Population identity and movements of moose in the Togiak, Kulukak, and Goodnews River drainages, southwest Alaska

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SUMMARY

Thirty-six moose *(Alces alces)* were radiotracked from 30 March, 1998 to 14 April, 2000, primarily within Game Management Subunit (Unit) 17A. Aerial radio tracking was conducted monthly for all moose and weekly for cows during the calving period. Calf production and recruitment in 1999 was 138.9 and 66.7 per 100 cows, respectively. Twinning rate was 92.3%. The annual mortality rate of radiocollared moose with known fates was 22.6%. Composition data collected during October and early December, 1999, radio tracking flights suggest 83.0 bulls and 39.6 calves per 100 cows. Population surveys conducted 13-16 March, 2000, indicated a minimum of 422 moose in Unit 17A. Annual home range sizes for cows and bulls averaged 277.4 km^2 (107.1 mi^2) and 263.0 km^2 (101.6 mi^2), respectively. Sixty percent of cows and 77.8% of bulls are resident, with the remainder being migratory. Work on the development of a cooperative management plan for Unit 17A moose continued.

BACKGROUND

Moose are relative newcomers to southwest Alaska and in Unit 17A. Aerial surveys conducted in the 1980's and early 1990's often revealed less than 10 moose. Subsequent surveys revealed an increase from 84 moose in 1994 to 511 moose in 1999. The dramatic increase in numbers is attributed to: 1) continued immigration from neighboring Unit 17C; 2) regulation changes implemented by the Alaska Board of Game; 3) an apparent reduction of illegal harvests as a result of poor travel conditions and changing attitudes of local residents; 4) availability of the expanding Mulchatna Caribou Herd in Units 17 and 18 for subsistence; and, 5) good productivity and survival of Unit 17A moose due to mild winters, few predators, and pristine habitat. Along with the increasing moose population has come several regulatory requests to open/liberalize hunting seasons. Hunters reported taking 15, 10 and 10 moose during State registration permit hunts in 1997, 1998 and 1999, respectively. Because little was known regarding movements, immigration and population parameters of moose in Unit 17A, a 5 year study (see Aderman et al 1998) was initiated in 1998 to address these and other factors. Aderman et al (1998, 1999) provides summaries of the initial capture and radiocollaring of 36 moose and subsequent first year of radiotracking data and habitat assessment. The development of a cooperative management plan for Unit 17A moose (Appendix A) is a high priority to insure their continued success while providing an acceptable level of harvest.

STUDY AREA

The primary study area is on Togiak National Wildlife Refuge (TNWR), in northern Bristol Bay (Unit 17A), and includes the drainages between Cape Newenham and Cape Constantine (Figure 1). Adjacent areas, western Unit 17C and southern Unit 18, also are in the study area. The Wood River and Ahklun mountains begin at the southern boundary (coastline) and rise to over 1,500 m in the northern portion of the study area. Numerous rivers and creeks, bordered by

willows *(Salix sp.)* and cottonwoods *(Populus balsamifera)*, begin in alpine tundra and alder *(Alnus sp.)* covered slopes and drain though wet and dry tundra uplands. Most of the study area is Designated Wilderness. Petersen et al (1991) and USDI (1986) provide further detail of the study area.

METHODS

Radiotracking

We followed methodology described in Aderman et al (1999).

Population Estimate

We followed methodology described in Aderman et al (1999), however, we did not survey most of the Sample Units (SUs) in which moose had been absent during each of the 4 previous late winter surveys. Age composition (calf or adult) of moose was recorded.

Distribution, Home Range and Movements

Annual and seasonal home ranges of individual collared moose were calculated using the 100% minimum convex polygon (MCP) technique (Mohr 1947). Two females with <12 locations were excluded from analysis. The Animal Movement Analysis extension for ArcView was used to estimate home range size and distances moved between relocations (Hooge and Eichenlaub 1997). For seasonal home range analysis, winter was defined as November - April and summer as May - October, which corresponded to shrub phenology, i.e., leaf abscission - dormancy and leaf - flower bud break - maturation, respectively. For migratory status, we define migratory moose as having distinct summer and winter home ranges (<50% overlap), and nonmigratory moose as having >50% overlap of summer and winter ranges (MacCracken et al. 1997). For seasonal movement analysis, winter was defined as November - April, spring (calving) as May - June, summer as July - August and fall (rut) as September - October.

RESULTS AND DISCUSSION

Radiotracking

Thirty-six radiocollared moose were located 785 times during 58 flights from 30 March, 1998 - 14 April, 2000. Moose were observed visually during 85.6% of the locations and were seen more often in winter (95.0%) than summer (77.5%). Locations per animal averaged 22 and ranged from 3 to 30.

Calf Production, Chronology and Survival

Calf production averaged 109.3 per 100 cows during 1998 - 1999 and twinning rate averaged 51.6% (Table 1). In 1998, 18 of 25 radiocollared cows produced 22 calves. Fourteen cows, of which 2 were 2 years old, had single calves. Four cows had twin calves for a twinning rate of

22.2% (4 of 18). Minimum moose calf production in Unit 17A for 1998 was estimated at 88.0 calves per 100 cows. It is likely some cows had calves that perished and/or were not observed on subsequent flights. In 1999, 13 of 18 radiocollared cows produced 25 calves. We observed a twinning rate of 92.3% (12 of 13). Minimum moose calf production in Unit 17A for 1999 was estimated at 138.9 calves per 100 cows (Table 1).

Calving generally begins in mid-May and is nearly complete by early June. On average, 25.5% of calves were born by 20 May and 87.2% by 3 June. In 1998, radio-collared cows gave birth to 6 (27.3%) calves by 19 May and 18 (81.8%) calves by 3 June. Four (18.2%) calves were born on or after 3 June, 1998. In 1999, radio-collared cows gave birth to 6 (24.0%) calves by 20 May and 23 (92.0%) calves by 26 May. Two (8.0%) calves were born on or after 3 June, 1999.

Calf survival to fall averaged 51.1% during 1998 - 1999 (Table 1). Calf survival through late November 1998 and through late October 1999 was 54.5% (12 of 22) and 48.0% (12 of 25), respectively. Because some calves may not have survived before being observed, actual calf survival may be lower. Sources of calf mortality were not determined, but likely include predation, inclement weather, and accidents. Average (1998 - 1999) fall calf recruitment was 55.8 calves per 100 cows (Table 1). Calf recruitment rates were 48.0 (November 1998) and 66.7 (October 1999) calves per 100 cows.

Sex and Age Composition

Little inference can be made from our fall composition data collected thus far. Aerial surveys to determine moose sex and age composition are usually completed by late November when adequate snow cover is present and before bulls begin to lose their antlers. These conditions have not existed since November 1994, however, some composition data was collected during October and November, 1998, radio-tracking flights. During those flights, 234 moose were observed in Unit 17A and were classified as follows: 105 (44.9%) bulls; 98 (41.9%) cows; and 31 (13.2%) calves. These numbers suggest 107.1 bulls and 31.6 calves per 100 cows.

During October and early December, 1999, radio-tracking flights, 118 moose were observed in Unit 17A and were classified as follows: 44 (37.3%) bulls; 53 (44.9%) cows; and 21 (17.8%) calves. These numbers suggest 83.0 bulls and 39.6 calves per 100 cows.

