	0 (0)	2
2000	0	3	3 (100)	0	0	0 (0)	3
2001	0	2	2 (100)	0	0	0 (0)	2
2002	0	3	3 (100)	0	0	0 (0)	3
2003	0	1	1 (100)	0	0	0 (0)	1
2004	0	3	3 (100)	0	0	0 (0)	3

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 1998 = 1 July 1998–30 June 1999).
[b] RX110 = Tier I registration hunt in Unit 26B, east of the Dalton Highway Corridor Management Area; DX112 = drawing hunt in Unit 26B, east of the Dalton Highway.
[c] Local resident is a resident of Unit 26.

Table 4. Units 26B and 26C muskox hunter residency and success, Alaska, regulatory years[a] 1990–2005.

Regulatory year[b]	Successful				Unsuccessful hunters[d]	Total hunters[e]
	Local resident[c]	Nonlocal resident	Nonresident	Total		
1990	10	0	0	10	0	10
1991	5	0	0	5	0	5
1992	10	0	0	10	1	11
1993	9	0	0	9	0	9
1994	9	0	0	9	2	11
1995	12	0	0	12	0	12
1996	18	0	0	18[f]	1	19
1997	13	0	0	13	1	14
1998	14	4	0	18	5	23
1999	9	2	0	11	4	15
2000	15	5	0	20	1	21
2001	9	2	0	11	0	11
2002	6	3	0	9	1	10
2003	2	1	0	3	3	6
2004	4	4	0	8	2	10
2005	4	0	0	4	3	7

[a] Regulatory year (RY) begins 1 July and ends 30 June (e.g., RY90 = 1 July 1990–30 June 1991).
[b] Before RY86 only Alaska residents were allowed to hunt muskoxen. During RY90–RY97 muskox hunting was limited to local residents of Unit 26. In RY98 that portion of Unit 26B east of the Dalton Highway was opened to include all Alaska residents.
[c] Local resident is a resident of Unit 26.
[d] Incomplete residency data for "Unsuccessful" hunters because of lack of reporting in Unit 26C.
[e] From hunt reports received.
[f] One illegal muskox.

Table 5. Units 26B and 26C muskox harvest by transport method, Alaska, regulatory years[a] 1990–2005.

Regulatory year	Harvest by transport method							Total
	Highway vehicle	Airplane	Dog team/ski	Snowmachine	Boat	Off-road vehicle	Unk	
1990	0	1	1	6	0	0	0	8
1991	0	0	0	5	0	0	0	5
1992	0	0	0	10	0	0	0	10
1993	0	1	0	8	0	0	0	9
1994	0	0	0	9	0	0	0	9
1995	0	2	0	10	0	0	0	12
1996	0	0	0	17	1	0	0	18
1997	0	0	0	12	1	0	0	13
1998	1	0	0	15	2	0	0	18
1999	2	0	0	9	0	0	0	11
2000	2	0	0	16	3	0	0	21
2001	2	0	0	7	2	0	0	11
2002	2	1	0	3	3	0	0	9
2003	1	0	0	1	1	0	0	3
2004	3	0	1	0	3	0	1	8
2005	0	0	0	2	1	1	0	4

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 1990 = 1 July 1990–30 June 1991).

Table 6. Survival rates of radiocollared female muskox, Alaska, 1999–2014.

Period	No. of radiocollared muskoxen[a]	No. of mortalities	Survival rate	Standard deviation
1 June 1999–31 May 2000	13	3	0.77	0.102
1 June 2000–31 May 2001	10	0	1.0	0
1 June 2001–31 May 2002	12	3	0.75	0.108
1 June 2002–31 May 2003	9	1	0.89	0.99
1 June 2003–31 May 2004	10	4	0.60	0.120
1 June 2004–31 May 2005	12	0	1.0	0
1 June 2005–31 May 2006	14	2	0.86	0.087
1 June 2006–31 March 2007	15	1	0.93	0.062
1 April 2007–31 March 2008	22	6	0.73	0.081
1 April 2008–31 March 2009	26	4	0.85	0.065
1 April 2009–31 March 2010	22	2	0.91	0.058
1 April 2010–31 March 2011	20	5	0.75	0.084
1 April 2011–31 March 2012	21	2	0.90	0.061
1 April 2012–31 March 2013	21	3	0.86	0.071
1 April 2013–31 March 2014	26	1	0.96	0.037
1 April 2014–31 March 2015	25	2	0.92	0.052

[a] During 1999–2006 the number of radiocollared muskoxen is the number of active radio collars on 1 June, and the new collars deployed during the first 2 weeks of June. However, in 2001, 1 was collared in July, and in 2004, 1 was collared in September, and these were included. During 2007–2015, the number of radiocollared muskoxen is the number of active radio collars on 1 April. Collars deployed after these times were included in the following year's calculations.