Species Management Report ADF&G/DWC/SMR-2013-2

Muskox Management Report of Survey-Inventory Activities, 1 July 2010–30 June 2012

Patricia Harper, editor

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Alaska Department of Fish and Game Division of Wildlife Conservation

Species Management Report, ADF&G/DWC/SMR-2013-2

Muskox management report of survey-inventory activities, 1 July 2010–30 June 2012

Alaska Department of Fish and Game
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Cover Photo: Four female muskoxen on a ridge top north of Kotzebue during a spring snowfall. Muskoxen in northwest Alaska have expanded their range to the edge of forested areas. ©2013 ADF&G, photo by Jim Dau.

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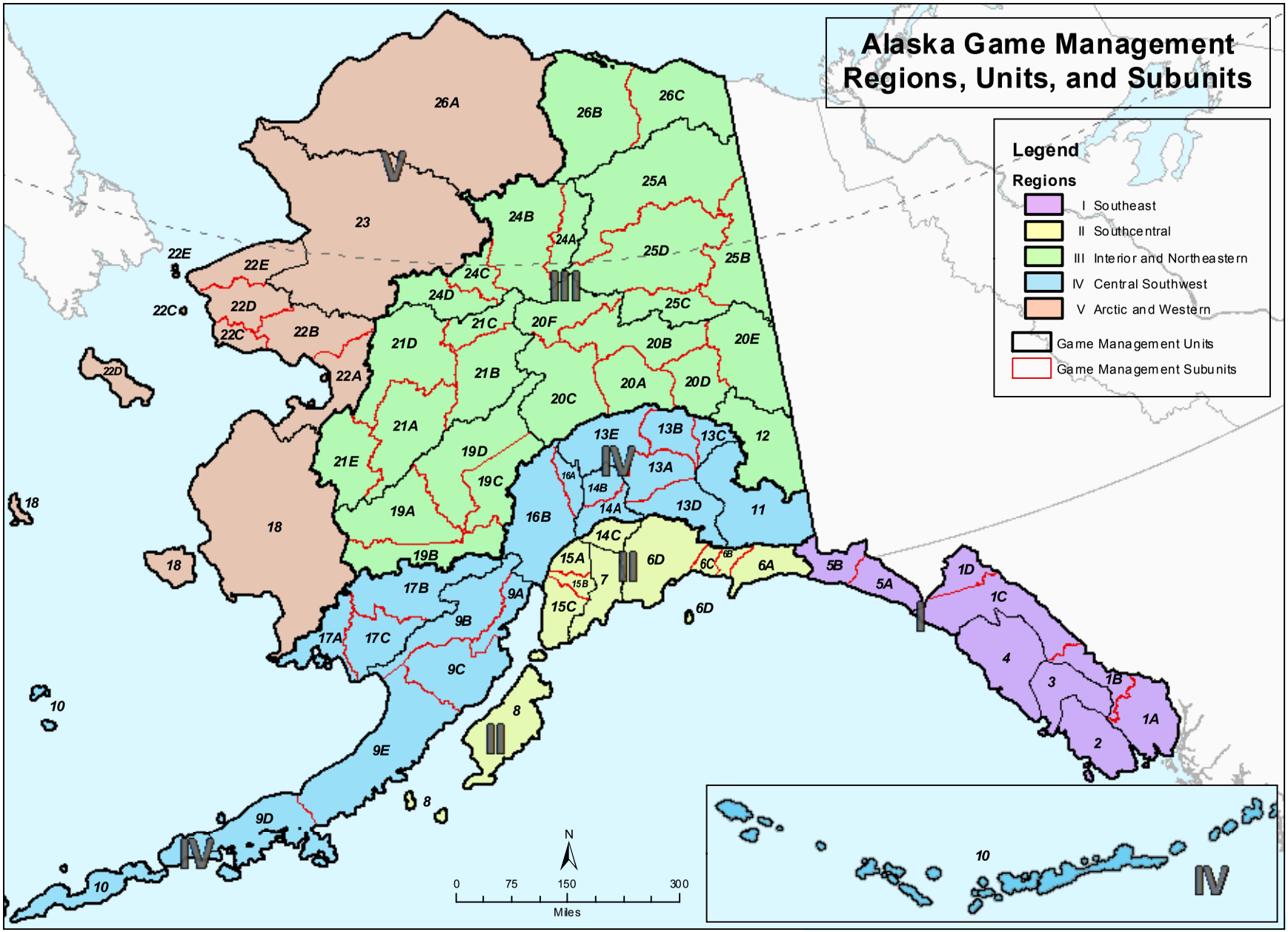
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SPECIES MANAGEMENT REPORT

Alaska Department of Fish and Game
Division of Wildlife Conservation
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MUSKOX MANAGEMENT REPORT

From: 1 July 2010
To: 30 June 2012

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 toward reintroducing this species to Alaska. 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 a population level of about 230 animals. In 1993 and 1994 the population dropped below 200 animals resulting in some closed hunting opportunity in 1995 and 1996. From 1995 through 2004 the population increased from 217 animals to just over 300. From 2007 through 2012 the population experienced consistent yearly growth exceeding the upper management goal of 450 animals. In 2012 the population had a minimum count of 761 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 100 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, and the area south and east of Baird Inlet. 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 at least 250 muskoxen on Nelson Island and 500–550 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 Husky A1-C fixed-wing aircraft on Nunivak Island in July 2010 and October 2012. No survey was completed in 2011. Population census flights were flown using Cub PA-18-160 aircraft on Nelson Island in September 2010 and July 2012. No surveys were completed during 2011. 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 passes to classify each group, resulting in less disturbance to groups during surveys.

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 to results as 'posthunt/precalving' levels, the number of calves were subtracted from the prehunt/postcalving census counts. This was done to compare current number to management goals that were established in cooperative agreement for the Island. 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., RY10 = 1 July 2010–30 June 2011). Harvests during RY10 and RY11 were monitored through the reporting system for drawing and registration permit hunts.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Throughout the reporting period, the population trend on Nunivak Island remained in a slight decline. The population fell below the targeted range of 500–550 animals posthunt precalving in both 2010 and 2011. We dramatically decreased the number of permits issued for cow muskox while maintaining a large but reduced harvest of bull muskox throughout the reporting period. We used drawing and registration permits to take 67 animals in RY09 and 34 in RY10.

The population on Nelson Island fluctuates significantly more than the Nunivak Island 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 July 2010, we counted 517 muskoxen. During a fixed-wing census conducted in October 2011, we counted 452 muskoxen.

When calves are excluded from the counts, the Nunivak Island population was at 433 and 395 posthunt precalving levels in 2010 and 2011, respectively. Both years were below the management goal of 500–550 posthunt precalving population for Nunivak Island (Table 1).

In September 2010, a prehunt postcalving census of Nelson Island muskoxen using a fixed-wing aircraft counted 561 muskoxen. A prehunt postcalving census on Nelson Island in June 2012 counted 761 muskoxen. No survey was done in 2011. When calves are excluded from the counts, the Nelson Island population was at 435 and 592 posthunt precalving levels in 2010 and 2012, respectively. Both years were above the management goal of 250 posthunt precalving population for Nelson Island (Table 2). The history of population counts from 1981–2012 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. Muskoxen have been observed moving on and off of Nelson Island to and from the mainland, confounding census data in both areas.

Population Composition

In July 2010 the classification of muskoxen on Nunivak was 172 three-year-old or older bulls, 125 three-year-old or older cows, 32 two-year-old-bulls, 65 yearlings, 84 calves and 39 of unknown age and sex (Table 3). In 2011 the classification was 145 three-year-old or older bulls, 130 three-year-old or older cows, 32 two-year-old-bulls, 59 yearlings, 63 calves and 23 unknown (Table 4). No survey was conducted on Nunivak in 2012.

Muskoxen counted on Nelson Island in June 2010 were classified as 110 three-year-old or older bulls, 191 three-year-old or older cows, 20 two-year-old bulls, 62 yearlings, 126 calves, and 52 of unknown age (Table 5). In July 2012, the classification was 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 6). No survey was conducted on Nelson Island in 2011.

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 2011 a single animal was poached between Hooper Bay and Scammon Bay. In the winter of 2011 a bull muskox was taken in defense of life and property (DLP) in the village of Kasigluk. In May of 2013 a group of 20 muskoxen was observed just up river of Bethel.

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 mi 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.

RY10 and RY11 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
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 one new regulatory action at the November 2011 BOG meeting in Barrow. The change allows the department to issue up to 100 bull permits for the spring draw hunt on Nunivak Island.

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–RY12 is shown in Table 7. Most bulls taken during this period were harvested under the drawing permit system. In RY10, 45 bulls were harvested by hunters who had drawing permits, and an additional 2 bulls were harvested by auction permit recipients. The RY11 bull harvest included 6 bulls in the fall and 24 in the spring through the drawing permit system; additionally, a hunter who was issued a fall cow registration permit harvested a bull and 1 bull was taken by a hunter with an auction permit.

Registration permits for hunting Nunivak Island cows are distributed on a first-come, first-served basis in Bethel and Mekoryuk. Five permits were available for the fall hunt and 20 for the spring hunt in RY10, 5 fall permits and 5 spring permits were available in RY11, and 0 fall permits and 5 spring permits in RY12. Twenty cows were harvested in RY10, 5 in RY11, and 6 in RY12 (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 the cessation of hunting. We distribute Nelson Island registration permits on a first-come, first-served basis. The location from which these registration 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–RY12 is shown in Table 8. In RY10, 25 bull and 17 cow permits were distributed in Nightmute, and in RY11, 25 bull and 17 cow permits were distributed in Chefornak. Twenty bulls and 17 cows were harvested in RY10. Twenty bulls and 15 cows were harvested in RY11. (Table 8).

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 RY10–RY11 a minimum of 3 muskoxen were harvested illegally on the mainland and one was killed in a DLP situation by a Village Public Safety Officer (VPSO) in Kasigluk.

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. Three nonresidents were drawn and one purchased an action permit in RY10; 4 nonresidents drew permits and 2 purchased auctioned permits in RY11. All Nelson Island registration permit hunters were Alaska residents for this reporting period.

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 take 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 are 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. 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, 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, followed by accidents—stranding, falling off cliffs, and falling through ice—and weather such as freezing rain.

HABITAT

Assessment

No direct study of habitat was undertaken during the report period. On Nunivak Island we believe reindeer have historically overgrazed the lichen range, yet the herd was within the management goal of no more than 2,000 animals precalving during this reporting period. In 2010, review of photographs of the reindeer simultaneously taken from the plane during the muskox survey conducted by ADF&G yielded a count of 1,605 reindeer on Nunivak Island. The October 2011 count was 1,534 reindeer. In July 2012 (after the reporting period) an incomplete survey of Nunivak had a minimum count of 1,792 reindeer (Table 9). 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 management plan (Wald 2009).

Muskoxen taken by hunters on Nunivak and Nelson islands in recent years are reported to be in good condition with adequate body fat and high pregnancy rates. A recent 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 over grazed 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 over grazing, 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. However, currently it is experiencing 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. Also, close monitoring of cow harvest is warranted with the existing population size and structure. 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 continue to be of minimum cost and of 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 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. The population is growing, and 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. Currently we are offering the legal maximum of 42 permits and have reached a population size that can support higher harvests. Until the BOG approves higher harvest rates on Nelson Island, the surplus animals are available to seed populations and expedite growth on the mainland.

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 100 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 greatly successful moose moratoriums in the area on both the Kuskokwim and Yukon rivers further demonstrate people's ability 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.

LITERATURE 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.

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Table 1. Unit 18 Nunivak Island muskox population, 1981–2012.

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	
1995		488	
1996			435
1997		593	
1998		643	
1999		620	
2000		628	
2001		609	
2002		527	
2003		657	
2004		638	
2005		588	
2006		615	
2007	No survey	No survey	No survey
2008	No survey	No survey	No survey
2009		567	
2010		517	
2011		452	
2012	No survey	No survey	No survey

Table 2. Unit 18 Nelson Island muskox population, 1981–2012.

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	
1998		293	
1999		297	
2000	233		
2001		306	
2002		293	
2003		327	
2004		318	
2005	No Survey	No Survey	No Survey
2006	No Survey	No Survey	No Survey
2007		374	
2008	No Survey	No Survey	No Survey
2009		541	
2010		561	
2011	No Survey	No Survey	No Survey
2012		761	

Table 3. Unit 18 Nunivak Island muskox composition, July 2010.

	Male		Female		Unknown		Total	
Age	N	%[a]	N	%[a]	N	%[a]	N	%[b]
+3 years[c]	172	58	125	42			297	57
2 years	32	100					32	6
Yearlings					65	100	65	13
Calves					84	100	84	16
Unknown					39	100	39	8
Total	204	62[d]	125	38[d]	188		517	

[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=329.

Table 4. Unit 18 Nunivak Island muskox composition, October 2011.

	Male		Female		Unknown		Total	
Age	N	%[a]	N	%[a]	N	%[a]	N	%[b]
+3 years[c]	145	53	130	47			275	61
2 years	32	100					32	7
Yearlings					59	100	59	13
Calves					63	100	63	14
Unknown					23	100	23	5
Total	177	58[d]	130	42[d]	145		452	

[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=307.

Table 5. Unit 18 Nelson Island muskox composition, September 2010.

	Male		Female		Unknown		Total	
Age	N	%[a]	N	%[a]	N	%[a]	N	%[b]
+3 years[c]	110	37	191	64			301	54
2 years	20	100					20	4
Yearlings					62	100	61	11
Calves					126	100	126	23
Unknown					52	100	52	9
Total	130	41[d]	191	60[d]	239		561	

[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=321.

Table 6. Unit 18 Nelson Island 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	100	103	14
Calves					169	100	169	22
Unknown					121	100	121	16
Total	168	46[d]	200	54[d]			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 7. Unit 18 harvest of Nunivak Island muskoxen, regulatory years 1992–2012.

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[a]		88
RY00	46[b]	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 [b]	35	6	80
RY09	51 [cd]	30		81
RY10	47[d]	20		67
RY11	32 [b d]	5		37
RY12	28 [d]	6 [a]		34
Total	791	628	7	1426

[a] Includes cow(s) taken by hunters issued a bull permit.
[b] Includes bull(s) taken by hunters issued a cow permit.
[c] 7 bulls taken during emergency order opening for stranded animals on Triangle and Abaramiut islands.
[d] Years that muskoxen were harvested with auction permits SX001 or SX003.

Table 8. Unit 18 permits and hunting harvest of Nelson Island muskoxen, regulatory years 1992–2012.

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	14	20
Total	229	353	208	297

Table 9. Nunivak Island reindeer survey numbers, 2009–2012.

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

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

MUSKOX MANAGEMENT REPORT

From: 1 July 2010
To: 30 June 2012

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). Since 1970 the population has grown and in April 2012 was estimated at 2,223 (95% CI: 1,971 to 2,660) 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 eastern areas of Unit 23 and western portions of Unit 24, and the extent of range expansion east of the core Seward Peninsula population is unknown.

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 (FWS), 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 censuses at 2-year intervals to document changes in population and distribution.

- Complete range wide 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 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. The 2010 and 2012 survey coverage corresponding to the previous minimum count census area was defined as the 'core count area' and the total 2010 and 2012 survey area including the additional areas covered in Units 22A, 23SE and 24 were defined together as the 'expanded count area'. Staff from the department, NPS, BLM, and FWS participated in the census. We adapted distance sampling

techniques (Buckland et al. 2001, 2004) to estimate abundance. The following methods, described in a census summary to agency participants (Schmidt et. al 2010), were used during aerial survey coverage and subsequent analyses to estimate the Seward Peninsula muskox population (see also Schmidt and Gorn 2013):

Survey Coverage. A Seward Peninsula muskox census was completed 28 January– 04 April 2012 in Units 22, 23SW, 23SE, and a small portion of Unit 24 (Fig. 2) using a distance sampling method and survey area (Gorn 2011). Survey lines were flown using Super Cub type aircraft and a Cessna 185 aircraft.

Aircraft and observer teams collected data 31 January–4 April, although 95% (277 of 293) of the lines were completed 31 January–25 March. High winds in the vicinity of Wales and Tin City prevented completion of the remaining sixteen lines until 4 April. Careful attention was placed on completing transect lines to prevent double counting groups due to small scale winter movements for the 'core count area' (minimum count) component of the survey. Complete snow cover is required to detect muskox groups during aerial surveys, because of a muskox's black appearance when observed from aircraft. Snow cover is not quantitatively evaluated; however, it is subjectively evaluated as complete or incomplete during pre-population survey flights that also evaluate distribution of groups as a function of snow cover and depth. Complete snow cover allows muskox to be viewed against a white background whereas incomplete snow cover produces a mottled black and white landscape that creates difficult survey conditions. Snow cover during all flights of the 2012 survey was classified as complete, except for the last flight on 4 April when southern facing mountain slopes of the York Mountains were incompletely covered due to spring melt and sublimation. A post survey radiotracking flight on 20 April did not find any additional groups of muskox that were not seen during the census survey.

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.

Population Composition During the reporting period a Robinson R44 helicopter and snowmachines were used to access groups. At each group, a team of 2 trained observers used binoculars and spotting scopes to classify muskoxen into 7 sex-age groups based on body size, conformation, and horn size/shape characteristics. Muskoxen were classified as: bulls 4-years-or-older, 3-year-old bulls, 2-year-old bulls, cows 4-years-or-older, 3-year-old cows, 2-year-old cows, and yearlings. MB:100 C (mature bull to 100 cows) ratios were calculated by expressing the number of mature bulls (4-years-or-older) per 100 cows 3- or 4-years-or-older. Y:100 C (yearling to 100 cows) ratios were calculated by expressing the number of yearlings per 100 cows 3- or 4-years-or-older.

In 2011, muskox composition surveys were completed during March or April in Units 22C, 22D, 22E, 23SW, and again in Unit 22E in August. Muskox groups that were located incidentally during aerial surveys and radiotracking flights were relocated during muskox composition surveys. Cochran's cluster sampling method (Cochran 1977) was used to calculate ratio summaries and confidence intervals.

In 2012, muskox composition surveys were completed in March or April in all areas of the population survey area, which included the Seward Peninsula and Unit 22A north of the Unalakleet River (Fig. 2). After locations of muskox groups were recorded during the peninsula-wide population survey, we randomized the list of known groups and sampled them in order until approximately 15 groups and 200 individuals had been sampled within each subunit (22A, 22B, 22C, etc.). This was consistent with the sample size recommendations for composition surveys proposed by Czaplewski et al.(1983), although we did not conduct a formal power analysis to assess the adequacy of sample size. We used Cochran's cluster sampling method (Cochran 1977) and a finite population correction factor to calculate ratio summaries and confidence intervals.

Harvest data are summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY10 = 1 July 2010–30 June 2011). Harvests during RY10 and RY11 were monitored through Tier I and Tier II hunt reports.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

The 2012 Seward Peninsula muskox census estimated 1,992 (95% CI: 1,782 to 2,350) animals in the 'core count area' and 2,223 (95% CI: 1,971 to 2,660) animals in the 'expanded count area'. We calculated unit and hunt area estimates for all areas (Table 1).

Snow cover and sightability varied greatly across the census area, but conditions were generally favorable across the census window. There was complete snow cover and aircraft flew when winds and lighting allowed for optimal sightability of muskoxen. There were no abnormalities observed related to muskox distribution.

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 the differences in 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 be improved.

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' represents a 13% annual rate of decline between 2010 and 2012. The 2012 population estimate of 2,223 muskoxen in the 'expanded count area' represents a 1.8% annual rate of increase since 2000, when a minimum count survey found 1,797 muskoxen (Fig. 1). However, it should be noted that the additional areas covered during the 2012 count were not covered during the 2000 count.

Unit 22A: This area was surveyed for the first time in 2010. We estimated 84 (95% CI: 58 to 139) muskoxen during the 2012 survey in Unit 22A north of the Unalakleet River which, is a 2% decline compared to the 2010 survey. However, we found additional groups of muskoxen outside of the defined survey area during the 2012 survey and future surveys should be expanded to include additional muskox habitat to the east of the expanded count area. We classified all muskoxen groups in Unit 22A (see next section), which included groups found outside the population survey area. The total numbers of groups and individuals classified were9 groups and 104 muskoxen.

Unit 22B: We used the Darby Mountains to divide Unit 22B into 2 count areas during the 2012 census. Muskoxen are now well established in Unit 22B west of the Darby Mountains (Unit 22B West) and the 2012 census estimated 380 (95% CI: 332 to 452) muskoxen, which represents a 4% increase in the population since 2010. We estimated 80 (95% CI: 49 to 150) muskoxen east of the Darby Mountains, which represents a 43% increase since 2010. This heavily forested area is unlike western Seward Peninsula units and usually receives deep snow during the winter. Muskoxen occur along the southern edge of the Darby Mountains and along coastal beaches during snow free months. The portion of Unit 22B located east of the Darby Mountains (4,184 . mi^2) appears to either be avoided and/or serves as transitional habitat to the treeless, windswept ridges of the Nulato Hills found farther to the east.

