

PROJECT TITLE: POPULATION DYNAMICS OF MUSKOXEN IN NORTHWEST ALASKA-CAPTURE AND TELEMTRY: PROGRESS REPORT, MARCH 2009 – DECEMBER 2010

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Once occurring throughout the circumpolar Arctic, muskoxen disappeared from Europe and Asia several thousand years ago, persisting only in the higher latitudes of North America (Lent 1999). More recently, muskoxen disappeared from Alaska in the late 1800s, probably as a result of the combined effects of environmental pressures and human exploitation. Efforts to restore muskoxen to Alaska began in the 1930s with transplants of Greenlandic stock to Nunivak Island (Paul 2009); subsequent transplants in the late 1960s-1970s from Nunivak to Nelson Island, the eastern North Slope, Cape Thompson and the western Seward Peninsula resulted in the reestablishment of muskoxen on the Alaskan mainland. As of 2007, there were about 4,500 muskoxen in Alaska, including 2,700 on the Seward Peninsula, and 350 making up the Cape Thompson population (Harper 2009).

Compared to other North American large mammals, the population dynamics of muskoxen and the ecological factors that influence them are poorly understood (Feldhamer et al. 2003). Muskox populations in northwest Alaska provide a unique opportunity to gain understanding of muskox population dynamics because the Seward Peninsula and Cape Thompson populations were reintroduced at the same time but have exhibited different population trends recently. Identifying the differences in vital rates that are responsible for the observed divergence in growth of these 2 populations should shed light on the important factors affecting muskox population dynamics. Also, with climate change effects becoming more apparent, it is more important than ever to determine the status and health of these populations as benchmarks for assessing future climate-related influences on Alaska's muskoxen.

Following a limited pilot effort in March-April 2008, we initiated a research project in March 2009 to compare and contrast vital rates and nutritional status of these 2 muskoxen populations with work centered at Bering Land Bridge National Preserve (Seward Peninsula population) and at Cape Krusenstern National Monument (Cape Thompson population). The overall goal of the research during 2009 - 2013 is to compare and contrast population trends, vital rates (calf production, calf recruitment,

adult female survival, sex/age structure), nutritional status (female body mass, growth patterns), and health (disease and parasite prevalence, stress levels) between muskoxen of the northern Seward Peninsula and Cape Thompson populations. Given that density-dependent resource limitation has been suggested as an explanation for the reduced growth of the Cape Thompson muskox population (Dau 2005), our studies include particular emphasis on the growth and reproductive performance of young females (< 4 years old), the cohorts most likely to exhibit differences in growth and sexual maturity if nutritional status differs between our 2 study populations (Adams and Dale 1998, Clutton-Brock et al. 1982). Specific project objectives for each study population include:

1. Determine population size and composition each year in late winter and evaluate population trends;
2. Assess relationships between age, body mass, and reproductive performance of females;
3. Estimate calf production, calf recruitment and adult female survival and assess annual variation in these vital rates;
4. Determine sex/age-related patterns of growth;
5. Assess disease exposure, parasite loads, and stress levels;
6. Document movement patterns and seasonal distribution; and
7. Evaluate climatic and habitat characteristics for each study area.

To meet these objectives, our muskox research program consists of 3 distinct components. This report covers progress during 2009-2010 stemming from the capture and handling of female muskoxen and the radiolocation of collared individuals. The second component, directed by Joel Berger, encompasses digital photogrammetry to assess growth patterns in subadult muskoxen and analyses of fecal hormones to assess population pregnancy rates and chronic stress levels. The final component includes the muskox population monitoring (population estimates and age-sex composition surveys) conducted by Brad Shults and Jim Lawler, in collaboration with the Alaska Department of Fish and Game.

STUDY AREAS

On the northern Seward Peninsula, our efforts are focused in and adjacent to Bering Land Bridge National Preserve south and east of Shishmaref, bounded on the south by and including the Arctic, Serpentine, and Goodhope River drainages (SP study area; Fig. 1). For the Cape Thompson muskox population, our study area includes lands in and adjacent to Cape Krusenstern National Monument ranging from the Kivalina River drainage on the north to the lower Noatak and Igichuk Hills on the southeast (CT study area; Fig. 1).

METHODS

Capture and radiocollaring

Muskoxen are captured by helicopter darting and radiocollared to monitor their survival and movements, and to aid in locating muskoxen for composition surveys, population counts, and ground-based fieldwork. Examination of captured animals and obtaining blood and fecal samples provides information on growth and body size, age-

specific productivity, and disease/parasite profiles allowing for comparisons between the study populations. Our goal is to capture muskoxen each March 2009-2012 to maintain a sample of 30 radiocollared adult females (≥ 46 months old) in each study area, with 20 individuals instrumented with conventional VHF radiocollars and 10 individuals fitted with GPS/ARGOS collars. In addition, we plan to capture an additional 15 subadult females (22 and 34 months of age) annually in each study area that are weighed and blood-sampled to evaluate age-specific productivity, and then fitted with only eartags.

Muskoxen are immobilized with a combination of carfentanil citrate and xylazine hydrochloride delivered via a 3-ml projectile syringe fitted with a 2.9 cm barbed tip and fired from a dart rifle with brown (or "Very Low") charges. Adult muskoxen ≥ 34 months old receive a dose of 4.8-5.4 mg carfentanil and 20-25 mg xylazine/dart; 22-month-olds are darted with 3.0-3.6 mg carfentanil and 15 mg xylazine/dart.

Once a darted muskox is immobilized, capture personnel position the muskox on its sternum, assess its state of immobilization and physical well-being, take its rectal temperature, and apply a blindfold. For the occasional individual that is not adequately immobilized, 10-20mg xylazine hydrochloride is administered intranasally (Cattet et al. 2004) resulting in adequate anesthesia within 2-3 minutes. During 2010 captures, we began injecting each individual with azaperone tartrate (35 mg for adults, 20 mg for 22-month-olds) about half way through the handling to smooth recovery from the immobilizing drugs and to provide calming, light sedation for a couple of hours following capture and handling.

Adult muskoxen captured for the radiocollared samples in each study area are fitted with standard VHF radiocollars or GPS/ARGOS collars. All GPS/ARGOS collars and those VHF radiocollars deployed in 2010 included automatic release mechanisms. We plan to recapture Individuals instrumented in 2009 during 2011-2012 captures to fit them with self-releasing collars so that muskoxen will lose their radiocollars at the end of the study (1 June 2013). All radiocollars include a mortality-sensing VHF transmitter and 15 cm x 23 cm individually-numbered marking flag to distinguish collared animals. Young females that are captured for assessing growth and age-specific productivity, but not radiocollared (22 and 34 months-of-age; 15 per study area) are fitted with 3.8 cm x 5.7 cm livestock eartags.

