Species Management Report ADF&G/DWC/SMR-2015-2

Muskox Management Report of Survey-Inventory Activities, 1 July 2012–30 June 2014

Patricia Harper and Laura A. McCarthy, editors

2017

Alaska Department of Fish and Game Division of Wildlife Conservation

Species Management Report, ADF&G/DWC/SMR-2015-2

Muskox management report of survey-inventory activities, 1 July 2012–30 June 2014

Alaska Department of Fish and Game
Division of Wildlife Conservation
P.O. Box 115526
Juneau, Alaska 99811-5526

Many of the activities referenced in this report were funded in part by the Federal Aid in Wildlife Restoration Program, Project 16.0.

Species management reports provide information about species that are hunted or trapped and management actions, goals, and recommendations for those species. Detailed information is prepared for each species every two or three years, depending on the species, by the area management biologist for game management units in their areas. Reports are not produced for species that are not managed for hunting or trapping or for areas where there is no current or anticipated activity. The individual unit reports are compiled in this statewide report. Unit reports are reviewed and approved for publication by regional management coordinators.

Any information taken from this report should be cited with credit given to authors and the Alaska Department of Fish and Game. Authors are identified at the end of each unit section.

If this report is referenced in its entirety, please reference as follows:

Harper, P., and L. A. McCarthy, editors. 2015. Muskox management report of survey-inventory activities 1 July 2012–30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-2, Juneau.

Please note that this report was released as a complete set in 2017, but is part of the 2015 set of species management reports. We encourage referencing this report as a 2015 report to maintain understanding of when reports were written and ease of locating this particular set of reports.

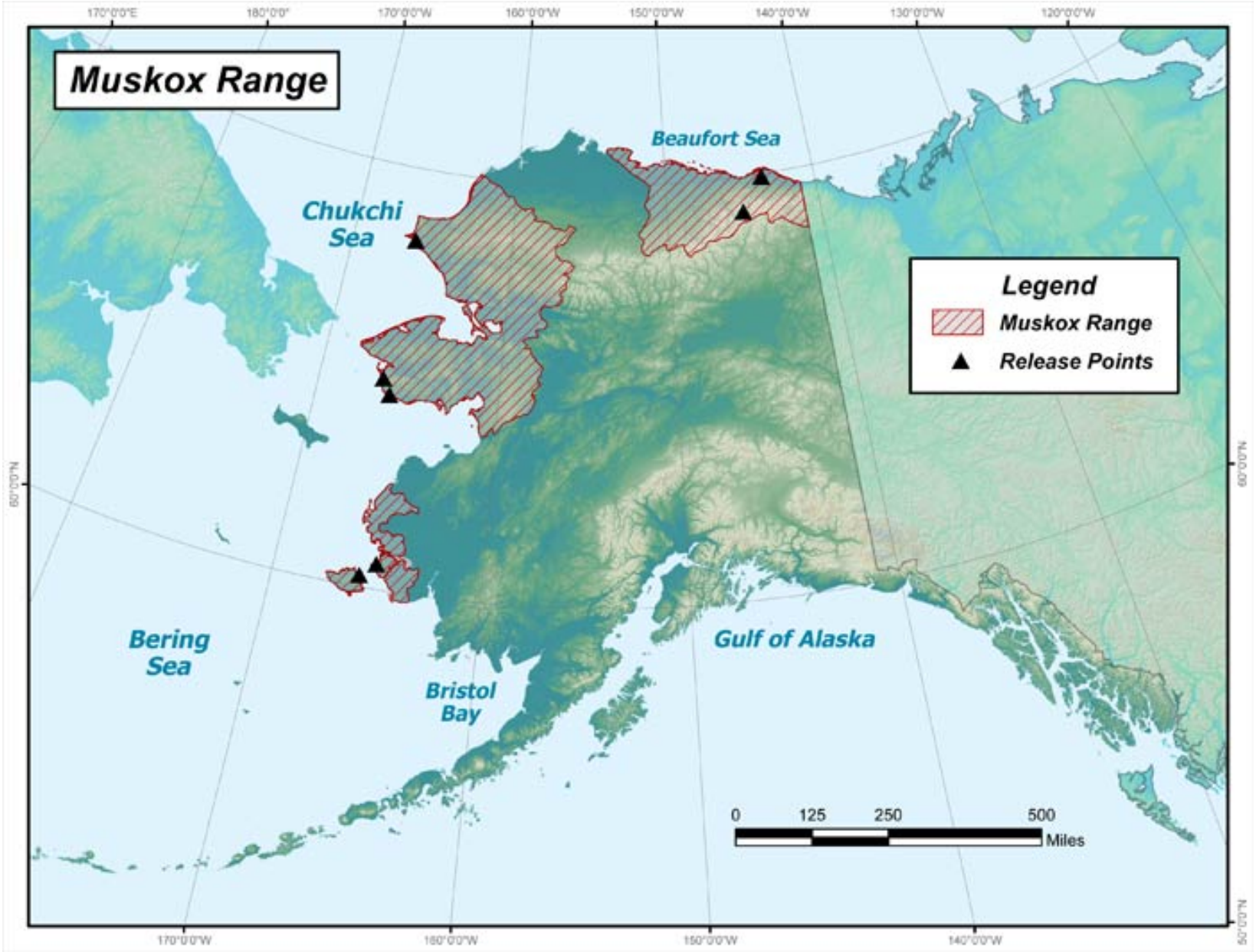
These reports are available from the Alaska Department of Fish and Game's Division of Wildlife Conservation, P.O. Box 115526, Juneau, Alaska 99811-5526; phone (907) 465-4190; email: dfg.dwc.publications@alaska.gov; website: www.adfg.alaska.gov. The report may also be accessed through most libraries, via interlibrary loan from the Alaska State Library or the Alaska Resources Library and Information Service (www.arlis.org).

Cover Photo: A young muskox grazes on the tundra with adults nearby, near Kotzebue, Alaska. ©2014 Jim Dau.

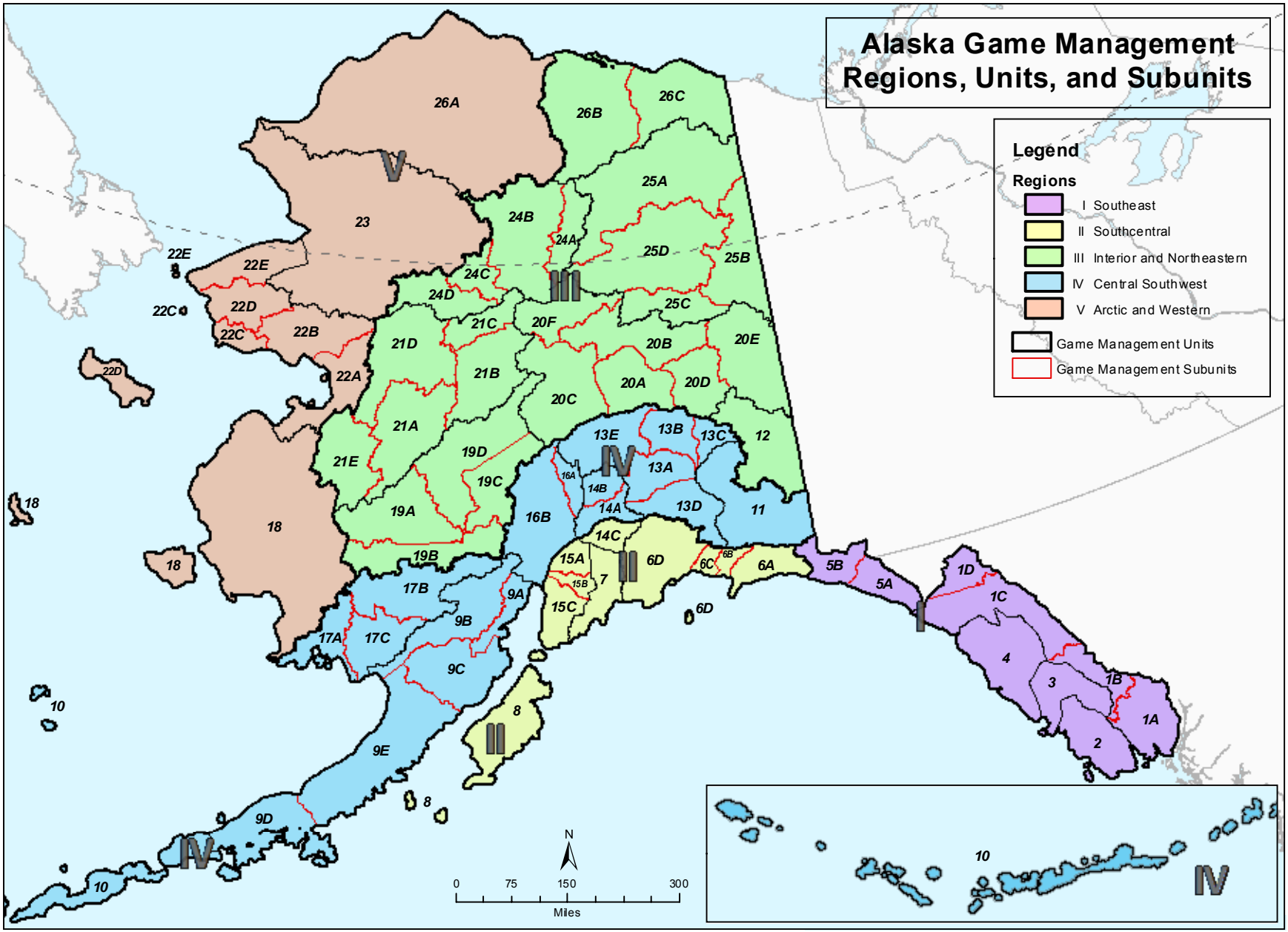
MUSKOX MANAGEMENT REPORT

TABLE OF CONTENTS

From: 1 July 2012
To: 30 June 2014


Muskox Range
Beaufort Sea
Chukchi Sea
Bering Sea
Bristol Bay
Gulf of Alaska
Legend
Muskox Range
Release Points
0 125 250 500
Miles
170°0'0"E
180°0'0"
170°0'0"W
160°0'0"W
150°0'0"W
140°0'0"W
130°0'0"W
120°0'0"W
60°0'0"N
70°0'0"N
170°0'0"W
160°0'0"W
150°0'0"W
140°0'0"W

11


Alaska Game Management
Regions, Units, and Subunits
Legend
Regions
I Southeast
II Southcentral
III Interior and Northeastern
IV Central Southwest
V Arctic and Western
Game Management Units
Game Management Subunits
N
0 75 150 300
Miles

Alaska Department of Fish and Game
Division of Wildlife Conservation
(907) 465-4190 – PO Box 115526
Juneau, AK 99811-5526

CHAPTER 1: MUSKOX MANAGEMENT REPORT

From: 1 July 2012
To: 30 June 2014

LOCATION

GAME MANAGEMENT UNIT: 18 (41,159 mi^2)

GEOGRAPHICAL DESCRIPTION: Yukon–Kuskokwim Delta

BACKGROUND

NUNIVAK ISLAND

Muskoxen were once widely distributed in northern and western Alaska but were extirpated by the middle or late 1800s. In 1929, with the support of the Alaska Territorial Legislature, the U.S. Congress initiated a program to reintroduce muskoxen in Alaska. Thirty-one muskoxen were introduced from Greenland to Nunivak Island in Unit 18 during 1935–1936, as a first step. The Nunivak Island population grew slowly until approximately 1958 and then began a period of rapid growth. The first hunting season was opened in 1975, and since 1981 the population has fluctuated between approximately 400 and 650 animals (Table 1), exhibiting considerable reproductive potential, even under heavy harvest regimes. Periods of low natural mortality and absence of predators benefit the Nunivak muskox population. Since 1992 a management plan with goals and strategies developed cooperatively by local organizations, land owners, stakeholders, subsistence users, and managing agencies has been used by the department as a basis for population and hunt management on Nunivak Island (Alaska Department of Fish and Game 1992).

NELSON ISLAND

During March 1967 and March 1968 groups of 8 and 23 subadult muskoxen, respectively, were translocated from Nunivak Island to Nelson Island, 20 miles across Etolin Strait. The Nelson Island muskox population exhibited an average annual growth rate of 22% between 1968 and 1981. When the population approached the management goal of 200–250 animals in 1981, the first hunting season was opened. From 1981 through 1992 the population fluctuated around 230 animals. In 1993 and 1994 the population dropped below 200 animals, resulting in closure of hunting opportunity in 1995 and 1996. From 1995 through 2004 the population increased from 217 animals to just over 300. From 2007 through 2014 the population experienced consistent yearly growth, exceeding the upper management goal of 450 animals. In 2014 the population had a minimum count of 979 animals, the single highest count for Nelson Island (Table 2).

In 1995, partially in response to a declining population, a cooperative management plan was drafted through a joint planning effort of Nelson Island Native village corporations, U.S. Fish

and Wildlife Service (USFWS), subsistence users, and the department (Alaska Department of Fish and Game 1995). Since its inception, the draft plan has been used to guide population and hunt management on Nelson Island; it allows hunting when the population is above a minimum goal of 250 animals.

YUKON–KUSKOKWIM DELTA

From an unknown number of seed animals emigrating from Nelson Island, the mainland population has grown to a minimum of 200 muskoxen inhabiting the Yukon–Kuskokwim Delta (Y-K Delta). These muskoxen are scattered in small groups from the Kilbuck Mountains south of the Kuskokwim River to the Andreafsky Mountains north of the Yukon River. They are most consistently observed in the area around the mud volcanoes, Askinak and Kusivak mountains, in the area south and east of Baird Inlet, and more recently near Bethel. Poaching is the major factor preventing the mainland population from becoming firmly established. Marked muskoxen have been documented leaving Nelson Island for a period of up to two years before returning to the island. This behavior complicates muskox management for Nelson Island and makes it difficult to determine the size of the mainland population.

MANAGEMENT DIRECTION

MANAGEMENT OBJECTIVES

- Survey populations on Nunivak and Nelson Islands in alternate years, using fixed-wing and/or rotary-wing aircraft, to estimate population size and composition.

- Maintain a posthunt/precalving population of a minimum of 250 and a maximum of 450 muskoxen on Nelson Island, and a minimum of 500 and maximum of 550 muskoxen on Nunivak Island.

- Issue drawing and registration permits for harvesting muskoxen to maintain optimal size, composition, and productivity of the muskox populations on Nunivak and Nelson islands.

- Provide prehunt orientation and posthunt checkout to ensure hunters understand permit requirements, properly identify legal muskoxen, and report their harvests in a timely and accurate manner.

- Determine the distribution and dispersal of muskoxen on the mainland.

- Use the cooperative management plans for Nunivak and Nelson islands.

METHODS

Censuses were flown using a PA-12 fixed-wing aircraft on Nunivak Island in August 2013 and June 2014. Population census flights were flown using 2 PA-18-160 aircraft on Nelson Island in June 2014. No surveys were completed during 2013. On all flights we classified muskoxen into 6 categories: calves, yearlings, 2-year-olds, 3-year-old and older bulls, 3-year-old and older cows, or unknown classification.

Since fixed-wing aircraft (with inherently higher flight speeds) were used to conduct surveys, animals were clumped into broad classes of age-sex composition. Within the time available to

study each animal, group size, and terrain on each pass, it becomes impractical to determine more detailed age-sex classification. Broader categories of composition allow for fewer numbers of aerial passes to classify each group, resulting in fewer disturbances to groups during surveys. The use of digital cameras and telephoto photography of group sizes of 5 animals and larger has also helped increase accuracy in classification and helped further reduce the need for multiple passes over individual groups.

The terminology describing composition cohorts used a single classification system even though data collections covered a wide range of months including precalving surveys in March/April and postcalving surveys occurring June through October. Initially, composition counts were conducted using snowmachines in late winter during the precalving period. At this time the youngest cohort was 10 months old and called "yearling," while the next older cohort, being nearly 2 years old, was called "2-year-olds", and so forth for older cohorts. In subsequent years, as surveys were completed between late June and early October, a "calf"' classification was added to the terminology to accommodate the presence of younger-aged animals. The "yearling" and older age classes were retained in both survey periods such that precalving age classes are "short" ages (e g. yearlings are 10 months old) and postcalving age classes are "long" ages (e g. yearlings range 14–18 months old). The standardized single classification system avoids confusion of multiple age classes from the same population, but means that comparing early records of precalving data with more recent postcalving records has a difference of 6–9 months within the same age class.

Currently, census and composition surveys have been completed after the calving period and before hunting commences so they are described as 'prehunt/postcalving' surveys. To express results as 'posthunt/precalving' levels, the number of calves was subtracted from the prehunt/postcalving census counts. This was done to compare the current number to management goals that were established in the cooperative agreements for both Nunivak and Nelson islands. These goals were all stated in posthunt/precalving terms.

Harvest data are summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY12 = 1 July 2012–30 June 2013). Harvests during RY12 and RY13 were monitored through the reporting system for drawing and registration permit hunts.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

The muskox population on Nunivak Island began to increase during this reporting period. However, the population fell below the targeted range of 500–550 animals posthunt/precalving in 2009–2011, and remained below objectives in 2013, and 2014. Nunivak Island was not surveyed in 2012.The numbers of permits issued for cow muskox were decreased while a large but reduced harvest of bull muskoxen was maintained throughout the reporting period.

The Nelson Island muskox population fluctuates significantly more than the Nunivak Island muskox population. Several factors contribute to the variability in numbers of muskoxen, including human-induced mortality and movements on and off the island. The population during the reporting period showed steady growth and remained healthy and productive.

Population Size

During a fixed-wing census of Nunivak Island conducted in August 2013 we counted 533 muskoxen. During a fixed-wing census conducted in June 2014 we counted 563 muskoxen. No survey was done in 2012. Excluding calves from the counts, the Nunivak Island population was at 468 and 434 posthunt/precalving levels in 2013 and 2014, respectively. Both years were below the management goal of a 500–550 posthunt/precalving population for Nunivak Island (Table 1).

In July 2012, a prehunt/postcalving census of Nelson Island muskoxen using a fixed-wing aircraft counted 761 muskoxen. No survey was done in 2013. In June 2014, a prehunt/ postcalving census of Nelson Island muskoxen using a fixed-wing aircraft counted 979 muskoxen. Excluding calves from the counts, the Nelson Island posthunt/ precalving population was at 592 in 2012 and 795 in 2014. From 2001 Nelson Island has been above the lower end of the management goal of a 250 posthunt/precalving population. In 2013 the department established 450 muskox as an upper end of the management goal for the island in an effort to preserve winter range. The population has been above 450 posthunt/precalving since 2012. The history of population counts 1981–2015 are shown in Table 2.

We do not have survey information to estimate the population of mainland muskoxen. Incidental observations from March 2010 indicate a minimum of 100 animals of mixed age and sex on the mainland. The population remains small and widely dispersed in Unit 18, with single animals and small groups now being observed in parts of Unit 19. Groups of muskoxen are commonly seen along the Unit 18/22A boundary. Lone bulls have been seen in Unit 17A. Muskoxen have been observed moving on and off of Nelson Island to and from the mainland, confounding census data in both areas.

Population Composition

No survey was conducted on Nunivak in 2012. In August 2013 the classification of muskoxen on Nunivak was 148 three-year-old or older bulls, 146 three-year-old or older cows, 32 two-year-old-bulls, 71 yearlings, 65 calves and 71 of unknown age and sex (Table 3). In June 2014 the classification was 113 three-year-old or older bulls, 158 three-year-old or older cows, 101 two-year-old-bulls and cows, 53 yearlings, 129 calves and 9 unknown (Table 4).

Muskoxen counted on Nelson Island in July 2012 were classified as 126 three-year-old or older bulls, 200 three-year-old or older cows, 42 two-year-old bulls, 103 yearlings, 169 calves, and 121 of unknown age (Table 5). No survey was conducted on Nelson Island in 2013. In June 2014, the classification was 176 three-year-old or older bulls, 257 three-year-old or older cows, 99 two-year-old bulls and cows, 131 yearlings, 184 calves, and 132 of unknown age (Table 6).

Distribution and Movements

Nunivak Island is a closed system. In the winter muskoxen are distributed throughout the island but are concentrated along the south and west sides of the island. In the summer muskoxen disperse more homogenously throughout the interior of the island.

Nelson Island muskoxen are distributed throughout the island but are concentrated on the cliffs of Cape Vancouver and on hills northeast of Tununak. Individuals and small groups are on the hills in the central portion of the island and along the escarpment above Nightmute.

Mainland muskoxen have been reported in the Kilbuck Mountains. In March 2011, an opportunistic flight from Bethel to Tuntutuliak, Kongiganak, Kipnuk, Chefornak, and Kasigluk and back to Bethel revealed 93 muskoxen in 5 separate mixed age-sex groups. Illegal harvest also confirms the distribution of animals elsewhere in Unit 18. In the winter of 2014 a single animal was poached just outside of Bethel city limits. In May 2013, a group of 20 muskoxen was near Bethel. This group evenly split into two groups, of which 9 animals remained near Bethel through the winter of 2014–2015.

Locations of mainland muskoxen collared during a 1989 cooperative collaring project by the department and federal staff (USFWS) show additional areas of distribution in Unit 18. Five collars were deployed in 2 groups of 9 and 12 animals, respectively, south of the Yukon River between Bethel and Pilot Station. A mature cow collared south of the Yukon River near Pilot Station in 1989 moved approximately 160 miles east to a location near the village of Lower Kalskag, north of the Kuskokwim River. Then, in 1990, a hunter legally shot this muskox near Toksook Bay on Nelson Island, approximately 200 mi west of its last known location.

MORTALITY

Harvest

Season and Bag Limit.

RY12 and RY13 Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Unit 18, Nunivak Island:		
RESIDENTS and NONRESIDENTS**:**		
1 bull by drawing permit only. Up to 10 permits will be issued for the fall season and up to 50 for spring season; or 1 cow by registration permit only, with up to 60 cow permits issued on a first-come, first-served basis.	1 Sep–30 Sep 1 Feb–15 Mar	1 Sep–30 Sep 1 Feb–15 Mar
Unit 18, Nelson Island:		
RESIDENTS and NONRESIDENTS		
1 muskox by registration permit only; up to 42 permits will be issued on a first-come, first-served basis.	1 Feb–25 Mar	1 Feb–25 Mar

RY12 and RY13 Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Remainder of Unit 18	No open season	No open season

Board of Game (BOG) Actions and Emergency Orders. No emergency orders were issued during this reporting period. The board adopted 2 new regulatory actions at the March 2014 BOG meeting in Anchorage, effective in RY14. The first regulation change allows the department to adjust the number of permits for the spring hunt on Nelson Island, and allocates how and where the department will make permits available. The second regulation change allocated a portion of Nunivak Island bulls to the registration hunt in years when cow harvest is not warranted, but bull harvest is sustainable.

Human-induced Harvest. On Nunivak Island we are using management plan goals and strategies to manage hunts. In general, hunting is regulated by drawing and registration permits for fall and spring hunts. Hunters wishing to harvest bulls obtain permits through the statewide drawing permit process. Harvest of cows is regulated primarily using registration permits. Occasionally, when harvestable surplus of bulls allows, auction permits are made available to qualified organizations for fundraising purposes.

The history of total harvest of bulls and cows on Nunivak Island for RY92–RY14 is shown in Table 7. Most bulls taken during this period were harvested under the drawing permit system. In RY12, 26 bulls were harvested by hunters who had drawing permits, and an additional 2 bulls were harvested by auction permit recipients. In RY13 the harvest of 32 bulls by drawing permit included 7 bulls in the fall and 25 in the spring; additionally, 2 bulls were taken by hunters with an auction permit. Additional harvest after the reporting period included 28 bulls in RY14.

Registration permits for hunting Nunivak Island cows are distributed on a first-come, first-served basis in Bethel and Mekoryuk. Zero fall and 5 spring permits were issued in RY12; and 0 fall and 5 spring permits in RY13. Six cows were harvested in RY12, and 6 in RY13. Additional harvest after the reporting period included 5 cows in RY14 (Table 7).

The Nelson Island cooperative management plan has been used to guide hunting when the population is at or above 250 animals. When the population falls below 250 animals, the plan calls for cessation of hunting. We distribute Nelson Island registration permits on a first-come, first-served basis. The location where these permits are distributed rotates through the local villages of Newtok, Toksook Bay, Tununak, Nightmute, and Chefornak.

The history of permits issued and harvest of bulls and cows for RY81–RY14 is shown in Table 8. In RY12, 25 bull and 17 cow permits were distributed in Newtok, and in RY13, 10 bull and 32 permits were distributed in Toksook Bay. Twenty-one bulls and 15 cows were harvested in RY12. Ten bulls and 28 cows were harvested in RY13. Due to a regulation change effective after the reporting period 100 bull and 200 cow permits were distributed in RY14; harvest included 87 bulls and 138 cows.

We occasionally receive reports of muskoxen taken illegally. However, the number of animals taken is difficult to determine because we may receive reports of the same animal(s) from more than one source. We believe that some muskoxen taken illegally go undetected, so tallies of illegal harvest are considered minimum estimates. During RY12–RY14 a minimum of 3 muskoxen were harvested illegally on the mainland.

Permit Hunts. All hunts for muskoxen in Unit 18 are either by drawing permit or registration permit; the "Human-induced Harvest" section of this report includes specific information regarding permit hunts.

Hunter Residency and Success. Most drawing permittees for Nunivak Island are residents of Alaska. Four nonresidents were drawn and one purchased an auction permit in RY12; 7 nonresidents drew permits and 2 purchased auction permits in RY13. All Nelson Island registration permit hunters in this reporting period were Alaska residents.