Unit 22C: We estimated 289 (95% CI: 247 to 355) muskoxen in Unit 22C. The Unit 22C population doubled between 2005 and 2007, which we believe was influenced by movement of animals from adjacent units. The 2012 Unit 22C estimate represents a 28% decline since 2010.

Unit 22D: We calculated 3 separate estimates for hunt areas in Unit 22D based on historical hunt areas. We estimated 208 (95% CI: 169 to 279) muskoxen in Unit 22D Kuzitrin River drainage; 77 (95% CI: 58 to 108) muskoxen in Unit 22D Southwest; and 344 (95% CI: 298 to 414) muskoxen in Unit 22D Remainder; totaling 629 muskoxen (Tables 1 and 2), which represents a 15% annual decline compared to results from the 2010 survey. The Unit 22D muskoxen population appeared to remain stable from 1998 to2007, when staff completed 5 separate minimum count surveys that averaged 760 muskox. During the same time period, populations in adjacent units (Units 22B, 22C, and 22E) experienced consecutive years of population growth (Table 2). Composition surveys completed in Unit 22D between 2002 and 2006 show the proportions of yearlings (19% and 16%, respectively; Table 3) were indicative of population growth in this unit. While the population within Unit 22D exhibited growth, it is likely that during 2005–2007 muskoxen from Unit 22D moved into adjoining count areas (Units 22C and 22B West); this is corroborated by composition counts not being aligned with observed growth in the adjoining areas, suggesting emigration from Unit 22D. A similar movement was documented in 2008 when a radiocollared muskoxen moved from the upper Niukluk River in Unit 22B to the western edge of the lava beds in Unit 22D. Movements between units and hunt areas can preclude meaningful comparison of population change at scales below the full population level.

Unit 22E: We estimated 431 (95% CI: 362 to 549) muskoxen in Unit 22E. Historically, Unit 22E has had the largest number and highest density of muskoxen; 0.3 muskoxen/mi^2 on the Seward Peninsula during the 2007 minimum count survey, but the 2012 estimate represents a 51% decline in Unit 22E between 2010 and 2012. It is likely the increase in muskox found in Unit 23SW during the 2012 survey is due in part to movement of animals from Unit 22E to Unit 23SW.

Unit 23SW: We estimated 222 (95% CI: 171 to 319) muskoxen in Unit 23SW. The 2010 survey estimate of 175 (95% CI: 137 to 241) represented an 8% annual rate of decrease compared to the minimum count of 219 muskoxen in 2007. A portion of the 12% annual increase found between 2010 and 2012 in Unit 22E most likely results from animal movements in Unit 23SW from Unit 22E, although some emigration from Unit 22D is possible. We suspect animal movements occur between Units 22D, 22E, and 23SW. Emigration from Unit 23SW is likely responsible for the colonization of areas to the east of the Seward Peninsula in the Nulato Hills and Selawik, Kobuk and Yukon river drainages. This movement may also account for some variability in the numbers from year to year within Unit 23SW.

Units 23SE and 24: We estimated 110 (95% CI: 84 to 159) muskoxen in the area including Unit 23 east of the Buckland River and south of the Selawik Hills, and the western portion of Unit 24. This area was enlarged to include western Unit 24 based on an increased number of incidental observations of muskoxen expanding their range eastward from Unit 23SW. The 2012 estimate represents a 5% annual rate of decrease between 2010 and 2012.

The next census of the Seward Peninsula muskoxen population is scheduled for March 2014.

Population Composition

The results of composition surveys in Units 22A, 22B, 22C, 22D, 22E and 23SW are shown in Table 3 and summarized below for the Seward Peninsula expanded count area, as well as

individual survey units. During the reporting period we classified 104 muskoxen in Unit 22A (1 survey), 303 muskoxen in Unit 22B (1 survey), 562 muskoxen in Unit 22C (2 surveys), 726 muskoxen in Unit 22D (2 surveys), 849 muskoxen in Unit 22E (3 surveys) and 454 muskoxen in Unit 23 SW (2 surveys). In addition, 26 muskoxen in Unit 22B East of the Darby Mountains and 81 muskoxen in a small portion of Unit 23 East of Tagagawik River (e g., Unit 23SE) were classified in the spring of 2012. Mature bulls are likely undercounted in composition surveys relative to other segments of the population, primarily because an unknown number occur as solitary animals and they 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. Although bull:cow ratios are minimums, they show useful trends through time.

Seward Peninsula Expanded Count Area: In March and April of 2012 we classified 1,449 muskox in 89 groups detected in the expanded count area. This represents 65% of the expanded count area population estimate. We found 29 MB:100 C ± 6 (95% CI) and 23 Y:100 C ± 4 (95% CI).

Unit 22A: In April 2012 we visited Unit 22A north of the Unalakleet River. This was the first time muskox composition surveys were conducted in Unit 22A. We classified 104 muskoxen in 9 groups (100% of the population), but were unable to meet our sampling objective because we classified less than 15 groups and/or 200 individuals in the area. We found 69 MB:100 C ± 53 (95% CI) and 69 Y:100 C ± 14 (95% CI).

Unit 22B: Composition surveys were not completed in Unit 22B West in 2011. In March 2012 we visited Unit 22B West and classified 303muskoxen in 15 groups. We found 30 MB:100 C (95% CI: 24 to 34) and 21 Y:100 C (95% CI: 15 to 23). The 2012 results show a decreasing trend in MB:C and Y:C ratios since 2002 when we found 58 MB:100C and 48 Y:100 C (Fig. 3). In Unit 22B East of the Darby Mountains 2 groups of muskox were classified. These groups were included in the overall estimate of MB:C and Y:C ratios for the Seward Peninsula however, no estimate of MB:C or Y:C ratios was calculated for the area given the small sample size and overall small population.

Unit 22C: In April 2011 we visited Unit 22C and classified 319 muskoxen in 19 groups. We found 21 MB:100 C ± 13 (95% CI) and 32 Y:100 C ± 10 (95% CI). In March 2012 we revisited Unit 22C and classified 243 muskoxen in 13 groups. We found 26 MB:100 C (95% CI: 22 to 31) and 22 Y:100 C (95% CI: 18 to 26). Results from 2012 composition surveys indicate the decreasing trend in MB:C and Y:C ratios observed since 2002 when we found 70MB:100C and 57 Y:100 C seems to have now stabilized. (Fig. 4).

Unit 22D: In April 2011 we visited Unit 22D and classified 467 muskoxen in 27 groups. We found 29 MB:100 C ± 8 (95% CI), and 24 Y:100 C ± 7 (95% CI). In March 2012 we revisited Unit 22D and classified 259 muskoxen in 15 groups. We found 22 MB:100 C (95% CI: 16 to 29) and 13 Y:100 C (95% CI: 9 to 19). Both ratios are the lowest they have been since 2002 (Fig. 5).

Unit 22E: In April 2011 we visited Unit 22E and classified 375 muskoxen in 25 groups. We found 53 MB:100 C ± 17 (95% CI) and 59 Y:100 C ± 10 (95% CI). In April 2012 we revisited Unit 22E and classified 219 muskoxen in 15 groups, and found 33 MB:100 C (95% CI: 25 to 45), and 28 Y:100 C (95% CI: 20 to 39) (Fig. 6). Results from composition surveys beginning in

2002 indicate the number of mature bulls and yearlings in Unit 22E have been relatively stable compared to the Southern Seward Peninsula, though recent surveys in Unit 22E indicate similar declines in MB:100C and Y:100 C ratios.

Unit 23SW: In April 2011 we visited Unit 23SW and classified 127 muskoxen in 8 groups. We found 22 MB:100 C ± 13 (95% CI) and 10 Y:100 C ± 18 (95% CI) . We revisited Unit 23SW in March of 2012 and classified 235 muskoxen in 12 groups. We found 26 MB:100 C (95% CI: 23 to 25) and 16 Y:100 C (95% CI: 21 to 24) (Fig. 7).

Unit 23SE In April 2012 we visited Unit 23SE, west of the Tagagawik River. This was the first time muskox composition surveys were conducted in Unit 23SE. We classified 81 muskoxen in 8 groups. We were unable to meet our sampling objective in Unit 23SE because we classified less than 15 groups and/or 200 individuals in the area. We found 27 MB:100 C ± 15 (95% CI) and 16 Y:100 C ± 28 (95% CI).

Distribution and Movements

The Seward Peninsula census area was expanded in 2010 to include portions of Unit 23 in the Tagagawik River drainage (23Other, 24) and the northern portion of Unit 22A (22A) (Fig. 2). The expanded effort was intended to further document range expansion of muskoxen emigrating east of the Seward Peninsula. Staff found 86 muskoxen in the northern portion of Unit 22A, and 120 muskoxen in Units 23SE and 24 (Table 1). Future surveys should be expanded to include additional muskox habitat to the east of the expanded count area since we found additional groups of muskoxen outside of the defined Unit 22A survey area during the 2012 survey.

MORTALITY

Harvest

Season and Bag Limit. During this reporting period the State administered Tier I subsistence registration hunts in Units 22B, 22C, 22D, 22E, and 23SW. 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:

RY10 Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
Unit 22A	No open season	No open season
Units 22B, 22C, and 22D and Unit 23 Southwest, that portion on the Seward Peninsula west of and including the Buckland River drainage		No open season

1 muskox by registration permit only;	1 Aug–15 Mar (Subsistence hunt only)	
or		1 Aug–15 Mar
1 bull by drawing permit only; up to 60 permits may be issued; 10 percent of animals may be issued to nonresident hunters	1 Aug–15 Mar	
Unit 22E		No open season
1 muskox by registration permit only;	1 Aug–15 Mar (Subsistence hunt only)	
or		1 Aug–15 Mar
1 bull by drawing permit only; up to 60 permits may be issued; 10 percent of animals may be issued to nonresident hunters	1 Aug–15 Mar	

RY11 Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
Unit 22A 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 22B, 22C, and 22D 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 percent of the permits will be issued to nonresident hunters in combination with Unit 22E.	1 Aug–15 Mar	1 Aug–15 Mar
Unit 22E		
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 musk oxen:		
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 percent of the permits will be issued to nonresident hunters in combination with Unit 22B, 22C, and 22D, 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

RY10 Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
Specific hunts administered in RY10:		
Unit 22A	No open season	No open season
Unit 22B, that portion east of the Darby Mountains, including drainages of Kwiniuk, Tubutulik, Koyuk and Inglutalik rivers		
1 bull by Tier I registration permit only (RX105; harvest quota is 3 bulls)	1 Aug–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22B		
1 bull by Tier I registration permit only (RX105; harvest quota is 23 bulls)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Unit 22C, excluding the area between the east bank of the Penny River and the west bank of the Flambeau River, extended along Safety Sound to Safety bridge, the Snake River drainage, and the Nome River drainage below and including Hobson and Rocky Mountain creek drainages		
1 bull by Tier I registration permit only (RX099; harvest quota is 20 bulls)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22C	No open season	No open season
Unit 22D Southwest, west of the Tisuk River drainage, west of the west bank of Canyon Creek beginning at McAdam's Creek continuing to Tuksuk Channel		
1 muskox by Tier I registration permit only (RX099; harvest quota is 8 muskox including up to 3 cows);	1 Jan–15 Mar (Subsistence hunt only)	No open season
or		
1 bull 4 years old or older by drawing permit (DX103; 5 permits issued)	1 Jan–15 Mar	1 Jan–15 Mar

Unit 22D, Kuzitrin River Drainage		
1 muskox by Tier I registration permit only (RX099; harvest quota is 17 muskox including up to 6 cows)	1 Jan-15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22D		
1 muskox by Tier I registration permit only; however, cows may be taken only during the period 1 Jan–15 Mar (RX104; harvest quota is 24 muskox including up to 11 cows);	1 Aug–15 Mar (Subsistence hunt only)	No open season
or		
1 bull 4 years old or older by drawing permit (DX102; 3 permits issued)	1 Aug–15 Mar	1 Aug–15 Mar
Unit 22E		
1 muskox by Tier I registration permit only; (RX104; harvest quota is 48 muskox including up to 44 cows);	1 Aug–15 Mar (Subsistence hunt only)	No open season
or		
1 bull by drawing permit (DX097; 18 permits issued)	1 Aug–15 Mar	1 Aug–15 Mar
Unit 23, that portion on the Seward Peninsula west of and including the Buckland River drainage		
1 muskox by Tier I registration permit only; however, cows may be taken only during the period 1 Jan–15 Mar (RX106; harvest quota is 8 muskox including up to 8 cows)	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. No-fee subsistence tag required.

4. One muskox permit per hunter per calendar year.
5. Season will be closed by emergency order when quota is reached.
6. In hunt RX099, head must be presented to ADF&G within 72 hours of harvest. For bulls with a boss horn, the distal portion of each horn will be cut at or above the position of the eye on the skull and retained by the department.
7. Trophy destruction required if skull removed from Units 22 or 23. The distal portion of each horn will be cut at or above the position of the eye on the skull and retained by the department.
8. Aircraft may not be used to transport muskox hunters, muskox, or muskox hunting gear.

Specific hunts administered in RY11 follow:

RY11 Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
Unit 22A	No open season	No open season
Unit 22B, that portion east of the Darby Mountains, including drainages of Kwiniuk, Tubutulik, Koyuk and Inglutalik rivers		
1 bull by Tier I registration permit only (RX105; harvest quota is 3 bulls)	1 Aug–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22B		
1 muskox by Tier I registration permit only (RX105; harvest quota is 15 muskox including up to 4 cows)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Unit 22C, between the east bank of the Penny River and the west bank of the Flambeau River extended along Safety Sound to Safety Bridge, the Snake River drainage, and the Nome River drainage below and including Hobson and Rocky Mountain creek drainages		
1 cow by bow and arrow, muzzleloader or shotgun only, by Tier I registration permit (RX096; harvest quota is 5 cows)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Unit 22C Remainder		
1 cow by Tier I registration permit only (RX094; harvest quota is 3 cows)	1 Jan–15 Mar (Subsistence hunt only)	No open season

RY11 Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
Unit 22D Southwest, west of the Tisuk River drainage, west of the west bank of Canyon Creek beginning at McAdam's Creek continuing to Tuksuk Channel		
1 muskox by Tier I registration permit only (RX099; harvest quota is 5 muskox including up to 3 cows),	1 Jan–15 Mar (Subsistence hunt only)	No open season
or		
1 bull 4 years old or older by drawing permit (DX103; 7 permits issued)	1 Jan–15 Mar	1 Jan–15 Mar
Unit 22D, Kuzitrin River Drainage		
1 muskox by Tier I registration permit only (RX099; harvest quota is 9 muskox including up to 5 cows)	1 Jan–15 Mar (Subsistence hunt only)	No open season
Remainder of Unit 22D		
1 muskox by Tier I registration permit only; however, cows may be taken only during the period 1 Jan–15 Mar (RX104; harvest quota is 16 muskox including up to 10 cows);	1 Aug–15 Mar (Subsistence hunt only)	No open season
or		
1 bull 4 years old or older by drawing permit (DX102; 3 permits issued)	1 Aug–15 Mar	1 Aug–15 Mar
Unit 22E		
1 muskox by Tier I registration permit only (RX104; harvest quota is 36 muskox including up to 28 cows);	1 Aug–15 Mar (Subsistence hunt only)	No open season
or		

RY11 Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
1 bull 4 years old or older by drawing permit (DX097; 18 permits issued) Unit 23 Southwest, that portion on the Seward Peninsula west of and including the Buckland River drainage	1 Aug–15 Mar	1 Aug–15 Mar
1 muskox by Tier I registration permit only; however, cows may be taken only during the period 1 Jan–15 Mar (RX106; harvest quota is 7 muskox including up to 4 cows)	1 Aug–15 Mar (Subsistence hunt only)	No open season

Subsistence hunt conditions:

1. Subsistence hunts open to Alaska residents only.
2. Season will be closed by emergency order when quota is reached.
3. In hunts RX094, RX096 and RX099, head must be presented to ADF&G within 72 hours of harvest. The distal portion of each horn will be cut at or above the position of the eye on the skull and retained by the department.
4. Trophy destruction required if skull removed from Units 22 or 23. The distal portion of each horn will be cut at or above the position of the eye on the skull and retained by the department.
5. 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 included muskox in Unit 22A and Unit 23SW (that portion of the Seward Peninsula west of and including the Buckland River drainage) in the Seward Peninsula Amount Necessary for Subsistence (100–150, including 10–25 in Unit 22E).

There were 11 emergency orders (EO) issued during the reporting period to close subsistence registration muskox hunts because harvest quotas were either reached, or expected to be reached, by the closure date on the EO:

1. Staff issued an EO on 10 August 2010 to close the fall portion of hunt RX106 in Unit 23 Southwest. The fall season opened on 1 August 2010.

2. Staff issued an EO on 2 January 2011 to close the winter portion of RX106 in Unit 23 Southwest. The winter portion opened 1 January 2011.

3. Staff issued an EO on 12 January 2011 to close the hunt for cow muskox by registration permit RX099 in Unit 22D, Kuzitrin River drainage. The season opened 1 January 2011.

4. Staff issued an EO on 13 January 2011 to close hunt RX099 in Unit 22C. The hunting season opened 1 January 2011.

5. Staff issued an EO on 19 January 2011 to close the hunt for bull muskox by registration permit RX099 in Unit 22D, Kuzitrin River drainage. The season opened 1 January 2011.

6. Staff issued and EO on 1 July 2011 to change the season dates for RX106 in Unit 23 Southwest for regulatory year RY11. The new season dates for hunt RX106 are 1 January 2012 through 15 March 2012.

7. Staff issued an EO on 11 October 2011 to close hunt RX104 in Unit 22D Remainder. The hunting season opened 1 August 2011.

8. Staff issued an EO on 2 January 2012 to close hunt RX099 in Unit 22D, Kuzitrin River drainage. The season opened 1 January 2012.

9. Staff issued an EO on 12 January 2012 to close hunt RX106 in Unit 23 Southwest. The season opened 1 January 2012.

10. Staff issued an EO on 29 January 2012 to close hunt RX099 in Unit 22D Southwest. The season opened 1 January 2012.

11. Staff issued an EO on 8 March 2012 to close hunt RX105 in Unit 22B, west of the Darby Mountains. The season opened 1 January 2012.

Human-Induced Harvest. In RY10, 109 bulls, 11 cows and 2 animals of unknown sex were harvested by Tier I permit, 18 bulls were taken by drawing permit, and 0 muskoxen were taken with federal permits for a total harvest of 140 muskoxen (127 bulls, 11 cows and 2 unknown). Table 4 shows the number of permits filled in RY10 for state and federal hunts in each unit.

In RY11, 65 bulls and 29 cows were harvested by Tier I permit, 16 bulls were taken by drawing permit, and 0 muskoxen were taken with federal permits for a total harvest of 110 muskoxen (81 bulls and 29 cows). Table 5 shows the number of permits filled in RY11 for state and federal hunts in each unit.

Permit Hunts. Hunting during this reporting period was by Tier I subsistence registration permit and drawing permit on state managed lands and by federal subsistence permit on federal public lands. Trophy destruction of muskoxen taken in Tier I hunts is required if the skull is removed from Unit 22 or Unit 23.

Hunter Residency and Success. During RY10, 396 Tier I registration permits were issued for Seward Peninsula muskoxen hunts and 122 permittees were successful for a 31% success rate.

Twenty six drawing permits were issued and 18 permittees were successful for a 69% success rate. No federal permits were issued during the reporting period. During RY11, 266 Tier I registration permits were issued for Seward Peninsula muskoxen hunts and 94 permittees were successful for a 35% success rate. Twenty eight drawing permits were issued and 17 permittees were successful for a 61% success rate.

In RY10, 74% of hunters issued state Tier I permits for Seward Peninsula hunts were local residents of Unit 22 or Unit 23 communities. Twenty five percent of hunters were Alaska residents living outside of Unit 22 or Unit 23. and 1% residency was unknown.

In RY11, 69% of hunters issued State Tier I permits for Seward Peninsula hunts were residents of Unit 22 or Unit 23 communities. Thirty percent of hunters were Alaska residents living outside of Unit 22 or Unit 23 and less than 1% residency was unknown.