Females ≤ 46 months-of-age are aged based on tooth eruption and horn development (Henrichsen and Grue 1980). Each muskox is weighed to the nearest 0.45 kg (1 lb) by placing them in a cargo net and suspending them under a digital scale via a come-a-long and tripod. Fat reserves are assessed by measuring rump fat depth of each individual via ultrasonography (Stephenson et al. 1998). A standardized suite of body measurements (head width and length, horn length, hindfoot length) are taken.

A 30 ml blood sample is drawn from each individual for pregnancy determination via pregnancy-specific protein B analyses (PSPB; Huang et al. 2000), disease screening, and trace mineral analyses. A fecal sample is obtained from the rectum for parasite analyses and to corroborate fecal progestagen assays to estimate population pregnancy rates. Parasite assessments include Baermann and fecal flotation analyses to assess levels of protostrongylid larvae and parasite eggs being shed by sampled muskoxen.

Once processing is complete, carfentanil effects are antagonized with an IM injection of naltrexone hydrochloride at 100 mg/mg carfentanil administered; tolazoline hydrochloride is administered IM to antagonize the xylazine effects at a dose of approximately 2 mg/kg (400 mg for adults; 300 mg for 22-month-olds). After delivery of antagonists, recovery of the individual is monitored and some attempt is made to bring the muskox and her original group within sight and a reasonable distance of each other if necessary. All radiocollared muskoxen are relocated repeatedly over the few days following capture to determine that they survived and rejoined other muskoxen.

Survival and seasonal distribution

Radiocollared female muskoxen are relocated by aerial radiotracking from fixed-wing aircraft to monitor survival on about a monthly schedule throughout the year. Muskoxen fitted with satellite-linked GPS collars provide ≤ 6 locations/day to assess fine-scaled movements. All mortalities are investigated by fixed-wing aircraft, snowmachine, or helicopter as soon as practical. Survival rates are calculated using Kaplan-Meier staggered-entry methodology (Pollock et al. 1989).

Calf production/survival

To assess natality rates for each study population, we combined results of late-winter composition surveys in 2009 and 2010 (proportions of all females ≥ 22 months-old that were in the following age-classes: 22 months-old, 34 months-old, and ≥ 46 months-old), and the age-specific productivity estimates from PSPB analyses to approximate the number of calves produced/mature female (≥ 2 years old). In mid-June, we estimated the proportion of mature females with surviving calves by first determining calf:older ratios via aerial digital photography and then combining that with late-winter composition survey results (proportion of the population, or “older” muskoxen, composed of females ≥ 22 months-old) to arrive at an estimate of calves/mature female. Dividing the resulting ratio by the calf production ratio provides an approximation of calf survival from birth to mid-June.

To determine the mid-June ratios of calves to older muskoxen, we aerially locate groups with radiocollared muskoxen and take a series of high-resolution digital photographs of the group as the aircraft circles and slowly descends from an altitude of ≈ 600 m AGL down to ≈ 100 -150 m AGL. Groups without radios that were observed in the process of finding marked groups were similarly classified. Following the flights, photographs are reviewed and calves and older animals counted in each group.

PRELIMINARY RESULTS

Captures

To date, we have captured 102 muskoxen including 38 in 2009 and 64 in 2010. In March 2009, we radiocollared 35 adult females (20 on SP study area, 15 on CT study area; Fig. 2) and experienced 1 capture mortality. The individual that died (09009) was captured without incident on 21 March 2009 and was observed alive on 23 March, but was dead by 28 March; investigation of her carcass did not reveal any evidence of an alternate cause of death. Two adults captured in the first 2 days were released without collars in 2009. The first muskox captured (09001) was smaller than

expected and we were unable to get a collar on her in a timely manner, due in part to the position of the marking flag and lack of the correct adjustment range prepunched in the collar. Rather than keeping her immobilized longer, we chose to release her without a collar after nearly an hour of immobilization. That evening, we modified the radiocollars as needed to alleviate this problem. The next day, we fired a dart at a muskox in a group (09003) but were unsure if we hit her. After watching the group for over 20 minutes with no sign of drug effects in any individual, we darted another muskox (09002). As we began handling 09002, we noticed a muskox laying down in the group a couple hundred yards away. By the time we finished with 09002, it had been about an hour since 09003 was initially darted; therefore we provided the antagonists and let her go uncollared. Following that capture we shifted to placing each dart in the back of the muskox where it was obvious, rather than low on the rump where it becomes lost in the long hair. We also captured a 22-month-old female (09012) with our original plan to radiocollar females in this age class. However, upon examining her and realizing how much she was likely to grow in the ensuing year, we opted not to fit her with a radiocollar and let her go with only an eartag. At that point, we revamped our study plan to not instrument any individuals < 34 month old. Poor weather and mechanical problems with the helicopter precluded reaching our sample size goals for radiocollared adults or handling subadult females.

In March 2010, of the 64 muskoxen we immobilized, 33 (15 SP study area, 18 CT study area) were adults that were fitted with radiocollars to reach a sample size of 30 individuals in each study area (Fig. 2). We experienced no capture mortalities. We also captured 30 22- and 34-month-old females, equally split between the 2 study areas.

Of the 102 muskoxen we have immobilized to date, 87 were darted once, 14 were darted twice, and 1 was darted 3 times. Of the 15 that were darted more than once, 12 showed no effect within 15 minutes of being darted, 2 showed some ataxia, and 1 was down but got up and ran off as the helicopter approached for handling. Of the 12 muskoxen that showed no effect, we recovered 5 initial darts for which the internal charge had not fired and 3 that were entangled in hair, but had not injected into the animal.

In 2009, we immobilized all adult females with 5.4 mg carfentanil/20 mg xylazine per dart. We started with that dose in 2010 but as captures progressed, we reduced the carfentanil to 4.8 mg and increased the xylazine to 25 mg because the sedation of individuals was deeper than necessary. Induction times for adults that were darted once did not differ significantly for the 2 dosages ($t = 1.39$, 66 *df*, $P = 0.169$), averaging 5.2 minutes overall ($n = 66$, range 1.3 – 13.9 min), but depth of anesthesia improved and all individuals were easily handled under the lower carfentanil dose. In 2010, most of 34 month-olds that were eartagged were captured with the 4.8 mg carfentanil/25 mg xylazine dose (15 of 16) and 22-month-olds were initially captured with 3.3 mg carfentanil/15 mg xylazine ($n = 3$) then the carfentanil was reduced to 3.0 mg for the remaining captures ($n = 11$).