Because bulls have antlers and form into groups after the rut, they are more easily detected than cows or cows with calves. Thus, there is probably a lower percentage of bulls and a higher percentage of cows and calves than was observed, however, radiotracking flights were biased towards cows (and calves associated with radiocollared cows).

Elsewhere in Alaska, fall composition counts reveal highly variable moose sex and age ratios. Bulls and calves per 100 cows ranged from 4 - 189 and 0 - 70, respectively (Stephenson 1998, Whitman 1998), however the numbers of moose classified were less than 90 in each instance.

Age composition data collected during March 1999 and 2000 moose surveys, revealed a minimum of 9.2 and 14.2 percent calves, respectively.

Adult Mortality

Between April 1998 and April 2000, annual adult mortality averaged 17.0%. Of the initial 36 moose (27 cows, 9 bulls) radiocollared, 11 (8 cows, 3 bulls) have perished and the status of 1 cow is unknown. Illegal harvest has accounted for 5 moose (4 cows, 1 bull), predation by brown bears (*Ursus arctos*) for 4 cows and fighting/antlers locked for 2 bulls (Table 2.)

Adult mortality during the first year (30 March, 1998 - 14 April, 1999) for radiocollared moose with known fates was 11.4% (4 of 35). The 4 radiocollared moose that died were all cows, suggesting a 15.4% (4 of 26) cow moose mortality rate. One cow died near Ongivinuk Lake (in Unit 17A) by mid-May, 1998, most likely killed by a brown bear. Two additional cows had died by 5 March, 1999, killed illegally (Middle Fork Goodnews River and Kwethluk River/Crooked Creek confluence). Another cow was killed illegally in the Kulukak drainage sometime before 14 April, 1999. The status of one cow, captured in Trail Creek and last relocated 18 June, 1998, is unknown.

Adult mortality during the second year (14 April, 1999 - 14 April, 2000) for radiocollared moose with known fates was 22.6% (7 of 31). Four radiocollared cows had died, suggesting a 18.2% (4 of 22) cow moose mortality rate. All 4 cows had died by 19 May, 3 of which were attributed to brown bear predation and 1 to illegal harvest. Three (33.3%) of 9 bulls died, 2 of which locked antlers with each other shortly before 27 September, 1999. The third bull was illegally harvested between 13 March and 14 April, 2000. Aerial observation of the two bulls with locked antlers suggested wolf (*Canis lupus*) or brown bear predation may have been the proximate cause of death, however, ground inspection of the bulls on 9 October, 1999 suggested the proximate cause to be drowning.

Despite the closure (1981 to 1997) of moose hunting season in Unit 17A, local residents continued to harvest moose. Both bulls and cows were taken, with an estimated annual illegal harvest of 15 to 25 moose, although lower in recent years. Moose were taken primarily during late winter and spring when daylight increases and conditions for traveling by snowmachine are generally excellent.

With the advent of a legal fall (August 20 - September 15, 1 bull) hunt in 1997, hunters reported taking 15 moose. Illegal harvest during the 1997-98 winter was estimated at 6 moose. Additionally, 2 apparent wolf killed moose were observed in February and March, 1998, and 1 bull died during radio-collar capture operations in April. During the fall hunt in 1998, hunters reported taking 10 moose. A minimum of 2 moose were taken illegally during the 1998-99 winter. During the fall hunt in 1999, hunters reported taking 10 moose. A minimum of 4 moose were taken illegally in Unit 17A during the 1999-00 winter.

Population Estimate

From 13-26 March, 2000 we surveyed most of mainland Unit 17A east of and including the Matogak River drainage and north of the Nushagak Peninsula (Figure 1). We observed a total of 422 moose in 14.0 survey hours (30.2 moose/hour). Sex composition data was not obtained as

most bulls had cast their antlers. A total of 79 SUs were surveyed, of which nearly one half (36) did not have any moose. Search intensity was approximately 3.5 km^2/minute but varied among SUs dependent on the amount and type of habitat and the number of moose encountered. The greatest concentration of moose was observed along the Togiak River between the confluences of the Ongivinuck and Kemuk rivers and below the confluence with Gechiak Creek.

The apparent decrease in the Unit 17A moose population from 1999 (511 moose in 15.45 survey hours or 33.07 moose/hour) is likely the result of several factors. Survey conditions in 2000 ranged from poor to excellent. Patchy snow cover in the southern one half of the survey area made moose difficult to see. Additionally, we did not survey most SUs that moose had not been observed in during previous surveys. For example, in 1999 a total of 108 SUs were surveyed, of which nearly one half (53) did not have any moose. It is possible some of these SUs, for which no moose had been counted in previously, harbored moose, and thus were missed. Previous surveys were completed in a few days (start to finish), whereas our 2000 effort took 2 weeks (13 March - 26 March) due to weather, and moose movements between SUs could have occurred. Other possibilities include a real decrease in the Unit 17A moose population due to mortality (see previous section) and/or emigration outside the survey area. Population surveys of adjacent areas were not conducted, however, 2 of 25 (8.0%) radiocollared moose were located in Unit 17C during Unit 17A surveys.

The Alaska Department of Fish and Game (ADF&G) started moose surveys in Unit 17 in 1971 (Faro 1973). In 1981, the first major survey of Unit 17A was conducted and only three moose were observed. Additional surveys were conducted by ADF&G and TNWR in 1982, 1984 and 1987 with similar results. In 1989, in an effort to determine factors contributing to low moose densities, ADF&G/TNWR biologists radiocollared 30 moose in western Unit 17C. Subsequent radio-tracking flights from 1989 to 1992 indicated movement of only one moose from the western part of Unit 17C into Unit 17A (Jemison 1994). However, the moose population in western Unit 17C showed an apparent increase since the study, and it is possible younger, non-collared moose, with less home range affinity, began dispersing to Unit 17A.

Surveys conducted during the 1990's indicated an increase in moose in Unit 17A (Figure 2). In January 1994, 84 moose were observed. A more thorough survey technique (Gasaway et al. 1986) was conducted for moose in Units 17A and 17C in February 1995. Survey results and extrapolation of the survey data indicated a population of 136 moose in Unit 17A (Aderman et al. 1995). During this survey, movement of 29 moose from Unit 17C into Unit 17A was documented. Surveys conducted in late February and early March 1997 indicated a minimum of 234 moose in Unit 17A. Subsequently, surveys conducted in February, 1998, revealed a minimum Unit 17A population of 429 moose. The dramatic growth and expansion of moose in Unit 17A parallels that of western Unit 17C during the 1980's and early 1990's.

Habitat Use and Activity

From April 1998 to April 2000, we obtained 529 and 178 observations of habitat use by radiocollared cows and bulls, respectively. Of the 9 habitat types used, >87% of all observations

occurred in 3 habitats (Tables 3 and 4). For both cows and bulls, willow, cottonwood and alder habitats were used the most. Birch and spruce were used least by cows, while spruce and water were used least by bulls. Willow habitats were used the most during winter by both bulls and cows. Overall use of cottonwoods was greater than use of alders, however, alders were used more than any other habitat during July and August (both cows and bulls) and in November (cows). Grass or herbaceous habitats were primarily used by both sexes during July, August and September. Use of tundra was sporadic except by bulls during October when it was the second most used habitat. October use of tundra by bulls is likely related to the rut.