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. First time permit holders often hunt early in the season during colder temperatures and shorter, darker days to ensure hunting opportunity before the season is closed by emergency order. When given the opportunity by drawing permit to hunt throughout the entire season or when hunting by registration permit in hunt areas with historically high harvest quotas, hunters prefer to take advantage of milder temperatures and longer hours of daylight found during the end of February and March to harvest their muskox.

In RY10, the proportion of harvest in each unit showed variation throughout the progression of the season: Unit 22B – August (7%), January (46%), February (11%), March (32%), Unknown (4%) ; Unit 22C – January (96%), March (4%); Unit 22D – August (14%), September (14%), October (7%), January (33%), February (3%), March (21%), Unknown (8%); Unit 22E – August (17%), September (25%), October (4%), February (29%), March (21%), Unknown (4%); Unit 23 – August (66%), January (17%), Unknown (17%).

In RY11, the proportion of harvest in each unit showed variation throughout the progression of the season: Unit 22B – January (19%), February (14%), March (67%); Unit 22C – January (13%), February (37%), March (50%); Unit 22D – August (5%), September (19%), October (11%), January (46%), March (14%), Unknown (5%); Unit 22E – September (3%), October (17%), December (3%), January (3%), February (51%), March (23%); Unit 23 – January (100%).

Transport Methods. Hunters reported snowmachines were used to hunt 65%, 3 or 4 wheelers 19%, boat 6%, off road vehicles 4%, plane, highway vehicles, foot travel each 1%, and other <1%. Transportation is unknown for 3% of hunters because method was not reported.

Other Mortality

The department deployed radio collars on cow muskox (≥3 years and older) located in Units 22B, 22C, and 22D in 2008 to understand mortality rates and movement of SPP muskox. An additional 11 cow muskox (≥3 years and older) were collared using an R44 helicopter during April 2010 to increase the sample of collars in the population. Each year, the department attempts to maintain a sample of 30 collared muskox; 22 collars were monitored in 2010 and 27

in 2011. Rates calculated from radiotracking flights found 9% (95% CI: 1%–28%) mortality in 2008, 4% (95% CI: 0%–22%) in 2009, 23% (95% CI: 8%–45%) in 2010, 22% (95% CI: 9%–42%) in 2011, and 21% (95% CI:6%–46% 95 C.I) in 2012. The average number of collars deployed in the SPP (n=23) since 2008 represents 1% of the western Seward Peninsula population as of 2012 (Fig. 1) and is not randomly distributed throughout the population, so localized events such as icing, deep snow, or different predator regimes may preclude the use of this mortality rate as representative of the entire population. Lastly, the selection of animals for capture is not truly random, as obviously injured or diseased animals were intentionally not selected for collaring.

The timing of mortality events observed from aerial radiotracking flights found 88% (14 of 16) of the mortality 2008–2012 occurred 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 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 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 muskoxen 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 gastrointenstinal 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 and Coxiella which can have negative reproductive effects.

Muskox serum were tested for copper levels and results found levels between 0.8–1.1ppm (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 Alaskan muskox populations, and we are awaiting results.

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

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 has 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 at the airport. 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 encounter pets as they move 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; however, the willow removal proved largely ineffective to deterring muskox presence along the runway, but did increase visibility for vehicle traffic along the road that parallels the runway. Department staff issue public service announcements informing the public on ways to live and interact with muskox, and staff attend public meetings to relay information and discuss solutions for local area muskox issues.

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. In areas closest to Nome the hunting season opens 1 January when most wildlife viewing has ended due to inaccessible snowed-in roads.

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 should be 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. 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 future surveys should be increased further to monitor eastward range expansion of the SPP.

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 is evident in all areas although declines occur at different rates between units. Composition data has become increasingly important to collect for Seward Peninsula hunt administration. As hunter harvest has increased though time (Fig. 8) 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.

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 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.

LITERATURE 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 Miscellaneous Report. Project W–20–2. 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.

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, Alaska USA.

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. National Park Service, Fairbanks, and Alaska Department of Fish and Game, Nome and Kotzebue. [Unpublished].

Schmidt, J. H., K. L. Rattenbury, J. P. Lawler, and M. C. MacCluskie. *In press.* Using distance sampling and hierarchical models to improve estimates of Dall's sheep abundance. Journal of Wildlife Management.

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/>

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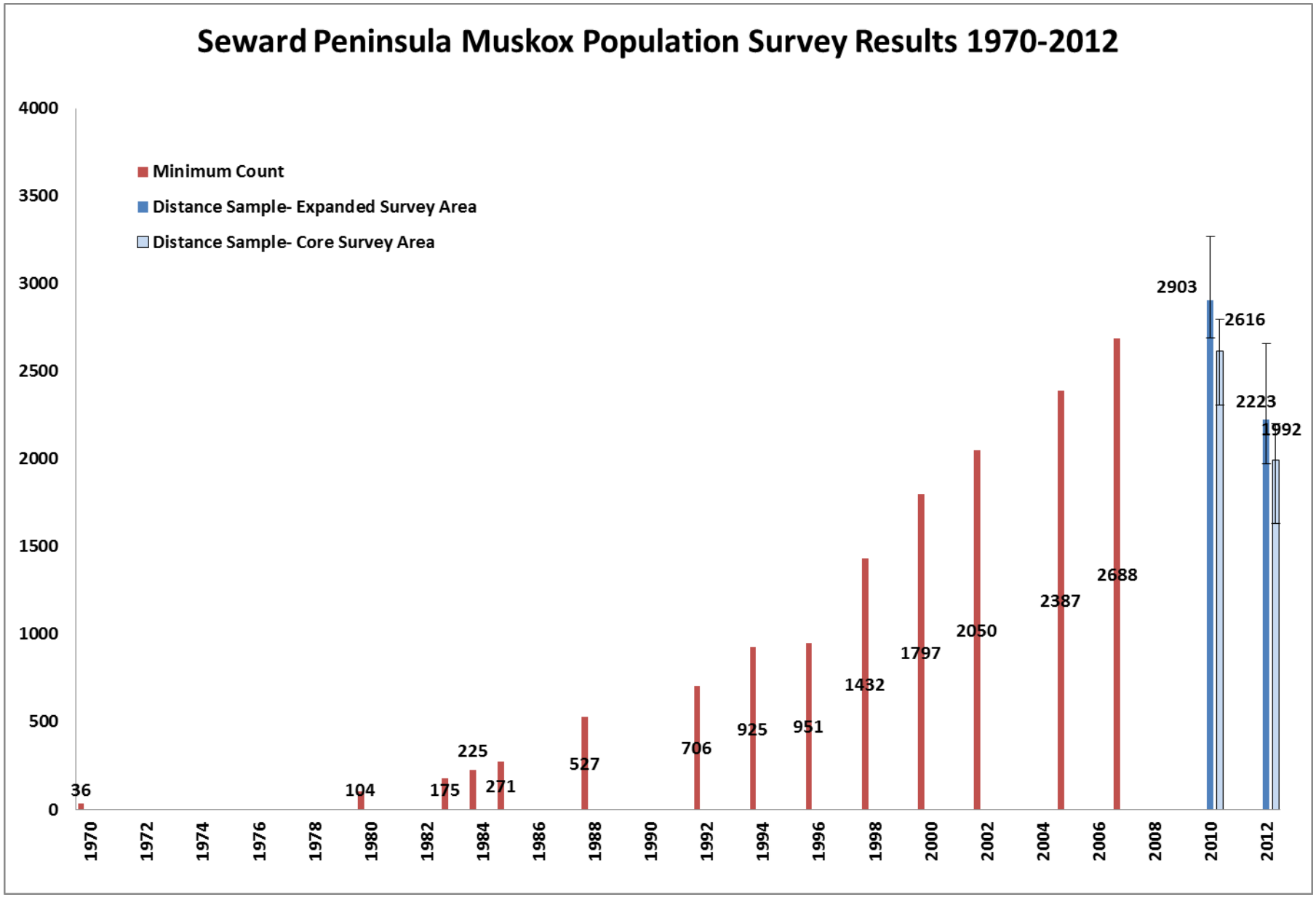

Figure 1. Census results from minimum count and distance sampling surveys of Seward Peninsula muskoxen, 1970–2012.

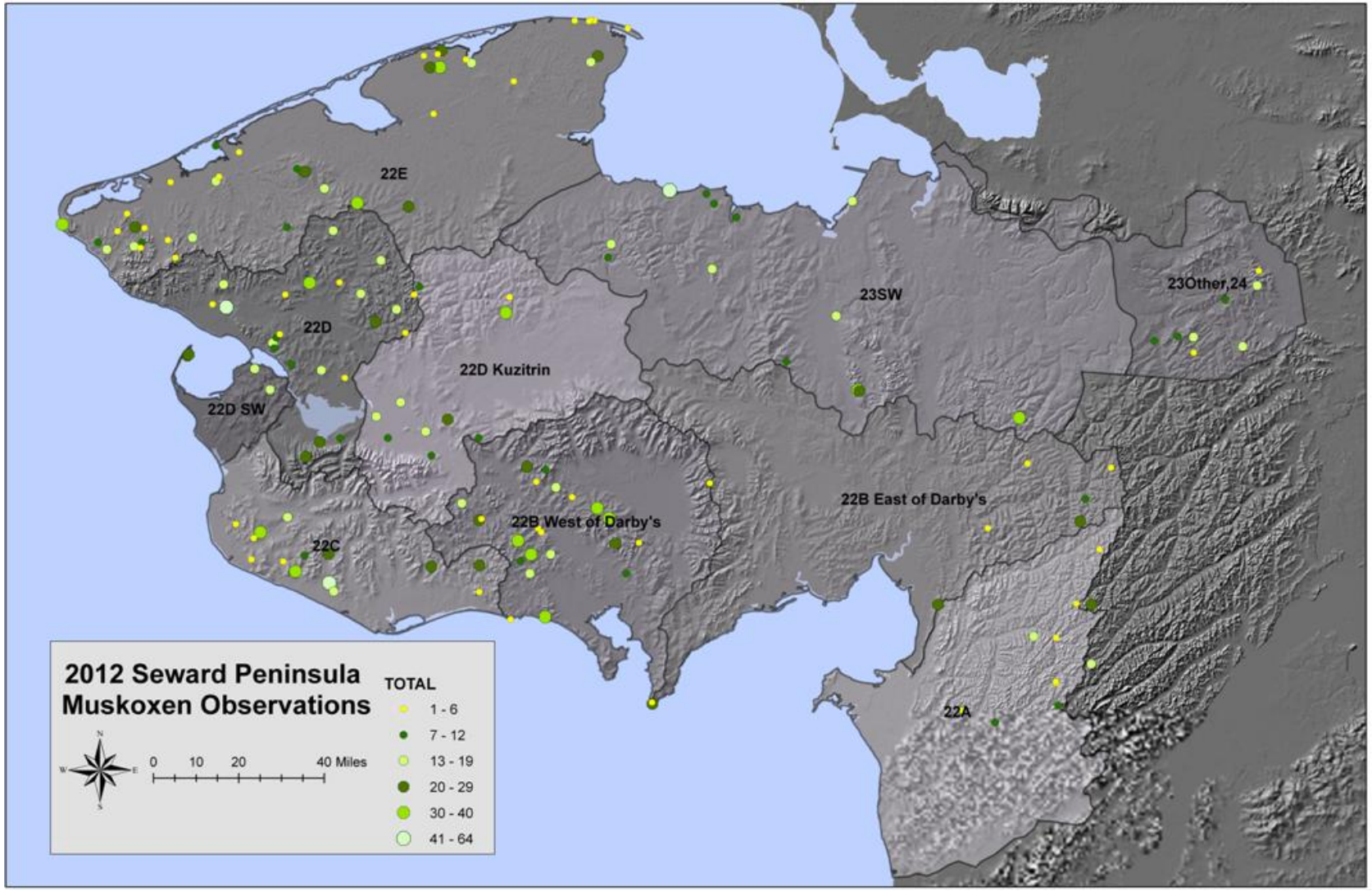

Figure 2. Location of Seward Peninsula muskox groups, spring 2012 census.

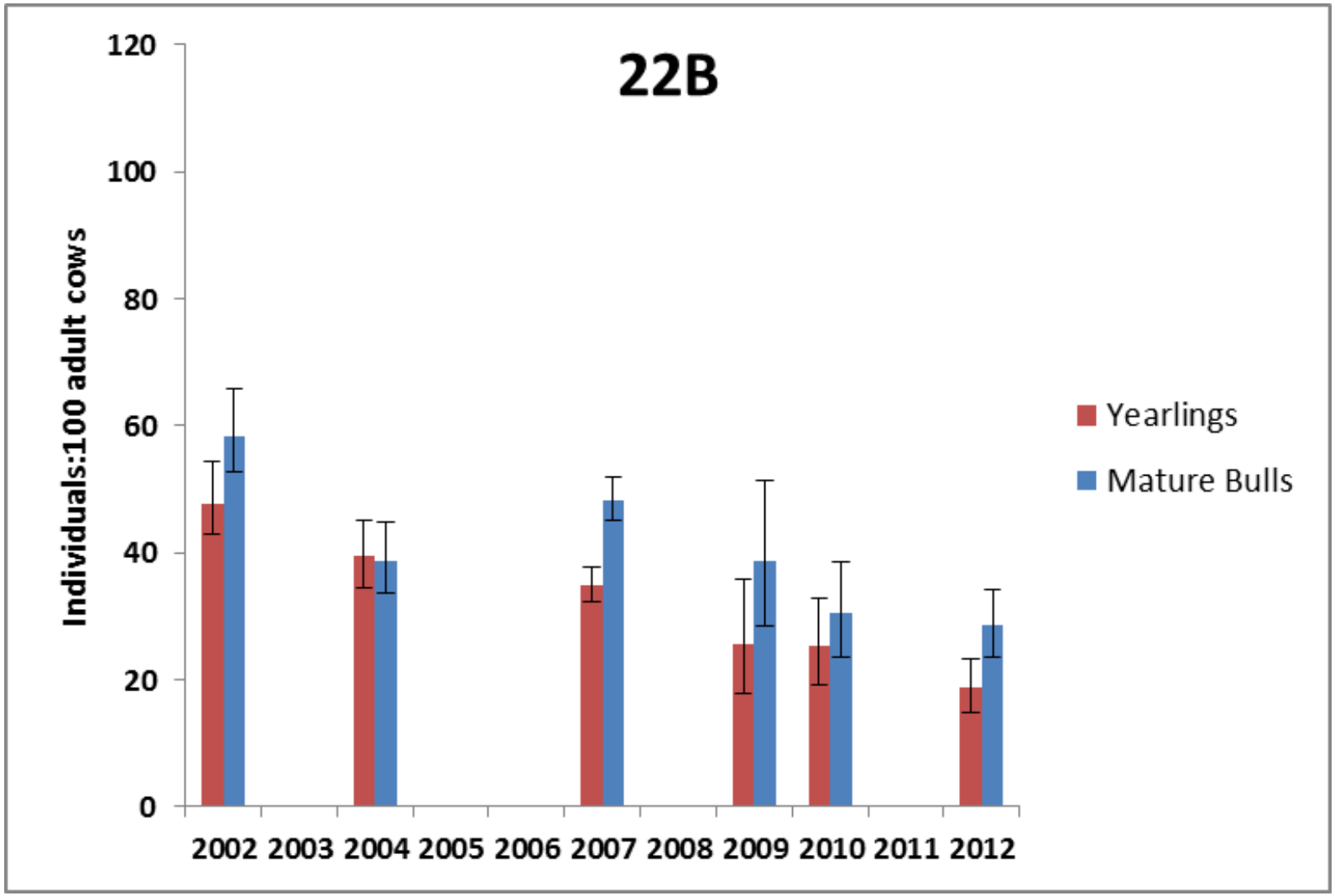

Figure 3. Unit 22B muskox composition data, 2002–2012.

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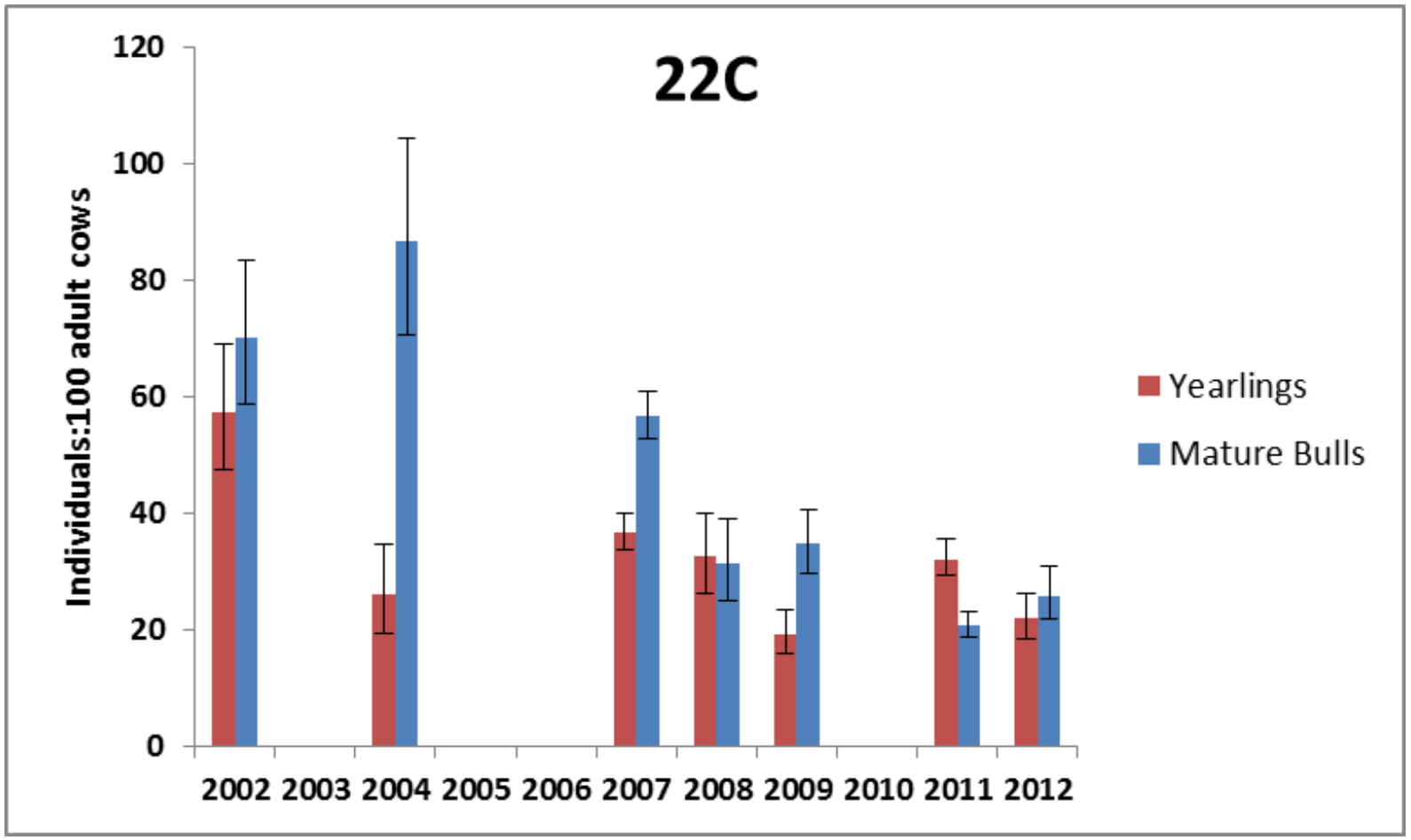

Figure 4. Unit 22C muskox composition data, 2002 –2012.