Body mass and other physical characteristics

In March 2009-10, we weighed 93 female muskoxen including 14 22-month-olds, 18 34-month-olds, and 61 older females (Table 1). Body masses of 22- and 34-month-olds in 2010 did not differ between our 2 study areas. Masses of older females varied significantly by year ($F = 6.64$, 1,57 *df*, $P = 0.013$), study area ($F = 14.08$, 1,57 *df*, $P < 0.001$), and year-study area interaction ($F = 7.87$, 1,57 *df*, $P = 0.007$) due to higher body masses of individuals captured on the SP study area in 2009 (Table 1). The high average body mass on the SP study area in 2009 was due to 7 females, of 15 total, that exceeded 238 kg (238.6 – 258.2).

We have measured the rumpfat depth for 90 females (Table 2). Rumpfat depths generally increased across the 3 age-classes with 22-month-olds carrying limited rumpfat. Rumpfat depths did not differ between study areas for 22-month-olds and 34-month-olds, although sample sizes are small. For older females, measured fat stores were similar between years ($F = 0.85$, 1,61 *df*, $P = 0.361$) but SP females carried significantly more rumpfat on average than CT females ($F = 18.75$, 1,61 *df*, $P < 0.001$; Table 2).

During handling of adult females we noted a surprising pattern in that muskoxen from the CT study area commonly had broken incisors, whereas broken teeth were very rare in SP females (Fig. 4). Of the 35 CT females ≥ 46 months-of-age we have handled, only 8 (23%) had all 6 incisors intact; the remainder had 1 to 5 damaged incisors (Table 3). In comparison, 32 of 33 SP females had no breakage; the remaining individual had a single broken incisor. Many CT muskoxen spend much of the winter on windblown ridges in the Igachuk Hills and Tahinichok Mountains that are predominantly covered with coarse gravel intermixed with the limited available forage, whereas winter habitats for the SP muskoxen are predominantly within the low-elevation coastal plain characterized by abundant vegetative cover (Fig. 5). We examined cheek teeth rows from 3 collared CT muskox that died and even though they had broken incisors (2, 3, and 3), we noted no breakage or unusual wear of their molars or premolars. We suspect that CT muskox break their incisors as a result of foraging on the gravel-dominated ridges they inhabit in winter. Alternatively, CT muskox may have some micronutrient imbalance that is resulting in brittle teeth and we will investigate this hypothesis further.

Age-specific pregnancy rates

During captures in March 2009 and 2010, we obtained blood samples from 91 female muskoxen (13 22-month-olds, 18 34-month-olds, and 60 ≥ 46 months-old). Within age-classes, pregnancy rates did not vary between our 2 study areas (Fisher Exact Tests; $P > 0.649$). Combined across study areas, age-specific pregnancy rates varied from 23% for 22-month-olds to 92% for females ≥ 46 months-old (Table 4). Pregnancy was strongly correlated with body mass ($G^2 = 26.6$, 1 *df*, $P < 0.001$; Fig. 3); no individuals that weighed < 145 kg were pregnant (including 11 22-month-olds and 1 34-month-olds), while above that threshold 90% (66 of 73) of female muskox we tested were pregnant.

Survival/mortality

We have radiocollared and monitored 35 and 33 female muskoxen ≥ 34 months-old on the SP and CT study areas, respectively. Of those, we experienced 1 capture mortality as described above, and 1 muskox lost her radiocollar within 2 months of capture, both from the CT study area. We have tallied 21 mortalities to date (12 and 9 for the SP and CT study areas, respectively; Fig. 6). Although the actual cause of death has often been difficult or impossible to determine, 12 muskoxen were killed or scavenged by grizzly bears, 3 were apparently killed by wolves, 1 died of an undetermined cause other than predation, and causes of death were not determined for the remaining 5 mortalities. Deaths have occurred predominantly in mid- to late-summer in the SP study area and May and mid-winter in the CT study area (Fig. 6). As of December 2010, we were monitoring 45 instrumented muskoxen, including 23 and 22 from the SP and CT populations, respectively. We estimated annual survival rates of 76.0% (95% CI = 64.2 – 87.8%) and 79.6% (95% CI = 67.6 – 91.5%) for the SP and CT study areas, respectively, based on the mortality results from our radiocollared muskoxen (Fig. 7). These survivorship patterns did not differ significantly (Log Rank Test; $\chi^2_{DCS} = 0.132$, 1df, $P = 0.716$).

Movements

From late March 2009 to early December 2010, we acquired over 1,000 aerial radiolocations of the 67 muskoxen successfully radiocollared in our study. We completed radiotracking bouts on average every 24 days ($n = 27$ bouts, range 5 -38 days) and 27 days ($n = 24$ bouts, range 8 – 55 days) on our CT and SP study areas, respectively. Locations acquired per muskox for those that survived to December 2010 have averaged 25.3 locations (range 16 – 30) and 10.5 locations (range 5 – 13) for 2009 and 2010 captures, respectively.

The extent of movements observed has varied widely among individual muskoxen. While many collared muskoxen have remained within limited home ranges, others have exhibited extensive movements. We arbitrarily chose to plot movements of individuals with the longest distance between any 2 radiolocations > 50 km; 19 individuals met this criterion (Fig. 8). Three additional SP muskoxen have been missing since mid-June 2010 and we suspect moved long distances from our study area. If that proves to be the case, then 6 SP and 2 CT muskoxen have dispersed substantial distances from the respective study areas. An additional individual (09011) made a long-distance movement from the upper Kivalina River, where she was collared in March 2009, to the vicinity of Chariot and Cape Thompson during late September 2009 (Fig. 8). She stayed there through mid-April 2010, then returned to the upper Kivalina by mid-May 2010 where she has resided since.

Of the 67 muskoxen we collared, 22 were fitted with GPS/ARGOS collars and by mid-November 2010, we accumulated over 46,000 locations for these muskoxen, averaging 4.7 locations/collar/day. Although few analyses of this data have been conducted to date, we plotted the movements of 2 females from each study area to illustrate limited home ranges and extensive movements (Fig. 9). For the CT population, 10044 was initially captured on 20 March 2010 in the southern Tahinichok Mountains (Fig. 9). She left that area on 6 May 2010 and travelled 75 km south to the

Igichuk Hills near Mount Noak and remained in that area until 28 May 2010. At that time, she headed north traveling 124 km in 3 days to Kikmiksot Mountain. From 31 May to 10 November 2010, when she died, she inhabited the Kikmiksot Mountain - Sivukat Mountain area. In comparison, 10039 was captured near the Agashashok River mouth on 19 March 2010 and has inhabited the lower 35 km of the river drainage since (Fig. 9). On the SP study area, 09022 was initially collared on 23 March 2009 about 30 km east of Shishmaref between the upper Cowpack River and the Serpentine River. She began moving in a southeasterly direction in early July 2009 and continued moving throughout the summer ending up south of Deering, where she was killed by a bear on 31 August 2009, a straightline distance of 190 km (Fig. 9). Muskox 09032, on the other hand, was captured on 25 March 2009 near Cape Espenberg and remained within about 20 km of there through to end of the available data in mid-November 2010.