Harvest Chronology. Most cow hunters on Nunivak Island harvested their muskox between late February and mid-March during periods of increasing daylight hours and milder weather. Nelson Island hunters also have taken most of their animals late in the season. Bull hunters on Nunivak Island usually hunted with guides or transporters. These hunters must fit their hunts into the times available with a particular guide or transporter and, consequently, these hunts were evenly distributed throughout the season.

Transport Methods. In the fall most hunters use a boat, all-terrain vehicle (ATV), or a small aircraft to access the hunting areas; access is occasionally on foot. All access in the winter season was by snowmachine.

Other Mortality

No natural predators of muskoxen are present on Nunivak Island, and large predators are rare on Nelson Island. Mainland muskoxen occur in areas that have few wolves, black bears, brown bears, and only occasionally polar bears, so predation rates are believed to be quite low. The only report of predation on muskox in Unit 18 was in the spring of 2009, when witnesses from Scammon Bay said a polar bear killed several small, presumably calf, muskoxen in the area between Scammon Bay and Hooper Bay. Most mortality is from illegal harvest, or by accidents—Drownings, stranding, falling off cliffs, and falling through ice—and weather such as freezing rain.

HABITAT

Assessment

No muskox habitat assessment activities were planned or completed during the reporting period. On Nunivak Island we believe reindeer have historically overgrazed the lichen range, yet the reindeer herd was within the management goal of no more than 2,000 animals precalving during this reporting period. In July 2012 an incomplete survey of Nunivak had a minimum count of 1,792 reindeer. The August 2013 count was 1,853 reindeer (Table 9). In June 2014 the number increased to 1,899 reindeer. The 2009 survey was the first time in 34 years that reindeer numbers were below the management goal objective of 2,000 animals that was established in the 1992 reindeer management plan (Wald 2009).

Anecdotally muskoxen taken by hunters on Nunivak and Nelson islands in recent years are reported to be in good body condition with adequate fat, and most harvested females are reported to be pregnant A department study of liver tissue from hunter harvested animals in RY07 and RY08 shows preliminary results that both island populations have healthy level of minerals and trace elements (Jones, unpublished data, ADF&G files, Bethel). Historically, Nunivak Island was overgrazed by wild caribou and more recently by high density of domesticated reindeer. There are no studies in place to determine if range conditions are improving as intended by managing for the current population goals of both reindeer and muskox on the island. Although we have no indications that habitat on Nelson Island has been damaged from overgrazing, there is concern that the high density of muskox on the western side of the island may impact winter habitat. Muskox habitat on the mainland is extensive and could support a much larger population.

Enhancement

No habitat enhancement activities were planned or completed during the reporting period. On Nunivak Island we are using hunt management strategies to meet muskox population goals and no enhancement is needed. On Nelson Island we are using hunt management strategies to meet muskox population goals and no enhancement is needed. Currently there are no habitat enhancement goals for the mainland.

NONREGULATORY MANAGEMENT PROBLEMS/NEEDS

There were no activities related to nonregulatory muskox management issues in Unit 18 during the reporting period.

CONCLUSIONS AND RECOMMENDATIONS

The Nunivak Island muskox population historically has been characterized by high productivity and low natural mortality. Currently, it is rebounding from a period of reduced productivity which has resulted in a lower population and harvest. We will continue to reduce the harvest of bulls and cows when the posthunt/precalving population is below 500 animals, or when bull:cow ratios warrant such actions. The management goals for Nunivak Island muskoxen include maintaining a maximum population of 500–550 muskoxen, translocation of muskoxen to other areas of Alaska, and providing opportunities to hunt muskoxen. When aerial surveys are conducted, it would be a minimum cost and high benefit to continue photographing Nunivak Island reindeer (simultaneously) while counting muskox. It adds approximately 1 hour of survey time to the muskox survey and substantiates direct counts of reindeer in survey reports to all parties involved in the Nunivak Island management plan.

Fluctuations in the observed size of the Nelson Island population are influenced by snow and ice conditions, the availability of escape terrain, and forage. The Nelson Island population is not confined to the island because animals can reach the mainland. The drop in population on Nelson Island from 297 in 1999 to 233 in 2000 was probably due to a combination of emigration and illegal harvest, both of which occurred and were reported during this reporting period. In recent years the Nelson Island population has continued to grow and appears healthy.

Variable annual harvests are needed to effectively manage the Nelson Island population in response to emigration and other natural losses. While the population is growing, we are harvesting variable numbers of muskoxen at a rate not exceeding 10% of the population to

maintain healthy age and sex components in the population. In each regulatory year of this reporting period the department issued the legal maximum of 42 permits. Currently Nelson Island has reached a population size that can support higher harvests. In March 2014 the BOG approved higher harvest rates on Nelson Island effective in RY14. Under the new regulation the department will attempt to reduce the population on Nelson Island to less than 550 animals within a 5-year period.

We continue to receive reports of mainland muskoxen, but illegal take of these animals is a key factor in preventing establishment of a reproductively viable population. A minimum of 200 muskoxen inhabit the extensive areas of mainland habitat. Although low numbers for mainland muskoxen are discouraging, there is still potential for a population to become established, particularly with the concern and cooperation shown by villagers from Nelson Island and with continued growth of the Nelson Island muskox population. The highly successful moose moratoriums in the area on both the Kuskokwim and Yukon rivers further demonstrate the ability of people to to work together to benefit local wildlife population.

A comprehensive information and education program explaining the benefits of a larger muskox population on the mainland of Unit 18 should be prepared for the benefit of local residents. We may want to pursue a cooperative project with the Yukon Delta National Wildlife Refuge and village councils to develop an educational program that encourages local residents to foster the establishment of a viable, harvestable mainland muskox population. We have purchased 3 GPS collars to use on adult cow muskoxen on the mainland to help determine distribution and movements. This will help promote understanding of the feasibility and importance of a large and healthy mainland population.

REFERENCES CITED

Alaska Department of Fish and Game. 1992. Nunivak Island reindeer and muskox management plan: Final, June 1992. Summary of cooperative planning by Alaska Department of Fish and Game, Alaska Soil and Water Conservation District, Bering Sea Reindeer Products, Bureau of Indian Affairs, NIMA Corporation, Soil Conservation Service, and U.S. Fish and Wildlife Service. Division of Wildlife Conservation, Bethel, Alaska.

Alaska Department of Fish and Game. 1995. Nelson Island muskox herd cooperative management plan. Preliminary draft, 24 January 1995. Summary of cooperative planning by Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, and Nelson Island native village corporations (United Villages of Nelson Island). Division of Wildlife Conservation, Bethel, Alaska.

Wald. E. J. 2009. Nunivak Island reindeer and muskoxen survey-2009. U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge, Technical Report Series Number 2009-01. Bethel, Alaska.

PREPARED BY:

Patrick Jones
Wildlife Biologist II

APPROVED BY:

Peter J. Bente
Survey-Inventory Coordinator

REVIEWED BY:

Phillip Perry
Wildlife Biologist III

Please cite any information taken from this section, and reference as:

Jones, P. 2015. Unit 18 muskox. Chapter 1, pages 1-1 through 1-17 [*In*] P. Harper and L. A. McCarthy, editors. Muskox management report of survey and inventory activities 1 July 2012–30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-2, Juneau.

While this unit report was actually published in 2016, it is part of the set of 2015 unit species management reports, so we suggest citing the report as a 2015 report to maintain its relationship to the other 2015 unit reports.

Table 1. Unit 18 Nunivak Island, Alaska muskox population survey results, 1981–2014.

Year	No harvest/precalving	Prehunt/postcalving	Posthunt/precalving
1981			494
1982			510
1983			483
1984		552	
1985			547
1986			487
1987			586
1988			609
1989			577
1990			568
1991			439
1992			407
1993			435
1994		438	361 [a]
1995		488	385 [a]
1996		435	363 [a]
1997		593	473 [a]
1998		643	536 [a]
1999		620	507 [a]
2000		628	526 [a]
2001		609	515 [a]
2002		527	440 [a]
2003		657	542 [a]
2004		638	526 [a]
2005		588	478 [a]
2006		615	524 [a]
2007	No survey	No survey	No survey
2008	No survey	No survey	No survey
2009		567	469 [a]
2010		517	433 [a]
2011		452	389 [a]
2012	No survey	No survey	No survey
2013		533	468 [a]
2014		563	434 [a]

[a] Are calculated numbers (removing the number of calves) from Prehunt/postcalving survey number for management purposes.

Table 2. Unit 18 Nelson Island, Alaska muskox population survey results, 1981–2014.

Year	No harvest/precalving	Prehunt/postcalving	Posthunt/precalving
1981		265	245
1982		217	190
1983		230	206
1984		200	176
1985		225	195
1986		287	263
1987		180	150
1988		213	183
1989		234	205
1990		239	208
1991		232	207
1992		214	182
1993		198	168
1994		149	123
1995	217		
1996	233		
1997		265	195 [a]
1998		293	225 [a]
1999		297	237 [a]
2000	233		172 [a]
2001		306	226 [a]
2002		293	220 [a]
2003		327	258 [a]
2004		318	253 [a]
2005	No Survey	No Survey	No Survey
2006	No Survey	No Survey	No Survey
2007		374	275 [a]
2008	No Survey	No Survey	No Survey
2009		541	453 [a]
2010		561	435 [a]
2011	No Survey	No Survey	No Survey
2012		761	592 [a]
2013		No Survey	795 [a]
2014		979	745 [a]

[a] Are calculated numbers (removing the number of calves) from Prehunt/postcalving survey number for management purposes.

Table 3. Unit 18 Nunivak Island, Alaska muskox composition, August 2013.

	Male		Female		Unknown		Total	
Age	*N*	%[a]	*N*	%[a]	*N*	%[a]	*N*	%[b]
+3 years[c]	148	50	146	50			294	55
2 years	32	100					32	6
Yearlings					71	100	71	13
Calves					65	100	65	12
Unknown					71	100	71	13
Total	180	55[d]	146	45[d]	207	37	553	

[a] Percentage of age-sex specific cohort based on number in sample.
[b] Percent of total sample classified.
[c] Adults are considered 3 years and older.
[d] Percentage based on known males and females (excludes unknown), *N*=326.

Table 4. Unit 18 Nunivak Island, Alaska muskox composition, June 2014.

	Male		Female		Unknown		Total	
Age	*N*	%[a]	*N*	%[a]	*N*	%[a]	*N*	%[b]
+3 years[c]	113	42	158	58			271	48
2 years					101	100	101	18
Yearlings					53	100	53	9
Calves					129	100	129	23
Unknown					9	100	9	2
Total	113	42[d]	158	58[d]	292	52	563	

[a] Percentage of age-sex specific cohort based on number in sample.
[b] Percent of total sample classified.
[c] Adults are considered 3 years and older.
[d] Percentage based on known males and females (excludes unknown), *N*=271.

Table 5. Unit 18 Nelson Island, Alaska muskox composition, July 2012.

	Male		Female		Unknown		Total	
Age	*N*	%[a]	*N*	%[a]	*N*	%[a]	*N*	%[b]
+3 years[c]	126	39	200	61			326	43
2 years	42	100					42	6
Yearlings					103		103	14
Calves					169		169	22
Unknown					121		121	16
Total	168	46[d]	200	54[d]	393		761	

[a] Percentage of age-sex specific cohort based on number in sample.
[b] Percent of total sample classified.
[c] Adults are considered 3 years and older.
[d] Percentage based on known males and females (excludes unkown), $N = 368$.

Table 6. Unit 18 Nelson Island, Alaska muskox composition, June 2014.

	Male		Female		Unknown		Total	
Age	*N*	%[a]	*N*	%[a]	*N*	%[a]	*N*	%[b]
+3 years[c]	176	41	257	59			433	44
2 years					99	100	99	10
Yearlings					131	100	131	13
Calves					184	100	184	19
Unknown					132	100	132	13
Total	176	41[d]	257	59[d]	546		979	

[a] Percentage of age-sex specific cohort based on number in sample.
[b] Percent of total sample classified.
[c] Adults are considered 3 years and older.
[d] Percentage based on known males and females (excludes unkown), $N = 433$.

Table 7. Unit 18 harvest of Nunivak Island, Alaska muskoxen, regulatory years[a] 1992–2014.

Regulatory year	Males	Females	Unknown	Total
RY92	45	31		76
RY93	47	26		73
RY94	35	23		58
RY95	20	5		25
RY96	20	19		39
RY97	25	24		49
RY98	26	30		56
RY99	43	45[b]		88
RY00	46[c]	40		86
RY01	45	42		87
RY02	43	41		84
RY03	45	43		88
RY04	45	42		87
RY05	43	44		87
RY06	37	38		75
RY07	29	39	1	69
RY08	39 [c]	35	6	80
RY09	51 [d,e]	30		81
RY10	47[e]	20		67
RY11	32 [c,e]	5		37
RY12	28 [e]	6 [b]		34
RY13	34 [e]	6 [b]		40
RY14	28 [e]	5		33
Total	853	639	7	1,499

[a] Regulatory year begins 1 July and ends 30 June, e.g., regulatory year 2012 = 1 July 2012–30 June 2013.
[b] Includes cow(s) taken by hunters issued a bull permit.
[c] Includes bull(s) taken by hunters issued a cow permit.
[d] 7 bulls taken during emergency order opening for stranded animals on Triangle and Abaramiut islands.
[e] Years that muskoxen were harvested with auction permits SX001 or SX003.

Table 8. Unit 18 permits and hunting harvest of Nelson Island, Alaska muskoxen, regulatory years[a] 1992–2014.

Regulatory	Permits issued		Muskoxen harvested	
year	Female	Male	Female	Male
RY92	15	15	15	15
RY93	0	30	0	30
RY94	5	25	5	21
RY95	0	0	0	0
RY96	0	0	0	0
RY97	10	10	7	10
RY98	10	10	10	10
RY99	15	15	15	15
RY00	15	15	14	15
RY01	0	0	0	0
RY02	2	1	1	2
RY03	15	23	14	22
RY04	15	24	14	24
RY05	15	23	14	21
RY06	15	23	11	15
RY07	15	15	14	14
RY08	14	24	13	22
RY09	17	25	15	21
RY10	17	25	17	20
RY11	17	25	15	20
RY12	17	25	15	21
RY13	10	32	10	28
RY14	200	100	138	87
Total	339	585	301	482

[a] Regulatory year begins 1 July and ends 30 June, e.g., regulatory year 2012 = 1 July 2012–30 June 2013.

Table 9. Nunivak Island, Alaska reindeer survey numbers, 2009–2014.

Year	Reindeer	Month of survey	Surveyed by	Survey method
2004	4,169	Late winter	Cooperative	Ground
2005	No Survey	No Survey	No Survey	No Survey
2006	3,250	March		Ground
2007	No Survey	No Survey	No Survey	No Survey
2008	No Survey	No Survey	No Survey	No Survey
2009	1,192	August	USFWS	Aerial
2010	1,605	July	ADF&G	Aerial
2011	1,534	October	ADF&G	Aerial
2012	1,792	July	ADF&G	Aerial
2013	1,853	August	ADF&G	Aerial
2014	1,899	June	ADF&G	Aerial

USFWS = U. S. Fish and Wildlife Service
ADF&G = Alaska Department of Fish and Game

Alaska Department of Fish and Game
Division of Wildlife Conservation
(907) 465-4190 PO Box 115526
Juneau, AK 99811-5526

CHAPTER 2: MUSKOX MANAGEMENT REPORT

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

LOCATION

GAME MANAGEMENT UNIT: 22 (25,230 mi^2) and southwest portion of 23 (1,920 mi^2)

GEOGRAPHIC DESCRIPTION: Seward Peninsula and that portion of the Nulato Hills draining west into Norton Sound

BACKGROUND

Historical accounts indicate muskoxen disappeared from Alaska by the late 1800s and may have disappeared from the Seward Peninsula hundreds of years earlier. In 1970, 36 muskoxen were reintroduced to the southern portion of the Seward Peninsula from Nunivak Island. An additional 35 muskoxen from the Nunivak Island herd were translocated to the existing population in 1981 (Machida 1997).

From 1970 through 2007, the initial population of 71 animals experienced high annual growth rates across broad areas of the Seward Peninsula, followed by moderate stability 2007–2010, and reached a peak population of 2,903 animals in 2010 (Fig. 1). Since 2010, the population status has been characterized by variable stability and decline depending on the area, portion of range, or subunit being considered. The range of the population has been expanding steadily. For comparative purposes, the population in the 'core count area' of the early population has been consistently assessed as census methods have evolved and as the population has colonized peripheral areas termed the 'expanded count area.' During the recent period of decline, hunt structures were changed and harvest quotas were reduced to promote population recovery. A population assessment in April 2015 shows the population has stabilized at 2,287 (95% CI: 1,895 to 2,832) animals (Fig. 1, Tables 1 and 2).

Muskoxen have extended their range to occupy suitable habitat throughout the Seward Peninsula. Herds are well established in Units 22A, 22B West, 22C, 22D, 22E, and 23 Southwest (Fig. 2). Survey flights and observations from members of the public have also documented groups of muskoxen in distant areas from the Seward Peninsula, including eastern areas of Unit 23, western portions of Unit 24 and western portions of Unit 21.

[1] Information from outside the reporting period may be included at the discretion of the Area Biologist.

MANAGEMENT DIRECTION

Muskox management on the Seward Peninsula is guided by recommendations from the Seward Peninsula Muskox Cooperators Group (The Cooperators) and local Fish and Game Advisory Committee groups. The Cooperators group is composed of staff from the department, U.S. National Park Service (NPS), U.S. Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), Bering Straits Native Corporation, Kawerak Inc., Reindeer Herders Association, Northwest Alaska Native Association, residents of Seward Peninsula communities, and representatives from other interested groups or organizations.

The management goals listed below form the basis of a cooperative interagency management plan for Seward Peninsula muskoxen developed during 1992 through 1994 (Nelson 1994) and follow muskox management policy guidelines developed by the department (ADF&G 1980).

MANAGEMENT GOALS

- Allow for continued growth and range expansion of the Seward Peninsula muskox population (SPP).

- Provide for sustained yield harvest in a manner consistent with existing state and federal laws by following the goals/objectives endorsed by the Seward Peninsula Muskox Cooperators Group and the Seward Peninsula Cooperative Muskox Management Plan (Nelson 1994)

- Manage muskoxen along the Nome road systems of Units 22B and 22C for viewing, education, and other nonconsumptive uses.

- Work with local reindeer herding interests to minimize conflicts between reindeer and muskoxen.

- Protect and maintain the habitats and other components of the ecosystem upon which muskoxen depend.

- Encourage cooperation and sharing of information among agencies and users of the resource in developing and executing management and research programs.

MANAGEMENT OBJECTIVES

- Complete population surveys at 2-year intervals to document changes in population and distribution.

- Complete rangewide composition surveys at 2-year intervals to document large scale patterns in age and sex structure of the population. Complete supplemental composition surveys on an annual basis to track trends of sex-age cohorts in selected areas.

- Participate in the Seward Peninsula Muskox Cooperators Group meetings and facilitate exchange of information and ideas among agencies and user groups.

- Administer Tier I/II subsistence hunts in Units 22B, 22C, 22D, 22E, and 23SW (the portion of Unit 23 west of and including the Buckland River drainage) in cooperation with federal managers of federal subsistence hunts in these units.

METHODS

Surveys for muskoxen have historically covered the entire Seward Peninsula to provide a minimum count of the entire population. Additional areas, including northern Unit 22A, southeastern Unit 23, and western Unit 24 were added during 2010 and 2012 surveys in response to population expansion into previously unoccupied and unsurveyed habitat. In 2015 the survey area was further expanded to include additional areas of the Nulato Hills (western portions of Unit 21D) to cover an area of continuous habitat at the boundary of Units 21D and 22 (Fig. 2). For comparative consistency, survey results corresponding to previous minimum count population survey efforts (1970–2007) are defined as the 'core count area' and include Units 22B, 22C, 22D, 22E, and 23SW. Survey results that include the 'core count area,' northern Unit 22A, Unit 23 Southeast, and Unit 21D are grouped together and defined as the 'expanded count area.' Staff from the department, NPS, BLM, and USFWS participated in the population survey. We adapted distance sampling techniques (Buckland et al. 2001, 2004) to estimate abundance. Methods for aerial survey coverage and subsequent analyses to estimate the population have not changed since 2010 and follow Schmidt et al. 2010, Schmidt and Gorn 2013, and Gorn and Dunker 2013.

Survey Coverage. No population counts were completed during the reporting period due to off-year scheduling in 2013 and inadequate snow cover in 2014. A Seward Peninsula muskox population survey was completed 9–13 March 2015. A survey summary can be found in Appendix A.

Abundance Estimation. Protocols for abundance estimation have been previously defined in Gorn and Dunker 2013. A summary of these methods can be found in Appendix B.

Population Composition. No composition counts were completed during the reporting period due to off-year scheduling in 2013 and inadequate snow cover in 2014. A Seward Peninsula muskox composition survey was completed 7 April–3 May 2015. Muskoxen were classified into 8 age/sex classes: bull ≥ 4yrs, bull = 3yrs, bull = 2yrs, cow ≥ 4yrs, cow = 3yrs, cow = 2yrs, short yearlings (15 months ≥ muskox ≥ 10 months), and calves (newly born animals) based on body size, horn characteristics and body conformation at the time of observation. The short yearling (SY) age class included yearlings to 15 months-old to make the survey comparable to previous composition surveys that were completed after the typical muskoxen calving period. Composition ratios were reported for mature bulls (MB) per 100 cows (C) and defined as MB:100C (males ≥ 4yrs/100 females ≥ 3yrs). Composition ratios were also reported for short yearlings (SY) per 100 cows defined as SY:100C (SY 15 months ≥ muskox ≥10 months/100 females ≥ 3yrs). Composition proportion estimates (expressed as percentages) were calculated for MB ($\hat{p}_{MB}$) and SY ($\hat{p}_{SY}$) and reported with 95% confidence. Percent recruitment was calculated as short yearlings per all muskox sampled, excluding calves [SY/(*N*-calves)]. A 2015 composition survey summary can be found in Appendix C.

Collaring, distribution, mortality. In 2008, the department began collaring muskoxen in Units 22B, 22C, and 22D to understand distribution, movement patterns, and mortality rates. A sample of 20–30 collared muskoxen has been maintained by deploying radio collars on cow muskox (≥ 3 years of age). Eight cow muskox and 7 cow muskox were collared in 2012 and 2013, respectively. Ground-based capture methods were used instead of helicopter-based methods. The

choice was made to minimize concerns over helicopter-based captures negatively affecting the health of other individuals within the target group as well as potentially biasing the selection of animals for capture. The majority of captures took place in the fall (September–October) allowing staff to use the Nome road system to gain access to muskox groups. Cooler fall temperatures (<45°F) allowed for the safe capture of muskox. One animal was collared using ground-based capture methods in March following composition surveys.

Aerial radiotracking flights were based out of Nome using a Piper PA-12 with either a solo pilot or a dual pilot/observer team. The location, distribution, and status of collared muskox were monitored with a scheduled frequency of at least 2 flights per month. Annual mortality estimates were calculated for a 12-month collar-year period (October–September) as the percentage of collared animals lost to non-hunting mortality compared to the total number of collared animals known to be active during the collar-year period. Collars with unknown fate (not mortality) and hunting mortalities were censored from the sample and not included when estimating mortality. The proportion of muskox that died annually is reported with 95% confidence.

Harvest data are available via the ADF&G website (https://secure.wildlife.alaska.gov/index.cfm?adfg=harvest.main)

Data are summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY12 = 1 July 2012–30 June 2013). Harvests were monitored through Tier I and Tier II hunt reports during RY12 and RY13 and added to the department database during the reporting period.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

The 2015 Seward Peninsula muskox population survey estimated 1,853 (95% CI: 1,541 to 2,285) animals in the 'core count area' and 2,287 (95% CI: 1,895 to 2,832) animals in the 'expanded count area.' We calculated unit and hunt area estimates for all areas (Table 1 and Appendix A). Additional information related to population status and trend can be found in Appendix A.

It is difficult to make direct comparisons between abundance estimates using different data collection protocols. Prior to 2010 a minimum count method assuming 100% coverage was used with varying effort between years, so individual minimum counts may not be directly comparable. Starting in 2010, we implemented a distance sampling protocol with 100% coverage of an expanded survey area. Because of constraints on search technique imposed by distance sampling protocol, the minimum count derived during distance sample surveys is expected to be lower than previous minimum counts. It is unknown how comparable previous minimum counts are to point estimates generated by distance sampling methods, but for the purposes of administering Seward Peninsula muskox hunts, point estimates from the distance sample technique are used in the same manner as previous minimum count abundance estimates. Despite different methodology, past minimum count survey results and distance-based estimates were used in a similar manner to determine population growth rates, changes in abundance between units, and long-term changes to the entire Seward Peninsula population. Because the new methodology allows future changes in effort to be quantified, the continuity of the data stream should improve.

The Seward Peninsula muskox population experienced 13% annual growth between 1970 and 2007. The population was stable between 2007 and 2010. The 2012 population estimate of 1,992 muskoxen in the 'core count area' represented a 13% annual rate of decline when compared to the 2010 population estimate, and the 2012 population estimate of 2,223 muskoxen in the 'expanded count area' represented a 1.8% annual rate of increase since 2000, when a minimum count survey found 1,797 muskoxen (Fig. 1). The 2015 population estimate represents a stable population between 2012 and 2015 (a 3 % increase during that time) in the 'expanded count area.' However, it should be noted that additional areas covered during the 2015 'expanded count area' were not covered during the 2012 count. The 2015 'core count area' estimate indicated a 7% decline between 2012 and 2015.