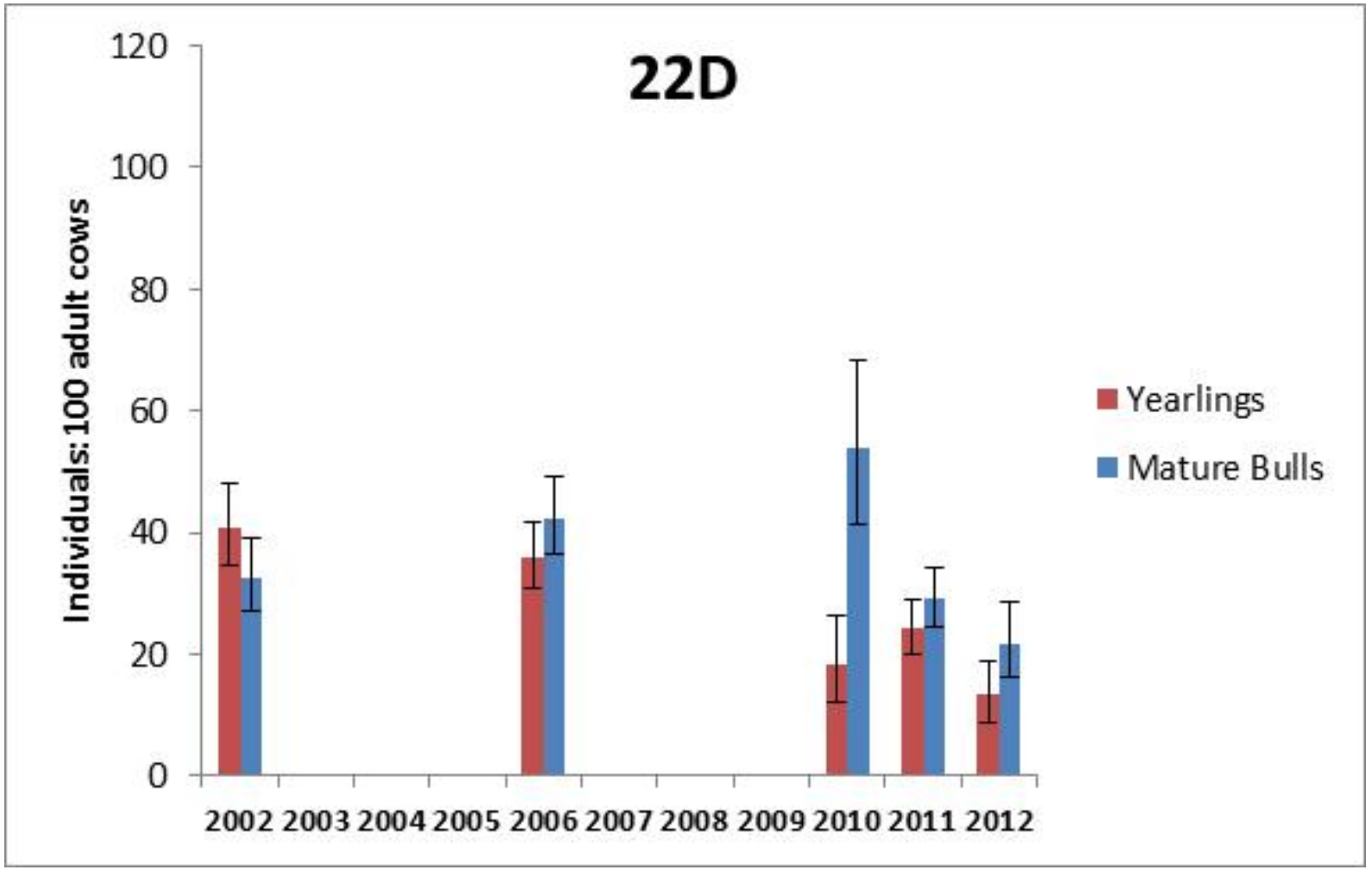

Figure 5. Unit 22D muskox composition data, 2002–2012.

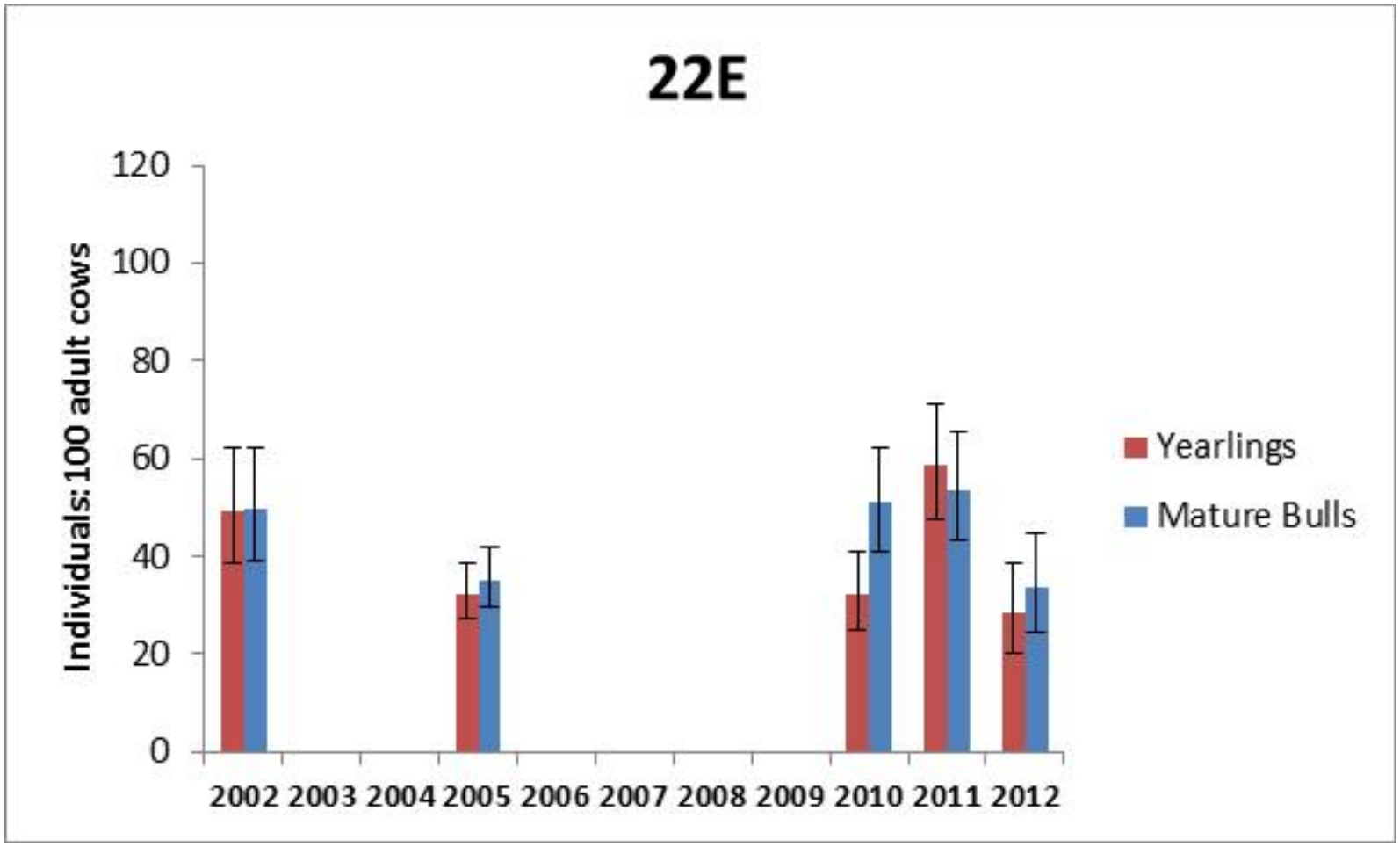

Figure 6. Unit 22E muskox composition data, 2002–2012.

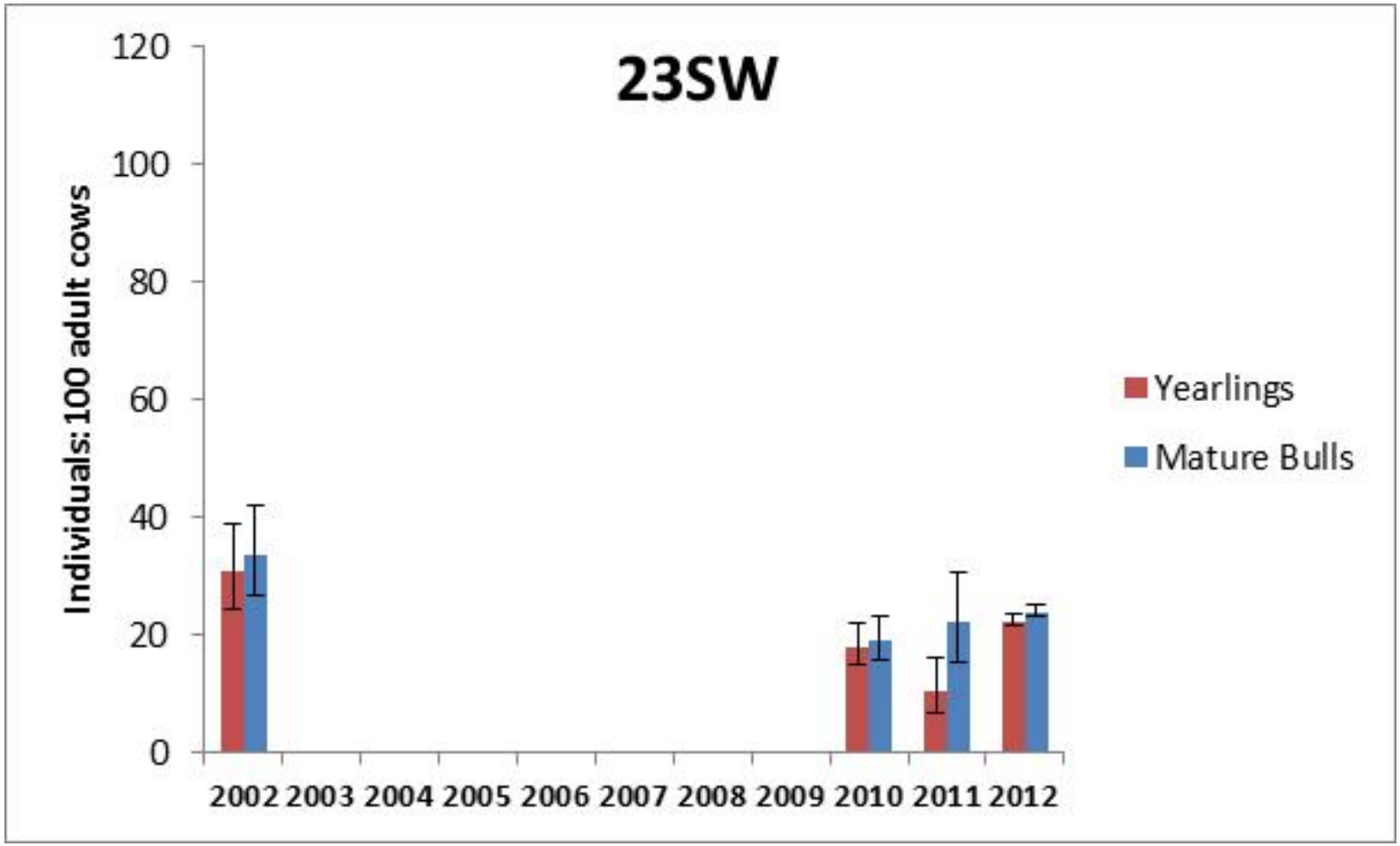

Figure 7. Unit 23 Southwest muskox composition data, 2002–2012.

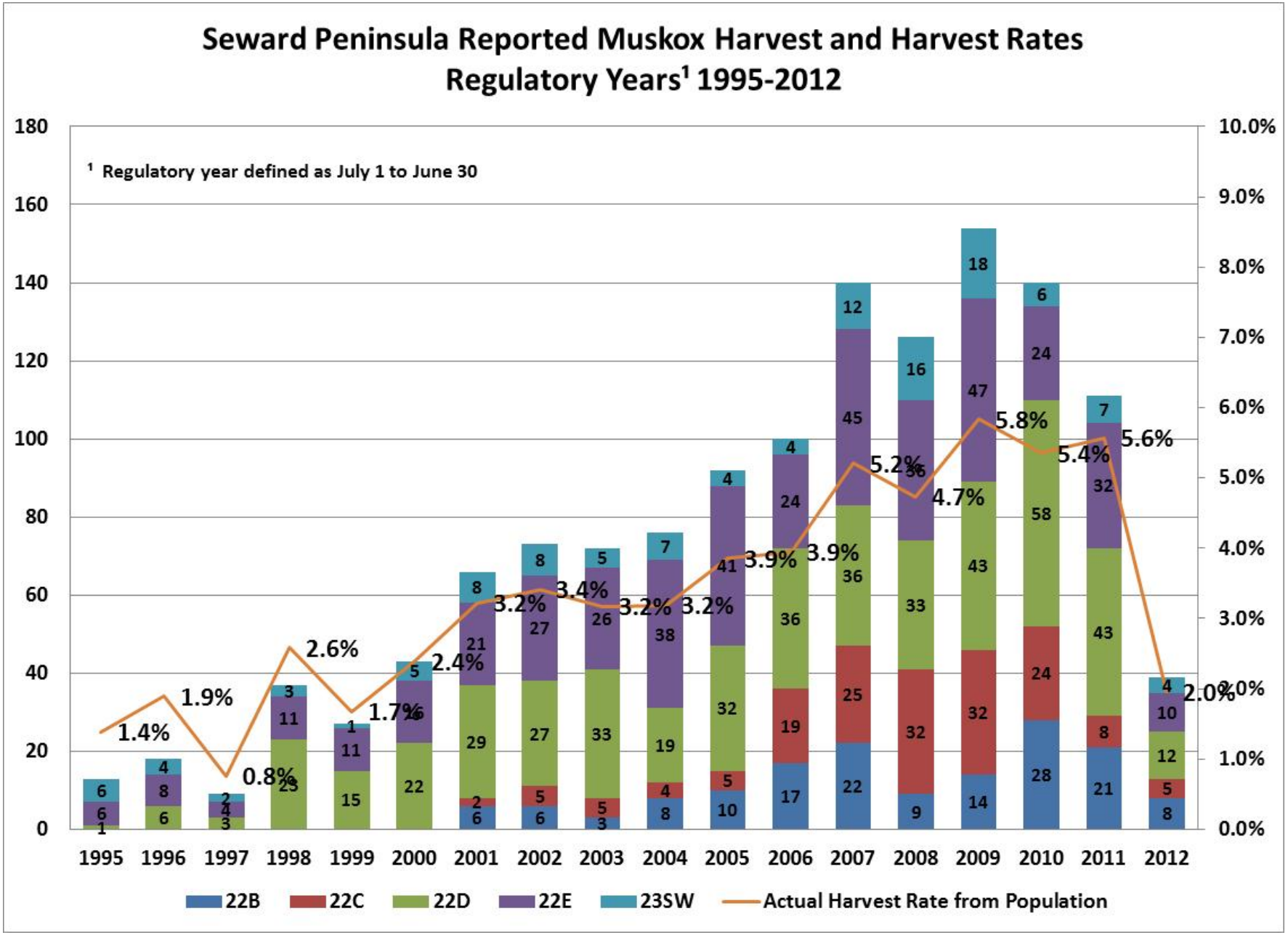

Figure 8. Seward Peninsula muskox harvest and harvest rates, 1995–2012.

Table 1. Seward Peninsula muskox census results with coefficients of variation and 95% credible intervals for Units 22, 23 Southwest, 23 Southeast, and 24; spring 2012.

Unit	Mean	CV	2.5%	97.50%
22A	84	25%	58	139
22B East of Darby Mtns.	80	33%	49	150
22B West of Darby Mtns.	380	8%	332	452
22C	289	9%	247	355
22D Kuzitrin Drainage	208	14%	169	279
22D Southwest	77	16%	58	108
22D Remainder	344	9%	298	414
22E	431	11%	362	549
23 Southwest	222	17%	171	319
23 Southeast and 24	110	17%	84	159

Table 2. Seward Peninsula muskox census results; Units 22, 23 Southwest, 23 Southeast, and 24; 1992–2012.

	Unit							
Year	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

[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. Age and sex composition of Seward Peninsula muskox groups, 2002–2013.

Age and Sex Composition of Seward Peninsula Muskox Groups, 2002-2013																						
			Males ≥4 years old		Females ≥4 years old		Females 3 or 4 years old		Females 3 years old		Males 3 years old		Males 2 years old		Females 2 years old		Short Yearlings		Calves		Unknown		Mature Bull:	Yearling:
Unit	Year	N	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	No.	%[a]	100 Cows[b,d]	100 Cows[c]
22A	2012	104	24	23%	27	26%	0	0%	8	8%	9	9%	7	7%	5	5%	24	23%	0	0%	0	0%	69/100	69/100
22B	2002	178	39	22%	38	21%	10	6%	19	11%	13	7%	13	7%	13	7%	32	18%	0	0%	1	1%	58/100	48/100
22B	2004	236	42	18%	86	36%	0	0%	23	10%	11	5%	16	7%	15	6%	43	18%	0	0%	0	0%	39/100	39/100
22B	2007	317	65	21%	103	32%	0	0%	32	10%	18	6%	19	6%	31	10%	47	15%	0	0%	2	0.6%	48/100	35/100
22B	2009	196	33	17%	60	31%	0	0%	26	13%	17	9%	11	6%	15	8%	22	11%	5	3%	7	3.6%	38/100	26/100
22BW	2010	215	36	17%	98	46%	0	0%	21	10%	7	3%	12	6%	8	4%	30	14%	0	0%	3	1.4%	30/100	25/100
22BW	2012	303	48	16%	129	43%	0	0%	30	10%	21	7%	11	4%	20	7%	34	11%	0	0%	10	3.3%	30/100	21/100
22BW	2013	95	24	25%	35	37%	0	0%	7	7%	2	2%	4	4%	1	1%	16	17%	0	0%	6	6.3%	57/100	38/100
22C	2002	209	49	23%	35	17%	5	2%	30	14%	14	7%	20	10%	16	8%	40	19%	0	0%	0	0%	70/100	57/100
22C	2004	217	70	32%	56	26%	0	0%	25	12%	18	8%	10	5%	17	8%	21	10%	0	0%	0	0%	86/100	26/100
22C	2007	412	101	25%	151	37%	0	0%	27	w	15	4%	25	6%	28	7%	65	16%	0	0%	0	0%	57/100	37/100
22C	2008	283	43	15%	123	43%	0	0%	15	5%	18	6%	16	6%	13	5%	45	16%	6	2%	4	1%	31/100	33/100
22C	2009	352	56	16%	109	31%	0	0%	53	15%	31	9%	19	5%	33	9%	31	9%	2	1%	18	5%	35/100	19/100
22C	2011	319	34	11%	120	38%	0	0%	45	14%	8	3%	27	8%	28	9%	53	17%	0	0%	4	1%	21/100	32/100
22C	2012	243	33	14%	94	39%	0	0%	34	14%	12	5%	16	7%	21	9%	28	12%	0	0%	5	2%	26/100	22/100
22C	2013	104	14	13%	45	43%	0	0%	12	12%	2	2%	3	3%	6	6%	20	19%	0	0%	2	2%	25/100	35/100
22D	2002	455	70	15%	157	35%	9	2%	49	11%	17	4%	30	7%	33	7%	88	19%	0	0%	2	0.4%	33/100	41/100
22D	2006	516	99	19%	193	37%	0	0%	41	8%	32	6%	28	5%	26	5%	84	16%	0	0%	13	3%	42/100	36/100
22D Rem	2010	259	68	26%	105	41%	0	0%	22	8%	18	7%	12	5%	9	3%	23	9%	0	0%	2	1%	54/100	18/100
22D	2011	467	72	15%	190	41%	0	0%	59	13%	20	4%	28	6%	27	6%	60	13%	0	0%	11	2%	29/100	24/100
22D	2012	259	33	13%	131	51%	0	0%	21	8%	11	4%	12	5%	20	8%	20	8%	0	0%	11	4%	22/100	13/100
22E	2001	310	38	12%	77	25%	0	0%	24	8%	10	3%	14	5%	24	8%	58	19%	65	21%	0	0%	38/100	57/100
22E	2002	341	57	17%	84	25%	3	1%	29	9%	19	6%	32	9%	32	9%	57	17%	28	8%	0	0%	49/100	49/100
22E	2005	517	84	16%	169	33%	0	0%	69	13%	28	5%	43	8%	34	7%	77	15%	7	1%	6	1%	35/100	32/100
22E	2008	199	37	19%	59	30%	0	0%	14	7%	13	7%	9	5%	12	6%	19	10%	35	18%	1	1%	51/100	26/100
22E	2009	282	39	14%	93	33%	0	0%	6	2%	8	3%	21	7%	14	5%	35	12%	63	22%	3	1%	39/100	35/100
22E	2010	363	84	23%	138	38%	0	0%	27	7%	17	5%	19	5%	22	6%	53	15%	0	0%	3	1%	51/100	32/100
22E	2010	182	18	10%	51	28%	0	0%	16	9%	7	4%	12	7%	11	6%	29	16%	38	21%	0	0%	27/100	43/100
22E	2011	375	72	19%	95	25%	0	0%	40	11%	21	6%	23	6%	41	11%	79	21%	0	0%	4	1%	53/100	59/100
22E	2011	255	27	11%	72	28%	0	0%	30	12%	11	4%	9	4%	21	8%	42	16%	39	15%	4	2%	26/100	41/100
22E	2012	219	33	15%	73	33%	0	0%	26	12%	11	5%	19	9%	19	9%	28	13%	0	0%	10	5%	33/100	28/100
23SW	2002	162	24	15%	52	32%	0	0%	20	12%	8	5%	15	9%	21	13%	22	14%	0	0%	0	0%	33/100	31/100
23SW	2008	141	19	13%	52	37%	0	0%	8	6%	8	6%	7	5%	8	6%	16	11%	20	14%	3	2%	32/100	27/100
23SW	2009	117	12	10%	42	36%	0	0%	12	10%	7	6%	5	4%	5	4%	15	13%	19	16%	0	0%	22/100	28/100
23SW	2010	157	18	11%	66	42%	0	0%	29	18%	4	3%	5	3%	13	8%	17	11%	0	0%	5	3%	19/100	18/100
23SW	2011	127	17	13%	61	48%	0	0%	17	13%	4	3%	5	4%	9	7%	8	6%	0	0%	6	5%	22/100	10/100
23SW	2012	235	29	12%	79	34%	0	0%	31	13%	11	5%	6	3%	21	9%	18	8%	0	0%	40	17%	26/100	16/100
23SE	2012	81	12	15%	36	44%	0	0%	8	10%	3	4%	3	4%	10	12%	7	9%	0	0%	2	2%	27/100	16/100

[a] Percentage of age-sex specific cohort based on total composition sample size (N).
[b] Number of males ≥4 years old/100 cows ≥3 years old.
[c] Number of yearlings/100 cows ≥3 years old.
[d] Mature bull:cow ratios are probably underestimated due to sampling regime that favored selection of large groups for comp counts.