Calf production/survival

Estimated calf production for the 2 study populations in 2009 and 2010 were similar, ranging from 0.71 to 0.83 calves produced/mature female (Table 5). Given that these estimates were based on the overall age-specific productivity estimates, the low rate in 2010 for the CT population resulted strictly from the lower proportion of females ≥ 46 months-old observed during composition counts that winter.

Calves were noticeably more prevalent in the SP population by mid-June compared to CT population, in spite of a lower proportion of mature females in the SP population overall (Table 5). Therefore, estimated calf survival to mid-June was markedly higher for SP muskoxen (Table 5).

PLANNED RESEARCH ACTIVITIES

The capture and radiotelemetry component of the muskox research program as described above is slated to continue to 1 June 2013. During the remainder of the research we plan to:

1. Conduct capture operations in March 2011 and 2012 in each study area to radiocollar adult female muskox as needed to maintain 30 instrumented individuals and to capture and process 15 subadult females;
2. Radiotrack all instrumented muskox every 3-4 weeks throughout the year;
3. Determine the ratios of calves to older muskox in each study area in mid-June 2011 and 2012.

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Table 1. Body masses (kg) of female muskoxen weighed in northwest Alaska during March 2009-10. CT = Cape Thompson study area; SP = Seward Peninsula study area.

Age class	Area/yr	<i>n</i>	mean	range	<i>t</i> -test
22 months	CT-2010	8*	133.8	114.1 – 152.7	
	SP-2010	6	132.6	109.5 – 151.8	$t = 0.18, 12df, P = 0.864$
34 months	CT-2010	7	164.0	146.4 – 189.1	
	SP-2010	11	169.8	119.5 – 218.6	$t = 0.58, 16df, P = 0.572$
Older	CT-2009	9	202.1	170.9 – 224.1	
	CT-2010	19	203.1	177.3 – 238.6	$t = 0.16, 26df, P = 0.872$
	SP-2009	18	232.2	194.5 – 258.2	
	SP-2010	15	207.5	170.9 – 232.7	$t = 3.87, 31df, P < 0.001$

* One individual captured and weighed in 2009.

Table 2. Rump fat depths (mm) of female muskoxen from northwest Alaska during March 2009-10. CT = Cape Thompson study area; SP = Seward Peninsula study area.

Age class	Area/yr	<i>n</i>	mean	range	<i>t</i> -test
22 months	CT-2010	4	5.5	2 – 14	$t = 0.58, 5df, P = 0.587$
	SP-2010	3	8	3 – 14	
34 months	CT-2010	7	12.7	4 – 20	$t = 0.79, 16df, P = 0.441$
	SP-2010	11	14.9	3 – 28	
Older	CT-09,10	32	15.7	7 – 29	$t = 4.42, 63df, P < 0.001$
	SP-09,10	33	22.6	10 – 41	

Table 3. Incisor breakage in female muskoxen ≥ 46 months-old from northwest Alaska, March 2009-10. CT = Cape Thompson study area; SP = Seward Peninsula study area.

Incisors broken	CT	SP
0	8	32
1	11	1
2	8	0
3	4	0
4	2	0
5	2	0
6	0	0
Total	35	33

Table 4. Pregnancy results (pregnant/total) for female muskox from northwest Alaska during March 2009-10, as determined by pregnancy-specific protein B analyses. CT = Cape Thompson study area; SP = Seward Peninsula study area.

Age class	CT	SP	Combined
22 months	2/7	1/6	23%
34 months	6/7	9/11	83%
Older	24/27	31/33	92%

Table 5. Estimates of calf production and early survival (to mid-June), based on late composition counts and age-specific productivity estimates, for muskoxen from the Cape Thompson (CT) and Northern Seward Peninsula (SP) populations, 2009-10.

	Late-winter composition ^a					Calves/Fem≥22 mo		Estimated
	Fem/age-class (%)				Mid-June	Produced	Survived	calf survival
	≥46 mo	34 mo	22 mo	Fem≥22 mo (% of pop.)	calf/older=ratio		to mid-June	to mid-June
CT								
2009	0.76	0.12	0.12	0.60	23/112=0.21	0.83	0.34	0.42
2010	0.55	0.21	0.17	0.67	50/226=0.22	0.71	0.33	0.47
SP								
2009	0.66	0.20	0.14	0.52	80/272=0.29	0.80	0.57	0.71
2010	0.70	0.17	0.14	0.48	106/361=0.29	0.82	0.61	0.75

^a 2009 classification conducted by Joel Berger during April fieldwork; 2010 classification is based on the average results from counts during April fieldwork by Joel Berger and mid-March composition surveys conducted by NPS and ADF&G.

Fig. 1. Study areas (cross-hatched) for investigations of population dynamics and ecology of muskoxen in northwestern Alaska 2009-2013. The Cape Thompson study area encompasses Cape Krusenstern National Monument and adjacent areas; the Seward Peninsula study area includes much of northeastern Bering Land Bridge National Preserve.