The 2015 population estimate found a southern and eastward movement pattern of muskox groups compared to groups detected during the 2012 survey (Fig. 2, Appendix A). We understand from past population surveys that muskox groups move between subunits in relatively short time periods, and the continued decreases in abundance since 2012 in Unit 22E (-32%) and Unit 22D Remainder (-25%) are likely due to eastward emigration and not primarily a function of mortality or overharvest of the subpopulation alone. Increases found during the same time period in Unit 22A (+131%), Unit 22B east of the Darby Mountains (+126%), and Unit 22C (+24%) are not likely caused by high productivity, reduced hunter harvest, or natural population growth; instead, they may be the result of redistribution of neighboring animals. Past population surveys documented high rates of increase in Unit 22C (42% annual rate of increase between 2005 and 2007) followed by the redistribution of animals into adjacent subunits (Units 22B and 22D). The history showing lack of neighboring animals available for redistribution in Unit 22B east of the Darby Mountains and Unit 22A may indicate the beginning of long-term natal increases in abundance and range expansion east of the 'core count area.'

The next population survey of the Seward Peninsula muskoxen population is scheduled for March 2017.

Population Composition

The results of composition surveys in Units 22A, 22B, 22C, 22D, 22E, 23SW and the Seward Peninsula expanded count area are summarized below. During the 2015 Seward Peninsula muskox population composition survey we classified 164 muskox in Unit 22A, 218 muskox in Unit 22B, 155 muskox in Unit 22C, 287 muskox in Unit 22D, 142 muskox in Unit 22E and 96 muskox in Unit 23 SW. Based on results from previous surveys, mature bulls are likely to be undercounted in composition surveys relative to other segments of the population, primarily because an unknown number occur as solitary animals and are less likely to be detected during incidental flights (e g., moose censuses) or pre-survey flights used to locate muskox groups for composition counts. However, we used group locations from the Seward Peninsula muskox population survey which included solitary animals and likely reduced some of this potential bias, thereby improving the precision of our estimate of bulls in the population.

Seward Peninsula Expanded Count Area: In April and May of 2015 we classified 1,062 muskox in 76 groups detected in the 'expanded count area'. Mature bull (MB) ratios and short yearling (SY) ratios per 100 cows (C) were as follows: 39 MB:100C ($\hat{p}_{MB}$=20% [18–22% at 95% CI]) and 17 SY:100C ($\hat{p}_{SY}$=8% [7–9% at 95% CI]).

Units 22A and 21D: In May 2015 we visited Unit 22A north of the Unalakleet River and a portion of Unit 21D in the Nulato Hills. This was the second time muskox composition surveys were conducted in Unit 22A and the first time surveys were completed in Unit 21D Nulato Hills. We classified 164 muskoxen in 18 groups and found: 64 MB:100C ($\hat{p}_{MB}$=24% [21–27% at 95% CI]) and 21 SY:100C ($\hat{p}_{SY}$=8% [6–10% at 95% CI]).

Unit 22B: In April 2015 we visited both Unit 22B West and Unit 22B East and classified 218 muskoxen in 20 groups. We found 44 MB:100C ($\hat{p}_{MB}$=22% [18–26% at 95% CI]) and 21 SY:100C ($\hat{p}_{SY}$=6% [4–8% at 95% CI]).

Unit 22C: In April 2015 we visited Unit 22C and classified 155 muskoxen in 8 groups. We found 45 MB:100C ($\hat{p}_{MB}$=26% [21–31% at 95% CI]) and 7 SY:100C ($\hat{p}_{SY}$=4% [2–6% at 95% CI]). This is the lowest recruitment observed in Unit 22C since 2002. This is also the lowest individual subunit recruitment rate observed during the 2015 composition survey.

Unit 22D: In April 2015 we visited Unit 22D and classified 287 muskoxen in 17 groups. We found 26 MB:100C ($\hat{p}_{MB}$=15% [12–18% at 95% CI]), and 19 SY:100C ($\hat{p}_{SY}$=11% [9–13% at 95% CI]).

Unit 22E: In April 2015 we visited Unit 22E and classified 142 muskoxen in 7 groups. We found 29 MB:100C ($\hat{p}_{MB}$=18% [13–23% at 95% CI]) and 21 SY:100C ($\hat{p}_{SY}$=10% [6–14% at 95% CI]).

Unit 23SW: In April 2015 we visited Unit 23SW and classified 96 muskoxen in 6 groups. We found 32 MB:100C ($\hat{p}_{MB}$=17% [12–22% at 95% CI]) and 26 SY:100C ($\hat{p}_{SY}$=14% [9–19% at 95% CI]).

Overall, rangewide estimates of MB:100C increased from 2012 to 2015. A similar trend was observed in the MB:100C estimates of individual subunits. Recruitment range-wide continues to be low (<10%) and remains a serious concern. Additional analysis of these results can be found in Appendix C.

Distribution and Movements

The Seward Peninsula population survey area was expanded in 2015 to include portions of Unit 21D (Fig. 2). The expanded effort was intended to further document range expansion of muskoxen emigrating east of the Seward Peninsula, and to provide survey coverage of all areas of known muskox habitat east of the Seward Peninsula.

Radio collars are primarily used to estimate natural mortality and exact locations of groups are not determined during every flight. However, radiotracking flights completed during the previous reporting period (Gorn and Dunker 2013) and current data continue to document the movement of collared cow (≥3 years old) muskox between Unit 22 subunits. A collared cow previously located in the Casadepaga drainages (Unit 22B) has recently been located in the vicinity of Deering (Unit 23 Southwest). Similarly, a collared cow previously located near the Sinuk River was found deceased in Unit 22E along the Nuluk River. In both instances the animals had traveled approximately 75 miles from the previous location.

MORTALITY

Harvest

Season and Bag Limit. During this reporting period ADF&G administered Tier I subsistence registration permit hunts in Unit 22E and, Tier II subsistence permit hunts in Units 22B, 22C, 22D, and 23SW authorized by the State of Alaska's Board of Game. State hunts are conducted in combination with federal subsistence hunts for federally qualified subsistence users on federal public lands in Units 22B, 22D, 22E and 23SW.

Generalized regulatory language in 5 AAC 85.050 (2) for the reporting period follows:

RY12 and RY13 Units and Bag Limits	Resident Open Season Subsistence and General Hunts	 Nonresident Open Season
Unit 22(A) and Unit 23 that portion south and west of the Kobuk River drainage and North and east of the Buckland River drainage	No open season	No open season
Units 22(B), 22(C), and 22(D) and Unit 23, Southwest, that portion on the Seward Peninsula west of and including the Buckland River drainage, as follows:		
If the harvestable portion is 99 muskoxen or less:		
1 muskox by Tier II subsistence hunting permit only	1 Aug–15 Mar (Subsistence hunt only)	No open season
If the harvestable portion is greater than 99 muskoxen but less than 151 muskoxen:		
1 muskox by registration permit only	1 Aug–15 Mar (Subsistence hunt only)	No open season
If the harvestable portion is greater than 150 muskoxen:		
1 muskox by registration permit only;	1 Aug–15 Mar (Subsistence hunt only)	No open season
or		
1 bull 4-year-old or older by drawing permit only; up to 60 permits may be issued; 10	1 Aug–15 Mar	1 Aug–15 Mar

RY12 and RY13 Units and Bag Limits	Resident Open Season Subsistence and General Hunts	Nonresident Open Season
percent of animals may be issued to nonresident hunters, in combination with Unit 22(E)		
Unit 22(E) If the harvestable portion is 9 muskoxen or less:		
1 muskox by Tier II subsistence hunting permit only	1 Aug–15 Mar (Subsistence hunt only)	No open season
If the harvestable portion is greater than 9 muskoxen, but less than 26 muskoxen:		
1 muskox by registration permit only	1 Aug–15 Mar (Subsistence hunt only)	No open season
If the harvestable portion is greater than 25 muskoxen:		
1 muskox by registration permit only; or	1 Aug–15 Mar (Subsistence hunt only)	No open season
1 bull 4-year-old or older by drawing permit only; up to 60 permits may be issued; 10 percent of the permits will be issued to nonresident hunters, in combination with Units 22(B), (C), and (D) and Unit 23, that portion on the Seward Peninsula west of and including the Buckland River drainage	1 Aug–15 Mar	1 Aug–15 Mar

Specific hunts administered in RY12 and RY13:

RY12 and RY13 Units and Bag Limits	Resident Open Season Subsistence and General Hunts	Nonresident Open Season
Unit 22A	No open season	No open season

RY12 and RY13 Units and Bag Limits	Resident Open Season Subsistence and General Hunts	Nonresident Open Season
Unit 22B, that portion east of the Darby Mountains, including drainages of Kwiniuk, Tubutulik, Koyuk and Inglutalik rivers		
1 bull by Tier II permit only (TX105; harvest quota is 1 bull)	1 Aug–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22B		
1 bull by Tier II permit only (TX105; harvest quota is 7 bulls)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Unit 22C Inner Nome Area, that portion of the Snake River drainage downstream of the Glacier Creek confluence and including the Glacier Creek drainage, that portion of the Nome River drainage downstream of and including the Basin Creek and Shephard Creek drainages, and all drainages flowing directly to Norton Sound between the mouths of the Nome River and the Snake River.		
1 bull, by bow and arrow, muzzleloader or shotgun only, by Tier II permit only (TX095; harvest quota is 3 bulls)	1 Jan–15 Mar (Subsistence hunt only)	No open season

RY12 and RY13 Units and Bag Limits	Resident Open Season Subsistence and General Hunts	Nonresident Open Season
Unit 22C Outer Nome Area, that portion of drainages flowing to Norton Sound: 1) between the east bank of the Penny River and the Snake River drainage, 2) the Snake River drainage up stream of the Glacier Creek confluence and excluding the Glacier Creek drainage, 3) the Nome River drainage upstream of and excluding the Basin Creek and Shepard Creek drainages and 4) between the Nome River drainage and the west bank of the Flambeau River extended along Safety Sound to the Safety Bridge.		
1 bull by Tier II permit only (TX096; harvest quota is 2 bulls)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22C	No open season	No open season
Unit 22D Southwest, that portion west of the Tisuk River drainage, west of the west bank of Canyon Creek beginning at McAdam's Creek continuing to Tuksuk Channel		
1 bull by Tier II permit only (TX103; harvest quota is 1 bull)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Unit 22D, Kuzitrin River drainage		
1 bull by Tier II permit only (TX102; harvest quota is 4 bulls)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22D		
1 bull by Tier II permit only (TX102; harvest quota is 7 bulls)	1 Aug-15 Mar (Subsistence hunt only)	No open season

RY12 and RY13 Units and Bag Limits	Resident Open Season Subsistence and General Hunts	Nonresident Open Season
Unit 22E		
1 bull by Tier I registration permit only (RX104; harvest quota is 10 bulls)	1 Aug–15 Mar (Subsistence hunt only)	No open season
Unit 23 Southwest, that portion on the Seward Peninsula west of and including the Buckland River drainage		
1 bull by Tier II permit only (TX106; harvest quota is 4 bulls)	1 Aug–15 Mar (Subsistence hunt only)	No open season

Subsistence hunt conditions:
1. Subsistence hunts open to Alaska residents only.
2. Tag fee waived for subsistence hunting.
3. One muskox permit per hunter per calendar year.
4. Season will be closed by emergency order when quota is reached.
5. All Skulls require trophy destruction be completed at the kill site subject to permit conditions
6. Aircraft may not be used to transport muskox hunters, muskox, or muskox hunting gear.

Board of Game (BOG) Actions and Emergency Orders. In November 2011, the BOG adopted regulation changes to allow the department flexibility to manage subsistence Tier II permit hunts, subsistence Tier I permits hunts, or a combination of subsistence Tier I or Tier II permit hunts along with drawing permit hunts based on the relationship of harvestable surplus of muskox and the amount necessary for subsistence. The adopted regulatory changes resulted in Tier II permit hunts in Units 22B, 22C, 22D, 22E, and 23SW (available to all Alaska residents).

The BOG lowered the muskox amount necessary for subsistence in Unit 22E to 10–25 muskox, and then added new muskox ranges in Unit 22A and in that portion of Unit 23 south and west of the Kobuk River drainage as the population area basis for the Seward Peninsula Amount Necessary for Subsistence (100–150, including 10–25 in Unit 22E).

No actions that affect Seward Peninsula muskox were taken by the BOG during the reporting period. Detailed meeting information and board actions affecting Seward Peninsula muskox can be found at the Alaska Department of Fish and Game website (

http://www.adfg.alaska.gov/index.cfm?adfg=gameboard.meetinginfo).

One emergency order (EO) was issued during the reporting period to close the Tier II muskox hunt, TX102, in the Unit 22D remainder area (the American and Agiapuk River drainages). The EO was issued on 9 October 2012 following the illegal harvest of 7 muskoxen. No other EOs were issued during the reporting period.

Human-Induced Harvest. Seward Peninsula muskox hunts utilize 2 harvest guidelines for hunt management. Hunt area harvest quotas are calculated to harvest approximately 10% of the estimated number of mature bulls in each area, and the range-wide harvest rate is 2% of the population point estimate (Fig. 2). Detailed analysis of specific hunt type (Tier I Registration, Tier II), harvest history, transportation methods used, harvest by residency, and seasonality of harvest is not presented in this report but is available to the public for hunt planning on the ADF&G website (https://secure.wildlife.alaska.gov/index.cfm?adfg=harvest.main).

Permit Hunts. Hunting during this reporting period was by Tier I subsistence registration permit and Tier II subsistence permit on state managed lands, and by federal subsistence permit on federal public lands. Trophy destruction at the kill site is required for muskoxen taken in Tier I and Tier II hunts.

Hunter Success. During RY12, 39 permits (10 Tier I, and 29 Tier II) were issued for state managed Seward Peninsula muskoxen hunts. An additional 8 federal permits were issued. Harvest reports indicate 22 state and 2 federal hunters were successful for a 51% success rate. During RY13, 40 permits (10 Tier I, 30 Tier II) were issued for state managed hunts. One additional Tier II permit was issued for a cow muskox located near Buckland, Alaska that was tangled in a subsistence fish net. An additional 15 federal permits were issued. Harvest reports indicate 20 state and 10 federal hunters were successful for a 55% success rate.

Harvest Chronology. Muskox hunt effort and chronology in northwest Alaska is driven by both weather and hours of available daylight in units with winter hunting seasons. Although Tier II hunt management can make it more difficult for hunters to secure a permit, hunters have a longer season to hunt because seasons generally are not closed early by emergency orders. This allows hunters the opportunity to take advantage of good weather and long hours of daylight during February and March.

Other Mortality

Natural mortality rates calculated from radiotracking flights since 2008 have been as low as 4% in 2009 and as high as 26% in 2011 (Table 3). Several factors may preclude the use of collar-based mortality rates as representative of the entire population. The average number of collars deployed in the SPP ($\bar{x}$ = 24) since 2008 represents 1% of the Seward Peninsula population based on the 2015 population estimate (Fig. 1). Collars are not randomly distributed throughout the population, so localized events such as icing, deep snow, or different predator regimes may influence observed mortality rates. Also, the selection of animals for capture is not truly random, as obviously injured or diseased animals were intentionally not selected for collaring.

Based on aerial radiotracking flights during 2008–2014, observed mortality events (n = 24, 2 unknown) occurred at a frequency of 88% between April and October. The timing of these events suggests brown bears may be partially responsible for muskox mortality, but detecting the primary cause of mortality is difficult due to the low frequency of radiotracking flights (≤2

flights per month April–October). Causative agents are not easily determined because the period of time between detection on radiotracking flights and investigation of kill sites may be days, weeks, or even months apart, making it hard to distinguish causes of mortality from actions by scavengers found on the Seward Peninsula.
We frequently observe old muskoxen, and believe mortality from disease has been relatively low. However, there is increasing evidence that predation is becoming more common as bears learn to prey on muskoxen and wolf numbers increase on the Seward Peninsula. As more Seward Peninsula bears learn to prey on muskoxen, we can expect predation to have a greater impact on growth of the muskoxen population. Increasing numbers of wolves associated with the wintering range of the Western Arctic caribou herd are also likely to increase predation on muskoxen (Persons 2005).

Disease. Seward Peninsula blood serum samples collected since 2008 during capture projects have tested negative for zoonotic diseases and the muskox population is considered a healthy population and subsistence resource (Gorn 2009). Samples have tested negative for Toxoplasma, Neospora, Giardia, and Cryptosporida, which all may lead to decreased reproduction in muskox populations. Animals tested since 2008 have had elevated levels of larvae from lungworm and gastrointestinal parasites. Exposure to respiratory disease complex viruses and Leptospirosis was less than moose or caribou in the area, or other populations of muskoxen (Beckmen 2009). Three muskoxen tested positive for Chlamydiophila, a pathogen known to negatively impact reproduction in other wildlife species; however, out of 9 samples, these 3, as well as those from 4 other muskoxen, tested positive for pregnancy (2 muskoxen were not tested for pregnancy). All muskoxen tested negative for Mycoplasma, a type of pneumonia. They also tested negative for Coxiella, which can have negative reproductive effects.

Muskox serum samples were tested for copper levels and results found levels of 0.8–1.1 ppm (mean = 1.0 ppm), which suggests the potential for copper deficiency exists. However, Seward Peninsula muskoxen tested negative for additional trace elements (iron, zinc, selenium) present in other Alaska muskox populations adversely impacted by trace element deficiencies (Beckman 2009). Six liver samples were collected from hunter-harvested animals to compare trace element (i.e., copper, iron, zinc, selenium) levels between different Alaska muskox populations, and we are awaiting results.

None of the results from testing found disease exposure or parasite prevalence that would indicate Seward Peninsula muskoxen health is at risk; however, disease surveillance should be continued to monitor population health.

Results from blood samples collected during the reporting period are not yet available from ADF&G's Division of Wildlife Conservation Wildlife Health program.

HABITAT

Assessment

There were no activities undertaken to directly assess muskox habitat on the Seward Peninsula during the reporting period.

Enhancement

There were no muskox habitat enhancement activities on the Seward Peninsula during the reporting period.

NONREGULATORY MANAGEMENT PROBLEMS/NEEDS

Seward Peninsula Muskox Cooperators Group

The Seward Peninsula Muskox Cooperators Group did not meet during the reporting period.

Conflicts with Humans and Wildlife

More Seward Peninsula residents have come to value muskoxen as a subsistence resource since hunting has been allowed and negative attitudes toward muskoxen have decreased. Some Seward Peninsula residents, especially in Nome, Teller, and Shishmaref, favor capping or reducing the population in their immediate areas. Subsistence gatherers complain that muskoxen compete with them for greens and trample traditional berry picking areas, and there are repeated instances of muskoxen rubbing against grave markers in the Deering cemetery that have angered community residents. Although there are no reports of anyone being harmed by muskoxen, their presence near villages, camps, and berry picking areas is often frightening. When threatened or hazed, muskoxen generally hold their ground rather than flee; this behavior contributes to people's dislike of them because it is sometimes impossible to (permanently) move them from areas where they are not wanted (Persons 2005).

The redistribution of muskox groups in the Nome area observed between 2005 and 2007, and continued increased abundance (Appendix A) have caused considerable angst with an increased number of Nome residents. The historically positive outlook towards muskox being visible from the Nome Road system has changed for some local residents because, beginning in 2005, muskox are now located near homes, in town, and near the two Nome airports. The department spends a considerable amount of time each summer moving muskox groups from airports, residential sites, and plush habitat immediately surrounding Nome. There have been several instances of domestic dog injuries and fatalities when muskoxen have encountered pets as they moved through residential areas of Nome. Also, muskoxen are commonly found near airport runways, and during the fall of 2011, airport staff removed a section of willows at Nome City Field Airport to discourage the presence of muskox along the runway. While the willow removal proved largely ineffective to deterring muskox presence along the runway, it did increase visibility for vehicle traffic along the road that parallels the runway. From 21 May 2014 to 9 September 2014 department staff responded to 17 after hours (5:30PM to 7:00AM) nuisance muskox calls in the Nome area. Department staff issue public service announcements informing the public on ways to live and interact with muskox, and staff attended public meetings to relay information and discuss solutions for local area muskox issues. Hunting season dates in Unit 22C were changed during the reporting period to open 1 August at the request of the public to help mitigate the presence of local muskox groups. At this point, harvesting muskox at current low levels (2% harvest rate) does not appear to affect local muskox abundance or cause muskox groups to emigrate from the local area.

Muskox and Reindeer

For many years after muskoxen were introduced to the Seward Peninsula, reindeer herders complained that muskoxen competed with and displaced reindeer. There is widespread concern across the Arctic about displacement of caribou by muskoxen, and these concerns cannot be dismissed. However, habitat and diet selection studies have found that although caribou, reindeer, and muskoxen often occupy the same feeding areas, they select different forage species (Ihl and Klein 2001). Neither interspecies avoidance nor competition for habitat has been documented on the Seward Peninsula or Nunivak Island. It is not uncommon on the Seward Peninsula to observe reindeer and muskoxen occupying the same ridgetop, and single deer have been observed in the middle of large groups of muskoxen.

Muskox Viewing

The Unit 22 road system provides a unique opportunity to view muskoxen in their natural habitat. There are few places where wild muskoxen are so easily accessible or where local residents, tourists, photographers, cinematographers, and wildlife enthusiasts from around the world can seek out and enjoy watching these unusual animals. The Cooperators have maintained their commitment to protect viewing opportunities in Unit 22C and along much of the Nome road system (Persons 2005). The Cooperators have worked with staff to create hunt areas and set season dates that promote wildlife viewing opportunities.

CONCLUSIONS AND RECOMMENDATIONS

In 2010 we adapted the distance sampling survey technique to estimate abundance of Seward Peninsula muskoxen. We believe distance sampling estimates will provide more useful data and improve long-term monitoring efforts of Seward Peninsula muskoxen compared to minimum count survey methods completed prior to 2010. Additional effort was made to better understand eastward emigration from central areas of the Seward Peninsula into Unit 22A, Unit 23 east of the Buckland River, and Unit 24 by expanding the survey area. These areas are searched less intensively throughout the year because of their distant proximity to Nome and Kotzebue. The 2012 population survey area was expanded to gather additional information on muskoxen located east of the Seward Peninsula, and the 2015 survey area was increased further to monitor eastward range expansion of the SPP. The 2015 survey area encompasses all known areas of muskox habitat in proximity to the Seward Peninsula, and it is not anticipated that the survey area will be increased for future surveys.

Since 2002, composition survey results indicate an apparent decrease in mature bulls and yearlings throughout an expanding area of the Seward Peninsula, which now includes Units 22C, 22B, 22D, and 23SW. The downward trend has been evident in all areas although declines occur at different rates between units. Collecting composition data has become increasingly important for Seward Peninsula hunt administration. As hunter harvest has increased through time (Fig. 3) and recent population growth has apparently slowed compared to earlier periods of rapid growth (e g., 1970–2000), staff now considers the number of mature bulls in the population as the primary basis for establishing hunt area harvest rates; the previous method used population counts and abundance estimates for the entire population. To supplement this change in metrics to determine harvest, composition is now collected using a sampling protocol across the entire range of the herd (Schmidt and Gorn 2013), rather than using earlier methods where composition

surveys were based on drainages or unit boundaries. This revised protocol to collect composition data should be continued to better understand range-wide composition and recruitment of the SPP.

Following 3 years of decreased harvest the 2015 composition survey identified a range-wide increase in the proportion of mature bulls in the population. Since 2012, the annual realized harvest rate has been below 2% and is the likely cause of this apparent increase in mature bulls (Fig. 3).

It is important to determine the factors influencing growth so we can ensure our management strategy is appropriate for conservation of the herd. Current regulatory language allows for increased flexibility of hunt management and it is important to consider changes in harvest rates and their subsequent effect on population structure. Other factors affecting population growth could include limited extent of wintering areas, density-dependent behavioral factors, predation, weather or snow conditions, and human disturbance unrelated to harvest. Wolf numbers on the Seward Peninsula have increased since 1996 in response to caribou wintering in the area in larger numbers, and reports of bear predation on muskoxen groups have also increased. We also know disturbance by people or predators during calving periods can cause calf separation and mortality. Close attention to these factors should be given high priority and harvest rates adjusted appropriately in the future.

Muskox viewing continues to be a high priority in areas near Nome and along much of the road system, and The Cooperators have attempted to recommend hunt structures that would help ensure hunting does not affect the animals in areas most important for viewing. Near Nome and on the road system, we must watch for changes in behavior and distribution of muskoxen that are attributable to hunting and recommend adjustments to hunt areas boundaries or timing of hunts, as necessary (Persons 2005). Some local residents continue to be upset by muskoxen occurring near villages and camps and by competition between muskoxen and subsistence users for greens and berries at traditional gathering sites. Hunting has been the best antidote for resentment toward muskoxen. Now that hunting muskoxen is allowed, more people are learning to value this new resource for its meat and qiviut, the warm wool undercoat (Persons 2005).

There have been many biological, regulatory, and social changes influencing muskoxen management since the Seward Peninsula Cooperative Muskox Management Plan was written in 1994, when the population was 994 muskoxen. Although parts of the plan are pertinent to current management scenarios, there are many sections that are obsolete to the current understanding of muskoxen. While management through working with The Cooperators has generally followed the basic goals of the plan, the plan should be updated to serve as a blueprint for future social and biological management decisions.

REFERENCES CITED

Alaska Department of Fish and Game. 1980. Muskox management policies. Pages X-1–X-4 [*In*] Alaska Wildlife Management Plans: Species Management Policies. Alaska Department of Fish and Game, Federal Aid in Wildlife Restoration Project W–20–2, Juneau.