Table 4. Results of state and federal muskox hunts on the Seward Peninsula, RY10.

	Nr. of permits											
	Quota		State			Federal			Harvest			
Hunt Area	Muskox	Cow	Bulls Harvested	Cows Harvested	Unk Harvested	Issued	Bulls Harvested	Cows Harvested	Bull	Cow	Unk	Total Harvest
22B												
RX105 East	3	0	2	0	0	0	0	0	2	0	0	2
RX105 West	23	0	26	0	0	0	0	0	26	0	0	26
22C												
RX099	20	0	24	0	0	0	0	0	24	0	0	24
DX099	NA	NA	0	0	0	0	0	0	0	0	0	0
22D SW												
RX099	8	3	7	0	1	0	0	0	7	0	1	8
DX103	5	NA	4	0	0	0	0	0	4	0	0	4
22D Kuz												
RX099	17	6	11	5	0	0	0	0	11	5	0	16
22D Rem												
RX104	24	11	24	3	0	0	0	0	24	3	0	27
DX102	3	NA	3	0	0	0	0	0	3	0	0	3
22E												
RX104	48	44	11	1	1	0	0	0	11	1	1	13
DX097	18	NA	11	0	0	0	0	0	11	0	0	11
SX097	NA	NA	0	0	0	0	0	0	0	0	0	0
23SW												
RX106	8	8	4	2	0	0	0	0	4	2	0	6
DX106	up to 2	NA	0	0	0	0	0	0	0	0	0	0
									127	11	2	140

Table 5. Results of state and federal muskox hunts on the Seward Peninsula, RY11.

	Nr. of permits											
	Quota		State			Federal			Harvest			
Hunt Area	Muskox	Cow	Bulls Harvested	Cows Harvested	Unk Harvested	Issued	Bulls Harvested	Cows Harvested	Bull	Cow	Unk	Total Harvest
22B												
RX105 East	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
RX105 West	**15**	**4**	**17**	**4**	**0**	**0**	**0**	**0**	**17**	**4**	**0**	**21**
22C												
RX094	**0**	**3**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**3**
RX096	**0**	**5**	**1**	**4**	**0**	**0**	**0**	**0**	**1**	**4**	**0**	**5**
22D SW												
RX099	**5**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**2**
DX103	**6**	**NA**	**5**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**5**
22D Kuz												
RX099	**9**	**5**	**5**	**13**	**0**	**0**	**0**	**0**	**5**	**13**	**0**	**18**
22D Rem												
RX104	**16**	**10**	**16**	**0**	**0**	**0**	**0**	**0**	**16**	**0**	**0**	**16**
DX102	**3**	**NA**	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**2**
22E												
RX104	**36**	**28**	**18**	**4**	**0**	**0**	**0**	**0**	**18**	**4**	**0**	**22**
DX097	**19**	**NA**	**9**	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**	**9**
SX097	**NA**	**NA**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
23SW												
RX106	**7**	**4**	**6**	**1**	**0**	**0**	**0**	**0**	**6**	**1**	**0**	**7**
DX106	**up to 2**	**NA**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
									81	**29**	**0**	**110**

SPECIES MANAGEMENT REPORT

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

MUSKOX MANAGEMENT REPORT

From: 1 July 2010
To: 30 June 2012[1]

LOCATION

GAME MANAGEMENT UNIT: 23 (43,000 mi^2)

GEOGRAPHICAL DESCRIPTION: Western Brooks Range and Kotzebue Sound

BACKGROUND

Muskoxen are indigenous to northwest Alaska; however, they disappeared before or during the nineteenth 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 muskoxen management report covers the Seward Peninsula muskox population and includes information for Game Management Units (UNITs) 22 and 23 Southwest.

In 1970 the department also 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. The majority of the Cape Thompson muskox population probably 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

[1] This report also contains information collected outside the reporting period at the discretion of the reporting biologist.

Unit 23. 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 GMU 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

1. To allow for growth and expansion of muskoxen into historic ranges.
2. To provide for subsistence hunting and eventually for recreational hunting of muskoxen on a sustained yield basis.
3. To provide for nonconsumptive uses of muskoxen; e.g., viewing and photography.

MANAGEMENT OBJECTIVES

1. To survey the Cape Thompson population at least once every 3 years.
2. Assess population level range expansion.
3. To monitor the sex and age composition of the Cape Thompson muskoxen population.
4. To 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 from 1987 to 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 the distribution of animals within the traditional survey area have decreased (Fig. 1, Westing 2011). For these reasons, it was deemed necessary to survey the known range and potential habitat in Units 26A and 23 north of the Kobuk River that may be supporting muskoxen to try to understand the overall status of the population and develop a better tool for monitoring changes in population size and distribution. This increased the survey area from 10,440 km^2 to ~66,000 km^2, making a minimum count approach impractical.

Distance Sampling. In 2010, distance sampling methods were successfully used to estimate the size of the Seward Peninsula muskoxen population (Gorn 2011). In 2011, we adopted distance sampling techniques (Buckland et al. 2001, 2004) to estimate abundance. The following methods, described in a survey summary to agency participants (unpublished agency report, Schmidt, and Westing, 2011), were used to estimate the Cape Thompson muskox population (see also Schmidt et al. *In pres*s). Since 2011, the expanded area will be considered on a 4-year rotation with the next survey performed in 2015.

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. During the 2010 Seward Peninsula survey, it was discovered that attempting to maintain a constant altitude in hilly terrain may decrease sightability in a wide strip near the line. To remedy this, we allowed flight altitudes AGL 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.

The pilot and observer worked together to search all terrain on both sides of the aircraft out to the midpoint between transects. 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. Teams were instructed to concentrate on the area nearest the aircraft first to ensure detection was 1.0 near the centerline.

Survey Techniques. In 2011, survey area boundaries were determined using locations of observed muskoxen and exclusionary habitat criteria (e.g., complete snow coverage with no exposed vegetation) for Units 23 and 26A. Areas at elevations over 700 m were considered non-habitat and were excluded from the survey. This criterion was set after analyzing the elevation of all muskoxen sightings in the muskoxen database that has 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 square mile could be added back for continuity. Finally, the coverage was converted to a shapefile delineating survey boundaries. After removing areas of non-habitat, 65,833 km^2 were considered for the study (Fig. 2).

One requirement of distance sampling methodology is that ~100 groups must be detected to achieve reasonably precise estimates, but only ~40 groups were typically detected in the traditional survey area during minimum count surveys. To increase the number of detections in the model, a supplemental survey area on the Seward Peninsula (from Unit 22E, and portions of 22D and 23SW within Bering Land Bridge National Preserve) covering 27,425 km^2 was surveyed by NPS. All surveys were conducted 3 March 2011 to 1 April 2011 to provide similar weather and lighting conditions. Snow coverage was adequate (complete or near complete) in each survey area. Many areas that usually remain snow free had abnormally extensive snow

cover due to higher than average snow fall and icing events that may have prevented snow from blowing away.

Parallel transects were generated over the entire study region at two intensities, the choice of intensity depending on the suspected density of muskoxen in each area. Transects in the traditional survey area for the Cape Thompson population, most areas on the Seward Peninsula, and a few smaller areas north of the Brooks Range and along the coast in Unit 26A were placed at 6.4 km (4 mi) intervals. The remaining area was covered at 7.2 km (4.5 mi) intervals to reduce overall effort and cost in regions not likely to contain substantial numbers of muskoxen. This resulted in 79 transects being generated in the Seward Peninsula survey area and 205 transects in the entire Cape Thompson survey area (Fig 2).

In 2012, the Cape Thompson traditional survey area was resampled to increase the number of area specific detections and to decrease the reliance on Seward Peninsula detections in future years. We adopted 4.8 km (3 mi) spacing for compatibility with Seward Peninsula surveys. Techniques were as described above. All transects were flown 3–15 Mar 2012. Snow coverage was adequate (complete or near complete) in each survey area.

Analysis. Perpendicular distances from the flight line to each observed group were calculated using ArcMap 9.3.1. The observed distance data were right truncated at 3.2 km, 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. Program Distance 6.0 (Thomas et al. 2009) was used to select the best fitting detection function, and AIC was used to select among competing models.

We re-fit the best approximating detection model in a Bayesian framework using R 2.12 programming language (http://www.r-project.org/) and WinBUGS (Spiegelhalter et al. 2004). The overall model structure was similar to that used for the 2010 Seward Peninsula and contained 3 submodels: detection probability, probability of presence, and group size. However, two important improvements over the original 2010 analysis were made to the group size submodel based on the results of a similar analysis for Dall's sheep (Schmidt et al. *2011*). These additions included treating group size as a covariate influencing detection probability (see Buckland et al. 2004 and Marques et al. 2007) and the addition of a random effect. The former allowed detection probability to increase with group size, assuming that larger groups would be more detectable than smaller groups. The random effect helped to account for the overdispersed nature of the observed group sizes, reducing bias in abundance estimates. Without this random term, mean group size tends to be overestimated, inflating abundance estimates. When combined, these two additions are expected to produce more accurate and precise estimates than was previously possible.

We assumed that the Cape Thompson area would have a different probability of presence than the Seward Peninsula and that the probability of presence would be higher on longer transects (i.e., the number of muskoxen seen on longer transects will be higher than for shorter transects).

We also included a random effect to account for remaining unexplained variation in presence on each transect. Cluster size was assumed to differ between the two survey areas, although detection probability was not. With this basic model structure, we generated estimates for subsections within the Cape Thompson and Seward Peninsula survey areas. To provide comparable abundance estimates between years for some survey areas on the Seward Peninsula, we also reanalyzed the 2010 data using this new model formulation. Abundances were estimated at the transect level, and estimates for each unit or subunit were produced by weighting the abundance estimate for each individual transect by the proportion of that transect that was within the unit. The total transect-level abundance for the subunit was then converted to density before multiplying by the total area of the subunit to produce the overall abundance estimate.

Population Composition

Composition information was collected by ADF&G and NPS in March–April 2010, 2011, and 2012 as we transitioned to collecting data during a time when sightability is more optimal. A 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. In the spring of 2012, we sampled groups on a range-wide basis for the entire traditional survey area. For ratio estimates we defined 'cow' as any female ≥2 yrs old and 'bull' as any male ≥2 yrs old. In earlier reports the ratio of bulls:100 cows was based on bulls per females aged ≥3 yrs old. Because we know that females are reproductive as 2 yr olds, the ratio is now expressed as bulls: 100 cows ≥2 yrs old. Data collected in the spring is based on "short" classifications; e.g., a 3-year-old male is 2 years and 11 months old. Composition information was also collected each August in 2010, 2011, and 2012 in partnership with NPS. 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, casual conversations between department staff and local residents, commercial operators, hunters, and nonconsumptive users provided information regarding the distribution of muskoxen in Unit 23.

MORTALITY

No radio collars were deployed in this population by department staff during the reporting period; therefore, we did not estimate annual population mortality rates. However, NPS is engaged in a multi-year study that involves maintaining a sample size of 30 collars on animals in the Cape Thompson population. All agency staff examined kill 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., RY10 = 1 July 2010–30 June 2011). Harvests during RY10 and RY11 were monitored through the Tier II hunt report system.

HABITAT

Assessment

The department did not monitor muskoxen range condition in Unit 23 during the reporting period.

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

From 1970 to 1998 the Cape Thompson muskoxen population within the sampled area grew approximately 8% annually (Fig. 3). After 1998, the growth of this population within the sampled area slowed dramatically (2% annually). Since 2005, the muskox population within the traditionally sampled area has continuously declined. Data from 2011 and 2012 are from distance sampling surveys and do not directly compare with previous minimum count techniques. The following interpretation of results from distance sampling surveys is mostly excerpted from the aforementioned survey summary to agency participants (unpublished agency report, Schmidt, and Westing, 2011).

Distance Surveys 2011. We determined that 200 m was an appropriate left truncation distance to account for the area with limited visibility under the aircraft, and the number of detections increased dramatically at distances >200 m from the transect line. We also right truncated the data at 3.2 km, the distance at which viewing distance for adjacent transects overlapped. After right and left truncation, 85 detections from the Seward Peninsula survey and 39 from the Cape Thompson survey remained for analysis. This was in line with our original goal of ≥100 total groups. Both the hazard-rate and half-normal detection functions fit the data, but the half-normal was selected based on AIC (ΔAIC = 1.0). The detection function for the 2011 surveys indicated that detection probability was very near 1.0 at 500 m, suggesting little to no bias in the 2010 estimates due to the larger left truncation distance in that year (Fig. 4). The Bayesian estimates for each subunit had CVs <15% for the 2011 survey (Fig. 5).

Based on this analysis, we estimated there were 447–612 (95% CI) muskoxen in the entire northern survey area in 2011. Estimates were also generated for the traditional core sample area (176–248 95% CI), Unit 26A (187–279 90% CI) and the Cape Thompson population that exists in Unit 23 (244–355 95% CI) (Fig. 5). All of these data are presented as ranges rather than point estimates due to the fact that the estimates may change in future years as more area specific data are available.

While borrowing detections from the Seward Peninsula in 2011 was necessary to estimate the detection function and provide reasonable levels of precision for abundance estimates, the joint estimation of this detection function assumes that the detection process is similar between the two areas, and bias could result if this assumption is not met. Terrain ruggedness and snow cover often differ between the two areas, possibly causing differences in detectability between the two regions. Future distance sampling surveys in the Cape Thompson area will allow us to examine these potential differences and are expected to reduce the reliance on observations from Seward Peninsula surveys. As a result, the collection of additional information specific to the Cape

Thompson population may result in updated estimates over time as data are reanalyzed in light of new information.

Distance estimates for the traditional survey area should be interpreted with care due to sampling limitations associated with low local sample sizes and the reliance on allowable samples from other areas to complete the analysis. At present, with a borrowed detection function there is potential for bias. As additional data are collected, estimates for the traditional area will become less reliant on data from other areas and become more independently robust. If future work finds little difference in detection between separate areas, then all data can be combined to improve estimates for both populations and point estimates will be generated for trend analysis.

Distance estimates generated for subareas have revealed some counterintuitive trends. As presented earlier, more muskoxen were estimated for Unit 26A than in the Cape Thompson traditional survey area. Comparatively, using minimum count data, there were fewer muskox in Unit 26A (42%) compared to the traditional survey area (49%), along with 9% in other areas of Unit 23. There was a dramatic group size difference in the respective areas that may influence the accuracy of estimates (Unit 26A mean=14, SD 15.5 vs. traditional area mean=7, SD 5.7) (Fig. 5). Future work should continue to attempt to understand the potential effect of group size between these areas.

Distance Surveys 2012. The estimate for the traditional survey area was 174–309 95% CI (Fig. 3.). Observations from the concurrent 2012 Seward Peninsula surveys were used. Although the line spacing was closer and more muskoxen overall were observed, confidence intervals widened. This may be the result of stochastic functions but it could also come from the increased reliance on a Cape Thompson specific detection function.

Population Composition

Each year in 2010, 2011, and 2012 spring composition surveys were conducted in April following the revised protocol for composition surveys. We observed 39, 27, and 8 yearlings (11 month calves):100 cows (≥2 yrs old) in 2010, 2011, and 2012, respectively (Table 1, Fig 6). Mature bull:cow ratios (bulls ≥4yrs:100 cows ≥2 yrs old) for these years were 50, 44, and 19 in 2010, 2011, and 2012, respectively (Table 1, Fig 7). The ratios of all bulls:100 cows ≥2 yrs old were 69, 63, and 32 in 2010, 2011, and 2012, respectively (Table 1, Fig 8).

Fall composition surveys found 27, 19, and 39 calves:100 cows (≥2 yrs old) in 2010, 2011, and 2012, respectively (Table 1, Fig 6). Mature bull:cow ratios (bulls ≥4yrs:100 cows ≥2 yrs old) for these years were 30, 30, and 21 in 2010, 2011, and 2012, respectively (Table 1, Fig 7). The ratios of all bulls:100 cows ≥2 yrs old were 39, 46, and 33 in 2010, 2011, and 2012, respectively (Table 1, Fig 8).

Comparing fall and spring data, spring surveys found more bulls. This may demonstrate the difficulties of observing bulls in the summer. Composition survey search intensity during is low compared to population surveys, and mature bulls are often alone or in very small groups that could easily be missed. Regardless, looking exclusively at fall data seems to suggest that bull:cow ratios are declining (All bulls R^2=53%, Mature bulls R^2=60% (Figs 7 and 8).

Due to sample size, the lack of known-aged animals over 4-years-old, and the limitations of data collected in the fall, little can be said regarding the survival of individual cohorts. After more spring surveys are conducted, further investigation may be possible. However, in most years, about half of the population estimate is observed during composition surveys (Table 2). 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.

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 the spring of 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 just outside of the sample boundary and in the Kelly and Kugururok Drainages, totaling >20 muskoxen. It is important to consider potential variability due to small scale movements that may lead to the inclusion or exclusion of groups from year to year. Collar data from the previously mentioned 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, USGS, 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 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. Its proximity to Kivalina makes it very likely that we would be advised of any odd occurrences regarding these groups.

MORTALITY

Harvest

Season and Bag Limit. , Sixpermits have been issued annually for the Tier II muskoxen hunt in northwest Unit 23 (TX107) since the hunt began in RY00; 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
RY10 and RY11		
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)

Units and Bag Limits	Resident/Subsistence Hunters	Nonresident Hunters
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. Trophy destruction required if skull is removed from Unit 23. Horns are cut at or above the eye and the distal portion of the horn is retained.
4. 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 muskoxen 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. Under this quota, one bull was taken in the RY05 season and one bull was taken in RY07. Because there are virtually no permanent residents living within the monument, this hunt is rarely used.

Board of Game Actions and Emergency Orders. There were no Board of Game actions or Emergency Orders during this reporting period.

Human-Induced Harvest. Few muskoxen have been harvested under TX107 since this hunt was established (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. This shift demonstrates that the Tier II process favors applicants that are experienced with and comfortable navigating a paper-based and formulaic application process. Applicants, from the villages especially, may be easily discouraged when they are not successful and may see the application as too difficult for an uncertain result. As a result, village hunters rarely accumulate a long hunt history that allows them to be competitive in securing Tier II permits. Additionally, applying for a hunt that takes place 8–12 months later is culturally counterintuitive for Inupiaq hunters. The shift in distribution of permits has happened despite educational efforts to encourage applications from villages and help offered to applicants as they navigate the Tier II process. Since successful applicants have a perfect score for the application/hunt history, it is impossible for new applicants (or those who do not apply every year) to establish enough history to receive enough points to win a permit. 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 above; all hunting is by resident hunters. Annual success rates for TX107 in most recent years have been 100%. However in RY09 and RY10, one-third of the permit winners who hunted did not harvest a muskox. This was likely due to the absence of muskoxen during those years in the relatively small area where Kotzebue hunters focus their effort.

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

Preliminary analysis of mortality data shows an 84% adult cow survival rate (77–91 95% CI) (L. Adams, USGS, Anchorage, personal communication). A significant amount of the mortality of NPS-collared muskoxen has been attributed to brown bear predation (J. Lawler, NPS, Fairbanks, personal communication). However, it can be difficult to discern predation by bears from scavenging by bears. In the course of the NPS study, wolves were also observed preying upon muskoxen. When composition surveys were performed in April 2012, a cow muskox was observed missing a 12-inch square of flesh from her hindquarter. Wolf tracks suggested that the group had been targeted but no animals had yet been killed.