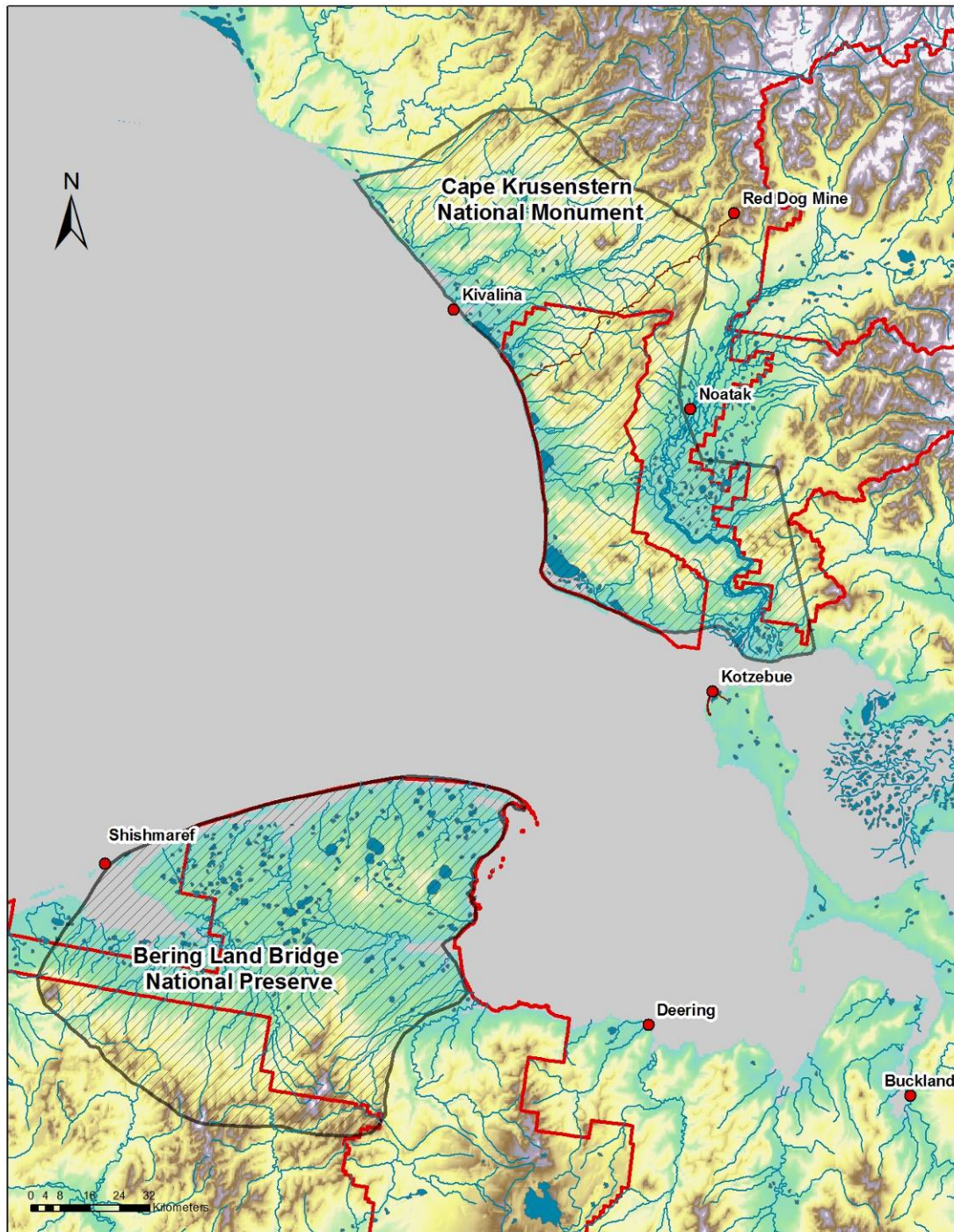


Fig. 2. Capture locations for adult and subadult (22- or 34-month-old) female muskoxen during March 2009 and 2010 on the Cape Thompson and Seward Peninsula study areas, northwest Alaska.

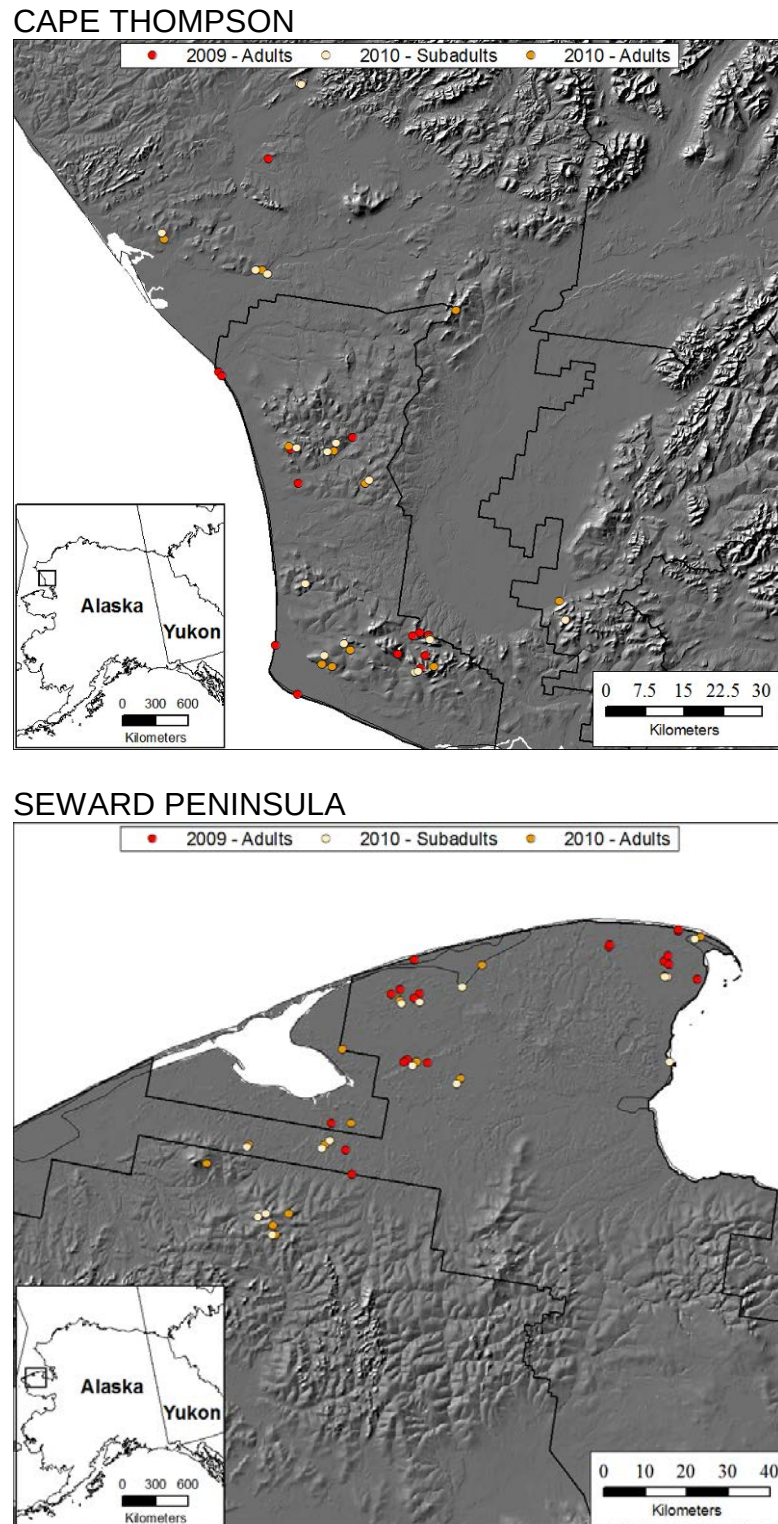


Fig. 3. Probability of pregnancy relative to body mass for female muskoxen ≥ 22 months-old from northwest Alaska based on pregnancy-specific protein B analyses of blood serum collected in March 2009 and 2010.