From April 1998 to April 2000, we obtained 464 and 160 observations of activity by radiocollared cows and bulls, respectively. Of the 4 types of activity recorded, moose were most often observed lying or bedded (Tables 5 and 6). Observations of lying moose are likely biased low for three reasons. The first is moose response to survey aircraft. Bedded moose have been observed changing their activity (to standing) when approached or circled by low level aircraft. The second reason has to do with habitat and season. Of 100 relocations where moose were not visually observed (and no activity recorded), 94.0% were in willow, alder or cottonwood dominated habitats, and, most (74.0%) occurred during June, July or August. Lastly, a bedded moose presents less of a visual target than when upright. Of 120 visual observations during June, July and August, 78 (65.0%) were of standing or walking moose.

Distribution, Home Range and Movements

Radiotracking data from 17 April, 1998 to 14 April, 2000 indicated a minimum of 10 moose moving outside Unit 17A. Two cows moved to Unit 18 and were killed illegally in late winter, 1999. Eight moose (5 cows and 3 bulls) moved to Unit 17C, however, 6 of them (4 cows and 2 bulls) returned to Unit 17A. Of 785 relocations of radiocollared moose, 721 (91.9%) were in Unit 17A, 51 (6.5%) were in Unit 17C and 13 (1.6%) were in Unit 18. This indicates the majority of radiocollared moose are staying in Unit 17A.

In recent years, moose have been observed throughout most of the willow and cottonwood dominated habitats in mainland Unit 17A. Generally, these habitats occur along the waterways. Moose are more dispersed during summer months and tend to aggregate in winter (Figure 3).

Annual home range sizes for cows (n = 25) and bulls (n = 9) averaged 277.4 km^2 (107.1 mi^2) and 263.0 km^2 (101.6 mi^2), respectively (Tables 7 and 8). Home range sizes ranged from 10.0 - 1039.2 km^2 (3.9 - 401.2 mi^2) for cows and from 44.5 - 545.8 km^2 (17.2 - 210.7 mi^2) for bulls. On average, bulls had bigger summer and winter home ranges than cows. Mean winter home range sizes for both sexes were larger (15.8% for cows, 6.1% for bulls) than their summer home ranges.

Using the MCP method, it is likely our moose home ranges will increase as more relocations are obtained. Median relocations (and ranges) for cows and bulls in this study are 26 (12 - 30) and 24 (17 - 25), respectively. Ballard et al. (1991), using MCPs, determined estimated size of home range of Alaskan moose began to level off after 60 to 90 relocations had been obtained for an individual animal. In a review of North American moose seasonal home ranges, Hundertmark

(1998) concluded that below 60 degrees north latitude, seasonal home range sizes did not exceed 51.2 km^2 (20 mi^2). During this study 785 relocations ranged between 58° 51.95' and 60° 15.33', with only 7 (0.9%) being above 60 degrees north latitude. Seasonal home range sizes for both cows and bulls in this study (Tables 7 and 8) are more than double expected at this latitude range.

Ten (40.0%) collared cows were migratory, having distinct summer and winter home ranges (<50% overlap) with areas of overlap ranging from 2.0 - 138.5 km^2. Two (22.2%) bulls were migratory. The other collared animals, 15 (60.0%) cows and 7 (77.8%) bulls were considered nonmigratory or resident with >50% overlap of summer and winter home ranges. Figures 4 and 5 show examples of individual resident and migratory moose.

Distances moved between relocations averaged 6.94 and 7.72 km for cows and bulls, respectively (Table 9). Cows moved most during winter (7.42 km) and least during spring (5.93 km), whereas, bulls moved most during the fall (11.93) and least during summer (5.37 km). By month, cows moved most during February (10.09 km) and least during March (4.36 km). Bulls moved most during September (13.45 km) and least during March (1.76 km). Longest straight-line distance moved by a cow was 80.2 km in 30 days (2.67 km/day). Longest straight-line distance moved by a bull was 37.1 km in 27 days (1.37 km/day).

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Table 1. Production and recruitment of moose calves by radiocollared cows, southwest Alaska, 1997-1999.

Togiak Moose ID Number	Year 1997 Prod	1997 Recruit	1998 Prod	1998 Recruit	1999 Prod	1999 Recruit	1998 - 1999 Cumulative Prod	1998 - 1999 Cumulative Recruit
1	1	1	1	1	dead	-	1	1
2	1	1	1	0	2	0	3	0
3	1	1	0	0	2	0	2	0
5	0	0	1	1	0	0	1	1
7	2	2	2	2	0	0	2	2
10	2	2	0	0	0	0	0	0
12	0	0	1	0	dead	-	1	0
13	0	0	unknown	-	-	-	0	0
14	2	2	0	0	0	0	0	0
16	0	0	0	0	2	2	2	2
17	2	2	1	1	dead	-	1	1
18	0	0	dead	-	-	-	0	0
19	0	0	1	0	2	2	3	2
21	1	1	1	0	0	0	1	0
22	1	1	1	1	2	1	3	2
25	1	1	0	0	dead	-	0	0
26	0	0	1	1	dead	-	1	1
27	2	2	2	1	2	1	4	2
29	1	1	0	0	1	0	1	0
30	0	0	2	1	2	1	4	2
31	2	2	0	0	2	1	2	1
33	0	0	1	1	dead	-	1	1
36	0	0	1	1	2	2	3	3
37	2	2	1	0	dead	-	1	0
38	0	0	1	0	2	0	3	0
39	1	1	2	1	2	2	4	3
41	0	0	1	0	2	0	3	0
Total calves	22	22	22	12	25	12	47	24
Adult cows	23	23	25	25	18	18	43	43
Twinning %	46.7		22.2		92.3		51.6	
calves/ 100 cows	?	95.6	88.0	48.0	138.9	66.7	109.3	55.8
% Survival		?		54.5		48.0		51.1

Cows were radiocollared in April, 1998
Adult cow = cow 2 years or older
Prod = Production
Recruit = Recruitment (measured in October - November)

Table 2. Mortalities associated with radiocollared moose, southwest Alaska, 1998 - 2000.

Record	TM	Sex	Date last known live	Date first known dead	Date recovered	lower jaw/ skull	Cause	Location
1	18	F	04/17/1998	05/19/1998	*	no/no	br bear	Ongivinuck L. trib
2	12	F	01/28/1999	03/05/1999	**	no/no	shot	Kwethluk/Crooked Cr.
3	26	F	01/26/1999	03/05/1999	05/28/1999	no/no	shot	lower Kukakthlik R.
4	33	F	03/05/1999	04/14/1999	05/25/1999	no/no	shot	mid-Kulukak R.
5	17	F	04/14/1999	05/18/1999	05/25/1999	yes/yes	br bear	upper Ongivinuck R. trib.
6	25	F	04/14/1999	05/18/1999	05/25/1999	yes/yes	br bear	mid-Togiak R.
7	1	F	04/14/1999	05/19/1999	05/25/1999	yes/yes	br bear	upper Togiak valley
8	37	F	04/14/1999	05/19/1999	05/25/1999	no/no	shot	mid-Kulukak R.
9	11	M	08/24/1999	09/27/1999	10/09/1999	yes/yes	fighting	lower Kemuk R.
10	23	M	08/24/1999	09/27/1999	10/09/1999	yes/yes	fighting	lower Kemuk R.
11	6	M	03/13/2000	04/14/2000	05/19/2000	no/no	shot	upper Togiak R.