Other Mortality

Given the propensity 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 Shesaulik will likely continue and could become more frequent in the future. Inn the summer of 2008 a muskox was taken in defense of property. At least 2 other muskoxen, both bulls, have been shot and left unsalvaged in the vicinity of Shesaulik over the past 8 years.

Illegal harvests may have also reduced muskoxen numbers in the northern portion of this area. For example, since 2003 we have 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. Agency staff spends little time in the northern portion of this muskoxen range so we do not know the magnitude of illegal harvests.

HABITAT

The strong fidelity muskoxen exhibit for coastal areas is probably attributable to their dependence on high winds to minimize snow depth on exposed ridges during winter. Although snow in these areas is minimal, the quantity and quality of forage appears to be limited. Muskoxen may be attracted to coastal areas during summer by cooler conditions than occur inland.

Assessment

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

Enhancement

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

NONREGULATORY MANAGEMENT PROBLEMS/NEEDS

Conflicts among muskoxen, caribou, and reindeer

For many years, local residents have expressed concern about muskox displacing *Rangifer* (caribou and reindeer) from traditional hunting areas and worry about competition (between *Rangifer* and muskoxen) for food resources (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 two species (Thomas et. al 1999.) Additionally, on the Seward Peninsula, although muskoxen and reindeer overlap in their use of feeding areas, they select forage plants differently from each other (Ihl and Klein, 2001). Although most published information indicates that competition is not a serious issue, traditional knowledge in many areas of the state indicates that indirect and direct competition may be an issue between *Rangifer* and muskox. Until this concern is adequately addressed, it will continue to impede muskox management in northwest Alaska (see also 'Other Mortality' section above).

CONCLUSIONS AND RECOMMENDATIONS

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.

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 herd with reference to the majority of its range. In 2011, the department, in concert with the NPS, used slight modifications of distance sampling (Schmidt et al. 2010) to estimate the Cape Thompson muskox population. Our results confirm previous work suggesting that distance sampling is a useful tool for estimating muskoxen abundance at a population wide level (Schmidt et al. 2010). We successfully produced estimates for the Cape Thompson population by combining information from the Seward Peninsula to help estimate the detection function. Improvements to the group size submodel used in Unit 23 also increased precision and accuracy and should improve the ability to detect population trends. Because a majority of the detection information came from groups observed on the Seward Peninsula, abundance estimates for the traditional Cape Thompson survey area could be biased low if true detection probabilities are lower in that area for some reason (e.g., incomplete snow

cover, more rugged terrain). Future surveys should focus on developing a Cape Thompson specific detection function. Another population wide survey should be completed in 2015.

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

As the number of mixed-sex age groups in new areas increases, 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.

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.

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.

LITERATURE 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.

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.

Dau, J. 2005. Muskoxen survey-inventory management report. Unit 23. Pages 38-48 *in* C. Brown, editor. Muskox 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 and inventory activities 1 July 2008–30 June 2010. Alaska Department of Fish and Game, Division of Wildlife Conservation, 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 (4):954–972.

Marques, T. A., L. Thomas, S. G. Fancy, and S. T. Buckland. 2007. Improving estimates of bird density using multiple-covariate distance sampling. Auk 124:1229–1243.

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, 66:1–77.

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. National Park Service, Fairbanks, and Alaska Department of Fish and Game, Nome and Kotzebue. [Unpublished report]

Schmidt, J. H. and C. Westing. 2011. A range-wide assessment of the Cape Thompson muskoxen population and implications for future distance sampling surveys. National Park Service, Fairbanks, and the Alaska Department of Fish and Game, Kotzebue. [Unpublished report]

Schmidt, J. H., K. L. Rattenbury, J. P. Lawler, and M. C. MacCluskie. 2011. Using distance sampling and hierarchical models to improve estimates of Dall's sheep abundance. Journal of Wildlife Management 76(2):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. Prairie and Northern Region, Canadian Wildlife Service Environmental Conservation Branch. Technical Report Series Number 343.

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/>

Westing, C. 2011. Unit 23 muskox. Pages 48–62 [*In*] P. Harper, editor. Muskox management report of survey and 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.

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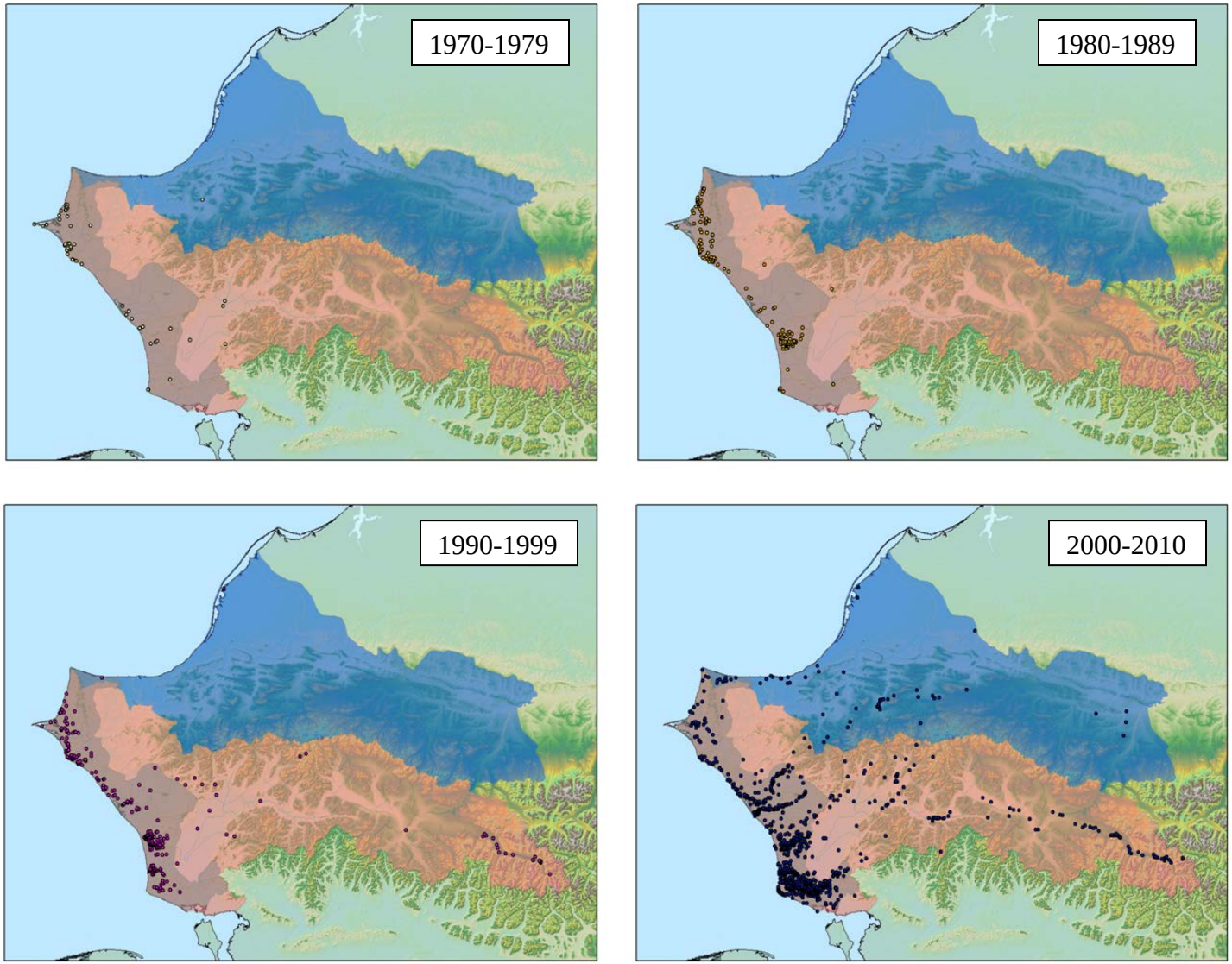


Figure 1. Locations of muskoxen observations by decade, 1970–2010. (Includes incidental, census, and composition efforts occurring in the traditional survey area only; Unit 23 in pink; Unit 26A is shown in blue; traditional survey area in gray.)

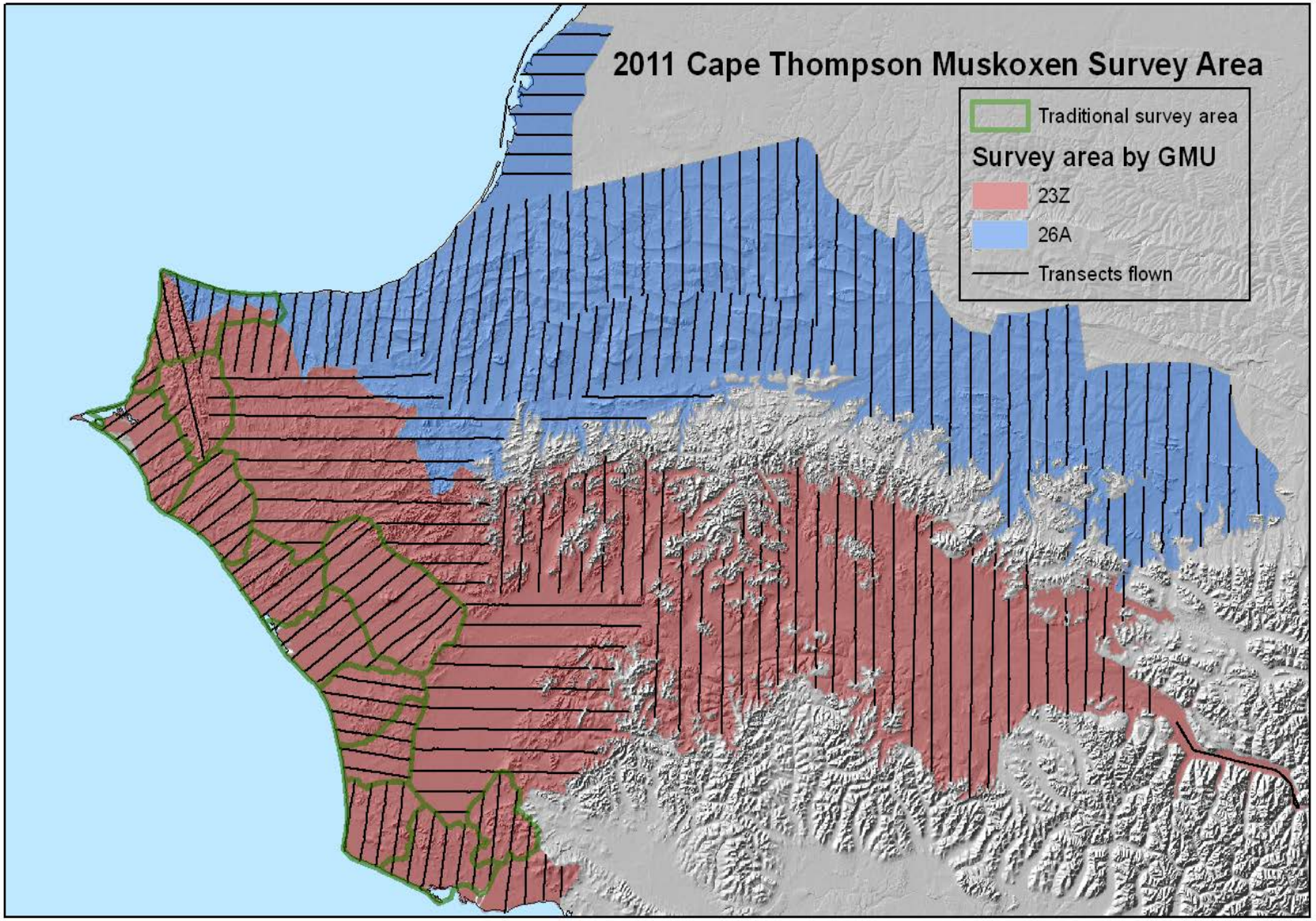


Figure 2. 2011 Cape Thompson Muskoxen Survey Area.

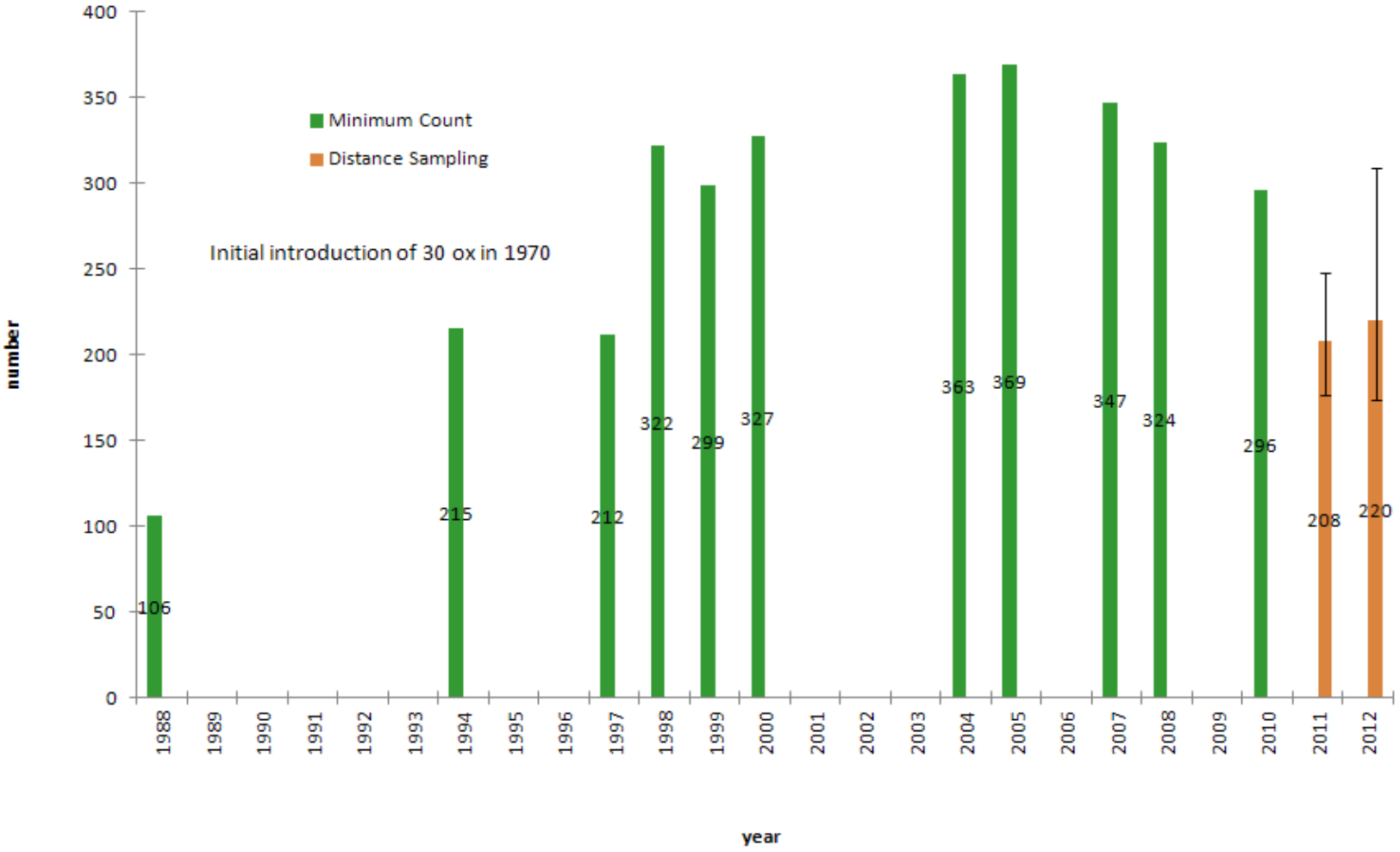


Figure 3. Cape Thompson muskoxen abundance survey for the traditional survey area, 1970–2012.

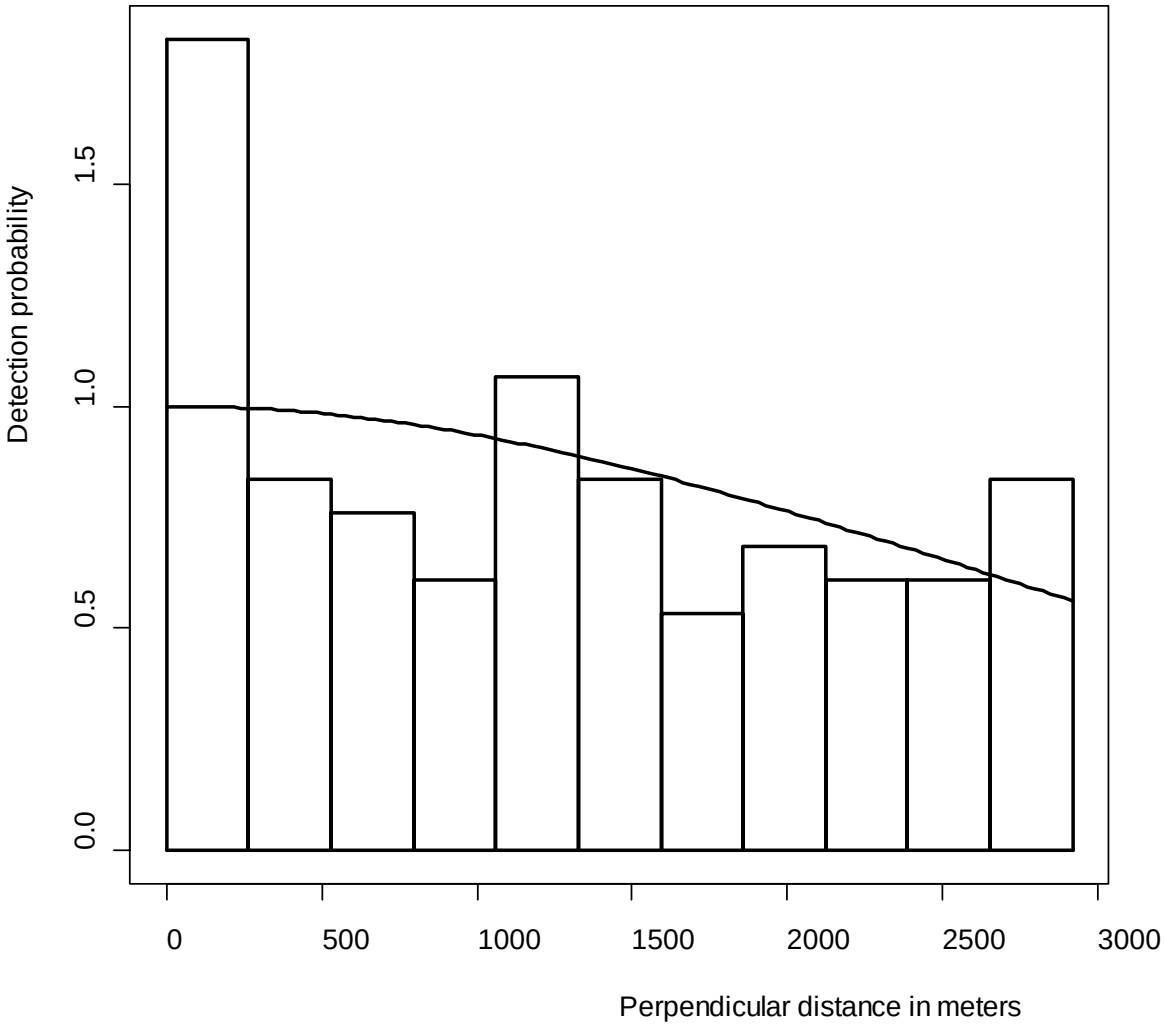
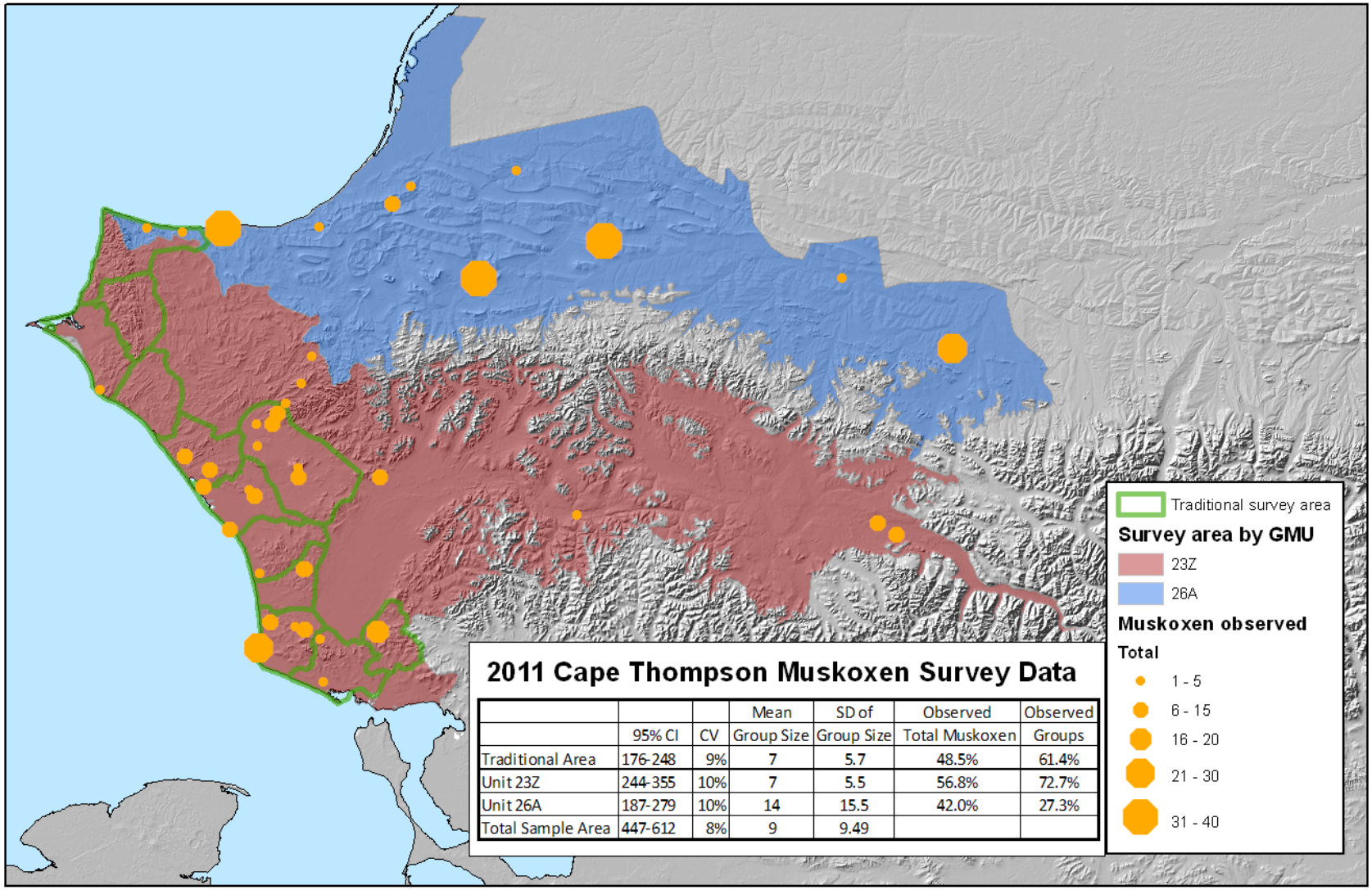


Figure 4. Muskox distance sampling histogram of data from the Cape Thompson and Seward Peninsula survey areas combined after left and right truncation. The solid line represents the fitted half-normal detection function for a basic model assuming a linear decline in detection probability with distance. The bars indicate the relative number of observations in each distance category.