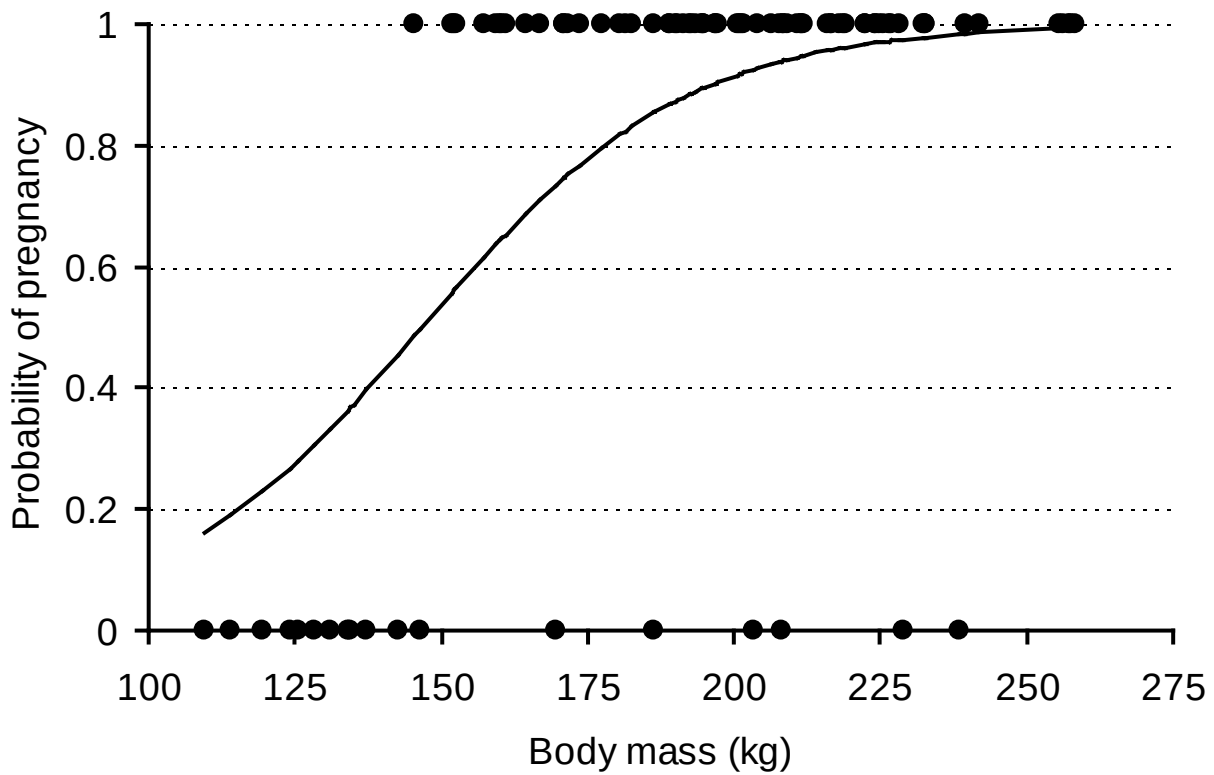


Fig. 4. Examples of muskoxen with broken incisors from the Cape Thompson population, compared to normal dentition in muskox from the northern Seward Peninsula, northwest Alaska. Photographs are of females ≥ 46 months-old captured during March 2009.

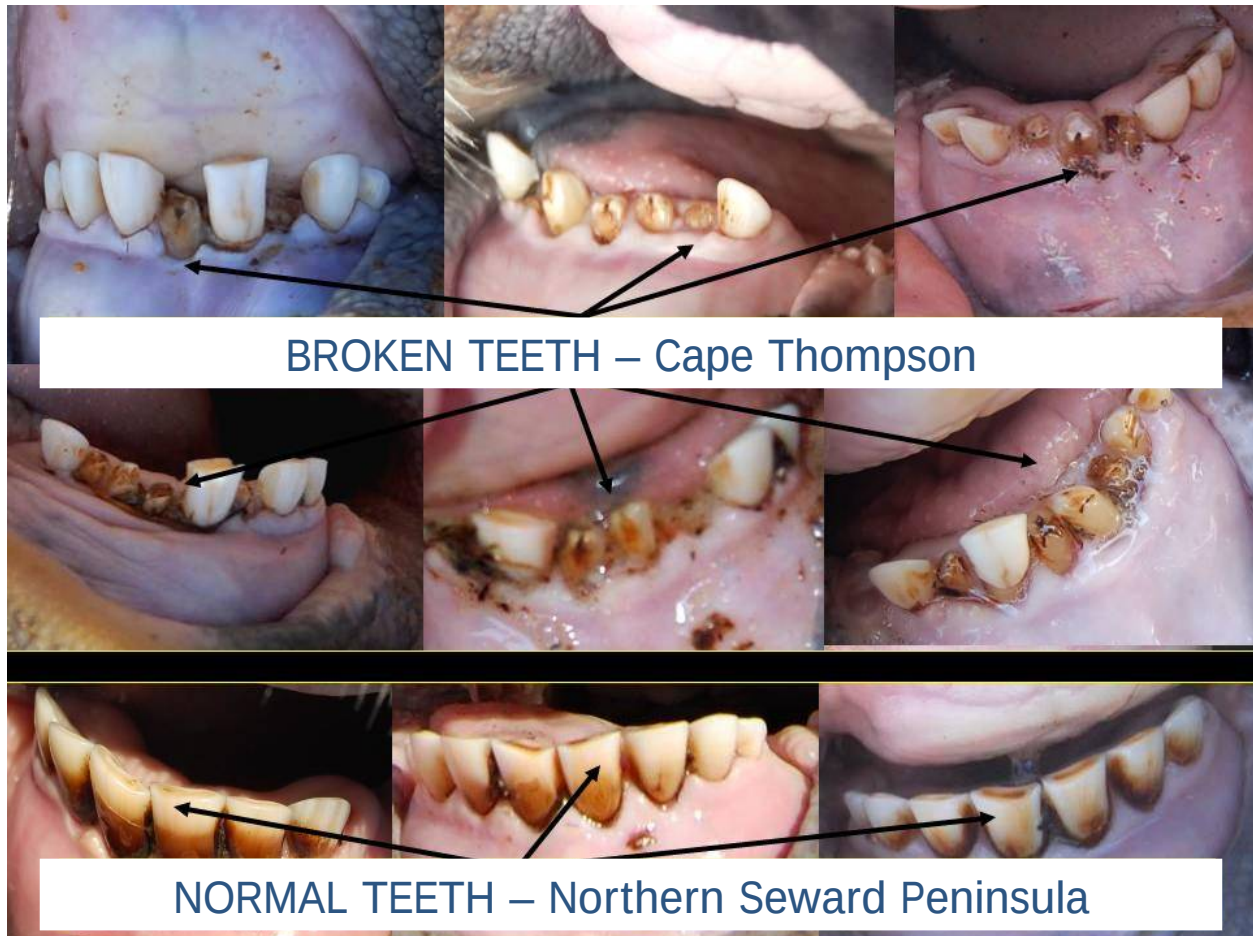


Fig. 5. Examples of characteristic habitats used by muskoxen in winter in the ranges of the Cape Thompson and northern Seward Peninsula populations, northwest Alaska.