*attempts in July, 1998 (in creek) and 05/25/99 (under ice)

**attempt 5/26/99 (in flooded Kwethluk R.)

Table 3. Monthly percent habitat use by radiocollared cow moose (n = 27) from aerial relocations (n = 529), southwest Alaska, April 1998 - April 2000.

	Predominant Species/Cover Type									Number of
Month	Alder	Willow	Birch	Cottonwood	Spruce	Tundra	Grass	Gravel Bar	Water	Relocations
Jan	3.6	50.0	3.6	25.0	7.1	3.6	--	3.6	3.6	28
Feb	--	52.6	--	31.6	--	--	--	5.3	10.5	19
Mar	--	65.0	--	22.5	5.0	--	--	5.0	2.5	40
Apr	1.5	55.2	1.5	29.9	1.5	3.0	--	4.5	3.0	67
May	16.5	45.6	3.8	27.8	--	3.8	2.5	--	--	79
Jun	16.4	53.7	--	17.9	--	3.0	3.0	--	6.0	67
Jul	38.1	28.6	--	23.8	--	--	9.5	--	--	42
Aug	38.2	23.5	2.9	11.8	--	--	20.6	--	2.9	34
Sep	13.2	50.9	--	18.9	--	1.9	13.2	1.9	--	53
Oct	30.6	44.4	2.8	16.7	--	--	5.6	--	--	36
Nov	60.0	28.0	--	12.0	--	--	--	--	--	25
Dec	7.7	53.8	--	33.3	5.1	--	--	--	--	39
Average	17.2	47.3	1.3	23.1	1.3	1.7	4.5	1.5	2.1	44.1

Table 4. Monthly percent habitat use by radiocollared bull moose (n = 9) from aerial relocations (n = 178), southwest Alaska, April 1998 - April 2000.

	Predominant Species/Cover Type									Number of
Month	Alder	Willow	Birch	Cottonwood	Spruce	Tundra	Grass	Gravel Bar	Water	Relocations
Jan	9.1	72.7	18.2	--	--	--	--	--	--	11
Feb	--	71.4	--	28.6	--	--	--	--	--	7
Mar	6.3	62.5	--	31.3	--	--	--	--	--	16
Apr	4.2	75.0	--	16.7	--	--	--	--	4.2	24
May	10.5	52.6	--	26.3	--	10.5	--	--	--	19
Jun	25.0	31.3	--	37.5	--	6.3	--	--	--	16
Jul	38.9	22.2	--	16.7	--	--	22.2	--	--	18
Aug	40.0	13.3	6.7	13.3	--	--	26.7	--	--	15
Sep	29.4	47.1	--	17.6	--	--	5.9	--	--	17
Oct	14.3	42.9	--	7.1	7.1	28.6	--	--	--	14
Nov	12.5	62.5	--	25.0	--	--	--	--	--	8
Dec	15.4	53.8	--	23.1	--	7.7	--	--	--	13
Average	18.0	49.4	1.7	20.2	0.6	4.5	5.1	0.0	0.6	14.8

Table 5. Monthly percent activity of radiocollared cow moose (n = 27), from aerial relocations (n = 464), southwest Alaska, April 1998 - April 2000.

	% Activity				Visual	Total
Month	Lying	Standing	Walking	Running	Relocations	Relocations
Jan	69.4	25.0	5.6	--	36	42
Feb	50.0	50.0	--	--	18	20
Mar	75.0	17.5	7.5	--	40	41
Apr	66.2	27.7	6.2	--	65	67
May	45.2	50.7	2.7	1.4	73	80
Jun	31.4	64.7	3.9	--	51	68
Jul	28.6	57.1	14.3	--	14	43
Aug	33.3	66.7	--	--	21	34
Sep	47.8	41.3	10.9	--	46	53
Oct	63.9	36.1	--	--	36	37
Nov	60.0	36.0	4.0	--	25	25
Dec	48.7	43.6	5.1	2.6	39	42
Average	53.0	41.6	5.0	0.4	38.7	46.0

Table 6. Monthly percent activity of radiocollared bull moose (n = 9), from aerial relocations (n = 160), southwest Alaska, April 1998 - April 2000.

	% Activity				Visual	Total
Month	Lying	Standing	Walking	Running	Relocations	Relocations
Jan	72.7	27.3	--	--	11	15
Feb	71.4	28.6	--	--	7	7
Mar	68.8	25.0	6.3	--	16	16
Apr	87.5	12.5	--	--	24	24
May	35.3	64.7	--	--	17	19
Jun	36.4	63.6	--	--	11	16
Jul	42.9	57.1	--	--	14	18
Aug	55.6	33.3	11.1	--	9	15
Sep	30.8	69.2	--	--	13	17
Oct	50.0	50.0	--	--	14	14
Nov	62.5	37.5	--	--	8	8
Dec	50.0	50.0	--	--	16	16
Average	56.3	42.5	1.3	0.0	13.3	15.4

Table 7. Annual, summer (May - Oct) and winter (Nov - Apr) home range sizes (Minimum Convex Polygon), percent summer/ winter home range overlap and migratory status of radiocollared cow moose (n = 25), southwest Alaska, March 1998 - April 2000.

Togiak	Annual			Summer			Winter			%	Migratory
Moose	n	sq km	sq mi	n	sq km	sq mi	n	sq km	sq mi	Overlap	Status
17	16	9.99	3.86	9	8.00	3.09	7	1.54	0.59	81.17	N
10	28	52.17	20.14	16	27.90	10.77	12	35.48	13.70	57.63	N
33	17	53.78	20.77	9	20.23	7.81	8	42.05	16.24	66.14	N
31	26	54.92	21.20	14	38.94	15.03	12	28.54	11.02	68.75	N
3	27	69.43	26.81	15	36.86	14.23	12	15.46	5.97	58.54	N
19	24	102.64	39.63	12	79.76	30.80	12	42.10	16.25	73.54	N
39	27	105.28	40.65	15	16.25	6.28	12	99.83	38.54	96.62	N
25	16	116.09	44.82	9	68.50	26.45	7	78.59	30.34	71.55	N
30	26	120.89	46.67	14	25.12	9.70	12	119.16	46.01	97.85	N
29	26	145.17	56.05	14	92.36	35.66	12	51.64	19.94	46.03	M
22	26	148.72	57.42	14	36.64	14.14	12	124.40	48.03	93.61	N
41	26	160.85	62.10	12	42.48	16.40	14	110.10	42.51	42.42	M
37	16	215.67	83.27	9	21.11	8.15	7	169.29	65.36	53.39	N
1	16	248.58	95.98	9	123.32	47.61	7	164.99	63.70	48.10	M
7	24	261.77	101.07	13	70.90	27.37	11	207.61	80.16	67.24	N
14	26	286.17	110.49	15	63.29	24.43	11	257.16	99.29	88.13	N
2	26	286.46	110.60	14	116.23	44.87	12	137.81	53.21	30.06	M
5	30	333.57	128.79	18	199.69	77.10	12	105.75	40.83	28.67	M
21	29	351.75	135.81	17	259.49	100.19	12	134.87	52.07	63.98	N
12	12	414.34	159.98	6	150.37	58.06	6	80.41	31.05	15.91	M
36	26	431.37	166.55	14	145.64	56.23	12	169.08	65.28	1.34	M
38	26	540.93	208.85	15	102.98	39.76	11	367.15	141.76	60.47	N
16	25	569.42	219.85	13	194.47	75.09	12	342.88	132.39	24.98	M
26	12	816.14	315.11	6	231.57	89.41	6	294.38	113.66	26.04	M
27	25	1039.21	401.24	13	817.57	315.66	12	282.63	109.12	49.00	M
ave	26	277.41	107.11	14	119.59	46.17	12	138.51	53.48	56.45	60.0N/40.0M

n = number of relocations
ave = median (n), arithmetic mean (sq km, sq mi)
M = migratory, N = nonmigratory

Table 8. Annual, summer (May - Oct) and winter (Nov - Apr) home range sizes (Minimum Convex Polygon), percent summer/ winter home range overlap and migratory status of radiocollared bull moose (n = 9), southwest Alaska, March 1998 - April 2000.