Beckmen, K. 2009. Wildlife health and disease surveillance in Alaska. Alaska Department of Fish and Game, Federal Aid Annual Research Performance Report 1 July 2008–30 June 2009, Federal Aid in Wildlife Restoration Project 18.74, Juneau.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas, Eds. 2004. Advanced distance sampling. Oxford University Press.

Czaplewski, R. L., Crowe, D. M., and McDonald, L. L. 1983. Sample sizes and confidence intervals for wildlife population ratios. Wildlife Society Bulletin 11:121–128.

Cochran, W. G. 1977. Sampling techniques. John Wiley and Sons. New York, New York.

Gorn, T. 2009. Unit 22 muskox. Pages 13–33 [*In*] P. Harper, editor. Muskox management report of survey and inventory activities 1 July 2006–30 June 2008. Alaska Department of Fish and Game, Division of Wildlife Conservation, Project 16.0, Juneau.

Gorn, T. and W. R. Dunker. 2013. Unit 22 muskox. Pages 17–51 [*In*] P. Harper, editor. Muskox management report of survey and inventory activities 1 July 2010–30 June 2012. Alaska Department of Fish and Game, Division of Wildlife Conservation, Species Management Report ADF&G/DWC/SMR-2013-2, Juneau.

Ihl, C. and Klein R. 2001. Habitat and diet selection by muskoxen and reindeer in western Alaska. Journal of Wildlife Management 65(4):964–972.

Machida, S. 1997. Muskox survey-inventory management report. Pages 16–20 [*In*] M. V. Hicks, ed. Annual report of survey-inventory activities, muskox. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Progress Report Grant W23–4, W–23–5, Study 16.0. Juneau.

Nelson, R. 1994. Seward Peninsula Cooperative Muskox Management Plan [unpublished agency document]. Alaska Department of Fish and Game, Division of Wildlife Conservation, Nome, Alaska.

Persons, K. 2005. Muskox survey-inventory management report. Pages 13–37 [*In*] C. Brown, ed. Annual report of survey-inventory activities. Muskox. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Progress Report Grant W27–4, W–27–5, Juneau.

Schmidt, J. H., and T. S. Gorn. 2013. Possible secondary population-level effects of selective harvest of adult male muskoxen. PLoS ONE 8(6): e67493. doi:10.1371/journal.pone.0067493

Schmidt, J. H., T. S. Gorn, and C. Westing. 2010. Using distance sampling to estimate muskoxen abundance on the Seward Peninsula, Alaska. Summary report prepared for

2010 Seward Peninsula muskox census participants, April 27, 2010 [unpublished]. National Park Service, Fairbanks, and Alaska Department of Fish and Game, Nome and Kotzebue.

Schmidt, J. H., K. L. Rattenbury, J. P. Lawler, and M. C. MacCluskie. 2012. Using distance sampling and hierarchical models to improve estimates of Dall's sheep abundance. Journal of Wildlife Management 76:317–327.

Spiegelhalter, D. J., A. Thomas, N. G. Best, and D. Lunn. 2004. WinBUGS Version 1.4.1. User manual. MRC (Medical Research Council) Biostatistics Unit, Cambridge, United Kingdom.

Thomas, L., J. L. Laake, E. Rexstad, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, M. L. Burt, S. L. Hedley, J. H. Pollard, J. R. B. Bishop, and T. A. Marques. 2009. Distance 6.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. <http://www.ruwpa.st-and.ac.uk/distance/>

PREPARED BY:

Tony S. Gorn
Wildlife Biologist III

William R. Dunker
Wildlife Biologist I

SUBMITTED BY:

Peter J Bente
Survey-Inventory Coordinator

Please cite any information taken from this section, and reference as:

Gorn, T. and W. R. Dunker. 2015. Unit 22 muskox. Chapter 2, pages 2-1 through 2-44 [*In*] P. Harper and L. A. McCarthy, editors. Muskox management report of survey and inventory activities 1 July 2012–30 June 2014. Alaska Department of Fish and Game, Division of Wildlife Conservation, Species Management Report ADF&G/DWC/SMR-2015-2, Juneau.

While this unit report was actually published in 2017, it is part of the set of 2015 unit species management reports, so we suggest citing the report as a 2015 report to maintain its relationship to the other 2015 unit reports.

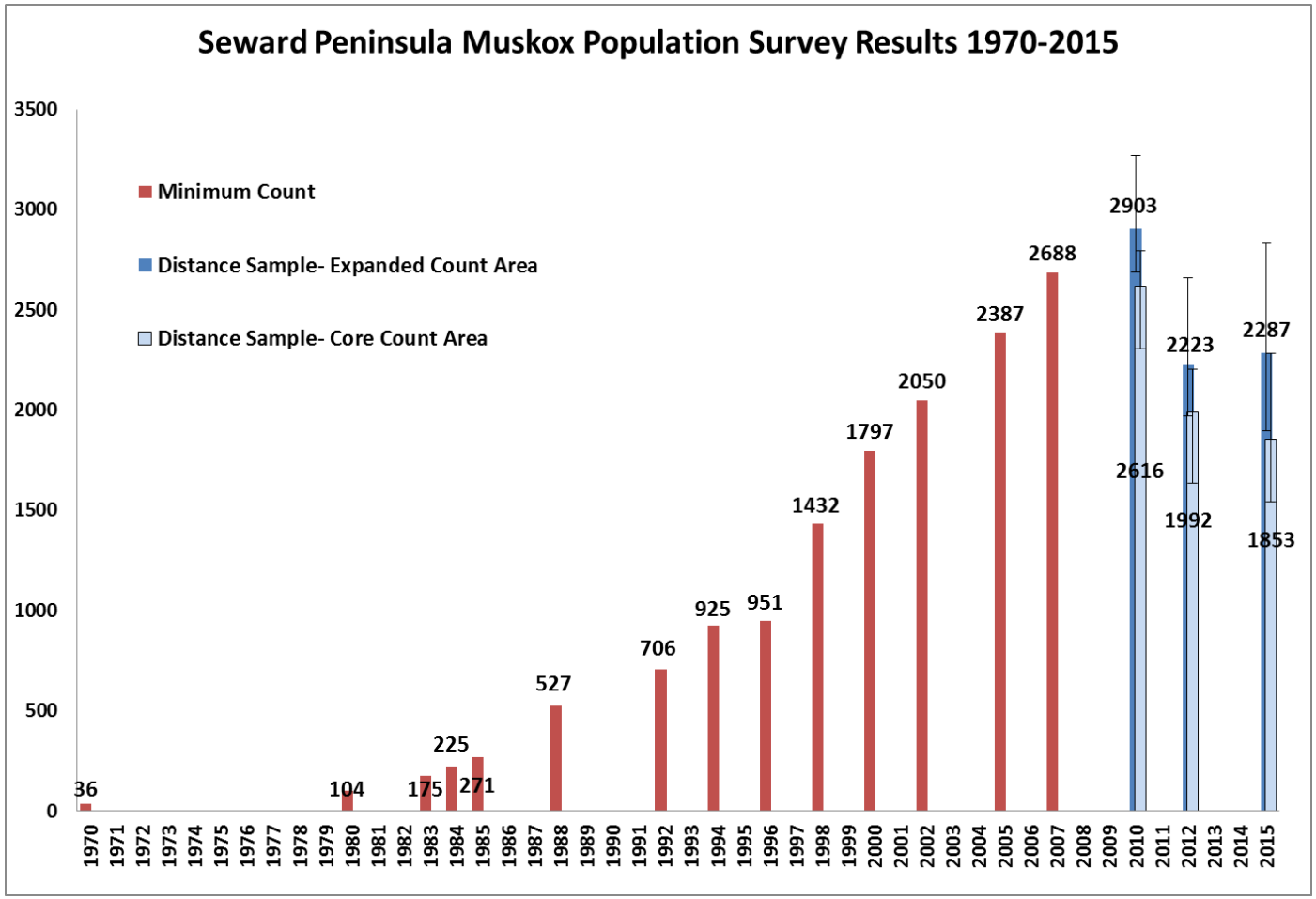


Figure 1. Census results from minimum count and distance sampling surveys of Alaska Seward Peninsula muskoxen, 1970–2015.

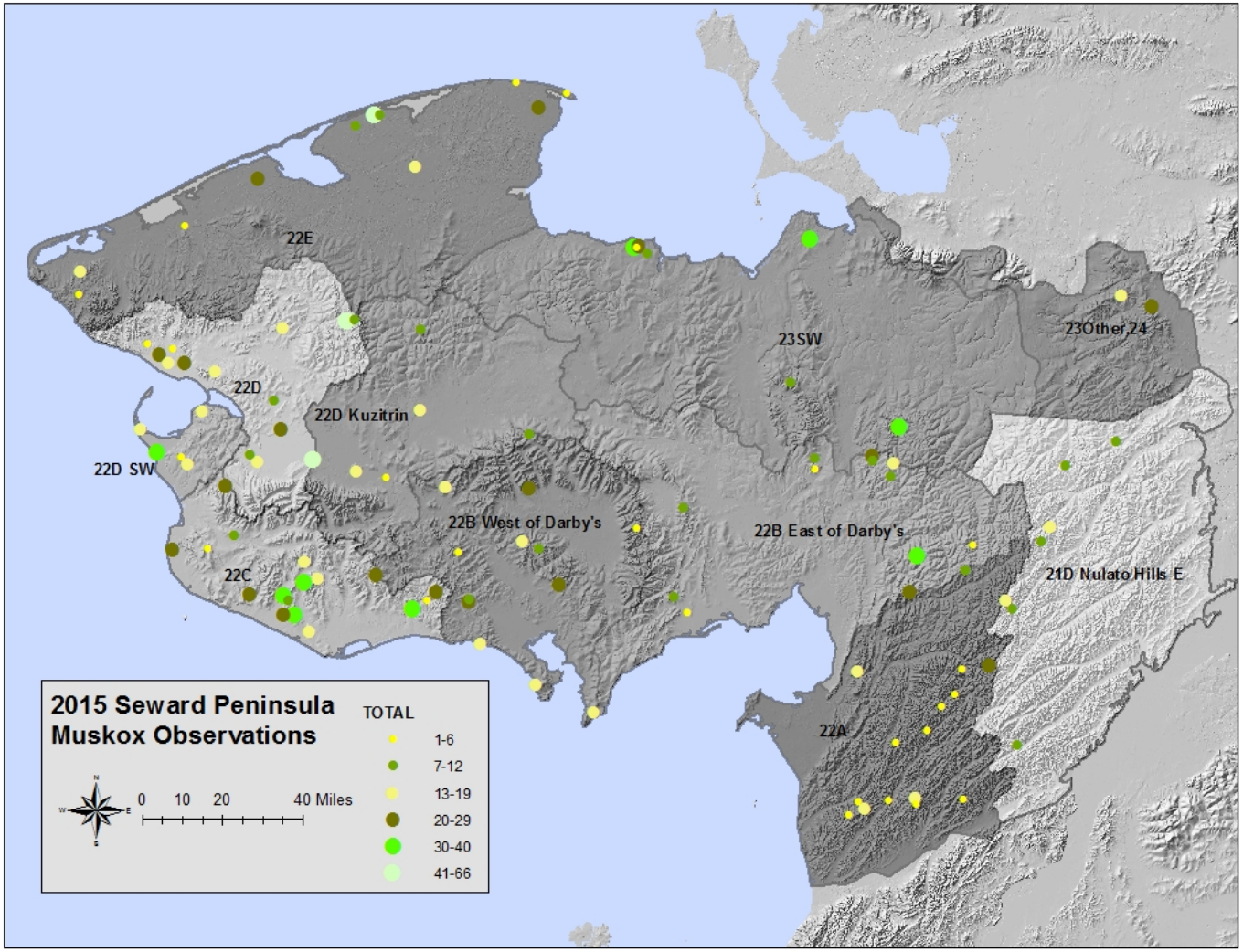


Figure 2. Location of Alaska Seward Peninsula muskox groups, spring 2015 census.

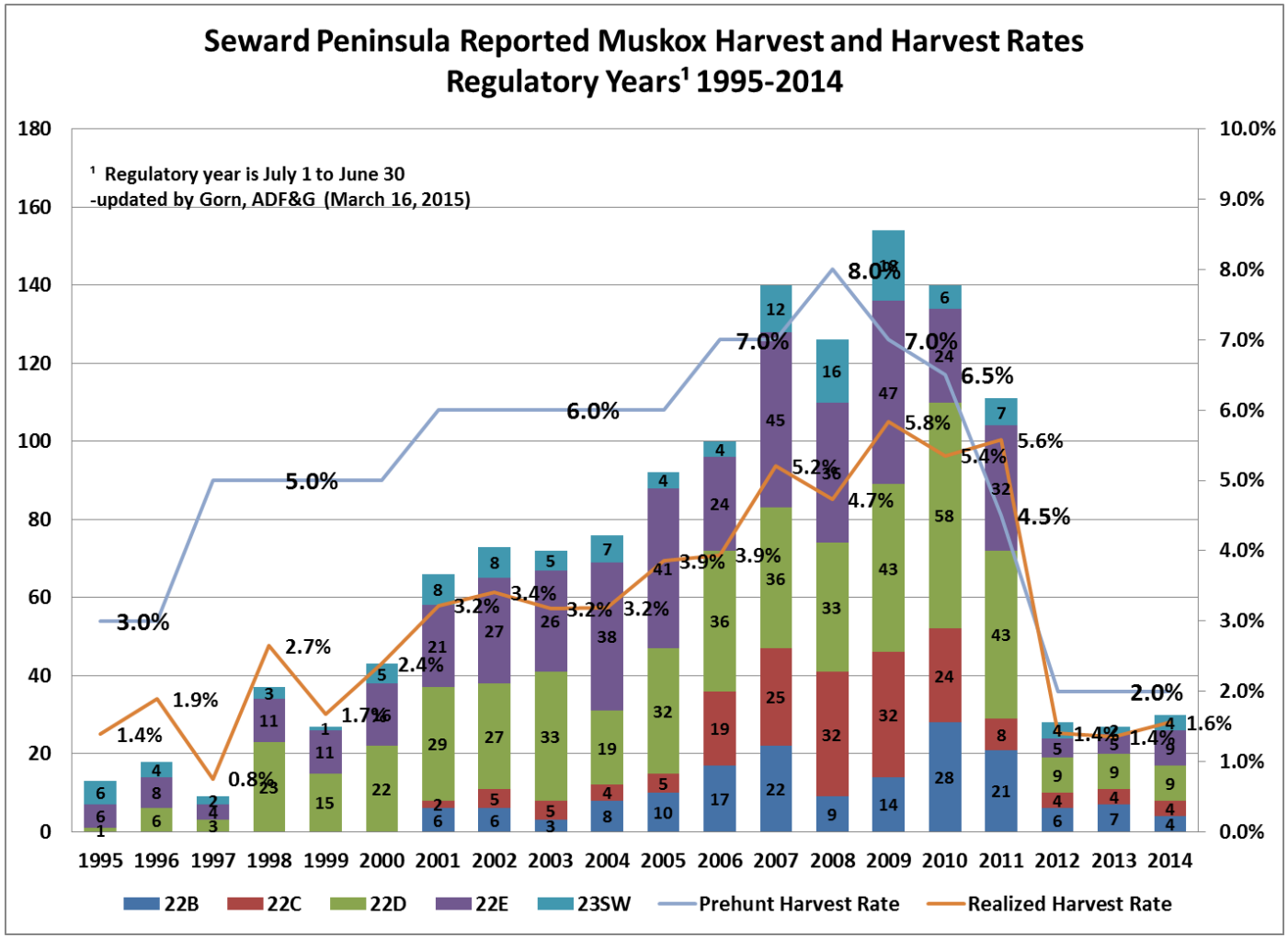


Figure 3. Alaska Seward Peninsula muskox harvest and harvest rates, regulatory years 1995–2014.

Table 1. Alaska Seward Peninsula muskox census results with coefficients of variation and 95% confidence intervals for select subunits of GMUs 21, 22, 23, and 24; spring 2015.

Unit	Mean	CV	2.5%	97.50%
21D	146	36%	78	278
22A	194	23%	136	306
22B East of Darby Mtns.	181	27%	112	305
22B West of Darby Mtns.	274	15%	216	377
22C	358	11%	302	456
22D Kuzitrin Drainage	187	22%	131	290
22D Southwest	78	24%	57	129
22D Remainder	258	15%	207	352
22E	291	20%	204	433
23 Southwest	192	32%	104	340
23 Southeast and 24	71	41%	39	149

Table 2. Alaska Seward Peninsula muskox census results for select subunits of GMUs 21, 22, 23, and 24; 1992–2015.

	Unit								
Year	21D	22A[a]	22B	22C	22D	22E	23SW	23SE/24[b]	Total[c]
1992			3	49	340	180	134		706
1994			11	79	405	184	246		926
1996			51	87	308	327	178		951
1998			27	124	714	362	205		1,432
2000			159	148	774	461	255		1,797
2002			189	257	771	632	201		2,050
2005			326	220	796	863	182		2,387
2007			329	445	746	949	219	78	2,766
2010		86	420	402	878	879	175	120	2,903
2012		84	460	289	629	431	222	110	2,223
2015	146	194	455	358	523	291	192	71	2,287

[a] This count area was not counted during 1992-2007 census counts.
[b] This count area was not counted during 1992-2005 census counts.
[c] Totals may not equal the sum of unit estimates. Each unit estimate column is an independent computer-generated estimate using the census method noted in the census method section of this report.

Table 3. Annual mortality rate (percent and range) of collared cows ≥ 3 years of age, Seward Peninsula muskox population, 2008–2014.

Year	Active Collars	Survived	Mortality rate, %	Mortality range, % (95% CI)
2008	23	21	9	1.1–28.0
2009	23	22	4	0.1–22.0
2010	22	17	23	7.8–45.4
2011	27	20	26	11.1–46.3
2012	19	16	16	3.0–39.6
2013	22	21	5	0.1–22.8
2014	25	19	24	9.4–45.1

APPENDIX A. 2015 muskox survey results memo, 6 May 2015 ERRATUM.

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game
DIVISION OF WILDLIFE CONSERVATION

Northwest
103 East Front Street
P.O.
Box 1148 Nome,
Alaska 99762-1148
Main: 907.443.2271
Fax: 907.443.5893

MEMORANDUM

TO: Distribution (see below)

DATE: May 6, 2015 ERRATUM

FROM: Tony Gorn
Wildlife Biologist
Wildlife Conservation
Nome

PHONE: 907-443-8189

SUBJECT: 2015 muskox survey results

ERRATUM: Short yearling (SY) defined as 10–15 months-old for comparison to previous surveys.

This memo summarizes the 2015 Seward Peninsula muskox population and composition surveys.

In 2010 and 2012 the distance sampling survey method required approximately 4 weeks to complete because of the Seward Peninsula's strong winds and unfavorable weather systems. During the 2015 survey period the survey area received heavy snow fall between 6 Mar- 8 Mar, followed by a week of clear weather and light winds. We were able to complete the population survey between 9 Mar- 13 Mar, and survey conditions were excellent with complete snow cover throughout the survey area, including the normally wind swept Nulato Hills. Several maps, tables, and figures are provided at the end of this document for reference to information provided in this summary.

The population survey was completed with contributions from the Alaska Department of Fish & Game, the National Park Service, the Bureau of Land Management, and the U.S. Fish & Wildlife Service. Staff and aircraft (Cessna 185 and PA-18 type) were based in Nome, Kotzebue, and Galena during the project.

Population Survey Area
The population survey area included portions of Unit 22A, Unit 21D, Unit 23, Unit 24 and all of subunits 22B, 22C, 22D, and 22E (Fig. 1). Transects were spaced at 4 mile intervals throughout the survey area (Fig. 2). The survey area included 263 transects that totaled 8,290 transect miles. Transect length varied between 3 miles - 68 miles in length with an average transect length of 32 miles.

Population Survey Results
Several considerations should be made when reviewing population survey results found in Table 1: 1) the distance sampling method is strongest when used to estimate the entire population (SewPen all), and 2) we provide hunt area estimates to guide hunt managers when establishing harvest quotas for Tier II and Tier I subsistence hunts. We acknowledge that individual subunits and hunt areas (management areas) do not represent unique "populations" of muskox.

The 2015 Seward Peninsula muskox population survey estimated 2,287 ±10% (95% CI: 1,895 to 2,832) animals for the entire range (SewPen.all) and suggests the population stabilized (1% annual increase) between 2012 and 2015. The population estimate within the entire range that includes hunting (SewPenOld) is 1,853 ±10% (95%CI: 1,541 to 2,285) and also suggests this portion of the survey area stabilized (2% annual decrease) during the same time period (Table 1) (Fig. 4).

Prior to the 2015 survey we added additional transects in the eastern portion of the 2012 survey area that included the eastern portion of the Nulato Hills (Fig. 2). Seven (7) muskox groups were detected on these transects during the 2015 survey. All areas of suitable habitat were covered during the survey, excluding the foothills of/and the Purcell Mountains located along the Unit 23/ Unit 24 boundary, however we have no evidence the Purcell Mountains contain large numbers of muskoxen.

The spatial distribution of muskox groups has changed since 1992 when a higher proportion of the population were detected in western, northern, and central areas of the Seward Peninsula (Units 22E and 22D) compared to the 2015 survey when greater proportions of the population were detected in southern and eastern areas of the Seward Peninsula (Units 22B, 22C, and 22A)(Fig. 3).

Mortality

Our sample (n= 20-30) of collared cow muskoxen indicates natural mortality rates between 5%- 24% during 2008 – 2014. However, the collared sample of muskox are not distributed equally across the survey area and it may not be appropriate to assume consistent mortality rates throughout the survey area. Additionally, muskox composition surveys completed between 2002- 2012 found long term declining trends in the number of short yearlings in subunit based composition surveys suggesting a population decline was likely, at some point, across the Seward Peninsula.

Although it is difficult to understand the composition of bull harvest due to limitations in current harvest reporting methods, discussions with hunters and the collection of horn specimens required by hunt conditions indicate a high proportion of harvested males are mature bulls (≥4 years old and older). Preseason harvest rates ranged between 2.0% and 8.0% between 1995 and 2014. The average realized harvest rate, 1995- 2011, was 3.6%. In 2012 we lowered harvest rates to help increase the number of mature bulls in the population. Average realized harvest rates, 2012- 2015, was 1.5%.

Composition Survey Results

Composition surveys were conducted following the completion of the population survey. The overall sample included a subsample of individuals from each Seward Peninsula muskox management area within the population survey count area. Previous range-wide surveys were conducted in 2002 and 2012. Subunit based surveys were conducted in 1-3 subunits annually in 2000, 2001, 2003- 2011 and 2013.

Muskox groups observed during the 2015 Seward Peninsula muskox population survey were divided into three classes based on group size; small (1-16 muskox), medium (17-33 muskox) and large (≥34 muskox). Within each management area, our goal was to sample a proportionate number of individuals from each group class with an overall sampling objective of 150 muskox per management area. In management areas where <150 muskox were observed, all groups were selected to be sampled. This new sampling protocol was adopted following biometric review of previous surveys and allowed for a reduction in sampling effort.

Composition surveys were completed during 7 Apr- 3 May to minimize conflict with subsistence muskox hunting. A total of 76 muskox groups comprised of 1,062 individuals, 46% of the 2015 population estimate (SewPen.all), were sampled. The range-wide composition survey results are 39MB: 100C[i], 17 SY:100C[ii], and 9% SY[iii].

---

[i] Bulls ≥ 4 years of age: 100 Cows ≥ 3 years of age

[ii] 15mo ≥ Muskox ≥ 10mo: 100 Cows ≥ 3 years of age

[iii] 15mo ≥ Muskox ≥ 10mo /All Muskox Sampled (Excluding Calves)

*Minimum Count

For the second time (2012 and 2015), we were able to survey Unit 22A, a management area without an established hunting season for muskox. Groups located in the eastern portion of the Nulato Hills were included in this portion of the survey. A total of 18 groups comprised of 143 individuals were classified, and the survey results are 64MB: 100C[i], 21SY:100C[ii], and 9% SY[iii].

Composition survey results within most management areas indicate stable or increasing bull cow ratios, while range-wide bull: cow ratios have increased from 29MB: 100C (2012) to 39MB: 100C (2015). As in 2012, the highest bull: cow ratios observed during 2015 existed in un-hunted portions of the population in the Nulato Hills with 64MB: 100C. The percent of short-yearlings classified (recruitment) remains low and composition data indicate all management areas below 14%. The range-wide recruitment rate is 8%.

We will provide further analysis and additional composition results in a separate report. Comparative composition survey results from all range-wide surveys can be found in Table 2. For the purposes of this summary several management areas were combined to allow for comparison among years (22B: 22B West and 22B East, 22A: 22A and 21D Nulato Hills, 22D: 22D Remainder, 22D Kuzitrin and 22D SW).

Distribution List:
Steve Machida, ADF&G- Anchorage
Peter Bente, ADF&G- Nome
Jim Dau, ADF&G- Kotzebue
Brandon Saito, ADF&G- Kotzebue
Letty Hughes, ADF&G- Nome
Bill Dunker, ADF&G- Nome
Adam Craig, ADF&G- Anchorage
Geoff Carrol, ADF&G- Barrow
Phil Perry, ADF&G- Bethel
Patrick Jones, ADF&G- Bethel
Beth Lenart, ADF&G- Fairbanks
Jim Lawler, NPS- Fairbanks
Jeanette Koelsch, NPS- Nome
Ken Adkisson, NPS- Nome
Josh Schmidt, NPS- Fairbanks
Marci Johnson, NPS-Kotzebue
Susan Georgette, USFWS- Kotzebue
Brad Scotton, USFWS- Galena
Bruce Seppi, BLM- Anchorage
Tom Sparks, BLM- Nome

Table 1. Estimated number of muskoxen in each game management subunit on the Seward Peninsula in March 2015. Estimated population change was calculated using the difference between the point estimates (based on distance sampling) from the two years. Although there were large apparent changes in several subunits, all 2015 estimates overlapped those from 2012. Change since 2012 represents the difference between the annual point estimates.