			Mean	SD of	Observed	Observed
	95% CI	CV	Group Size	Group Size	Total Muskoxen	Groups
Traditional Area	176-248	9%	7	5.7	48.5%	61.4%
Unit 23Z	244-355	10%	7	5.5	56.8%	72.7%
Unit 26A	187-279	10%	14	15.5	42.0%	27.3%
Total Sample Area	447-612	8%	9	9.49		

Figure 5. 2011 Cape Thompson muskoxen distance sampling results showing group size and location in Units 23 and 26A.

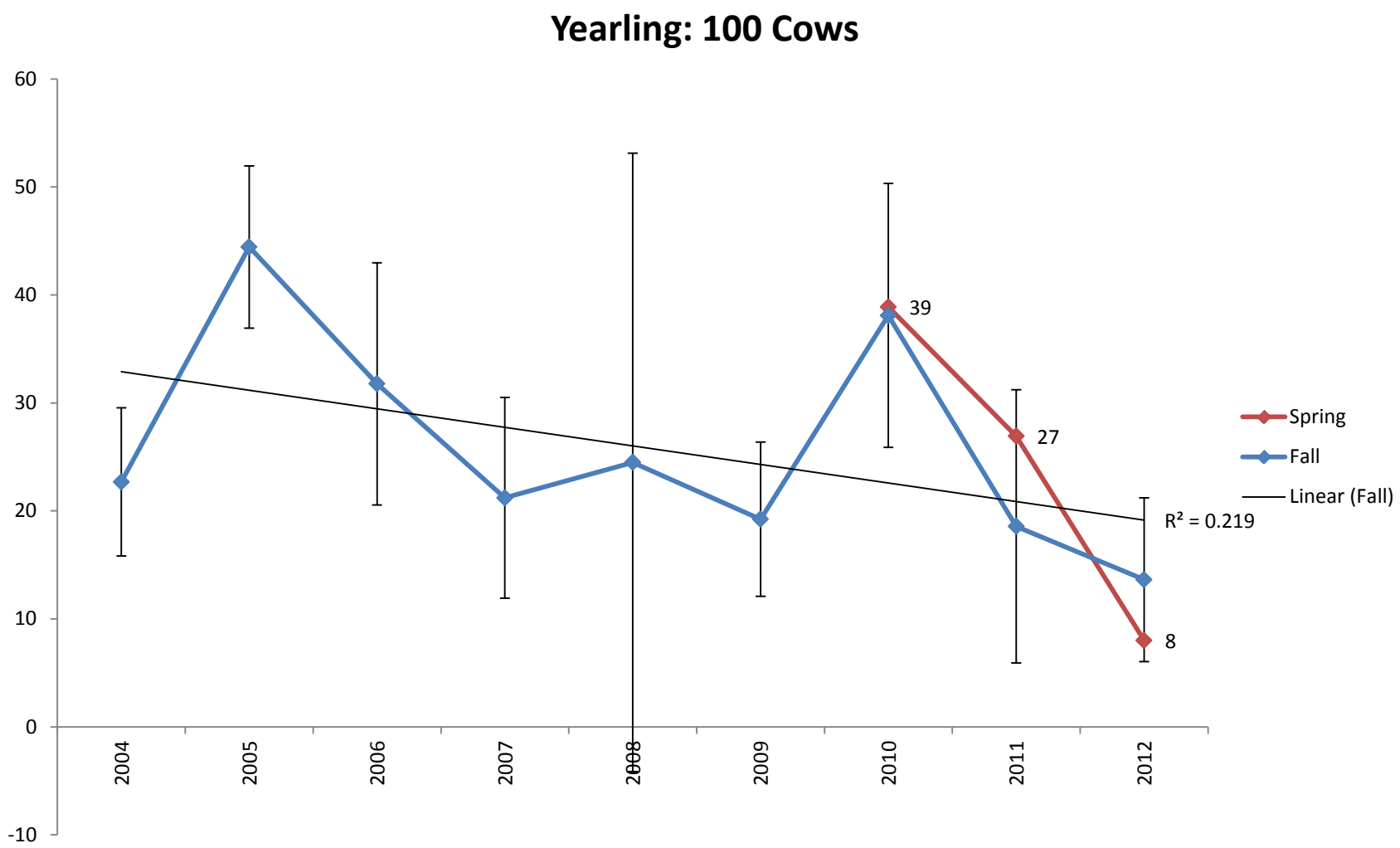


Figure 6. Muskox composition data for yearlings:100 cows (≥ 2 years old), Cape Thompson population, 2004–2012.

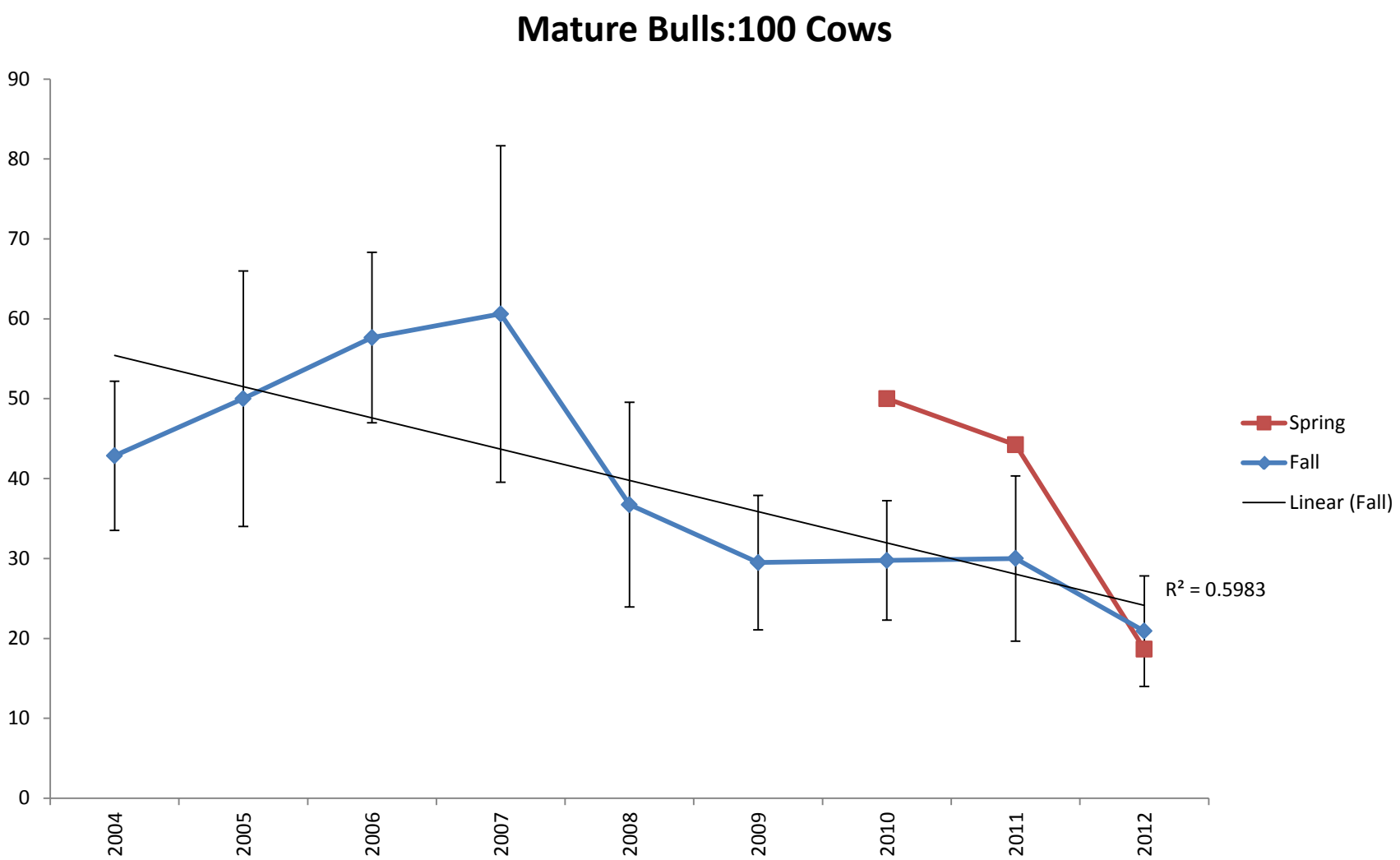


Figure 7. Muskox composition data for mature bulls (≥ 4 years old):100 cows (≥ 2 years old), Cape Thompson population, 2004–2012.

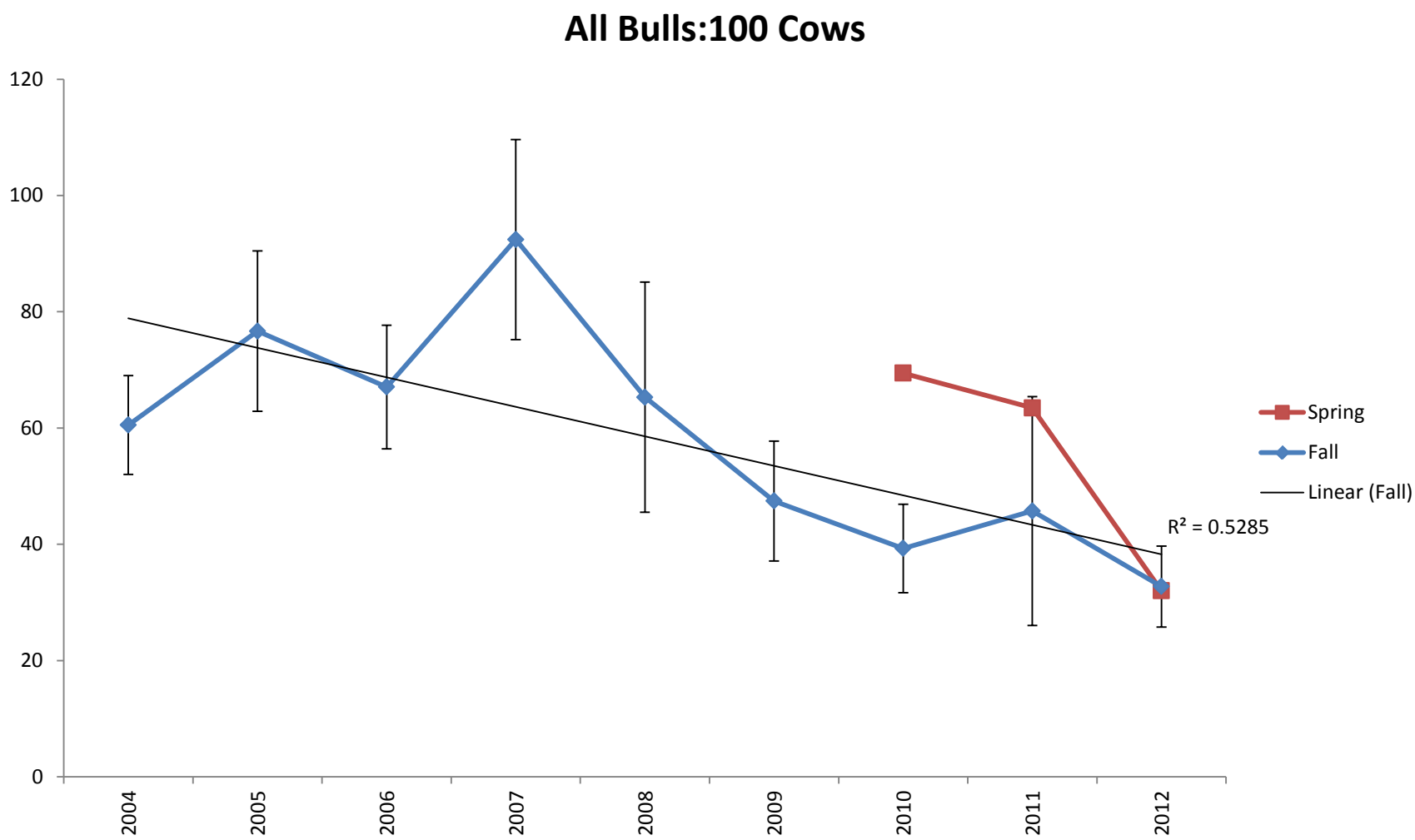


Figure 8. Muskox composition data for bulls (2≥ years old): 100 cows (≥ 2 years old), Cape Thompson population, 2004–2012.

Table 1. Age and sex composition of Cape Thompson muskoxen groups, 2004–2012.

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

[a] n represents the composition sample, the sum of individuals in each age-sex class.
[b] % Obs is the proportion of the population estimate contained in the composition sample.
[c] B:C denotes Bulls ≥2 years old per 100 Cows ≥2 years old.
[d] MB:C denotes Mature Bulls per 100 Cows ≥2 years old.
[e] Y:C denotes yearlings per 100 Cows ≥2 years old.
[f] nd represents no data, no population estimate to compute percentage.

Table 2. Harvest data for the Tier II muskoxen hunt, TX107 (6 permits issued annually) and the Federal muskoxen hunt (up to 2 permits available annually), Unit 23, regulatory years 2000–2011.

Regulatory year	Nr. Permits TX107 [a]	Harvest, Nr.		Total harvest	Hunter Residency				
		Bulls	Cows		Point Hope	Kivalina	Noatak	Kotzebue	Other
RY00	6	1	0	1	4	2	0	0	0
RY01	6	0	0	0	2	0	4	0	0
RY02	6	4	1	5	1	2	3	0	0
RY03	6	0	0	0	0	0	6	0	0
RY04	6	2	1	3	0	0	3	3	0
RY05[b]	6 (1)	(1)	0	1	0	1	3	2	(1)
RY06	6 (1)	4	0	4	1	1	1	3	(1)
RY07	6 (2)	6 (1)	0	7	0	0	0	6	(2)
RY08	6	5	0	5	0	0	1	5	0
RY09	6	4	0	4	0	0	0	6	0
RY10	6(1)	4	0	4	0	0	0	6(1)	0
RY11	7[c]	4	1	5	0	0	0	6	1

[a] Numbers in parentheses are from the federal hunt.
[b] Season closed by emergency order; quota taken illegally.
[c] An additional permit was issued when one permit was invalidated due to application falsification.

SPECIES MANAGEMENT REPORT

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

MUSKOX MANAGEMENT REPORT

From: 1 July 2010
To: 30 June 2012[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 Alaska Department of Fish and Game (ADF&G) reintroduced muskoxen to Nunivak Island during 1935–1936. 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 during 2007–2010 the population in Unit 26B stabilized at a reduced population size of approximately 190 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 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

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

when snow conditions, weather, or other factors were suitable for hunting 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 26C and 26B when the seasons were open. Some season and boundary changes have been made since 1998 (Lenart 2003).

MANAGEMENT DIRECTION

In April 1996 we 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. Some goals and objectives in this report were adopted directly from the plan.

Current management objectives were revised beginning 1 July 2010 and are listed below. These objectives were developed in response to results from research conducted during 2007–2010 and direction from Division of Wildlife Conservation headquarters staff.

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 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 will implement a program to selectively and lethally remove brown bears in Unit 26B that are known to prey on muskoxen or are observed on muskox 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 Units eastern 26A, 26B, and 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 and U.S. Fish and Wildlife Service, 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 ft 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. Flight lines 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 flight lines spaced 6 miles apart, whereby we attempted to observe all muskoxen within 3 miles of either side of the flight line. Six-mile wide transects were oriented north–south and extended from 70ºN to 69º15'N. Beginning in April 1999, survey flight lines extended farther south to 69ºN and flight lines 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 and Gates of the Arctic National Park and Preserve. 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. Flight lines, 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 flight line 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 flight lines 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 flight lines 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 Etivuluk River to the Kongakut River. The survey area included approximately 33,000 mi^2 (85,470 km^2).

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

In April 2011 we conducted a systematic survey of the eastern North Slope, similar to the 2006 effort, except the mountains were not searched. Details of the methods and miles flown will be in the next report.

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 because muskoxen groups were more difficult to locate in June. During 2009−2012, 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 1999–2012, 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. Beckmen, ADF&G Fairbanks, unpublished files). 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, and 11 in 2012 (2 in April, 9 in September) using methods described by Lenart (1999).

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 through 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 2012, we observed a precalving population of 191 muskoxen ≥1 year old in Unit 26B and eastern Unit 26A. This included locating all 19 radio collars in 8 groups, 1 unmarked mixed-sex group, 1 unmarked bull group, and 1 lone bull resulting in 188 muskoxen observed on 2 April. We observed an additional 3 bull muskoxen in an unmarked group during the course of other work in April.

In April 2011, we observed a precalving population of 190 muskoxen ≥1 year old in Unit 26B and eastern Unit 26A. This included 179 muskoxen in 16 groups observed along transects during the systematic survey dates, plus 3 bulls and a mixed-sex group of 8 muskoxen observed in the course of other work during April. Two of the bulls were killed by grizzly bears during April but were included in the population estimate because they were alive on 1 April. All 21 radiocollars were located. In late March 2011, just prior to the survey, 3 muskoxen were illegally shot and another from that group died of heart failure (presumably due to the stress of the incident). These animals were not included in the population estimate.

During 2007–2010, the precalving population in Unit 26B appeared stable at a reduced population size of approximately 190 muskoxen. Minimum numbers of muskoxen observed by ADF&G staff in Unit 26B and eastern Unit 26A during April 2007–2010 were 196, 192, 196,

and 184, respectively (S. M. Arthur, ADF&G files, Fairbanks). During 2007–2012, a small group that was often found on the Canning River on the boundary between Unit 26B and 26C was included in the Unit 26B totals.

Numbers observed during 2007–2012 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 2012 (190 muskoxen) cannot be determined. However, the population was relatively stable at approximately 190 animals during 2007–2012. 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 closely tracked or exceeded recruitment during 2003–2012.