Togiak	Annual			Summer			Winter			%	Migratory
Moose	n	sq km	sq mi	n	sq km	sq mi	n	sq km	sq mi	Overlap	Status
34	24	44.48	17.17	12	22.19	8.57	12	34.97	13.50	68.68	N
4	19	74.85	28.90	9	59.51	22.98	10	62.49	24.13	86.35	N
11	18	85.52	33.02	11	65.33	25.22	7	26.43	10.20	71.62	N
8	24	105.29	40.65	12	39.40	15.21	12	31.27	12.07	24.88	M
32	24	202.32	78.11	12	132.93	51.32	12	148.97	57.52	75.97	N
23	17	422.05	162.95	10	75.64	29.20	7	186.05	71.83	17.29	M
6	23	441.06	170.29	11	419.48	161.96	12	195.32	75.41	92.04	N
40	25	445.68	172.08	13	74.77	28.87	12	331.36	127.94	70.28	N
35	25	545.79	210.73	12	398.94	154.03	13	349.62	134.99	67.60	N
ave	24	263.00	101.55	12	143.13	55.26	12	151.83	58.62	63.86	77.8N/22.2M

n = number of relocations
ave = median (n), arithmetic mean (sq km, sq mi)
M = migratory, N = nonmigratory

Table 9. Average monthly and seasonal movements of radiocollared moose, southwest Alaska, April 1998 - April 2000.

	Average Distance Moved (km)			
Month	Cows (n =25)		Bulls (n =9)	
May	5.99		7.16	
Jun	5.79	5.93	8.39	7.72
Jul	8.65		7.19	
Aug	5.55	7.10	3.81	5.37
Sep	4.86		13.45	
Oct	9.93	7.21	10.08	11.93
Nov	9.61		8.51	
Dec	8.35		6.54	
Jan	5.55		9.11	
Feb	10.09		10.11	
Mar	4.36		1.76	
Apr	5.16	7.42	5.63	7.15
Average	6.94		7.72	

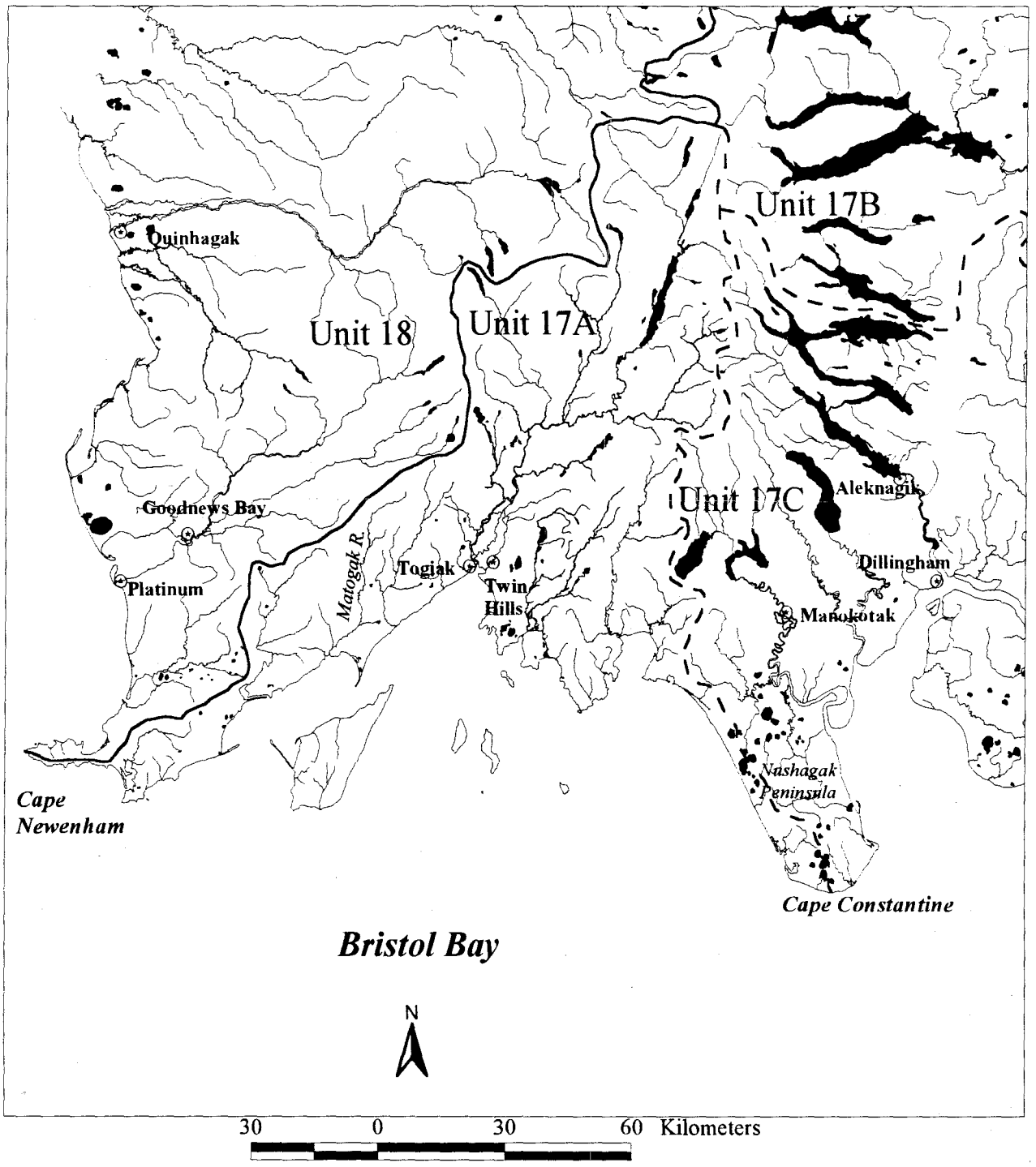

Figure 1. Location of the primary study area on Togiak National Wildlife Refuge (the drainages between Cape Newenham and Cape Constantine), southwest Alaska.