Cape Thompson



Seward Peninsula



Fig. 6. Timing of mortalities of radiocollared adult female muskoxen observed in the Seward Peninsula (SP) and Cape Thompson (CT) study areas, northwest Alaska, March 2009 – December 2010.

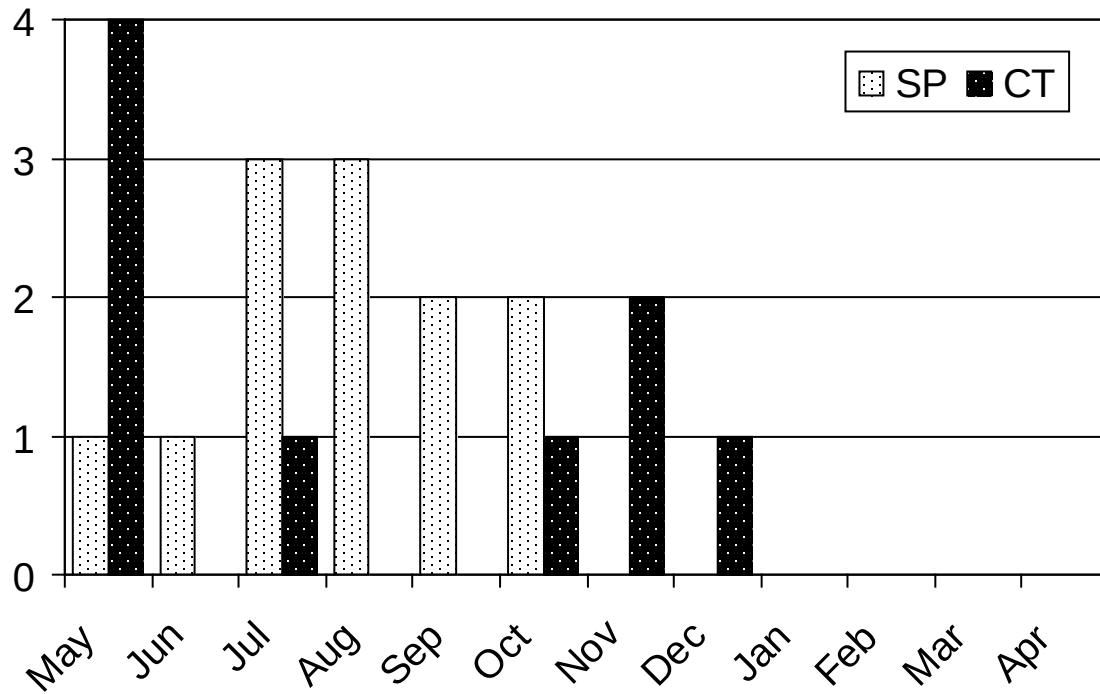


Fig 7. Survivorship (and 95% confidence intervals) for radiocollared adult female muskoxen from the Cape Thompson and Seward Peninsula populations in northwest Alaska, April 2009 – December 2010.

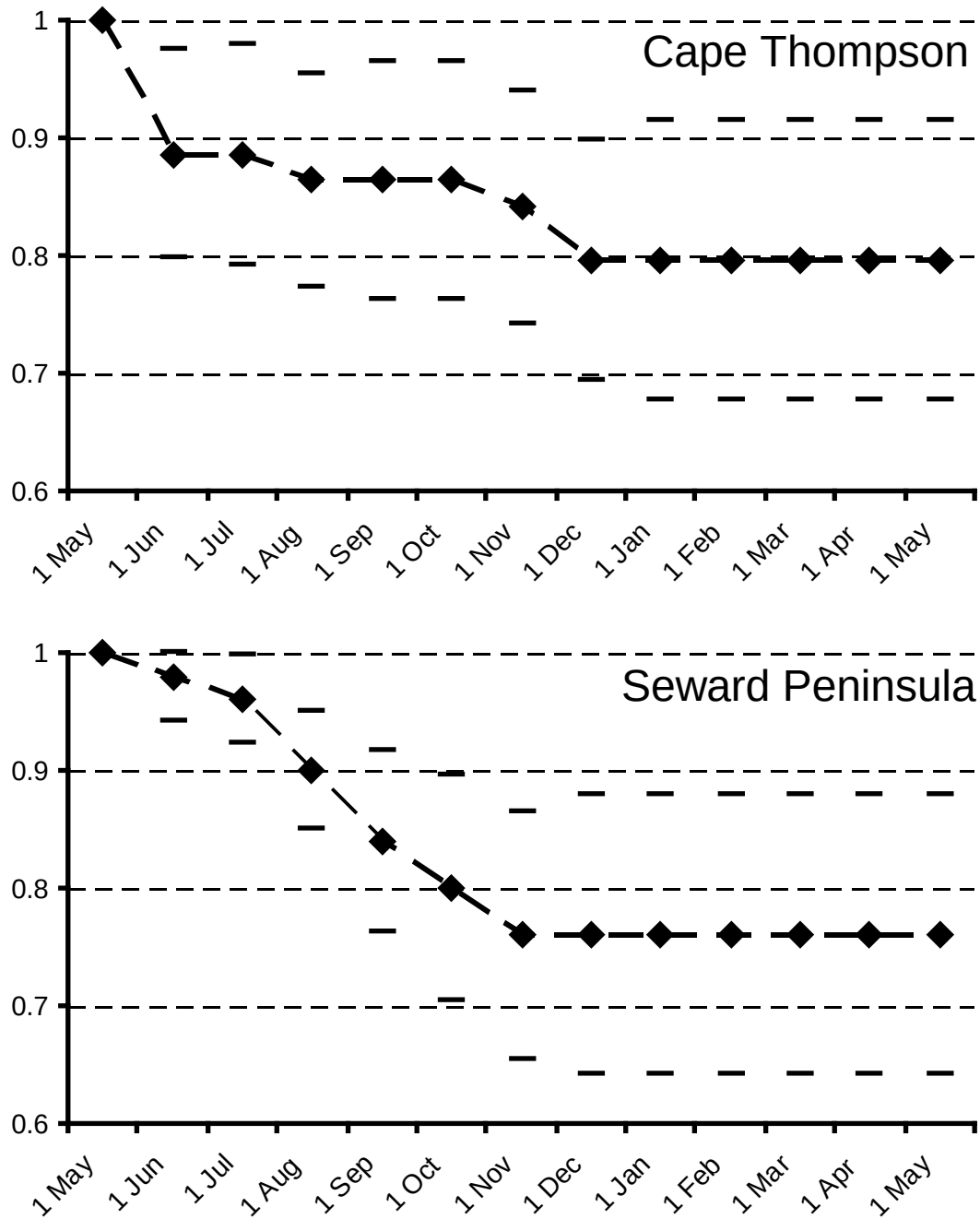
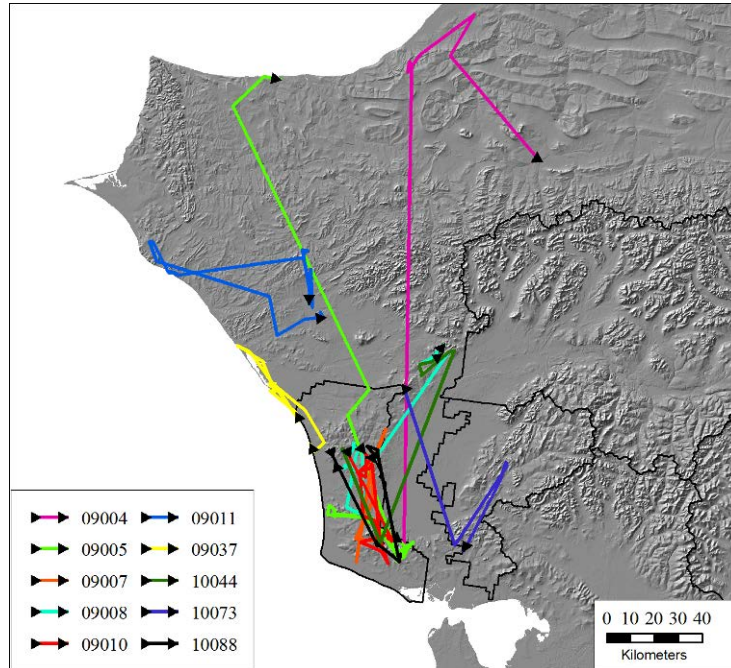