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, some distributional changes probably occurred.

Unit 26C. In 2011 and 2012, 16 muskoxen were observed 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 26C. The combined number of muskoxen observed during precalving surveys in eastern Unit 26A and Units 26B and 26C declined considerably; 491–603 were observed during 1995–2000, but only 331 muskoxen were observed in 2003, 217 in 2006, and 191 in 2012 (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, Dawson City, Yukon, unpublished files, 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 2007–2012.

Population Composition

Unit 26B and eastern 26A. In April 2011 and 2012, the ratio of yearlings:100 females >2 years old was 39:100 and 32:100, respectively, indicating calves were being recruited into the

population (Table 1). Recruitment was also considered good the previous 2 years with 39 yearlings:100 females >2 years in 2009 and 35:100 in 2010. Although yearling recruitment was good during 2009–2012, adult mortality remained high and may have approximately equaled recruitment, resulting in a stable population.

The low yearling ratios observed during April composition surveys in 2007 and 2008 followed low numbers of calves observed in the previous years (Table 1). Only 14 calves were observed in early June 2006 and 11 in early June 2007, indicating that 2006 and 2007 cohorts were small or suffered unusually high calf mortality. April composition surveys yielded different results for yearling recruitment compared with June composition surveys conducted in the same year. For example, the April 2007 ratio of yearlings:100 females >2 years old indicated poor recruitment (16:100) while the June survey indicated good recruitment (33:100) even though 2006 calf production was low (14 calves observed). These differences may have been because muskoxen are more dispersed during June resulting in fewer muskoxen classified, which could distort the ratio. Because the April counts are probably more accurate, we discontinued June composition surveys in 2009. In general, we determined that recruitment was low in 2007 and 2008 because calf production was low in previous years.

In April 2011 and 2012, the ratios of bulls >3 years old:100 cows >2 years were 31:100 and 42:100, 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 — During 2007–2012, ADF&G research and management staff collected data on number of calves and adults (>1 year old) observed during 1 April through 30 June to estimate the minimum number of births. Calves were born as early as 18 April and as late as 27 June (S.A. Arthur, E.A. Lenart, ADF&G Fairbanks, unpublished files). The minimum numbers of births was 55 calves in 2011 and 61 in 2012, which represented ratios of 66 and 78 births:100 cows > 2 years old (Table 1; S.M. Arthur, E.A. Lenart, ADF&G Fairbanks, unpublished files). During the previous 3 years, results were similar: 64, 56, and 52 minimum births were observed in 2008, 2009, and 2010 with ratios of 82, 72 and 61 births:100 cows >2 years old, respectively (Table 1; S.M. Arthur, ADF&G unpublished files). The minimum number of births observed in 2007 was substantially lower, at 35 with a ratio of 45 births :100 cows > 2 years old.

Calf survival through October was 53% in 2011 and 66% in 2012 (Table 1; S.M. Arthur, E.A. Lenart, ADF&G unpublished files). Survival during the previous 3 years also was moderate to good through October, and was 53%, 80%, and 62% in 2008, 2009, and 2010, respectively (Table 1; S.M. Arthur, ADF&G Fairbanks, unpublished files). Calf survival was notably lower in 2007, when only 13 calves (37%) survived until October.

Unit 26C. In Unit 26C the ratio of calves:100 females >2 years old was low (<14:100) during 1999–2001. Yearling recruitment also was low (range = 0–17:100 females >2 years old;

Table 1). Annual bull (>3 years):cow (>2 years) ratios ranged 40–60:100 during 1997–2001 (Table 1). No data were available for 2002–2010 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 2006–2012, muskoxen were found primarily near Kachemach River, Beechy Point and the Kuparuk River Delta, Deadhorse, and along the Sagavanirktok, Ribdon and Ivishak rivers in Unit 26B. One group (<25) was found near Lonely in eastern Unit 26A and would occasionally return to the Colville Delta; another small group (<15) was found on either the Kavik 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 Kachemach River moved to Teshekpuk Lake (approximately 100 miles). During 2007–2012, this group was observed at Lonely and Kogru, moved to the Colville Delta, 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. Reynolds, ANWR, 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 that 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 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	Permits; Hunt type; Bag limit	Resident Open Season	Nonresident Open Season
Unit 26B			
1990–1991 through 1994–1995	2; Tier II; 1 bull	1–31 Oct; 1–31 Mar	No open season
Unit 26B, west of Dalton Hwy			
1995–1996	3; Tier II; 1 bull	1–31 Oct; 1–31 Mar	No open season
1996–1997 through 1997–1998	3; Tier II; 1 bull	15 Sep–15 Nov; 1–31 Mar	No open season
1998–1999 through 1999–2000	9; Tier II; 1 muskox	15 Sep–31 Mar	No open season
2000–2001 through 2005–2006	9[a]; Tier II; 1 muskox	1 Aug–31 Mar	No open season
2006–2007 through 2008–2009	0; Tier II; 1 muskox	No open season	No open season
Unit 26B, east of Dalton Hwy			
1995–1996	2; Tier II; 1 bull	1–31 Oct; 1–31 Mar	No open season
1996–1997 through 1997–1998	2; Tier II; 1 bull	15 Sep–15 Nov; 1–31 Mar	No open season
1998–1999 through 2004–2005	∞ (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
2005–2006 through 2008–2009	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 through 1991–1992	9; Tier II/Federal; 1 bull	1–31 Oct; 1–31 Mar	No open season
1992–1993 through 1993–1994	10; Federal; 1 bull	1–31 Oct; 1–31 Mar	No open season
1994–1995 through 1995–1996	10; Federal; 1 bull	1 Oct–15 Nov; 1–31 Mar	No open season
Unit 26C continued			
1996–1997 through 1997–1998	15; Federal; 1 bull	15 Sep–15 Mar	No open season
1998–1999 through 2001–2002	15; Federal; 1 bull (3 permits for females)	15 Sep–31 Mar	No open season
2002–2003	2; Federal; 1 bull	15 Sep–31 Mar	No open season
2003–2004 through 2007–2008	0; Federal; 1 bull	No open season	No open season
2008–2009	1; Federal; 1 bull	15 Sep–31 Mar	No open season

[a] In regulatory year 2000–2001, 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 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 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 Plan which authorized a predation control plan to reduce the effects of brown bear predation on muskoxen (Alaska Administrative Code Title 5, regulation 92.126 [5 AAC 92.126]).

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 been allowed only 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 have been 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 through 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 Table 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 Units 26B and 26C (Reynolds et al. 1992). 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 Delvecchio 2009; S.M. Arthur, ADF&G Fairbanks, unpublished files). 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 and likely died of starvation. During 2007 and 2008, a total of 6 calves were observed to have died during or immediately after birth. Other observed causes of death include disease, winter malnutrition, and 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 1999–2011 ($\bar{x}$ = 0.83; 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 (Arctic National Wildlife Refuge 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 (K. Beckmen, ADF&G files, personal communication, 2009). However, antibodies to *Chlamydia* were present in muskoxen populations at Nunivak Island, Seward Peninsula, and Cape Thompson Alaska that are not declining (K. Beckmen, ADF&G Fairbanks, unpublished files, personal communication, 2009). Occurrence rates in sera from these 3 populations averaged 22% (n = 41; range: 17–25%).

During 2006–2008, blood and tissue samples from captured muskoxen and from carcasses of muskoxen that died were analyzed by ADF&G staff veterinarian Kimberlee Beckmen, DVM, PhD for prevalence of various pathogens and concentrations of trace minerals. These data indicated the presence in this population of several diseases that may influence reproduction and survival, including *Chlamidiophila, Brucella suis*, *Leptospira, Neospora*, bovine viral diarrhea, and herpes virus. In addition, concentrations of copper reserves in many muskoxen were low and may have been insufficient to maintain healthy immune function, reproduction, or survival through weaning. Imbalances between concentrations of copper and other essential trace elements (e.g., selenium, zinc, iron, molybdenum, manganese) were evident in muskox tissues, and may have exacerbated the low copper reserve. Emerging parasites and pathogens, including lungworm, *Pasteurella*, and *Arcanbacterium* were also present and possibly influencing survival.

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).

NONREGULATROY AND MANAGMEMENT NEEDS/PROBLEMS

Unit 26B Muskox Recovery Plan

In response to the Unit 26B Muskox Recovery Plan (5 AAC 92.126), ADF&G prepared the Unit 26B Muskox Recovery Operational Plan (Alaska Department of Fish and Game 2012) to provide supporting information and guidance to implement the recovery plan.

Results of the 2012 muskoxen recovery field work are summarized by Lenart and Caikoski (Unit 26B Muskox Recovery Program–Field Activities Summary 2012. Unpublished memorandum, 9pp. ADF&G Fairbanks). Three male grizzly bears were lethally removed from Unit 26B in April and May 2012 because they had either killed muskoxen or muskoxen were in imminent threat from the bears.

Three adult muskoxen ≥1 year old (including 1 radiocollared muskox) were killed by grizzly bears during April–June 2012. This compares to a 5-year mean (2007–2011) of 9 adult muskoxen ≥1 year old killed by bears annually. No adult muskoxen deaths unrelated to bear predation were documented during April–June 2012, compared to a 5-year mean (2007–2011) of 4 adult muskoxen ≥1 year old annually.

A minimum of 61 calves were born in 2012 and 49 survived to the end of June 2012. Calf survival to the end of June (49 calves alive/minimum number of 61 births) was 80% compared to the 5-year mean (2007–2011) of 64%. By the end of October 2012, 40 calves remained, indicating that summer calf survival was 66% compared to a 5 year mean (2007–2011) of 57%. During the October 2012 radiotracking flight, we did not locate all adult muskoxen thought to be alive (potentially 9 more adults were not located); therefore, any additional calves associated with these missing adults would not have been detected and calf survival was potentially higher. We documented 1 calf death in September 2012 caused by a wolf.

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.

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 composed 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 (RY10–RY11) 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 RY10–RY11.

We did not completely meet 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 shared information with users, but ADF&G staff developed the Unit 26B Muskox Recovery Program. The Muskox Recovery Program was presented to the Alaska Board of Game as a proposal and therefore this regulatory process provided some opportunity for public input. The program was adopted by the Board of Game.

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 RY10–RY11. 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. This program was initiated in spring 2012, and any potential indications of a population increase would not be realized until at least April 2013. 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 bear predation is reduced 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.

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.

LITERATURE CITED

Alaska Administrative Code. 2012. State of Alaska, Legislative Affairs Agency, Juneau. http://www.legis.state.ak.us/basis/folio.asp (Accessed 20 February, 2013).

Alaska Department of Fish and Game. 2012. Operational Plan for Unit 26B Muskox Recovery, 2012–2018. http://www.adfg.alaska.gov/static/home/about/management/wildlifemanagement/intensivemanagement/pdfs/unit26b_operational_plan_muskox.pdf (Accessed 12 February 2013).

Arthur, S. M. 2007. Distribution, movements, and survival of muskoxen in northeastern Alaska. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research Performance Report, 1 July 2006 through 30 June 2007. Project 16.10. Grant W-33-5. Juneau.

———. 2008. Distribution, movements, and survival of muskoxen in northeastern Alaska. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research

Performance Report, 1 July 2007 through 30 June 2008. Project 16.10. Grant W-33-6. Juneau.

——— and P. A. Del Vecchio. 2009. Distribution, movements, and survival of muskoxen in northeastern Alaska. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Research Performance Report, 1 July 2008 through 30 June 2009. Project 16.10. Grant W-33-7. Juneau.

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. Volume XIX, Part X. Alaska Department of Fish and Game. Study 16.0. Juneau, Alaska, USA.

Lenart, E. A. 1999. Units 26B and 26C muskox. Pages 30–43 *in* M. V. Hicks, editor. Muskox management report of survey–inventory activities. Alaska Department of Fish and Game. Study 16.0. Juneau, Alaska, USA.

———. 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 20002. Alaska Department of Fish and Game. Project 16.0. Juneau, Alaska, USA.

———. 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 20004. Alaska Department of Fish and Game. Project 16.0. Juneau, Alaska, USA.

———. 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. Project 16.0. Juneau, Alaska, USA.

Lent, P. 1998. Alaska's indigenous muskoxen: a history. Rangifer 18:133–144.

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

Reynolds, H. V., A. Gunn, and P. L. Clarkson. 1992. Grizzly bear predation on muskoxen in northern Alaska and Canada. Professional paper presented at the ninth international conference on bear research and management, Missoula, Montana, USA.

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, USA. pp. 1–11.

———. 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, USA. pp. 1–18.

———. 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, USA. pp. 1–6.

———. 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, USA. pp. 1–11.

———. 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, USA. pp. 1–9.

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

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

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Table 1. Units 26B (and eastern 26A) and 26C muskox precalving population estimates and composition counts, 1990–2012[a].

Location[d]/ Year	Precalving population estimate[b] Muskoxen observed	June and April composition[c] 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)	14
1991	156		98 (75)	35	69 (24)	26 (9)	23
1992	224		193 (162)	77	43 (33)	40 (31)	31
1993	237		131 (103)	51	41 (21)	20 (10)	28
1994	166		91 (76)	28	46 (13)	68 (19)	15
1995	330		145 (123)	53	55 (29)	36 (15)	22
1996	266		44 (41)	23	35 (8)	22 (5)	3
1997	279	30 Jun	123 (107)	47	49 (23)	51 (24)	16
1998	207	26–27 Jun	97 (78)	42	24 (10)	24 (10)	19
1999	237	22–23 Jun	194 (162)	71	62 (44)	32 (23)	32
2000	277	7 Jun	172 (131)	68	31[f] (21)	25 (17)	41
2001		10–11 Jun	286 (239)	99	64[f] (63)	39 (39)	47
2002	284	8–9 Jun	241 (203)	103	27[f] (28)	23 (24)	38
2003	302	26–28 Jun	162 (134)	53	87[f] (46)	15 (8)	28
2004	198	7–8 Jun	153 (123)	66	44 (29)	17 (11)	30
2005	186	5–7 Jun	119 (89)	46	39 (18)	28 (13)	30
2006	216	4–5 Jun	133 (119)	56	29 (16)	41 (23)	14
2007	196	13 Apr	153 (n/a)	73	41 (30)	16 (12)	35, 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)	64, 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)	56, 45
2010	187	15–16 Apr	187 (n/a)	88	25 (22)	35 (31)	52, 32
2011	190	14–15 Apr	186 (n/a)	84	31 (26)	39 (33)	55, 29
2012	191	18–22 Apr	175 (n/a)	74	42 (31)	32 (24)	61, 40

Location[d]/ Year	Precalving population estimate[b] Muskoxen observed	June and April composition[c] 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[g]	0						
2008[g]	37						
2009–2012[g]	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] Precalving estimates were determined in late March or April based on total muskoxen observed during systematic transect surveys or radiotracking flights.
[c] Composition classification was conducted during the second week of June through early July during 1990–2008 and during mid-April 2007–2011.
[d] Unit 26B surveys occurred east of the Sagavanirktok River until 1996 when the entire subunit from Colville to Canning Rivers was surveyed. Unit 26C surveys encompassed the Canning to Clarence Rivers.
[e] During 1990–2008, the number of calves includes calves observed on the ground during the composition survey. During 2007–2012, 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 in October.
[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] During 2007–2011, 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, regulatory years 1996–1997 through 2005–2006.

Regulatory year	Hunt/ Area[a]	Unit	Permits available[b]	Returned reports	Total hunters	Successful hunters[c]	Bulls	Cows	Total harvest
1996–1997	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	15	12	3[d]	15
1997–1998	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[d]	10
1998–1999	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
1999–2000	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
2000–2001	TX108	26B (West)	10[e]	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
2001–2002	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
2002–2003	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
2003–2004	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
2004–2005	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
2005–2006	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] 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.

[b] 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.

[c] Determined from returned reports.

[d] Illegal animal.; [e] Only 9 permits were supposed to be issued, but 10 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, regulatory years 1998–1999 through 2004–2005.

Hunt[a]/ Regulatory year	Successful			Unsuccessful			Total hunters
	Local[b] resident	Nonlocal resident	Total (%)	Local[b] resident	Nonlocal resident	Total (%)	
RX110							
1998–1999	2	1	3 (60)	1	1	2 (40)	5
1999–2000	0	0	0 (0)	0	0	0 (0)	0
2000–2001	4	2	6 (100)	0	0	0 (0)	6
2001–2002	4	0	4 (100)	0	0	0 (0)	4
2002–2003	1	0	1 (100)	0	0	0 (0)	1
2003–2004	0	0	0 (0)	0	0	0 (0)	0
2004–2005	0	1	1 (33)	0	2	2 (67)	3
DX112							
1998–1999	0	3	3 (100)	0	0	0 (0)	3
1999–2000	0	2	2 (100)	0	0	0 (0)	2
2000–2001	0	3	3 (100)	0	0	0 (0)	3
2001–2002	0	2	2 (100)	0	0	0 (0)	2
2002–2003	0	3	3 (100)	0	0	0 (0)	3
2003–2004	0	1	1 (100)	0	0	0 (0)	1
2004–2005	0	3	3 (100)	0	0	0 (0)	3

[a] 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.

[b] Local resident is a resident of Unit 26.

Table 4. Units 26B and 26C muskox hunter residency and success, regulatory years 1990–1991 through 2005–2006.

Regulatory year[a]	Successful				Unsuccessful hunters[c]	Total hunters[d]
	Local resident[b]	Nonlocal resident	Nonresident	Total		
1990–1991	10	0	0	10	0	10
1991–1992	5	0	0	5	0	5
1992–1993	10	0	0	10	1	11
1993–1994	9	0	0	9	0	9
1994–1995	9	0	0	9	2	11
1995–1996	12	0	0	12	0	12
1996–1997	18	0	0	18[e]	1	19
1997–1998	13	0	0	13	1	14
1998–1999	14	4	0	18	5	23
1999–2000	9	2	0	11	4	15
2000–2001	15	5	0	20	1	21
2001–2002	9	2	0	11	0	11
2002–2003	6	3	0	9	1	10
2003–2004	2	1	0	3	3	6
2004–2005	4	4	0	8	2	10
2005–2006	4	0	0	4	3	7

[a] Before regulatory year (RY) 1986 only Alaska residents were allowed to hunt muskoxen. In RY90 through 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.
[b] Local resident is a resident of Unit 26.
[c] Incomplete residency data for "Unsuccessful" hunters because of lack of reporting in Unit 26C.
[d] From hunt reports received.
[e] One illegal muskox.

Table 5. Units 26B and 26C muskox harvest by transport method, regulatory years 1990–1991 through 2005–2006.

Regulatory year	Harvest by transport method							Total
	Highway vehicle	Airplane	Dog team/ski	Snowmachine	Boat	Off road vehicle	Unk	
1990–1991	0	1	1	6	0	0	0	8
1991–1992	0	0	0	5	0	0	0	5
1992–1993	0	0	0	10	0	0	0	10
1993–1994	0	1	0	8	0	0	0	9
1994–1995	0	0	0	9	0	0	0	9
1995–1996	0	2	0	10	0	0	0	12
1996–1997	0	0	0	17	1	0	0	18
1997–1998	0	0	0	12	1	0	0	13
1998–1999	1	0	0	15	2	0	0	18
1999–2000	2	0	0	9	0	0	0	11
2000–2001	2	0	0	16	3	0	0	21
2001–2002	2	0	0	7	2	0	0	11
2002–2003	2	1	0	3	3	0	0	9
2003–2004	1	0	0	1	1	0	0	3
2004–2005	3	0	1	0	3	0	1	8
2005–2006	0	0	0	2	1	1	0	4

Table 6. Survival rates of radiocollared female muskox, 1999–2011.

Period[a]	No. of radiocollared muskoxen[b]	No. of mortalities	Survival rate
1999–2000	13	3	0.77
2000–2001	9	0	1.0
2001–2002	10	3	0.70
2002–2003	9	1	0.89
2003–2004	10	4	0.60
2004–2005	10	0	1.0
2005–2006	13	2	0.85
2006–2007	13	1	0.92
2007–2008	22	6	0.73
2008–2009	26	4	0.85
2009–2010	22	2	0.91
2010–2011	20	5	0.75
2011–2012	21	2	0.90

[a] The period during 1999–2000 through 2005–2006 is defined as 1 June–31 May. The period during 2006–2007 is defined as 1 June–31 March. The period during 2007–2008 through 2011–2012 is defined as 1 April–31 May.

[b] The number of radiocollared muskoxen is the number of active radiocollars on 1 June and the new collars deployed during the first 2 weeks of June for 1999–2006 or 1 April for 2007–2011. Collars deployed after this time were included in the following year's calculations.


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