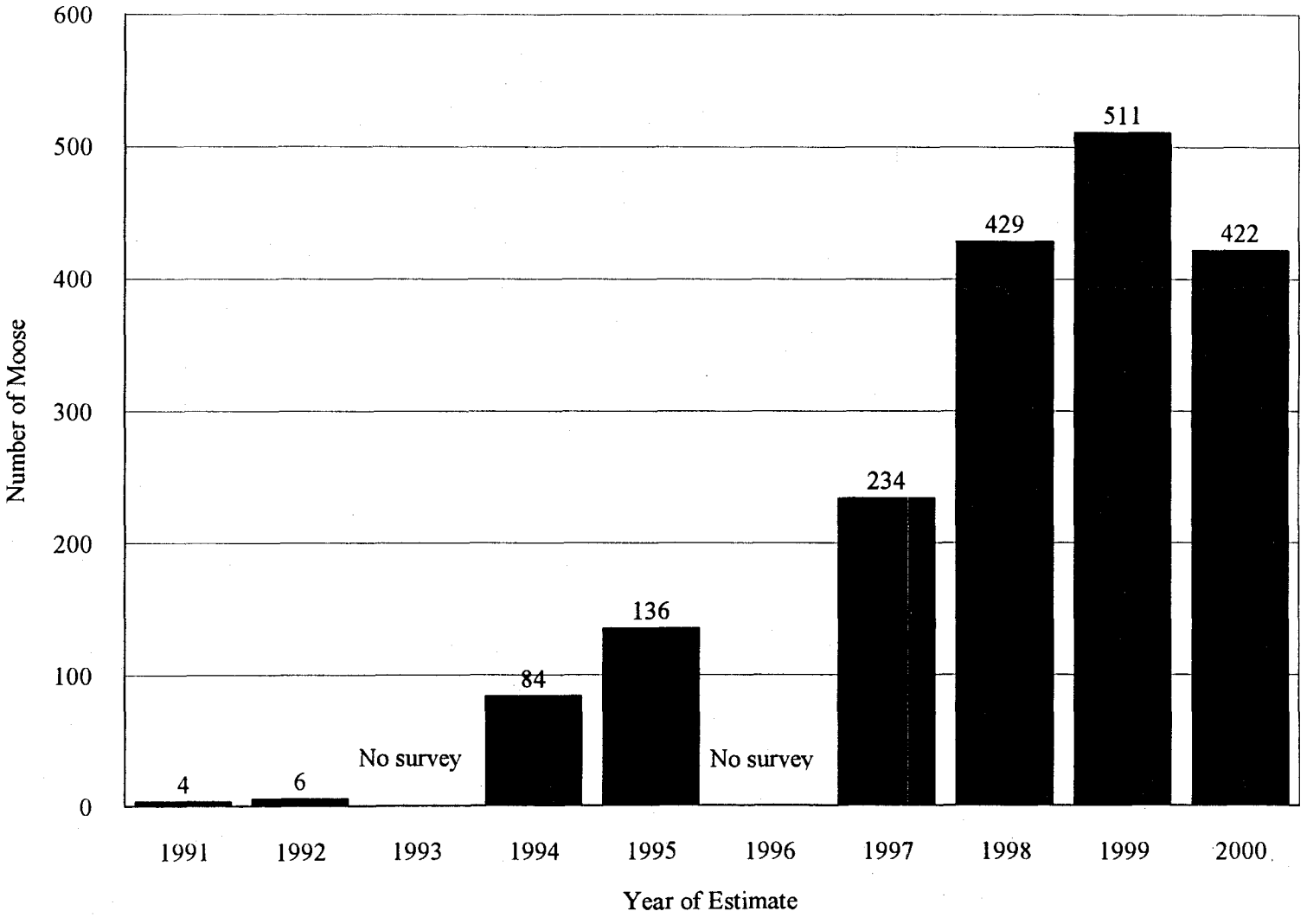

Figure 2. Number of moose observed during winter aerial surveys of Unit 17A, southwest Alaska, 1990-2000.

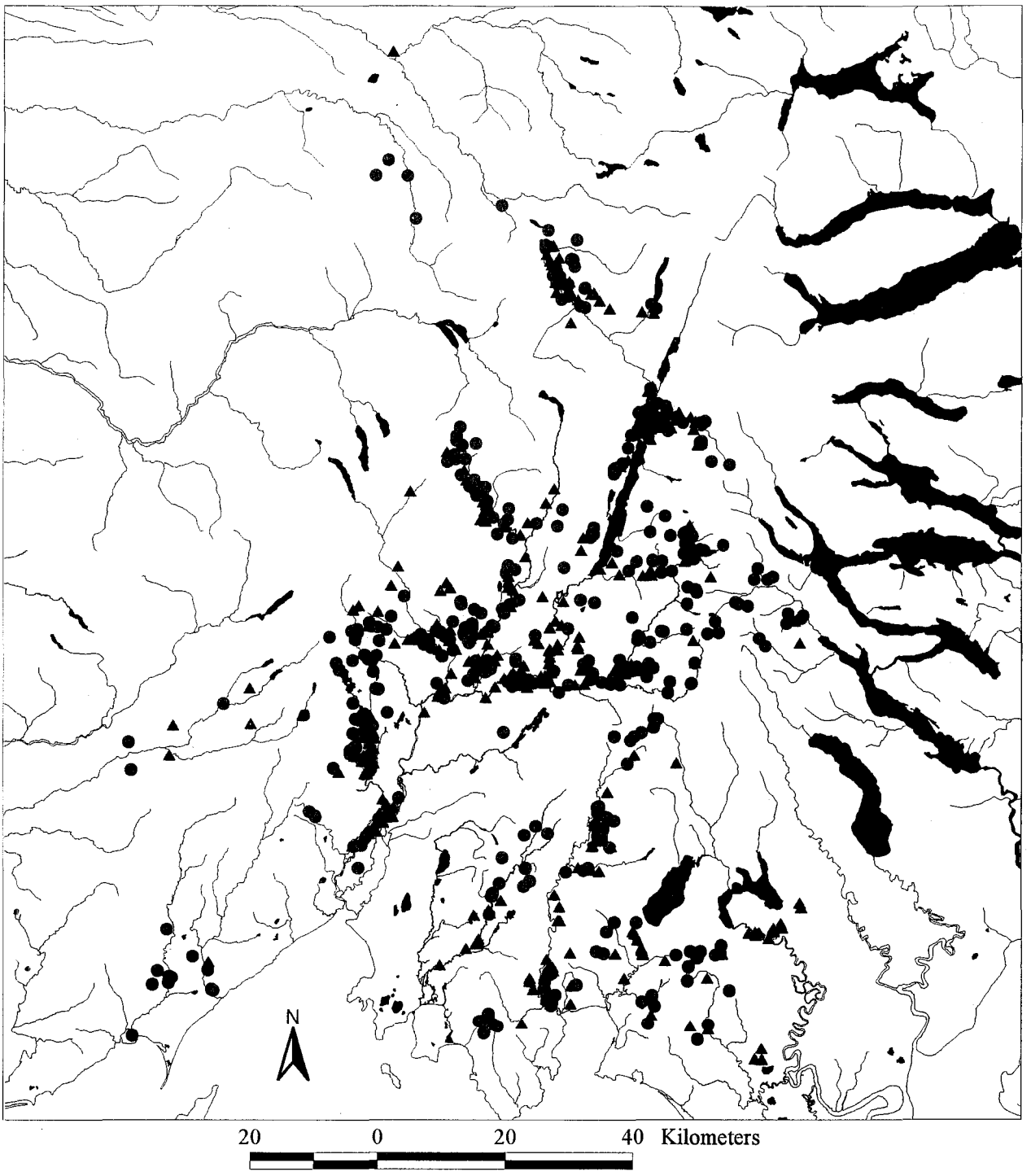

Figure 3. Winter and summer relocations of all radiocollared moose, southwest Alaska, March 1998 - April 2000.