GMU	2012	CV	2015	CV	Change since 2012
21d	—	—	146 (78-278)	36%	—
22a	84 (58-139)	25%	194 (136-306)	23%	+131%
22b.e	80 (49-150)	33%	181 (112-305)	27%	+126%
22b.w	380 (332-452)	8%	274 (216-377)	15%	-28%
22c	289 (247-355)	9%	358 (302-456)	11%	+24%
22d.kuz	208 (169-279)	14%	187 (131-290)	22%	-10%
22d.rem	344 (298-414)	9%	258 (207-352)	15%	-25%
22d.sw	77 (58-108)	16%	78 (57-129)	24%	1%
22e	431 (362-549)	11%	291 (204-433)	20%	-32%
23other	110 (84-159)	17%	71 (39-149)	41%	-35%
23sw	222 (171-319)	17%	192 (104-340)	32%	-14%
SewPen.all	2223 (1971-2660)	8%	2287 (1895-2832)	10%	+3%
SewPenNew	—		422 (296-621)	20%	—
SewPenOld	—		1853 (1541-2285)	10%	—

Table 2. Range-wide composition survey results.

Year	Total Grps	Total Sample	% Of Pop. Sampled	MB:100C[i]	SY:100C[ii]	%SY[iii]
2002*	76	1317	64%	44MB:100C	44SY:100C	18%
2012	89	1447	65%	29MB:100C	23SY:100C	12%
2015	76	1040	46%	39MB:100C	17SY:100C	8%

Figure 1. Muskox group locations found during the 2015 Seward Peninsula muskox population survey.

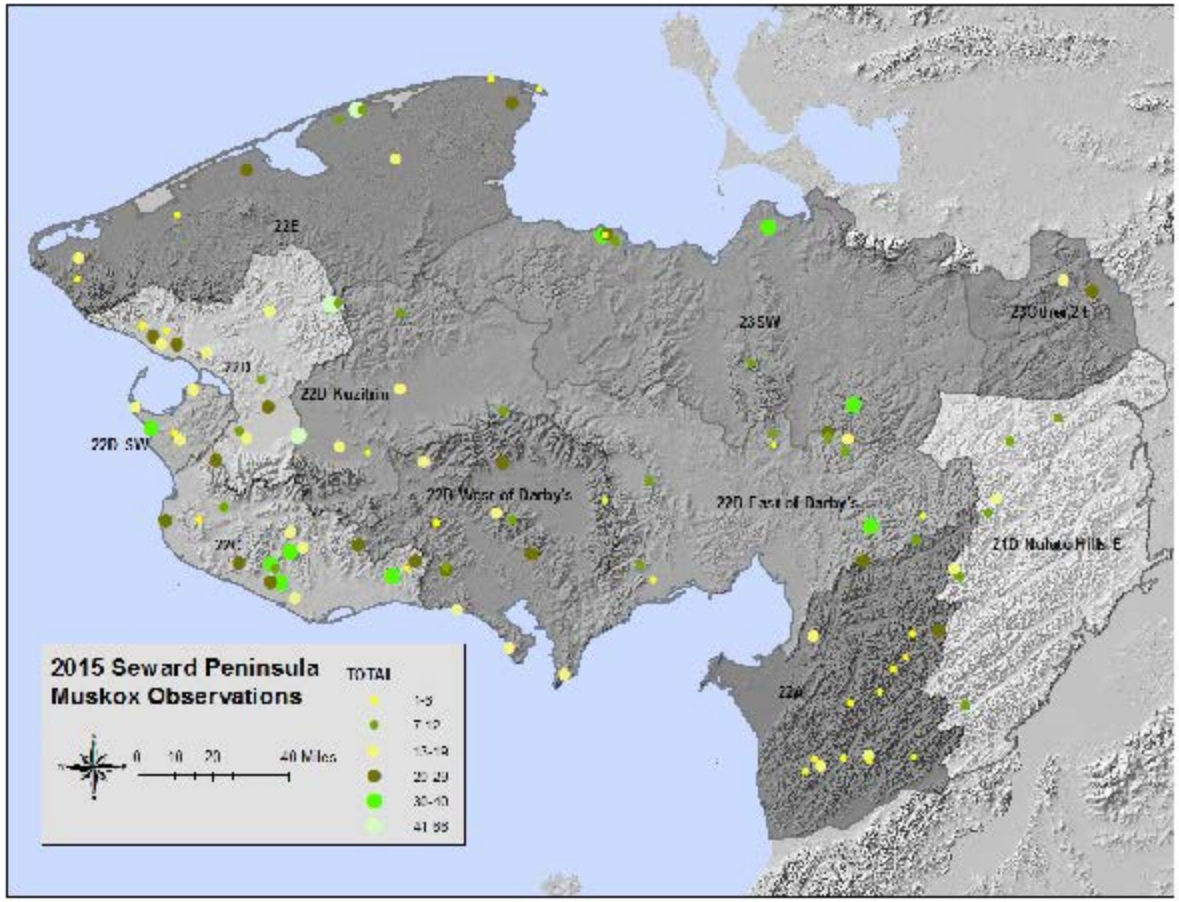


Figure 2. Distance sampling survey muskox transects (4 mile spacing) flown during the 2015 muskox population survey.

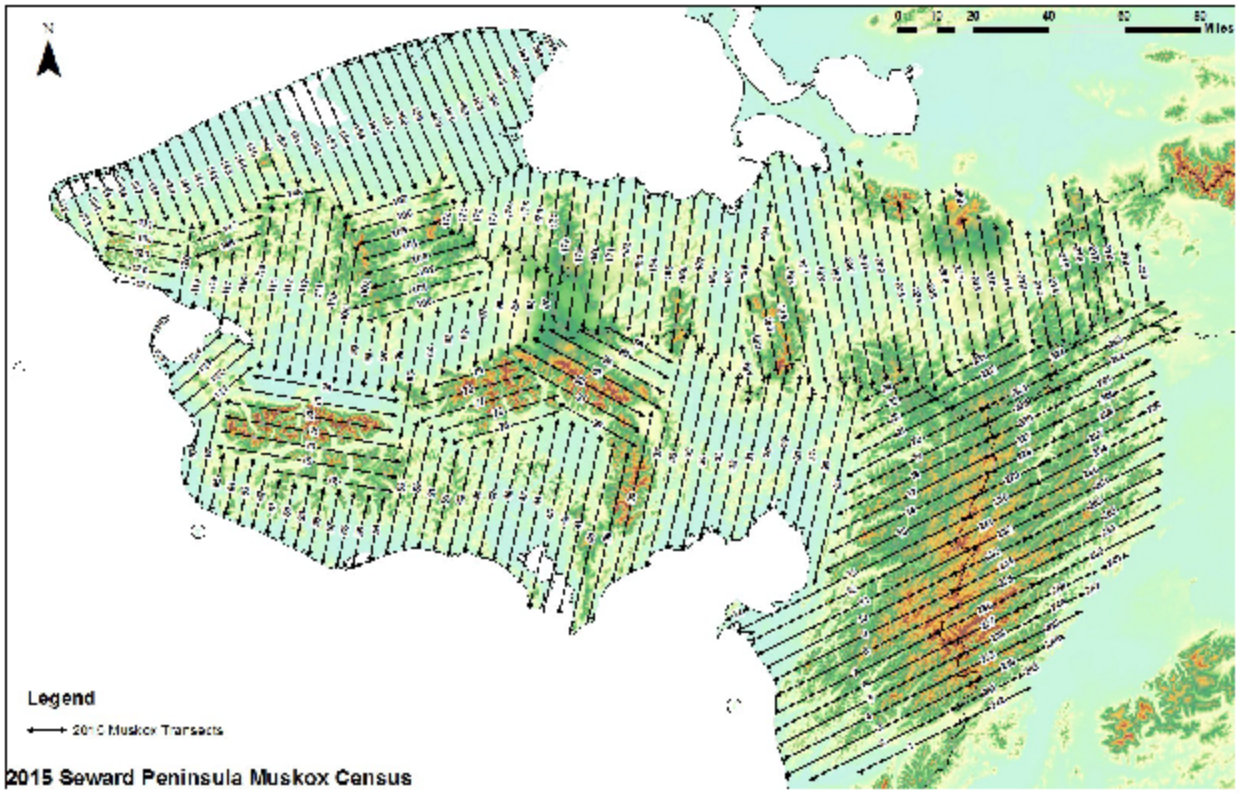


Figure 3. Proportional Distribution of Muskox Groups

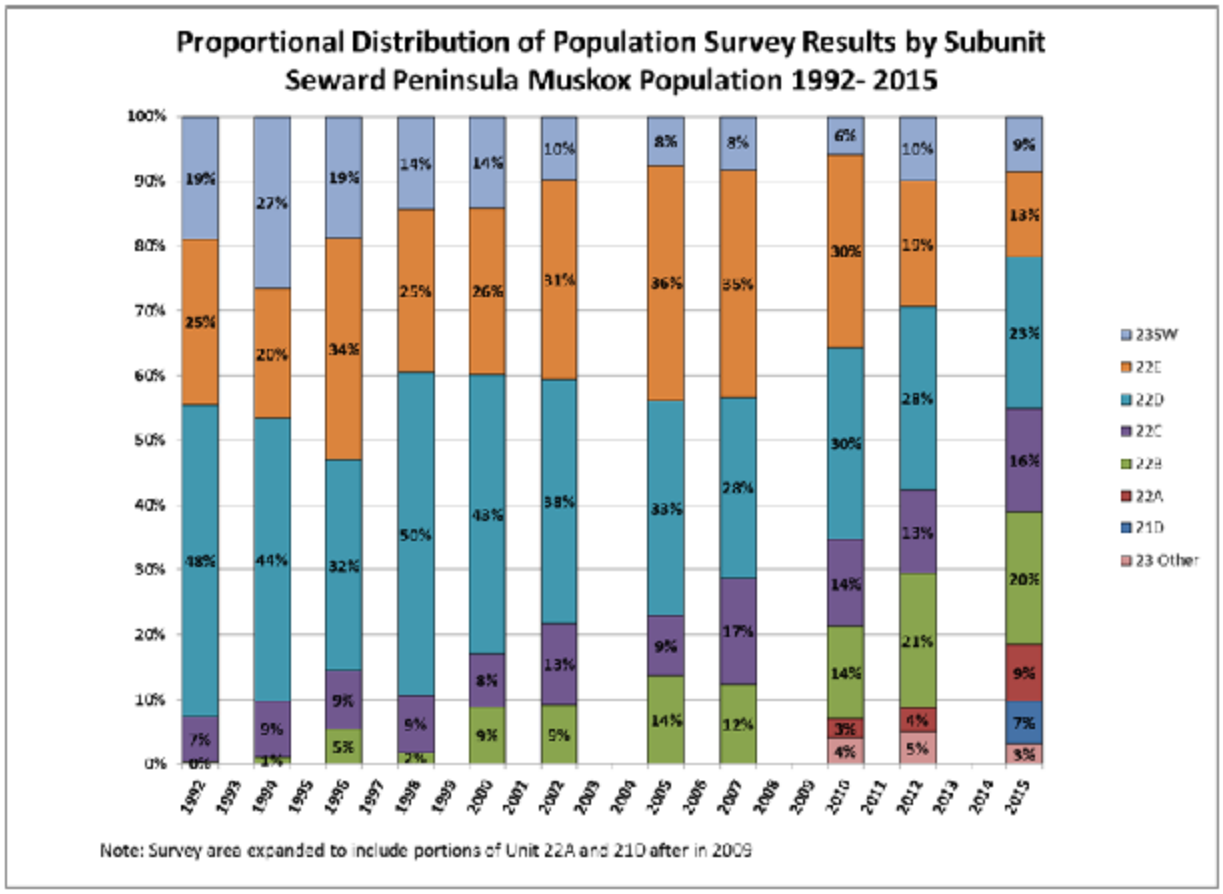
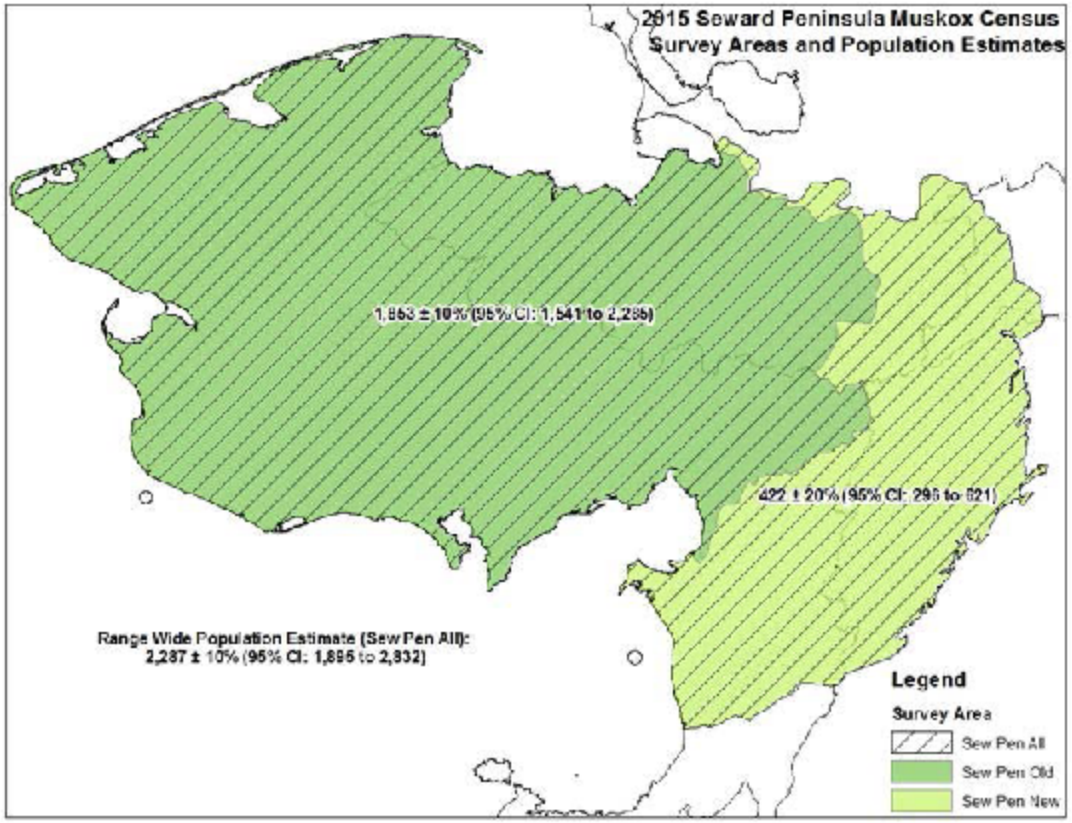


Figure 4. Distance sample population estimates Seward Peninsula muskox population survey areas.



APPENDIX B: METHODS FOR MUSKOX POPULATION ESTIMATION ANALYSES

Gorn, T. and W. R. Dunker. 2013. Unit 22 muskox. Pages 17–51 [*In*] P. Harper, editor. Muskox management report of survey and inventory activities 1 July 2010–30 June 2012. Alaska Department of Fish and Game, Division of Wildlife Conservation, Species Management Report ADF&G/DWC/SMR-2013-2, Juneau.

Pg. 19-20:

Population Estimation. Distances to each observed group were measured using ArcMap 9.3.1. Appropriate detection functions for these data were then identified using program Distance 6.0 (Thomas et al. 2009) which allows the user to compare several detection functions using Akaike's Information Criterion (AIC) and select the best approximating model for the detection process. Histograms of the observed data produced in Distance can also be used to assess the validity of critical assumptions. Because the width of the obstructed strip beneath the aircraft was unknown, we used these tools to select a left-truncation distance to eliminate the portion of the transect where detection probability was <1.0. The data were right truncated at 2.4 km because observers typically did not search past that distance and the few observations at greater distances contributed little information.

We refit the best approximating model (identified using program Distance) in a Bayesian framework using R programming language (http://www.r-project.org/) and WinBUGS (Spiegelhalter et al. 2004), which also allowed us to include spatially autocorrelated random effects on the probability of presence on each transect. The inclusion of this term helped to account for variables such as habitat suitability and quality that were not available for the entire survey area. Using autocorrelation among adjacent transects helped estimate local abundances more accurately. We also included transect length as a covariate based on the assumption that longer transects would have a higher probability of muskoxen presence due to the additional area surveyed. We did not include covariates for detection probability (e.g., weather, snow cover, pilot/observer), although this could be done in the future. Population estimates for each traditional hunt area were produced by weighting the abundance estimate for each individual transect by the proportion of that transect that was within the hunt area.

APPENDIX C. 2015 muskox composition survey results memo, 29 June 2015 ERRATUM.

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Fish and Game
DIVISION OF WILDLIFE CONSERVATION
Northwest

103 East Front Street
P.O. Box 1148
Nome, Alaska 99762-1148
Main: 907.443.2271
Fax: 907.443.5893

MEMORANDUM

TO:	Distribution (see below)	DATE: June 29, 2015 ERRATUM	
FROM:	Bill Dunker Wildlife Biologist I Wildlife Conservation Nome	PHONE: 907-443-8189 SUBJECT: 2015 Muskox Composition Survey Results	

ERRATUM: Short yearling defined as 10–15 months-old for comparison to previous surveys.

Overview:

Composition surveys were completed between 7 Apr, 2015 and 3 May, 2015, following the completion of the 2015 Seward Peninsula muskox population abundance survey, with contributions from the Alaska Department of Fish & Game and the National Park Service. Surveys were completed throughout the range of the Seward Peninsula muskox population, this included portions of Unit 22A, Unit 21D, Unit 23, Unit 24 and all of Subunits 22B, 22C, 22D, and 22E (Figure 1). A total of 76 groups totaling 1062 muskox were sampled (46% of the 2015 abundance estimate).

Methods:

Muskox groups observed during the 2015 Seward Peninsula muskox population abundance survey were divided into three classes based on group size; small (1-16 muskox), medium (17-33 muskox) and large (≥34 muskox). Within each management area, our goal was to sample a proportionate number of individuals from each group class with an overall sampling objective of 150 muskox per management area. In management areas where <150 muskox were observed, all groups were selected to be sampled.

As with previous composition surveys (2001-2012), these were ground based surveys conducted in early spring (March-May). Several groups in close proximity to Nome were accessed by snowmachine, however the majority of groups were accessed using an R-44 helicopter. At each group 2 trained observers used binoculars and spotting scopes to classify muskoxen into one of 8 sex/age classes (bull≥4yrs, bull=3yrs, bull=2yrs, cow≥4yrs, cow=3yrs, cow=2yrs, short yearlings (SY) and calves) based on body size, horn characteristics and conformation. In some instances, small groups of mature bulls were identified from fixed wing aircraft, either during the population abundance survey or during subsequent reconnaissance flights to relocate groups. Groups of this nature were not revisited during composition survey flights, but were included in the composition survey.

Ratios of MB:100C (males ≥4yrs/100 females ≥3yrs) and SY:100C (15mo≥ muskox ≥10mo/100 females ≥3yrs) as well as proportion estimates $\hat{p}_{SY}$ and $\hat{p}_{MB}$ were calculated. A 95% CI is reported for $\hat{p}_{SY}$ and $\hat{p}_{MB}$. Several subunit estimates include multiple management areas; subunit 22A includes management areas 22A and 21D Nulato Hills E, subunit 22B includes management areas 22B East and 22B West, subunit 22D includes management areas 22D Kuzitrin, 22D Remainder and 22D SW.

Results:

2015 range wide composition survey results for the Seward Peninsula muskox population are presented in Table 1 and Figure 2 along with the results of previous surveys for comparison (2002-2015). Similarly, 2015 survey results by subunit are presented in Table 2 and Figures 3-9.

Discussion:

The 2015 composition survey is now the third time (2002, 2012, and 2015) range wide surveys have been conducted (Table 1). We successfully completed composition surveys in all management areas except 23 Other, 24. The presence of a relatively small muskox population, in conjunction with the logistical considerations of the project as a whole, prevented us from committing time and resources to this portion of the range. Approximately 8 survey days were needed to complete the surveys. Survey crews operated out of both Kotzebue and Nome in order to improve the efficiency of the survey. Conducting surveys in 22A was the most time intensive and costly due to its distance from both Nome and Kotzebue.

The 2012 and 2015 range wide composition survey estimated 29 MB:100C ($\hat{p}_{MB}$=15% (14%-16% 95% CI)) and 39 MB:100C ($\hat{p}_{MB}$=20% (18%-22% 95% CI)), respectively, indicating a probable increase in mature bulls (bulls≥4yrs). Individual subunit estimates also indicate an increase in mature bulls in most subunits. The increase in mature bulls is likely a result of 3 consecutive years (regulatory years 2012-2014) of reduced harvest intended to increase the number of mature bulls in the population. The realized annual harvest rate was less than 2% during this time (Figure 10).

Recruitment rates remain low throughout the range of the Seward Peninsula muskox population. The 2015 survey estimate was 8% $\hat{p}_{SY}$ (7%-9% 95% CI) range wide. Recruitment was lowest in subunit 22C and the highest in subunit 23SW with 4% $\hat{p}_{SY}$ (2%-6% 95% CI) and 14% $\hat{p}_{SY}$ (9%-19% 95% CI), respectively. Anecdotal evidence suggests that low recruitment may be a result of bear predation during the calving period though this may not be the only cause.

The Seward Peninsula muskox population survey area was expanded in 2015 to include the eastern half of the Nulato Hills (21D, Nulato Hills E, Figure 1). Composition surveys were also conducted in this area. This provides a more complete understanding of the population composition in this portion of the range. This area is of particular interest because no muskox hunting has taken place since the reintroduction of muskox to the Seward Peninsula. 2015 survey estimates include 64 MB:100C ($\hat{p}_{MB}$=24% (21%-27% 95% CI)) with 8% $\hat{p}_{SY}$ (6%-10% 95% CI). This indicates that the number of mature bulls has remained relatively constant in the area since 2012. In addition, the proportion of bulls in this area is greater than in any other management area. However, the recruitment rate decreased significantly from 2012 when 23% $\hat{p}_{SY}$ (15-31% 95% CI)) were found.

Assessing how well our sampling effort met the sampling objectives in each management area is twofold: (1) did we sample 150 muskox? and (2) was a proportionate number of animals sampled from

each group size class? In management areas 22A, 21D Nulato Hills, 22B West and 22C, both sampling objectives were achieved. In management areas 22D Rem and 22E, we successfully sampled approximately 150 animals but did not sample a proportionate number of animals from each group size class due to a limited number of small groups encountered. In the remaining management areas we did not meet either sampling objective because of a limited number of muskox (<150). However, the sample size obtained in each of these management areas is still more than adequate since it included >50% of the minimum count (Table 3).

The 2015 composition survey sampling protocol reduced sampling effort in each management area. For comparison, the 2012 sampling objective was to classify at least 15 selected groups or 200 individuals in each management area. These guidelines were based on historic variability, the sample sizes and confidence intervals of previous surveys, as well as a series of simulations. They were established to ensure that composition surveys could effectively estimate MB:100C and SY:100C ratios with a degree of precision that allowed us to monitor changes in the demographics of the herd, range wide, as well as within individual subunits.

Obtaining precise estimates of MB:100C and SY:100C requires a great deal of sampling effort due to compounding variance. Following biometric review of the composition survey protocol it was determined that the 2015 survey effort and all future surveys of this nature should focus on obtaining precise estimates of $\hat{p}_{SY}$ and $\hat{p}_{MB}$. Focusing on these metrics ultimately allows us to reduce our sampling effort while still: (1) ensuring estimates fall within the range of precision necessary to meet management objectives, (2) continuing to monitor the population, and (3) effectively administering hunts. MB:100C and SY:100C ratios will continue to be reported, however confidence intervals will no longer be calculated for these metrics.