Fig. 8. Movements of radiocollared muskoxen that exhibited extensive movements (longest distance between any 2 radiolocations > 50 km) during late March 2009 – December 2010 (muskox with 09xxx IDs) or late March 2010 – December 2010 (muskox with 10xxx IDs), from the Cape Thompson and Seward Peninsula study areas in northwest Alaska.

CAPE THOMPSON



SEWARD PENINSULA

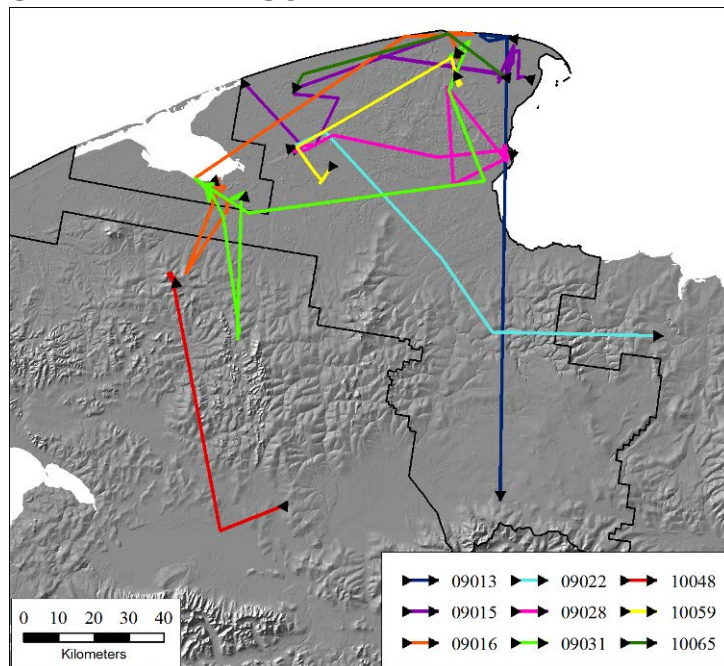
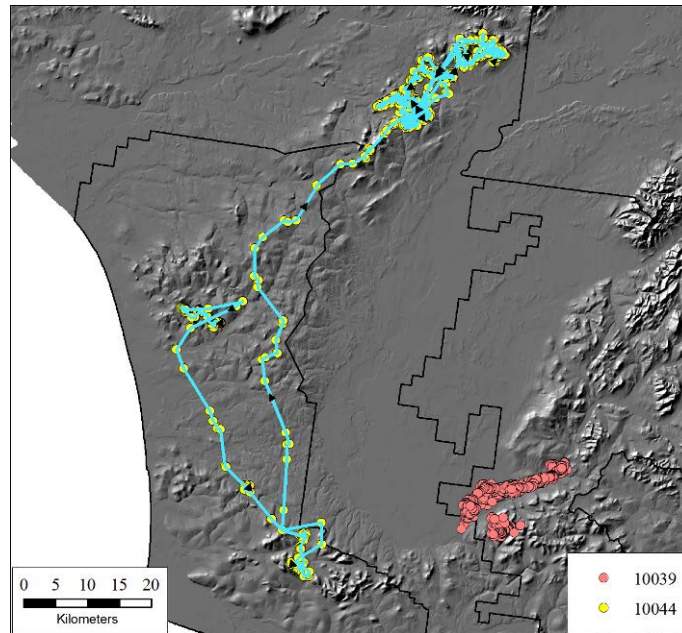


Fig. 9. Movements of adult female muskoxen fitted with GPS/ARGOS radiocollars on the Cape Thompson and Seward Peninsula study areas in northwest Alaska. To illustrate the range of movements noted, we plotted 1 individual with extensive movements and 1 with restricted movements for each study area. Locations depicted were acquired as follows: 10039: 19 March 2010 – 20 November 2010; 10044: 20 March 2010 – 10 November 2010; 09022: 15 April 2009 – 31 August 2009; and 09032: 12 April 2009 – 20 November 2010.

CAPE THOMPSON



SEWARD PENINSULA