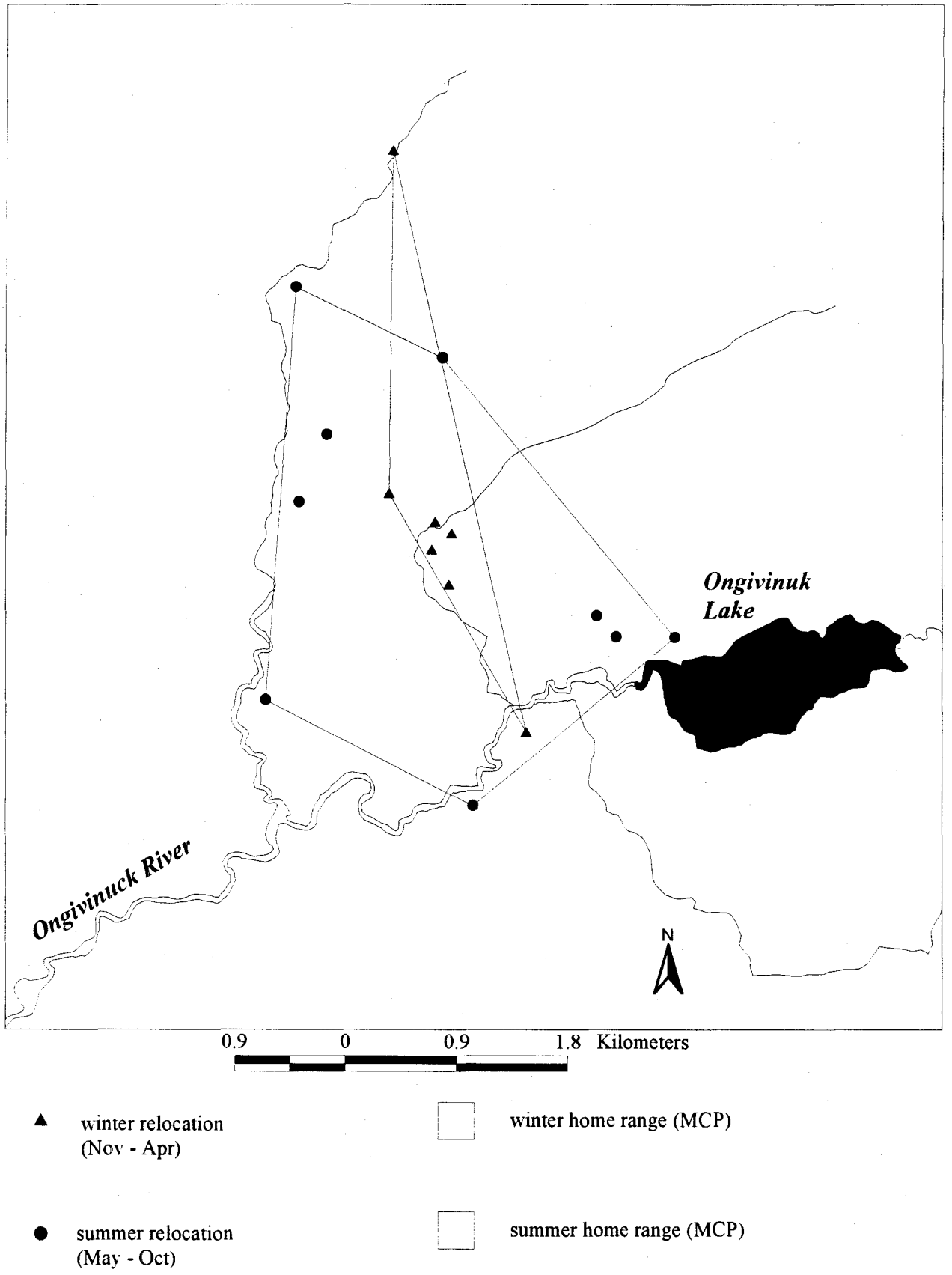

Figure 4. Example of a resident cow moose (TM17). Summer and winter home range overlap = 81.2%.

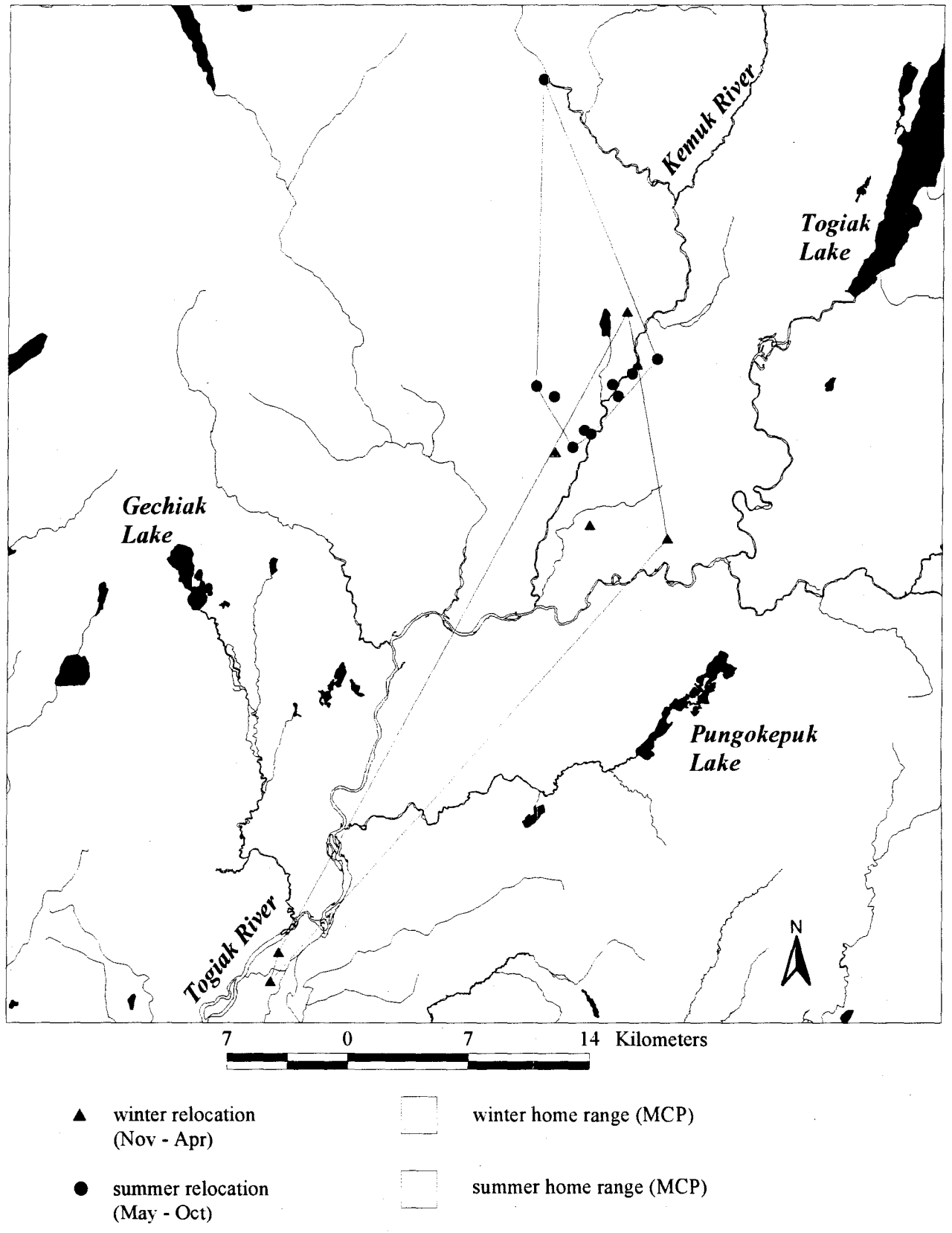

Figure 5. Example of a migratory bull moose (TM23). Summer and winter home range overlap = 17.3%.