Distribution List:

Steve Machida, ADF&G- Anchorage
Peter Bente, ADF&G- Nome
Jim Dau, ADF&G- Kotzebue
Brandon Saito, ADF&G- Kotzebue
Letty Hughes, ADF&G- Nome
Tony Gorn, ADF&G- Nome
Adam Craig, ADF&G- Anchorage
Ryan Klimstra, ADF&G- Barrow
Phil Perry, ADF&G- Bethel
Patrick Jones, ADF&G- Bethel
Beth Lenart, ADF&G- Fairbanks
Jim Lawler, NPS- Fairbanks
Jeanette Koelsch, NPS- Nome
Ken Adkisson, NPS- Nome
Josh Schmidt, NPS- Fairbanks
Marci Johnson, NPS-Kotzebue
Susan Georgette, USFWS- Kotzebue
Brad Scotton, USFWS- Galena
Bruce Seppi, BLM- Anchorage
Tom Sparks, BLM- Nome

Table 1. Range wide composition estimates 2002-2015

Population	Year	# Grps	# Muskox	MB:100C	SY:100C	$\hat{p}_{SY}$	$\hat{p}_{MB}$
Sew Pen	2002	76	1345	44	44	18%(17%-19% 95% CI)	18%(17%-19% 95% CI)
Sew Pen	2012	89	1449	29	23	12%(11%-13% 95% CI)	15%(14%-16% 95% CI)
Sew Pen	2015	76	1062	39	17	8%(7%-9% 95% CI)	20%(18%-22% 95% CI)

Table 2. Subunit composition estimates 2002-2015

Population	Year	# Grps	# Muskox	MB:100C	SY:100C	$\hat{p}_{SY}$	$\hat{p}_{MB}$
22A	2012	9	104	69	69	23%(15%-31% 95% CI)	23%(15%-31% 95% CI)
22A	2015	18	164	64	21	8%(6%-10% 95% CI)	24%(21%-27% 95% CI)
22B	2002	16	178	58	48	18%(17%-19% 95% CI)	22%(20%-24% 95% CI)
22B	2004	15	236	39	39	18%(13%-23% 95% CI)	18%(13%-23% 95% CI)
22B	2007	22	317	48	35	15%(14%-16% 95% CI)	21%(20%-22% 95% CI)
22B	2009	11	196	38	26	11%(6%-16% 95% CI)	17%(12%-22% 95% CI)
22B	2010	14	215	30	25	14%(11%-17% 95% CI)	17%(13%-21% 95% CI)
22B	2012	15	278	28	19	10%(8%-12% 95% CI)	16%(13%-19% 95% CI)
22B	2015	20	218	44	12	6%(4%-8% 95% CI)	22%(18%-26% 95% CI)
22C	2002	15	209	70	57	19%(17%-21% 95% CI)	23%(20%-26% 95% CI)
22C	2004	16	217	86	26	10%(6%-14% 95% CI)	32%(26%-38% 95% CI)
22C	2007	29	412	57	37	16%(15%-17% 95% CI)	25%(24%-26% 95% CI)
22C	2008	18	283	31	33	16%(12%-20% 95% CI)	15%(11%-19% 95% CI)
22C	2009	20	352	35	19	9%(6%-12% 95% CI)	16%(12%-20% 95% CI)
22C	2011	19	319	21	32	17%(13%-21% 95% CI)	11%(8%-14% 95% CI)
22C	2012	13	243	26	22	12%(10%-14% 95% CI)	14%(12%-16% 95% CI)
22C	2015	8	155	45	7	4%(2%-6% 95% CI)	26%(21%-31% 95% CI)
22D	2002	21	455	33	41	19%(17%-21% 95% CI)	15%(13%-17% 95% CI)
22D	2006	31	516	42	36	16%(13%-19% 95% CI)	19%(16%-22% 95%CI)
22D	2010	18	259	54	18	9%(6%-12% 95% CI)	26%(21%-31% 95% CI)
22D	2011	27	467	29	24	13%(10%-16% 95% CI)	15%(12%-18% 95% CI)
22D	2012	15	259	22	13	8%(5%-11% 95% CI)	13%(10%-16% 95% CI)
22D	2015	17	287	26	19	11%(9%-13% 95% CI)	15%(12%-18% 95% CI)
22E	2002	14	341	49	49	17%(14%-20% 95% CI)	17%(14%-20% 95% CI)
22E	2005	38	517	35	32	15%(13%-17% 95% CI)	16%(14%-18% 95% CI)
22E	2010	28	363	51	32	15%(12%-18% 95% CI)	23%(20%-26% 95% CI)
22E	2011	25	375	53	59	21%(17%-25% 95% CI)	19%(15%-23% 95% CI)
22E	2012	15	219	33	28	13%(10%-16% 95% CI)	15%(12%-18% 95% CI)
22E	2015	7	142	39	21	10%(6%-14% 95% CI)	18%(13%-23% 95% CI)
23SW	2002	10	162	33	31	14%(12%-16% 95% CI)	15%(13%-17% 95% CI)
23SW	2010	11	157	19	18	11%(9%-13% 95% CI)	11%(9%-13% 95% CI)
23SW	2011	8	127	22	10	6%(2%-10% 95% CI)	13%(7%-19% 95% CI)
23SW	2012	12	239	24	22	11%(7%-15% 95% CI)	12(8%-16% 95% CI)
23SW	2015	6	96	32	26	14%(9%-19% 95% CI)	17%(12%-22% 95% CI)
23SE	2012	8	81	27	16	9%(4%-14% 95% CI)	15%(9%-21% 95% CI)

Table 3. Distribution of muskox in minimum count and composition survey among different group size classes (S=small, 1–16 muskox; M=medium, 17–33 muskox; and L=large, ≥34 muskox).

Mgmt Area	Min Count #Ind	Min Count #Grps	Comp Surv #Ind	Comp Surv #Grps	Min Count % S	Min Count % M	Min Count % L	Comp Surv % S	Comp Surv % M	Comp Surv % L
22A, 21D Nulato Hills*	212	23	143*	18	83%	17%	0%	62%	38%	0%
22B East*	114	10	79*	8	80%	20%	0%	75%	25%	0%
22B West	182	12	138	12	58%	42%	0%	57%	43%	0%
22C	374	17	155	8	35%	41%	24%	28%	50%	22%
22D Rem	254	14	162	10	57%	29%	14%	31%	36%	33%
22D Kuz	54	5	33	2	80%	20%	0%	42%	58%	0%
22D SW	93	5	92	5	60%	20%	20%	37%	20%	43%
22E	171	11	142	7	64%	27%	9%	19%	27%	54%
23 SW	151	8	96	6	50%	38%	13%	40%	26%	34%
23, Other 24	39	2	0	0	0%	100%	0%	0%	0%	0%

*not including calves observed

Figure 1. 2015 Seward Peninsula Population Management Areas

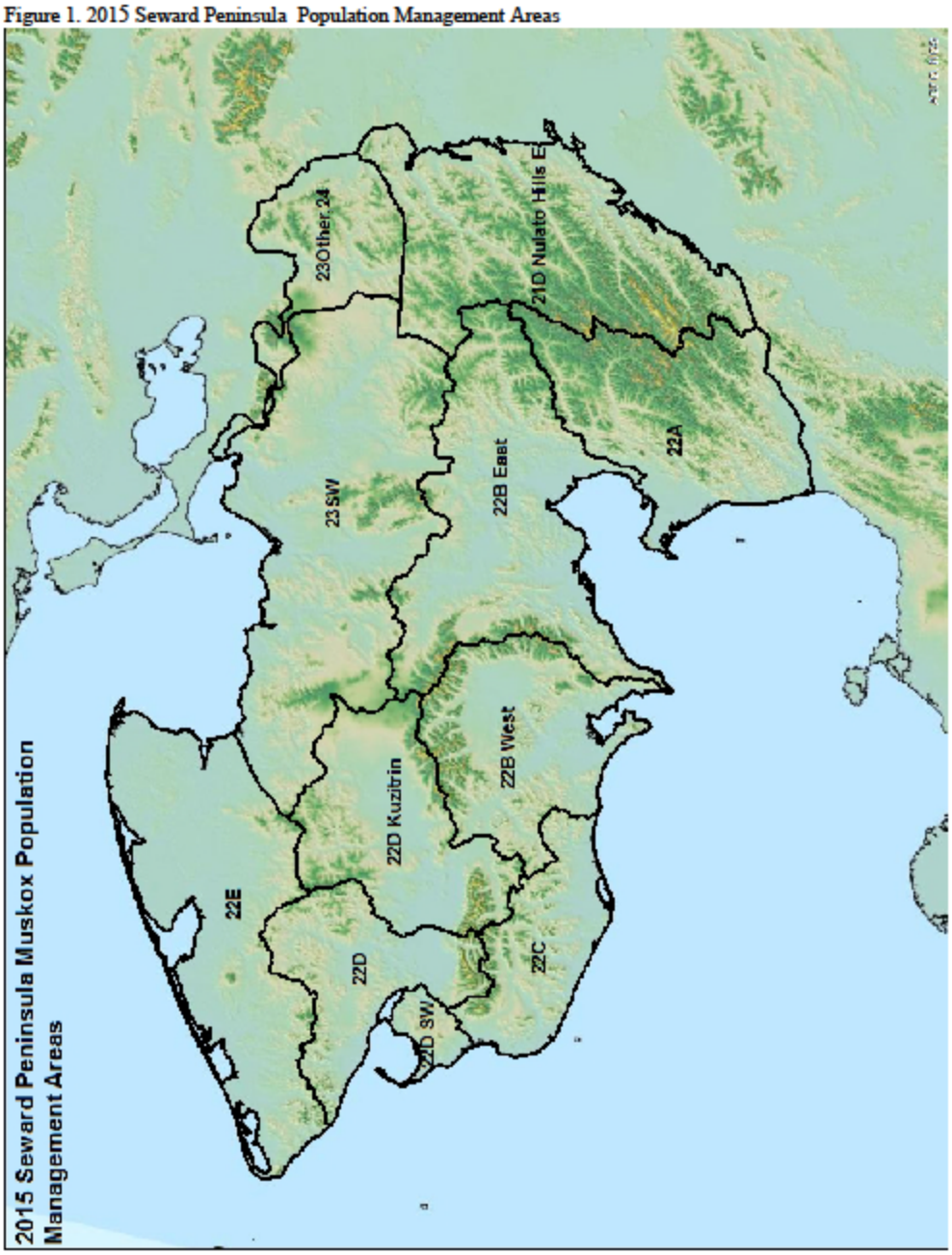


Figure 2. Seward Peninsula Muskox Population Composition, 2002-2015.

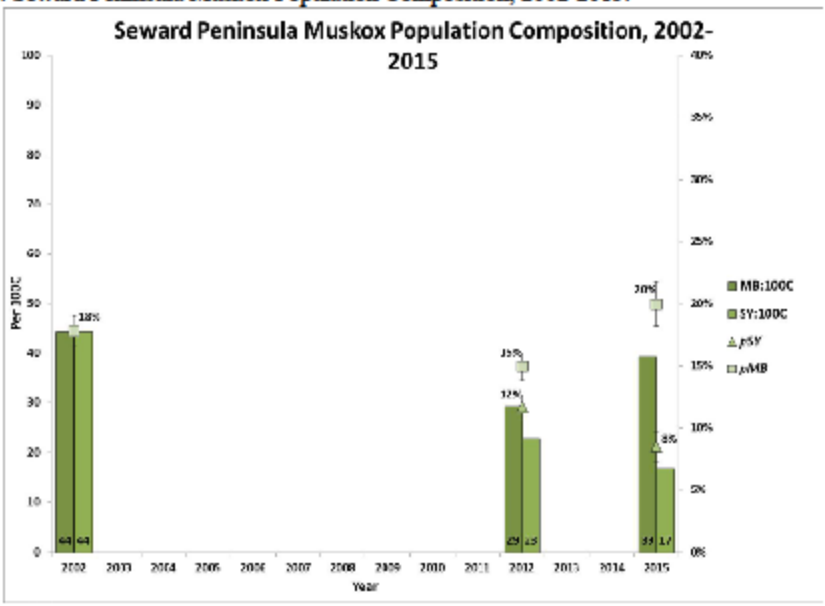


Figure 3. Subunit 22A Composition, 2012-2015.

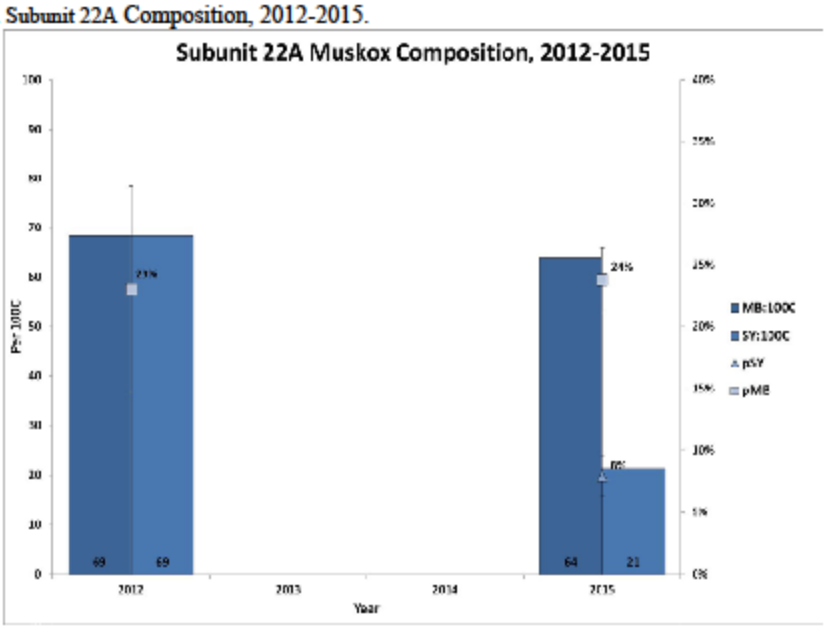


Figure 4. Subunit 22B Composition, 2002-2015.

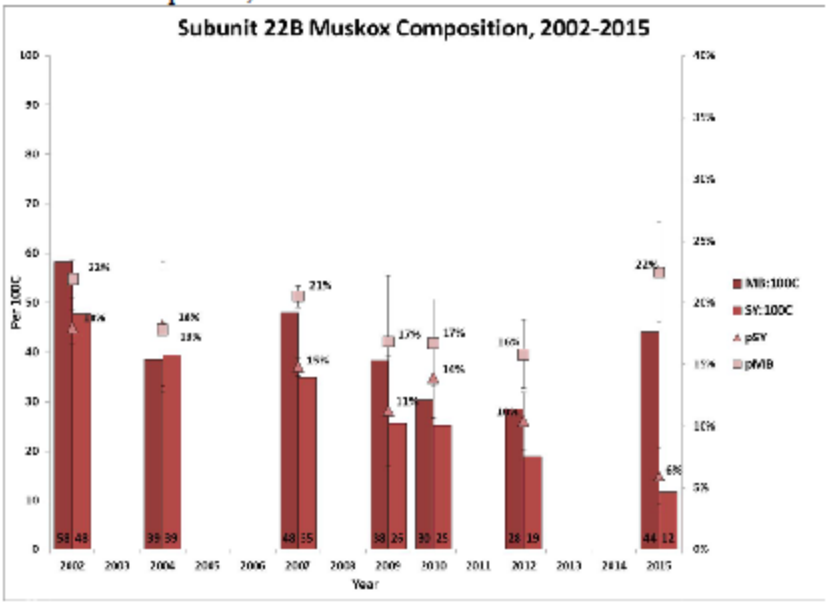


Figure 5. Subunit 22C Composition, 2002-2015.

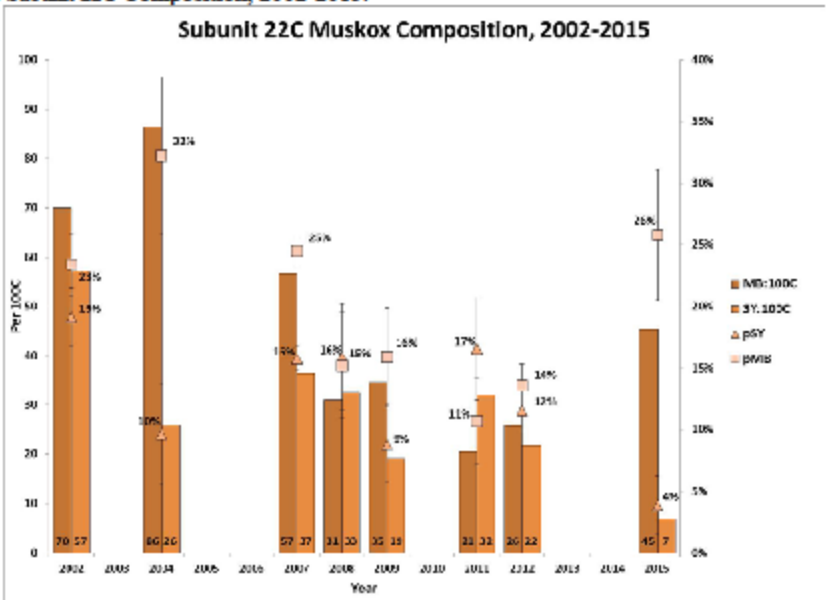


Figure 6. Subunit 22D Composition, 2002-2015.

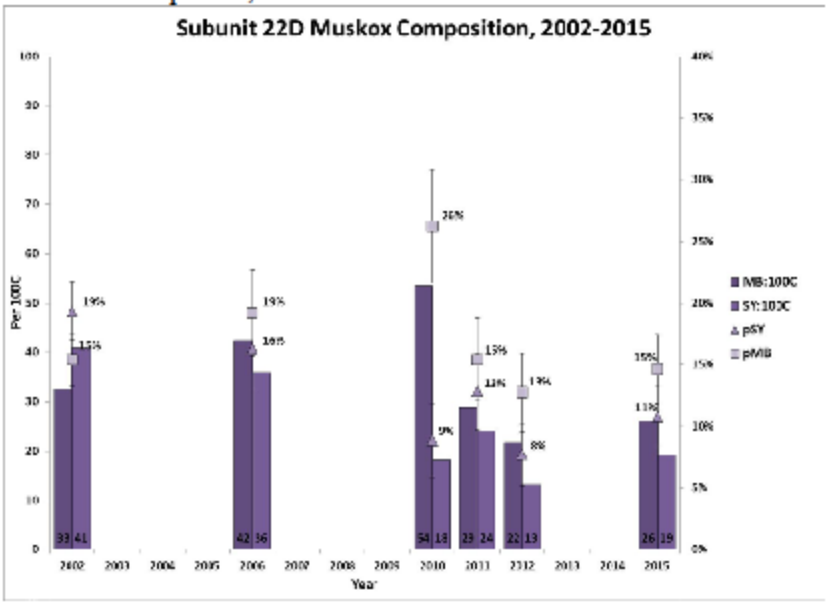


Figure 7. Subunit 22E Composition. 2002-2015 (Excludes fall Surveys).

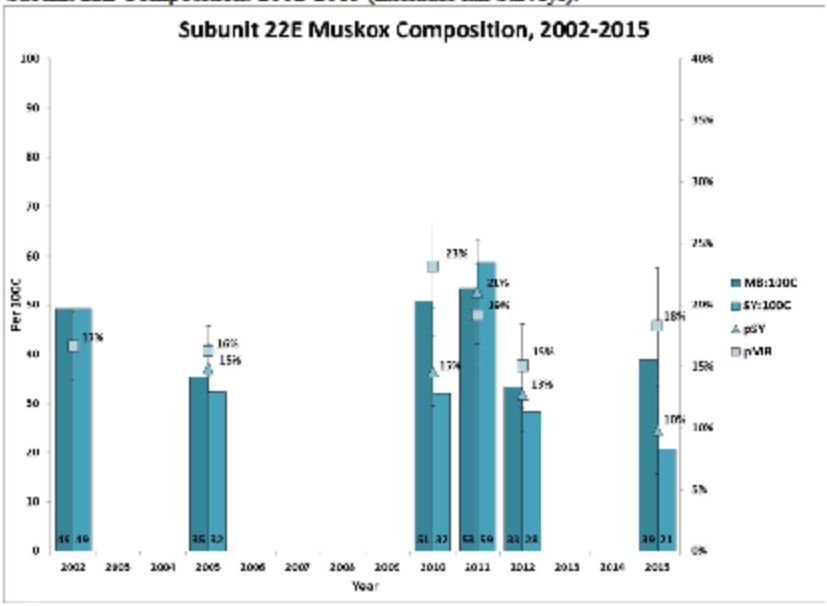


Figure 8. Subunit 23 SW Composition, 2002-2015 (Excludes fall Surveys).

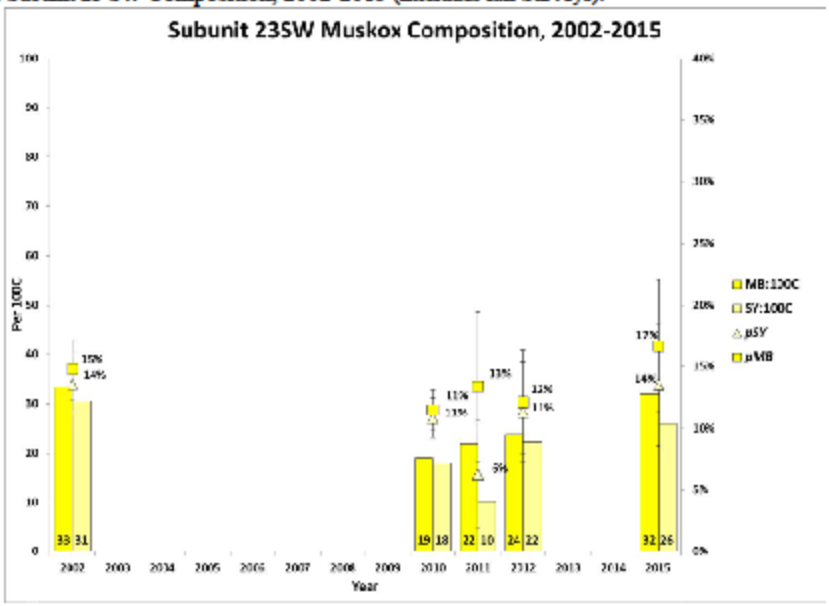


Figure 9. Subunit 23 SE Composition, 2012

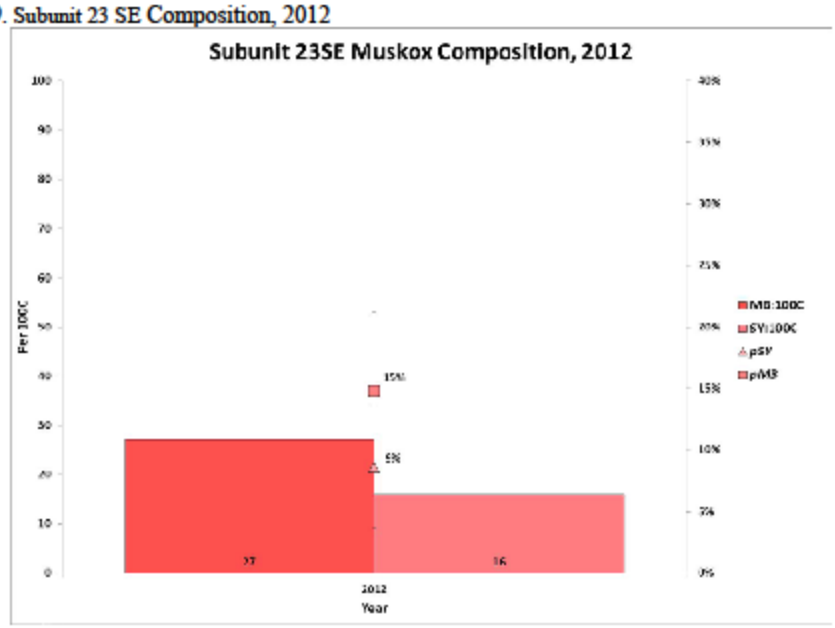
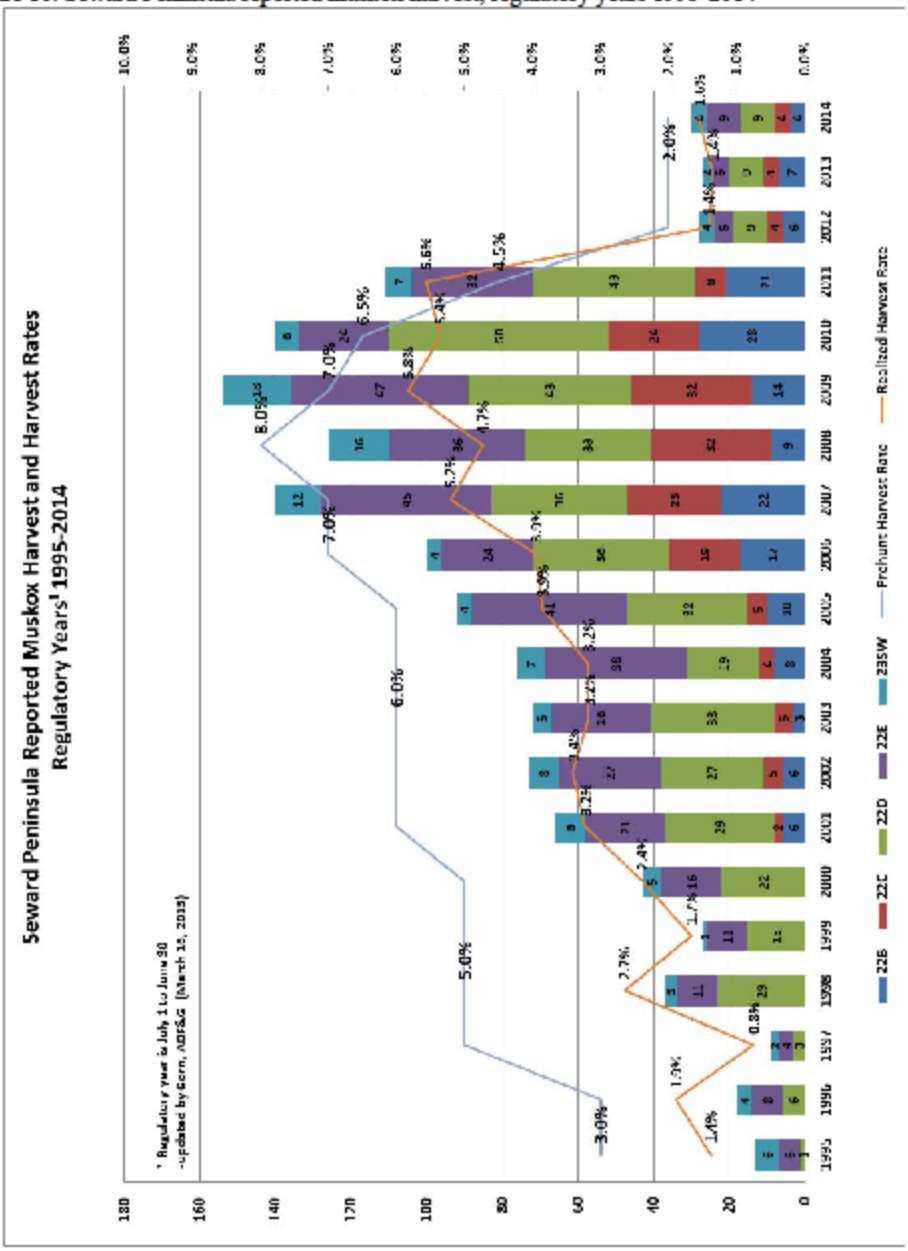


Figure 10. Seward Peninsula reported muskox harvest, regulatory years 1995-2014



Page 11

Alaska Department of Fish and Game
Division of Wildlife Conservation
(907) 465-4190 – PO Box 115526
Juneau, AK 99811-5526

CHAPTER 3: MUSKOX MANAGEMENT REPORT

From: 1 July 2012
To: 30 June 2014

LOCATION

GAME MANAGEMENT UNITS: 23 (43,000 mi^2) and 26A (56,000 mi^2)

GEOGRAPHIC DESCRIPTION: Kotzebue Sound and North Western Arctic Slope of Alaska

BACKGROUND

Muskoxen are indigenous to Northwest Alaska; however, they disappeared before or during the 19th century for unknown reasons. The North Pacific whaling fleet is often credited with decimating muskoxen in this region. However, muskoxen may have already disappeared from Alaska (but not northwestern Canada) by the time whalers arrived. Although there is ample evidence of several genera of muskoxen in Northwest Alaska from the Pleistocene period (McDonald and Ray 1989), there is little evidence that muskoxen existed south of the Brooks Range during the last several hundred years.