DRAFT

March 25, 2000

MOOSE MANAGEMENT PLAN
for
GAME MANAGEMENT UNIT 17A
(Togiak and Kulukak Bay drainages)

INTRODUCTION

The Moose Management Plan (Plan) for Game Management Subunit (Unit) 17A is the document upon which a cooperative management program for the moose population will be based. Moose are relatively new inhabitants in the Togiak and Kulukak drainages, immigrating into the area from western Unit 17C drainages. Until recently, populations were low, and moose season in Unit 17A was closed. Local residents harvested moose despite the closed season, however, marine mammals, caribou, reindeer, and beaver were historically the main sources of meat.

The Alaska Department of Fish and Game (ADF&G) began collecting data on the Unit 17A moose population in 1981. Only 3 moose were observed during 5.5 survey hours. Throughout the 1980's and early 1990's, surveys conducted by ADF&G and Togiak National Wildlife Refuge (TNWR) indicated few moose. A moose study in western Unit 17C (1989 - 1992) did not show a pattern of immigration to Unit 17A. However, the moose population in western Unit 17C showed an apparent increase since the study, and it is possible younger, non-collared moose, with less home range affinity, began dispersing to Unit 17A. In February 1995, movement of 29 moose from Unit 17C into 17A was documented. Aerial surveys in Unit 17A during the 1990's revealed a progressive and substantial increase in moose numbers. Surveys conducted in March 1999 indicate a minimum population of 511 moose.

Probable reasons for the moose population increase in Unit 17A include: 1) continued immigration from neighboring Unit 17C; 2) regulation changes implemented by the Alaska Board of Game; 3) some reduction of illegal harvests as a result of poor travel conditions in 1995 and 1996; 4) availability of the expanding Mulchatna Caribou Herd in Units 17 and 18; and 5) good productivity of the moose in Unit 17A due to mild winters, few predators, and excellent habitat.

The Plan will be used as a guide when making future regulatory proposals and decisions regarding moose in Unit 17A. Cooperation among Plan participants (TNWR, ADF&G, Togiak Fish and Game Advisory Committee, Nushagak Fish and Game Advisory Committee, Bristol Bay Subsistence Regional Advisory Council, and area residents) is critical to the success of this Plan.

PRINCIPLES

The Plan acknowledges the need for coordinated management consistent with State and Federal laws and regulations, and traditional lifestyle of area residents. Principles agreed upon by all parties concerning Unit 17A moose include:

1. Moose are an important subsistence resource for area residents.

2. The users and management agencies want moose to expand their range and increase in numbers consistent with available habitat.

3. An estimate of carrying capacity will be used when setting population level goals to ensure protection of the vegetation resource.

4. Effective management of Unit 17A moose is a high priority to insure a sustainable level of harvest as well as providing a subsistence priority on State and Federal lands.

5. Cooperation and participation between Plan participants is essential to achieve the goals and objectives of this Plan.

6. The management planning process is ongoing. Updating and improving the Plan will increase its effectiveness.

7. Continued monitoring of the size, production, movements, distribution and habitat of Unit 17A moose is essential to the success of the Plan.

8. The Plan should be integrated with other management programs.

MOOSE MANAGEMENT GOALS AND OBJECTIVES

Management goals of this plan explain what is planned for the management of moose in Unit 17A. Management objectives describe how the goals can be carried out.

Goal 1: Ensure the health, continued growth and viability of the moose population in Unit 17A.

Management Objectives for Goal 1

1. Maintain a minimum resident population of 300 moose; a bull:cow ratio of not less than 30 bulls:100 cows; and a conservative annual harvest which will allow the population to continue to grow.

2. Increase the Unit 17A moose population to carrying capacity (estimated at 1,100 to 1,750 moose). This population objective may be adjusted based on better estimates of carrying capacity, moose population condition and/or moose browse condition and trend analysis.

3. Monitor moose population parameters (sex and age composition, numbers, and distribution) through annual aerial surveys, radio-tracking, and a Gasaway-type census conducted every five years or as needed.

4. Maintain a minimum of 20 radio-collared moose (15 cows/5 bulls) to monitor calf production, survival and recruitment, movements and adult mortality.

5. Maintain a close working relationship among Plan participants in managing this moose population.

6. Consider and implement other research as necessary.

Goal 2: Maintain and protect moose habitat and other necessary components of the ecosystem in Unit 17A upon which the moose population depends.

Management Objectives for Goal 2

1. Continue to describe, quantify, and map existing vegetation cover types through the aid of satellite imagery computer aided analysis and ground truthing.

2. Monitor moose browse condition and trend in winter concentration areas to ensure the Unit 17A moose population does not exceed carrying capacity.

3. Determine nutritional qualities of browses consumed by moose as time and funding allows.

4. Work with village corporations and private landowners to minimize the impacts to moose habitat in Unit 17A.

Goal 3: Provide for a regulated harvest in a manner consistent with Federal and State laws, and the goals and objectives of this management plan.

Management Objectives for Goal 3

1. Until the population exceeds 300 moose, no hunting seasons will occur.

2. When the population exceeds 300 moose, allow a State and Federal fall harvest of bulls, by State registration permit.

3. When the population exceeds 600 moose, allow a Federal registration permit winter hunt for bulls.

4. When the population exceeds 1100 moose, allow a fall nonresident opportunity to harvest bulls.

5. Hunting regulation proposals and recommendations, consistent with this management plan, will be developed cooperatively with Plan participants and submitted to the Federal Subsistence Board and Alaska Board of Game.

Goal 4: Encourage cooperative management and communication between Plan participants in developing and carrying out management, research and enforcement programs, and with the public by exchanging ideas and knowledge about moose in Unit 17A.

Management Objectives for Goal 4

1. Plan participants will meet annually or as needed to update the plan and discuss issues involving moose in Unit 17A.

2. Plan participants will cooperate in formulating and reviewing management and research programs including but not limited to an aerial census, aerial surveys, radio telemetry monitoring, composition counts, recruitment surveys and harvest reporting.

3. Plan participants will coordinate to the extent possible enforcement activities that are to be conducted within Unit 17A or adjacent areas.

4. Plan participants will provide information to local residents and conduct public programs concerning the importance of protecting moose. In addition both agencies plan to provide information and educational materials concerning moose ecology, subsistence use and stress the significance of the cooperative moose management plan. Plan participants will work closely with area residents to ensure there are opportunities to discuss management activities and concerns people may have.

SIGNATURES

By their signatures below, the undersigned hereby certify their participation in and agreement with the Moose Management Plan for Game Management Unit 17A (Togiak and Kulukak Bay drainages).

Togiak Advisory Committee, Chairman	Date
Nushagak Advisory Committee, Chairman	Date
Bristol Bay Regional Advisory Council, Chairman	Date
Togiak National Wildlife Refuge, Refuge Manager	Date
Alaska Department of Fish & Game, Area Biologist	Date