Two muskox populations currently inhabit Unit 23, and both are products of translocations from Nunivak Island. The department released 36 muskoxen on the southwestern portion of the Seward Peninsula near Teller in 1970. In 1981 the department released an additional 35 muskoxen in the same area. Muskoxen inhabiting Unit 23 Southwest, the portion of Unit 23 between the Buckland and Goodhope rivers, are part of the Seward Peninsula population that resulted from these translocations near Teller. The Unit 22 muskox management report covers the Seward Peninsula muskox population and includes information for Units 22 and 23 Southwest.

In 1970 the department released 36 muskoxen near Cape Thompson, and in 1977 the department released an additional 34 muskoxen at the same site. Of the 4 translocations of muskoxen to Alaska, the Cape Thompson population has grown the least. A large portion of the Cape Thompson muskox population inhabits the portion of Units 23 and 26A from the mouth of the Noatak River to Corwin Bluff within 20–35 miles of the Chukchi Sea.

In addition to the relatively discrete Seward Peninsula and Cape Thompson populations that occupy stable, core ranges, muskoxen are also widely scattered throughout the remainder of the unit. Most of these scattered muskoxen occur in small groups of 1–4 individuals, and most are bulls. However, mixed sex-age groups have been observed in the Selawik, middle Noatak, and upper Noatak drainages during recent years, as well as large groups of >20 animals in the southwestern portion of Unit 26A and the headwaters of the Colville River. Muskoxen in the

Noatak drainage and in Unit 26A probably emigrated from the Cape Thompson area while those in the Selawik and Kobuk drainages probably came from the Seward Peninsula.

MANAGEMENT DIRECTION

MANAGEMENT GOALS

- Allow for growth and expansion of muskoxen into historic ranges.
- Provide for subsistence hunting and eventually for recreational hunting of muskoxen on a sustained yield basis.
- Provide for nonconsumptive uses of muskoxen; e.g., viewing and photography.

MANAGEMENT OBJECTIVES

- Survey the Cape Thompson population at least once every 3 years.
- Assess population level range expansion.
- Monitor the sex and age composition of the Cape Thompson muskoxen population.
- Minimize effects of development (e.g., mines and roads), hunting, and tourism on muskoxen and their habitat.

METHODS

POPULATION STATUS AND TREND

Population Size

The Cape Thompson muskoxen population has been surveyed since 1987 using fixed-wing aircraft. The traditional sample area includes that portion of Unit 23 between the mouth of the Noatak River and Corwin Bluff within approximately 20 miles of the Chukchi Sea coast. It also includes the lower 16 km (10 mi) of the Agashashok River (Aggie River). We used minimum count techniques during 1987–2010. Search efforts focused on known areas of use and prime muskoxen habitat along ridgelines and riparian areas; other areas were searched less intensively. To minimize disturbance, we approach groups of muskoxen at ~305 m (1,000–2,000 ft) above ground level (AGL) and repeatedly count them during a gradual, low power, spiral descent. These surveys had no estimates of sightability or confidence intervals and may have been vulnerable to observer bias.

Since introduction, incidental sightings have increased outside of the traditionally sampled area. In the last 20 years, the number of incidental sightings has increased dramatically, while in the last 5 years, counts within the traditional survey area have decreased (Fig. 1; Westing 2011). In 2011 a population-wide survey was completed that included the traditional area and potential habitat in Units 26A and 23 north of the Kobuk River. In 2012 and 2013 a distance sampling survey was completed in the 10,440 km^2 traditional sample area. Distance sampling surveys are planned for the traditional area in 2014 and 2015. The next population-wide survey that includes the new expanded areas will be in 2016, and thereafter considered on a 4-year rotation.

Distance Sampling. The distance sampling technique gives detections at various distances which can estimate abundance (Buckland et al. 2001, 2004). In 2010, distance sampling methods were successfully used to estimate the size of the Seward Peninsula muskoxen population (Gorn

2011). In 2011, the distance sampling method was adopted to estimate abundance for the Cape Thompson population. The following methods for the 2012 and 2013 survey were modified from the 2011 distance sampling survey (J. H. Schmidt and C. Westing, ADF&G, 2011, unpublished agency report, Kotzebue [W:\muskox\census results\ct2011]) to estimate the Cape Thompson muskox population in the traditional sample area (Schmidt et al. 2012).

All surveys were conducted at ~305 m AGL using tandem fixed-wing aircraft (i.e., Super Cub type aircraft) to reduce potential differences due to aircraft configuration and airspeed. Flight altitudes AGL were allowed to decrease when transects crossed hills to minimize changes in flight angle. If a hill could not be passed over safely without increasing the flight angle, teams were instructed to stop surveying and gain altitude before continuing the transect. In continuous mountainous terrain an altitude that maintained ~305 m AGL over a majority of the transect was selected by the pilot, although this situation was relatively rare (Westing 2013).

The pilot and observer worked together as a team to search all terrain on both sides of the aircraft out to the midpoint between transects. Teams were instructed to concentrate on the area nearest the aircraft first to ensure probability of detection was 1.0 near the centerline. When a group of muskoxen was detected, the team continued surveying until slightly past the group to prevent detections of additional groups after leaving the transect. The team then left the transect, marked the group location with a Global Positioning System (GPS), and recorded the total number of individuals and the number of short yearlings in the group. Digital photographs were used to confirm counts of larger groups when necessary.

Survey Techniques. The Cape Thompson traditional survey area was resampled in 2012 and 2013 to increase the number of area specific group detections, and to decrease the reliance on Seward Peninsula group detections in future surveys (Westing 2013). The parallel transect intervals were changed to 4.8 km (3 mi) spacing for compatibility with Seward Peninsula surveys, and to increase effort to get a better estimate (J. Schmidt, National Park Service [NPS], Fairbanks, personal communication). The 2012 survey was flown during 3–15 March 2012. Snow coverage was adequate (complete or near complete) in each survey area. The 2013 survey was flown during 27 February–2 March. Snow cover was adequate in all locations although ridges and knobs were windswept as is to be expected (Westing 2013; B. Saito, ADF&G, unpublished report, Kotzebue [W:\muskox\census results\ct2013]).

The survey area boundaries were determined using locations of observed muskoxen and exclusionary habitat criteria (e.g., complete snow coverage with no exposed vegetation) for Unit 23 (Westing 2013). Areas at elevations over 700 m were considered nonhabitat and were excluded from the survey. This criterion was set after analyzing the elevation of all muskoxen sightings in the muskoxen database that have been kept at ADF&G since the muskoxen introduction. ArcGIS 10 was used with a Spatial Analyst extension to remove areas higher than 700 m from a raster layer. The raster layer was converted to a coverage so polygons less than 1 mi^2 could be added back for continuity. Finally, the coverage was converted to a shapefile delineating survey boundaries.

Analysis. Perpendicular distances from the flight line to each observed group were calculated using ArcMap 9.3.1. The observed distance data in both surveys were right truncated at 2.23 km (1.4 mi) (J. Schmidt, personal communication), the distance at which adjacent transects

overlapped. The left truncation distance, accounting for the unobserved strip beneath the aircraft, was determined by examining a histogram of the observed data. A sharp increase in the number of detections in subsequent distance categories was used to identify the width of the partially observable strip. Because survey altitude was allowed to decrease while passing over hills, a small number of groups were recorded within the left truncation distance and were discarded prior to analysis. A half normal detection function was used, and the model was fit in a Bayesian framework using R 2.12 (R Development Core Team 2010) and WinBUGS (Spiegelhalter et al. 2004) (J. Schmidt, personal communication). The 2011 survey analysis included group size as a covariate (Westing 2013); however, the group size covariate was not used in the traditional area surveys (J. Schmidt, personal communication).

Population Composition

Composition information was collected by ADF&G and NPS during March–April 2012 and 2013 when sightability was more optimal. Composition information was also collected in August 2012 in partnership with NPS. Fall compositions were not completed in 2013. Muskoxen were classified into the following age and sex classes: mature bull ≥4yr; bull = 3 yr; bull = 2 yr; mature cow ≥4yr; cow = 3yr; cow = 2yr; short yearlings (15 months); and calves. The latter 2 classifications were collected during spring composition.

A Robinson R-44 helicopter was used for transportation to the groups where ground-based observations of muskoxen were performed. We classified as many muskoxen as possible, sometimes using 1 or 2 fixed-wing planes to help search the area between the Noatak River mouth and the Kivalina River. Locations of muskoxen observed during surveys were recorded using GPS coordinates.

Distribution and Movements

Locations of muskoxen observed opportunistically during other work were also recorded using GPS coordinates. In addition, conversations between department staff and local residents, commercial operators, hunters, and nonconsumptive users provided information regarding the distribution of muskoxen in Units 23 and 26A.

MORTALITY

NPS collared and monitored cow muskoxen between March 2009 and May 2013 for a mortality study. Staff from both agencies examined mortality sites when possible to attempt to determine causes of muskoxen mortality and collect samples.

Harvest

Harvest data are summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY12 = 1 July 2012–30 June 2013). Harvest during RY12 and RY13 was monitored through the Tier II hunt report system.

HABITAT

Assessment

The department did not monitor muskoxen range condition in Units 23 and 26A during the reporting period.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

The 2012 Cape Thompson muskox population survey estimated 220 (95% CI: 174–305) muskoxen in the traditional survey area and had 19 group detections.

The 2013 Cape Thompson muskox population census estimated 227 (95% CI: 178–367) muskoxen (Fig. 2) in the traditional survey area and had 20 group detections.

The difference between the 2 point estimates show a slight increase in the population; however, the confidence intervals drastically overlap one another, and analysis indicate there is no statistical change between the 2012 and 2013 Cape Thompson muskox population results. It is important to note that these 2 survey results are less comparable with minimum counts from surveys prior to 2011 since they utilized full coverage rather than transects with 3 mile spacing.

From 1970 to 1998 the Cape Thompson muskoxen population within the sampled area grew approximately 8% annually (Fig. 3). Since 1998 the growth of this population within the sampled area slowed dramatically to 2% annually. Since 2005 the muskoxen population within the traditionally sampled area has shown continuous decline.

Estimates for the traditional survey area should be interpreted with care due to sampling limitations. The fewer group observations in an area, the more reliant the model is on information from other areas and the more likely an estimate may be biased. Two more distance sampling surveys in the traditional survey area will take place in 2014 and 2015. In total these 4 surveys will give us enough specific group detections in the Cape Thompson population to use for the 2016 population-wide survey, and not rely on group detections from the Seward Peninsula population.

Population Composition

Spring composition surveys were conducted in April 2012 and 2013. We observed 8 and 36 short yearlings:100 cows, respectively (Table 1, Fig. 4), 19 and 23 mature bull:cow ratios, respectively (Table 1, Fig. 5), 32 and 36 all bulls:100 cows found, respectively (Table 1, Fig. 6).

Fall composition surveys in 2012 found 39 calves:100 cows (Table 1, Fig. 4), 21 mature bull:100 cows 21 (Table 1, Fig. 5), 33 all bulls:100 (Table 1, Fig. 6). Considering the fall and spring data together, spring surveys found more bulls (Westing 2013). This may demonstrate the difficulties observing bulls in the summer. Mature bulls are often alone or in very small groups that could easily be missed. Fall data suggest that bull:cow ratios are declining (All bulls R^2 = 53%, Mature bulls R^2 = 60% [Figs. 5 and 6]).

In most years, about half of the population estimate is observed during composition surveys. Composition data suggest calf production and yearling survivorship has varied substantially among years. Low calf production (in most years below 15%) combined with observations of mixed sex-age groups emigrating from the core range may suggest this population is beginning to experience density-dependent limitations (Westing 2013).

Distribution and Movements

Muskoxen in the northern portion of their range may be moving along the coast and emigrating into Unit 26A. For example, 48 animals were observed in spring 2009 at Cape Sabine, outside the traditional census area. In 2011, 38 animals were observed in the same area. Additionally, in recent years, there have been groups of >20 muskoxen just outside of the sample boundary and in the Kelly and Kugururok drainages. Collar data from the NPS study has also shown some impressive animal movement. One cow traveled 130 miles from the Igichuk Hills (summer 2009) to Corwin Bluff (February 2010) (L. Adams, U.S. Geological Survey, Anchorage, personal communication). Another cow was observed on the Noatak River near the mouth of the Kaluktavik River wearing a radio collar from capture work in the traditional survey area.

Muskoxen appear to use areas heavily and then nearly abandon them for extended periods (Dau 2005). One recent example of this may be the Wulik River. Summer composition surveys have shown a steady decline from 89 muskoxen in 2004 to 11–14 muskoxen in 2009–2012 (N = 9, R^2 = 0.68). There is no obvious answer to the cause of this decline. There have not been any noticeable increases in other nearby areas. There is no reason to believe a large mortality event occurred on the Wulik River.

MORTALITY

Harvest

Season and Bag Limit. During this reporting period the state administered a Tier II subsistence permit muskoxen hunt in northwest Unit 23 (TX107), the season has been 1 August–15 March, and the bag limit has been 1 bull.

Units and bag limits	Resident/Subsistence hunters	Nonresident hunters
RY11 and RY12		
Unit 23 Southwest, that portion on the Seward Peninsula west of and including the Buckland River drainage.	(see Unit 22 report)	(see Unit 22 report)
Unit 23, that portion north and west of the Noatak River.		
1 bull by Tier II subsistence hunting permit only; up to 15 bulls may be taken.	1 Aug–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 23	No open season	No open season

Tier II subsistence hunt conditions:
1. Subsistence hunts open to residents only.
2. Tag fee waived for subsistence hunting.
3. One muskox permit per hunter per calendar year.
4. Season will be closed by emergency order when quota is reached.
5. All skulls require trophy destruction be completed at the kill site subject to permit conditions.
6. Aircraft may not be used to transport muskox hunters, muskox, or muskox hunting gear.

In addition to the state Tier II hunt (TX107), the Federal Subsistence Board established a federal subsistence muskox hunt on Cape Krusenstern National Monument for residents of the monument that went into effect during RY05. The total annual quota has been 2 bulls with a 1 bull bag limit. The federal season is identical to the Tier II hunt. Three bulls have been harvested on the federal muskox permit during RY05–RY10. There have been no federal permits issued since RY10 (K. Adkisson, NPS, Nome, personal communication). The hunt is almost entirely unutilized because there are virtually no permanent residents living within the monument.

Alaska Board of Game Actions and Emergency Orders. An emergency order was issued 27 June 2013 to close the RY13 TX107 season after it was confirmed 5 cow muskoxen from the Cape Thompson population were illegally shot and left unsalvaged during January–February 2013. The illegal take of the cow muskoxen was additive to the legal harvest of bulls in the TX107 hunt, and filled the available TX107 harvest quota.

Human-Induced Harvest. Few muskoxen have been harvested under TX107 since this hunt was established in RY00 (Table 2). Until the RY04 season, all permits went to residents of Point Hope, Kivalina, or Noatak. However in the years since RY07, all but one of the successful applicants has been from Kotzebue. The shift of permits to Kotzebue hunters has resulted in nearly all recent harvest concentrated in the vicinity of the Noatak Hatchery. Since the RY06 season, all harvest has occurred in the small area west of the Noatak River and east of Cape Krusenstern National Monument.

Permit Hunts. See section above.

Hunter Residency and Success. See *Human-Induced Harvest* section; all hunting is by resident hunters. During RY12 and RY13, 6 and 7 TX107 permits were issued, respectively. Harvest reports for RY12 indicate 83% success rate (n = 5 hunters). The RY13 TX107 season was closed by emergency order and therefore had 0% success rate. During RY00 through RY13 an average annual harvest of 3 muskox per year are harvested by TX107 permit holders.

Harvest Chronology. Since the beginning of this hunt, most harvests have occurred during August–September and December–March.

Transport Methods. Most hunters have accessed the hunting area via snowmachine; however, nearly all hunters that have taken muskoxen in the fall have used boats.

Natural Mortality

The Cape Thompson collaring project monitored 48 adult cow muskoxen. Results found an 83% survival rate (76–90, 95% CI) (L. Adams, personal communication). During the study 37% (n = 18) of the collared cows died; 72% (n = 13) were either killed or scavenged by bears, 22% (n = 4) were killed by wolves, and 6% (n = 1) by unknown cause (L. Adams, personal communication).

Other Mortality

Given the natural tendency for muskoxen to travel along beaches during summer and their increasing numbers in the southern portion of their range, human-muskox conflicts occurring

between Sealing Point and Sisualik (aka Sheshalik) may likely continue. At least 2 bull muskoxen have been shot and left unsalvaged in the vicinity of Sisualik over the past 8 years, and a muskox was taken in defense of life or property in 2008 (Westing 2013).

Illegal harvests may have also reduced muskoxen numbers in the northern portion of this area. Since 2003 the department has found or received reports about at least 16 muskoxen illegally killed and abandoned north of Rabbit Creek. Many residents of Northwest Alaska have long resented the presence of muskoxen in areas they have used to hunt caribou, gather greens, and pick berries for generations (Westing 2013). Agency staff spend little time in the northern portion of this muskoxen range so we do not know the magnitude of illegal harvests.

HABITAT

Assessment

There were no muskox habitat assessment activities in Unit 23 or 26A during the reporting period.

Enhancement

There were no muskox habitat enhancement activities in Unit 23 or 26A during the reporting period.

NONREGULATORY MANAGEMENT PROBLEMS/NEEDS

Conflicts among Muskoxen, Caribou, and Reindeer

For many years, local residents have expressed concern about muskox competing and displacing *Rangifer* from traditional hunting areas (Dau 2005). However, studies on caribou and muskoxen interactions in the Northwest Territories of Canada have shown that, at least when densities of both species were low in relation to relative abundance of food, there was no competition between the 2 species (Thomas et. al 1999). Studies on the Seward Peninsula have found that although muskoxen and reindeer may occupy the same feeding areas, they select different forage plants (Ihl and Klein 2001). Although most published information indicates that competition is not a serious issue, traditional knowledge in many areas of the state suggest that indirect and direct competition may be an issue between *Rangifer* and muskox.

CONCLUSIONS AND RECOMMENDATIONS

1. Two distinct populations of muskoxen inhabit Unit 23. One population ranges primarily within 20–35 miles of the coast between the mouth of the Noatak River and Corwin Bluff. The other population inhabits the southwestern portion of Unit 23 as part of the Seward Peninsula population. Both populations stem from translocations initiated by the department in 1970. Small groups are scattered throughout much of the remainder of northern Unit 23 and some large groups exist in parts of Unit 26A. Additionally, mixed-sex age groups are becoming established within Unit 23 in the Selawik and upper Noatak drainages, and in Unit 26A and in the upper Noatak drainage.

2. As incidental observations outside of the traditionally sampled core have increased over the last 10 years, it has become increasingly important to try to evaluate the population size, distribution, and changes occurring for the Cape Thompson population with reference to the

majority of its range. A distance sampling survey in the traditional area was completed in 2012 and 2013. Two more distance sampling surveys will be completed in 2014 and 2015 that will increase the sample size of group detections to develop a specific detection function for future Cape Thompson population-wide surveys. The next population-wide survey will be completed in 2016.

3. A 2–3% harvest rate on a stable or slowly declining population allows subsistence opportunity without posing significant risk to the population. Therefore, the harvest strategy for TX107 should remain conservative with a 6 bull quota for Unit 23.

4. As an increasing number of mixed-sex age groups are observed in new areas, the department is considering ways to determine if natural range extensions of existing populations are occurring, or if discrete populations are becoming established. This will affect how harvest quotas are determined in the future and if new hunts should be established.

5. Harvests of muskoxen in the northwest portion of Unit 23 should be cooperatively managed by the department and NPS, similar to state-federal management occurring on the Seward Peninsula. That would better allow state and federal quotas to be based on the relative abundance of muskoxen on these lands.

6. Muskoxen use riparian areas during summer, and exposed, sparsely vegetated domes and ridges where snow cover is minimal during winter. Muskoxen use body-fat reserves and extremely conservative behavior to survive through winter. Disturbance to muskoxen during winter should be minimized.

REFERENCES CITED

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford University Press, New York.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas, editors. 2004. Advanced distance sampling. Oxford University Press, New York.

Dau, J. 2005. Unit 23 muskox. Pages 38–48 [*In*] C. Brown, editor. Muskox management report of survey-inventory activities 1 July 2002–30 June 2004. Alaska Department Fish and Game, Division of Wildlife Conservation, Federal Aid Wildlife Restoration Project 16.0, Juneau.

Gorn, T. 2011. Unit 22 muskox. Pages 16–47 [*In*] P. Harper, editor. Muskox management report of survey-inventory activities 1 July 2008–30 June 2010. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Project 16.0, Juneau.

Ihl, C., and D. R. Klein. 2001. Habitat and diet selection by muskoxen and reindeer in western Alaska. Journal of Wildlife Management 65:954–972.

McDonald, J. N., and C. E. Ray. 1989. The autochthonous North American musk oxen *Bootherium*, *Symbos*, and *Gidleya* (Mammalia: Artiodactyla: Bovidae). Smithsonian Contributions to Paleobiology, No. 66. Smithsonian Institution Press, Washington, D.C.

R Development Core Team. 2010. Version 2.12. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/ (Accessed 31 October 2016).

Schmidt, J. H., K. L. Rattenbury, J. P. Lawler, and M. C. MacCluskie. 2012. Using distance sampling and hierarchical models to improve estimates of Dall's sheep abundance. Journal of Wildlife Management 76:317–327. doi:10.1002/jwmg.216

Spiegelhalter, D. J., A. Thomas, N. G. Best, and D. Lunn. 2004. WinBUGS Version 1.4.1. User manual. MRC (Medical Research Council) Biostatistics Unit, Cambridge, United Kingdom.

Thomas, D. C., E. J. Edmonds, and H. J. Armbruster. 1999. Range types and their relative use by Peary caribou and muskoxen on Melville Island, NWT. Canadian Wildlife Service, Prairie & Northern Region, Technical Report Series No. 343, Edmonton, Alberta.

Westing, C. 2011. Unit 23 muskox. Pages 48–62 [*In*] P. Harper, editor. Muskox management report of survey-inventory activities 1 July 2008–30 June 2010. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Project 16.0, Juneau.

Westing, C. 2013. Unit 23 muskox. Pages 52–74 [*In*] P. Harper, editor. Muskox management report of survey-inventory activities 1 July 2010–30 June 2012. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2013-2, Juneau.

PREPARED BY:

Letty J. Hughes
Wildlife Biologist II

APPROVED BY:

Tony S. Gorn
Management Coordinator

Please cite any information taken from this section, and reference as:

Hughes, L. J. 2016. Units 23 and 26A muskox. Chapter 3, Pages 3-1 through 3-19 [*In*] P. Harper and L. A. McCarthy, editors. Muskox management report of survey and inventory activities 1 July 2012–30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-2, Juneau.

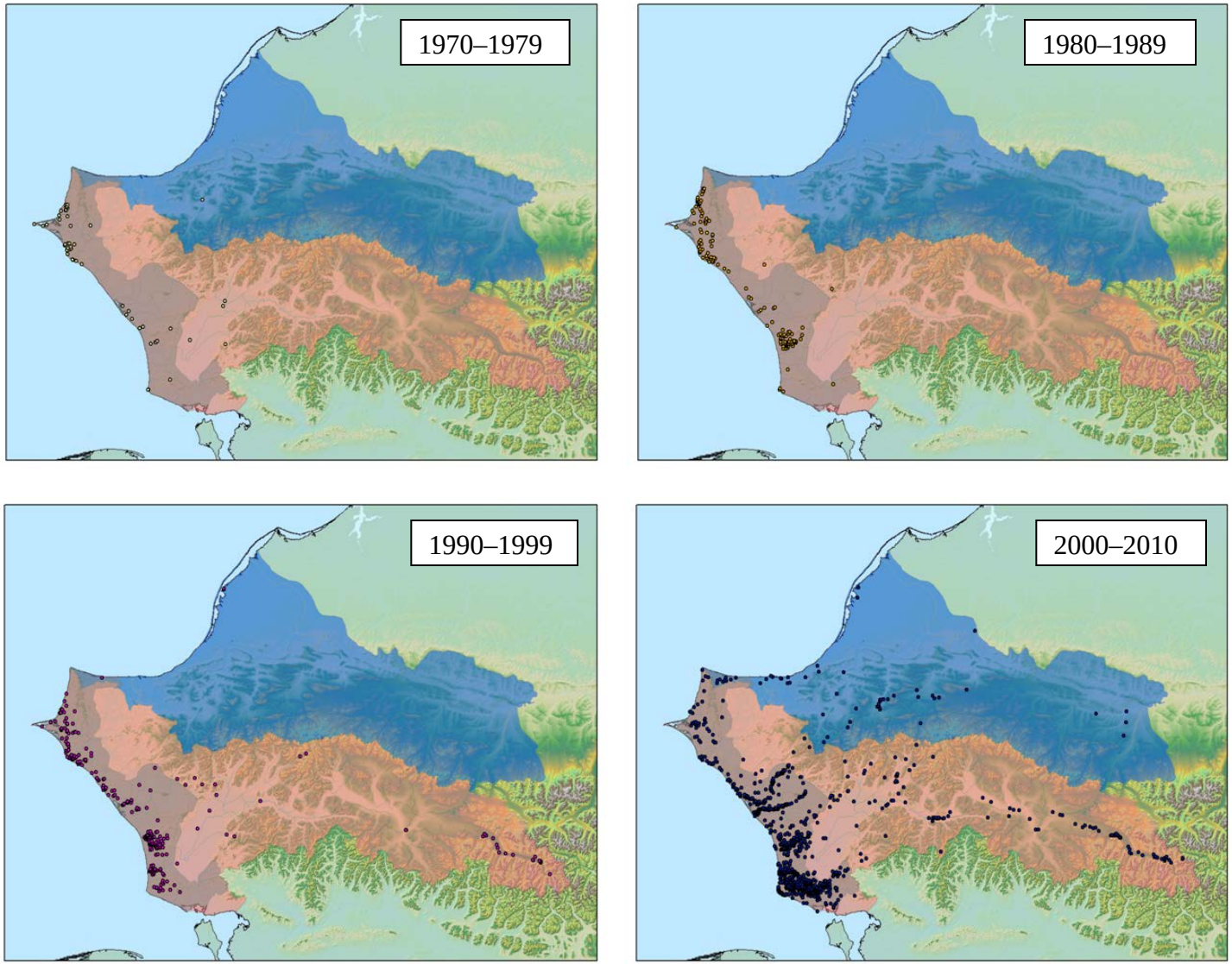


Figure 1. Locations of muskoxen observations by decade, Northwest Alaska, 1970–2010. (Includes incidental, census, and composition efforts occurring in the traditional survey area only; Unit 23 in pink; Unit 26A is shown in blue; traditional survey area in gray.)

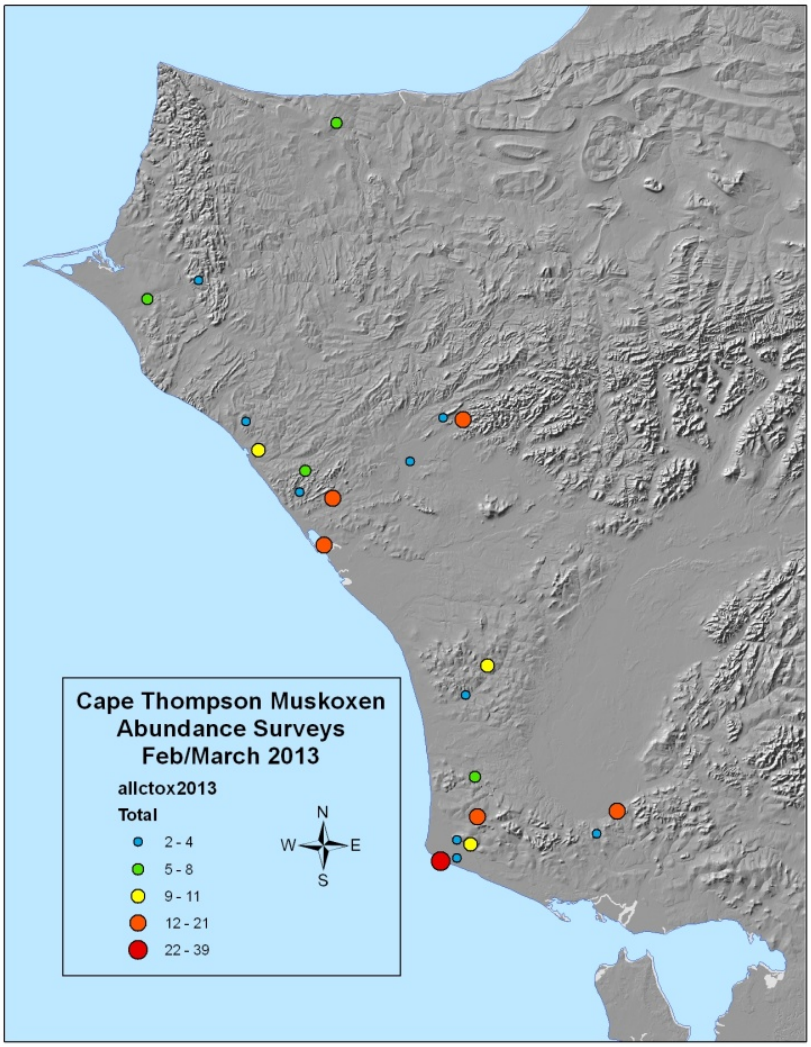


Figure 2. Cape Thompson 2013 distance sampling survey in traditional area, Northwest Alaska (Westing 2013; B. Saito, ADF&G, unpublished report, Kotzebue [W:\muskox\census results\ct2013]).

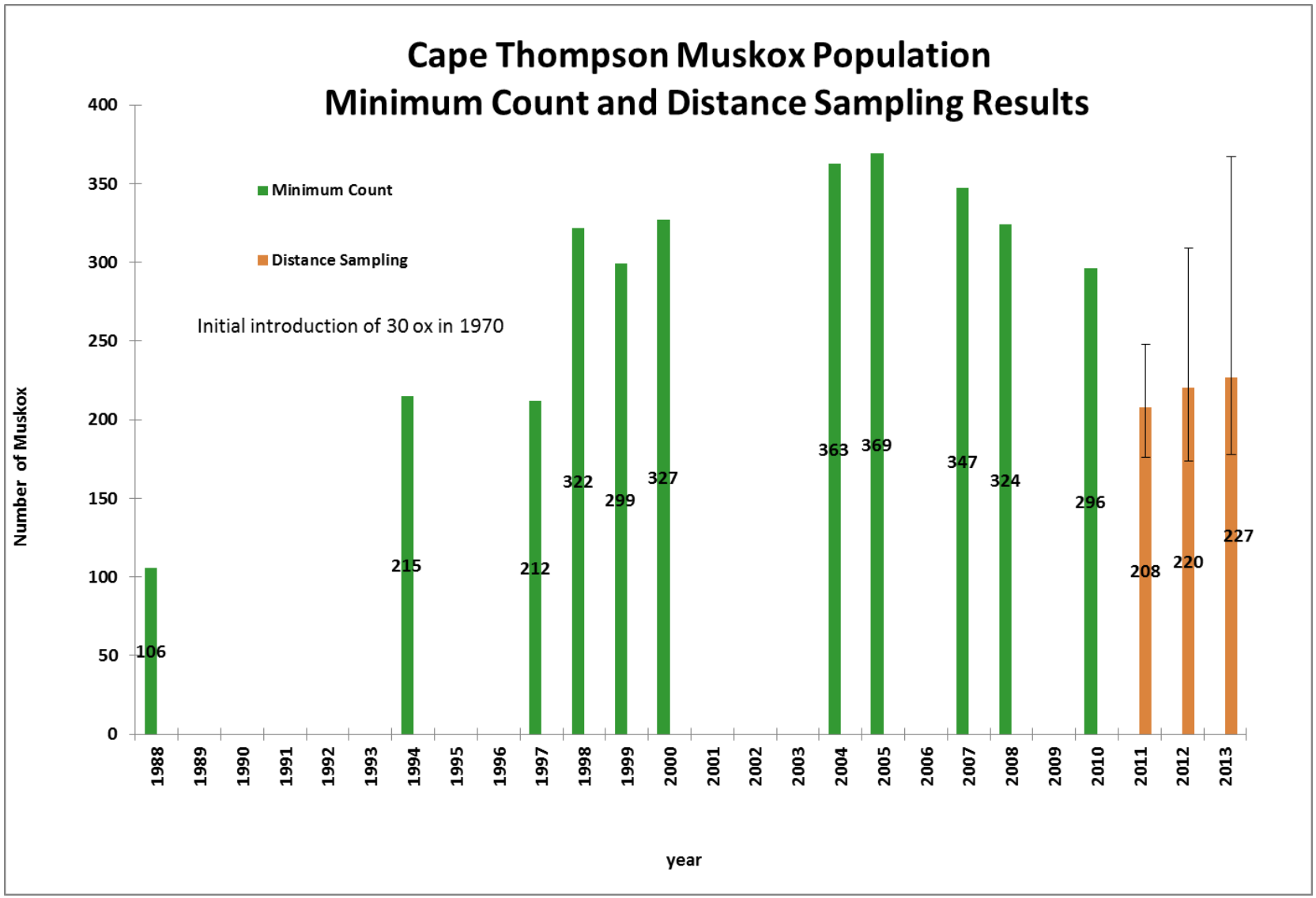


Figure 3. Cape Thompson muskoxen abundance estimate with minimum counts and distance sampling surveys, Northwest Alaska, 1988–2013.

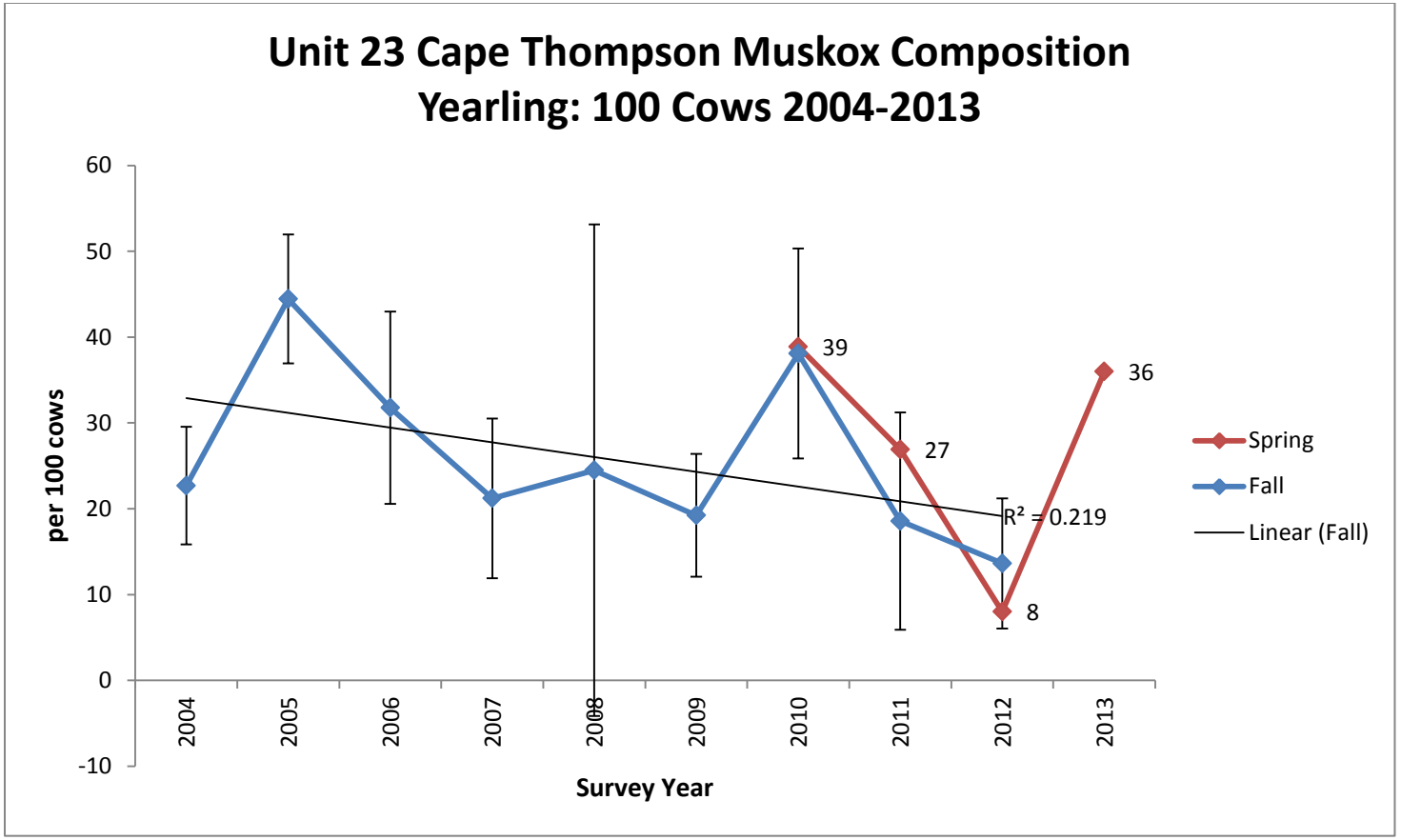


Figure 4. Muskox composition data for yearlings:100 cows, Cape Thompson population, Northwest Alaska, 2004–2013.

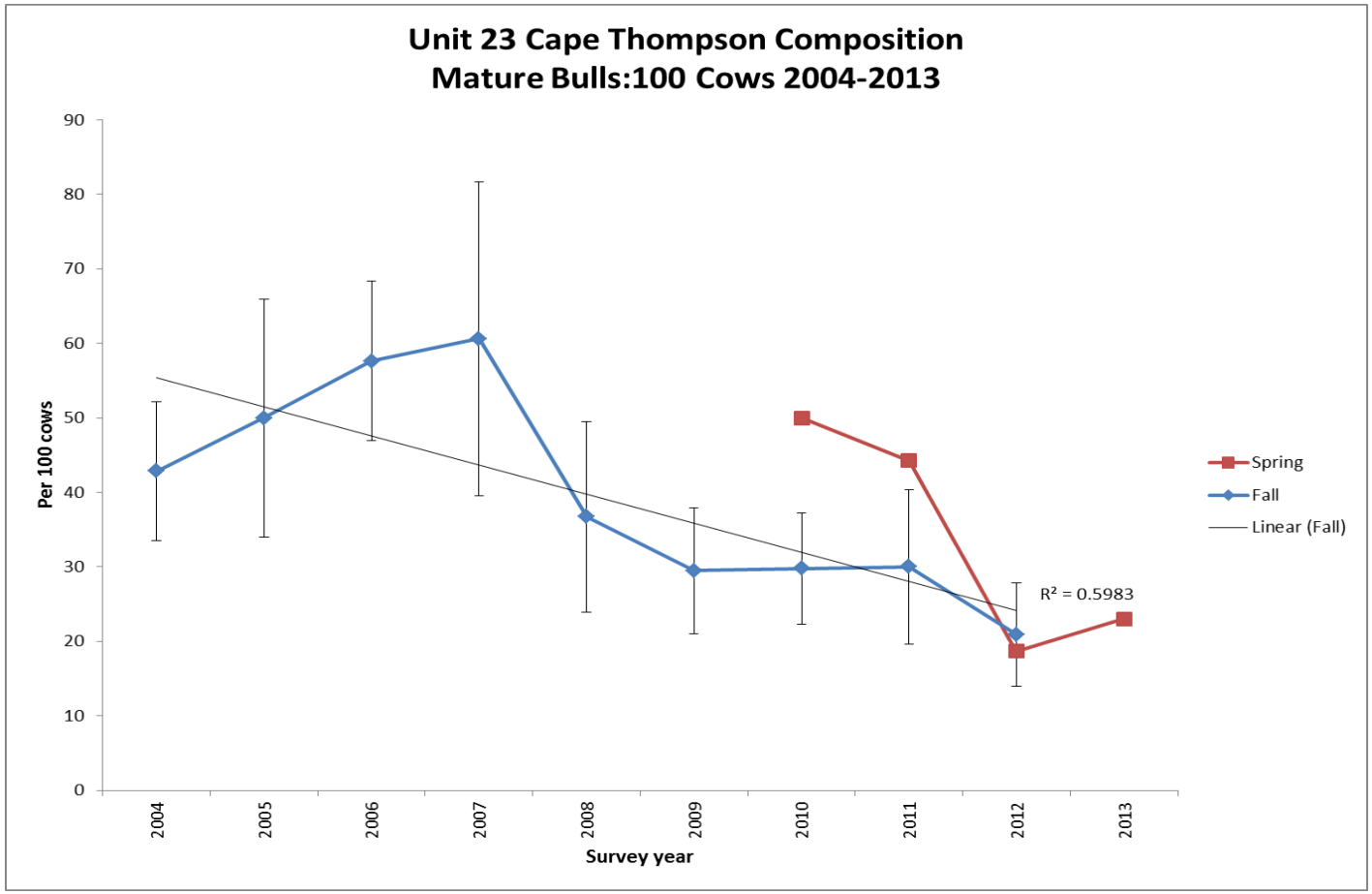


Figure 5. Muskox composition data for mature bulls:100 cows, Cape Thompson population, Northwest Alaska, 2004–2013.

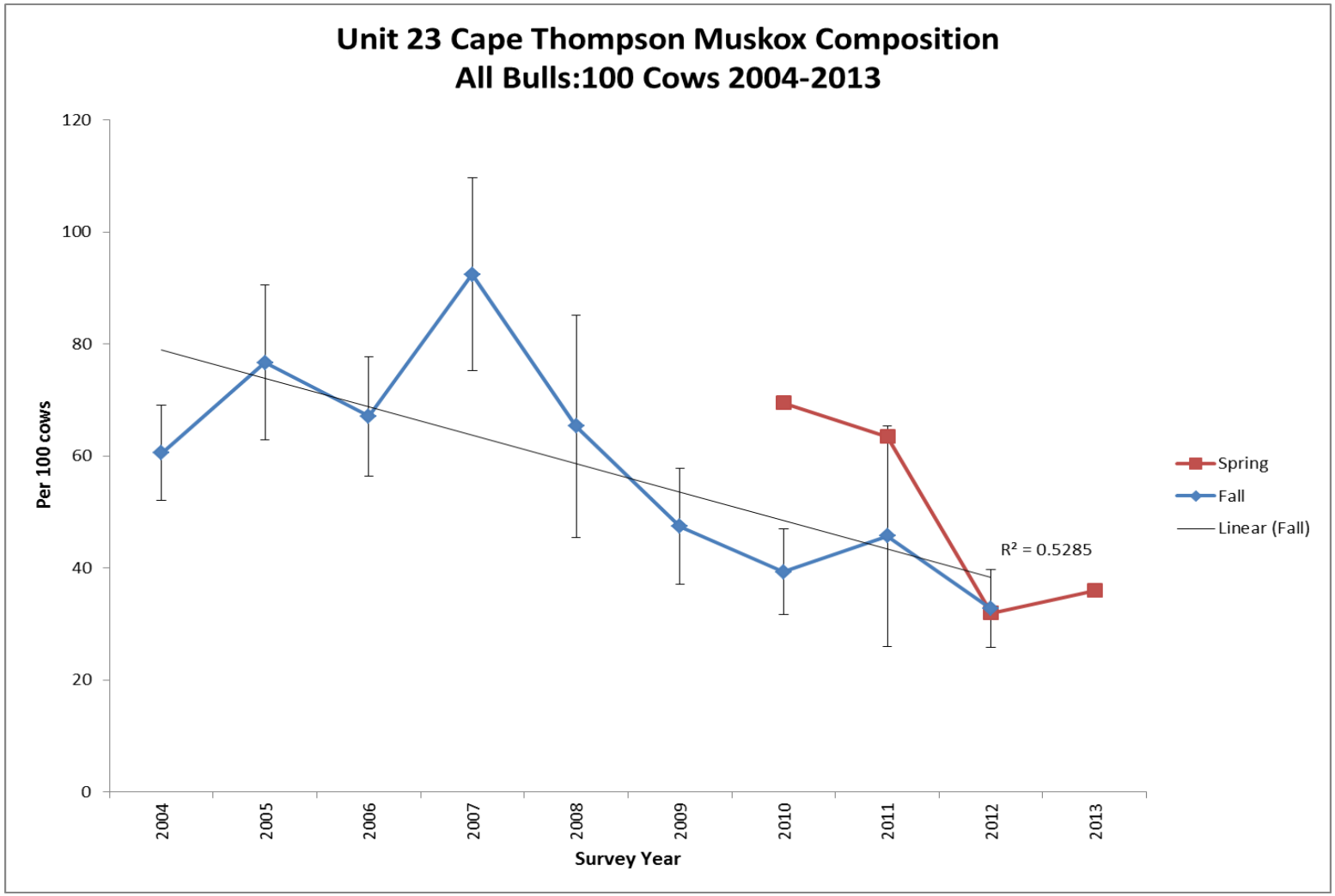


Figure 6. Muskox composition data for bulls: 100 cows, Cape Thompson population, Northwest Alaska, 2004–2013.

Table 1. Age and sex composition of Cape Thompson muskoxen groups, Northwest Alaska, 2004–2013.

Season/		%	Males ≥4 yr old		Females ≥4 yr old		Males 3 yr old		Females 3 yr old		Males 2 yr old		Females 2 yr old		Yearlings		Calves		Unk				
Year	*N*	Obs	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	B:C[a]	MB:C[b]	Y:C[c]
Fall																							
2004	269	74	51	19	98	36	4	1	10	4	17	6	11	4	27	10	48	18	3	1	61	43	40
2005	228	62	45	20	70	31	11	5	16	7	13	6	4	2	40	18	26	11	3	1	77	50	29
2006	190		49	26	69	36	4	2	15	8	4	2	1	1	27	14	21	11	0	0	67	58	25
2007	162	47	40	25	51	31	9	6	8	5	12	7	7	4	14	9	21	13	0	0	92	61	32
2008	97	30	18	19	39	40	10	10	4	4	4	4	6	6	12	12	4	4	0	0	65	37	8
2009	152		23	15	60	39	5	3	14	9	9	6	4	3	15	10	22	14	0	0	47	29	28
2010	173	58	25	14	65	38	6	3	12	7	2	1	7	4	32	18	23	13	1	1	39	30	27
2011	128	62	21	16	50	39	4	3	14	11	7	5	6	5	13	10	13	10	0	0	46	30	19
2012	211	96	23	11	71	34	5	2	22	10	8	4	17	8	15	7	43	20	7	3	33	21	39
Spring																							
2010	152	51	36	24	47	31	10	7	21	14	4	3	4	3	28	18	0	0	2	1	69	50	39
2011	101	49	23	23	35	35	2	2	7	7	8	8	10	10	14	14	0	0	2	2	63	44	27
2012	106	69	14	13	47	44	5	5	14	13	5	5	14	13	6	6	0	0	1	1	32	19	8
2013	182	80	24	13	78	43	8	4	18	10	6	3	10	5	38	21	0	0	0	0	36	23	36

[a] B:C denotes all bulls ≥2 years old per 100 cows ≥2 years old.
[b] MB:C denotes mature bulls per 100 cows ≥2 years old.
[c] Y:C denotes yearlings per 100 cows ≥2 years old.

Table 2. Harvest data for the Tier II muskoxen hunt, TX107, and the federal muskoxen hunt in Unit 23, Northwest Alaska, regulatory years[a] 2000–2013.

Regulatory year	No. of permits TX107[b]	Harvest		Total harvest	Hunter residency				
		No. of bulls	No. of cows		Point Hope	Kivalina	Noatak	Kotzebue	Other
2000	6	1	0	1	4	2	0	0	0
2001	6	0	0	0	2	0	4	0	0
2002	6	4	1	5	1	2	3	0	0
2003	6	0	0	0	0	0	6	0	0
2004	6	2	1	3	0	0	3	3	0
2005[c]	6 (1)	(1)	0	1	0	1	3	2	(1)
2006	6 (1)	4	0	4	1	1	1	3	(1)
2007	6 (2)	6 (1)	0	7	0	0	0	6	(2)
2008	6	5	0	5	0	0	1	5	0
2009	6	4	0	4	0	0	0	6	0
2010	6 (1)	4	0	4	0	0	0	6 (1)	0
2011	7	4	1	5	0	0	0	6	1
2012	6	5	0	5	0	0	0	6	0
2013[c]	7	0	5	5	0	0	2	5	0

[a] Regulatory year begins 1 July and ends 30 June, e.g., regulatory year 2000 = 1 July 2000–30 June 2001.
[b] Numbers in parentheses are from the federal hunt.
[c] Season closed by emergency order; quota taken with illegal cow harvest.

Alaska Department of Fish and Game
Division of Wildlife Conservation
(907) 465-4190 – PO Box 115526
Juneau, AK 99811-5526

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.

PREPARED BY:

Elizabeth A. Lenart
Wildlife Biologist III

APPROVED BY:

Jackie J. Kephart
Assistant Management Coordinator

REVIEWED BY:

Torsten W. Bentzen
Wildlife Biologist III

Laura A. McCarthy
Publications Technician II

Please cite any information taken from this section, and reference as:

Lenart, E. A. 2015. Units 26B and 26C muskox. Chapter 4, pages 4-1 through 4-26 [*In*] P. Harper and L. A. McCarthy, editors. Muskox management report of survey and inventory activities 1 July 2012–30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-4, Juneau.

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.


ALASKA
DEPARTMENT OF FISH AND GAME