DISTRIBUTION, MOVEMENTS, REPRODUCTION, AND SURVIVAL OF RADIO-COLLARED MOOSE, SOUTHWEST ALASKA

--A Summary Report of the Moose Collaring and Monitoring Effort by Togiak National Wildlife Refuge and the Alaska Department of Fish and Game

BY
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KEY WORDS:

Moose	Aerial Survey	Recruitment
Distribution	Radio-Telemetry	Mortality
Calving	Movements	Southwest Alaska

A COOPERATIVE EFFORT BETWEEN

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and

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SUMMARY

In 1989, 22 female and eight male moose (Alces alces) were captured and radio-collared in southwest Alaska. Twenty-four aerial surveys were flown from 1989 through February 1994 to determine distribution, seasonal movements, and immigration into the Togiak drainage. Reproductive information was also collected during the surveys.

In 1989, 64.3% of the radio-collared females were observed with calves; the twinning rate was 11%. In 1990 and 1991, 70.0% and 80.0% of the collared females produced calves; twinning rates were 64.3% and 66.7%, respectively. High twinning rates in 1990 and 1991 suggest that moose had sufficient food resources during those years. In 1989 no surveys were conducted during the calving season; this may have resulted in fewer observations of calves. Also, the more severe weather during the winter of 1988-1989 may have affected the twinning rate. Minimum recruitment rates were 50, 75, and 73 calves:100 females for 1989, 1990, and 1991, respectively. Average annual mortality of radio-collared moose with known fates was 12.2%.

Moose ranged from the northern end of Amakuk Arm in the north to the upper Wood River in the southeast to the Kulukak River in the west. The majority of the moose were concentrated in Sunshine Valley; Youth, Killian, and Ice creek drainages; and the Weary River drainage. Seasonal movements were subtle; there were no obvious, well defined movements during calving or rutting.

Contrary to expectations, tracking flights do not show a pattern of moose immigrating to the Togiak drainage. However, recent increases in the number of moose observed in the Togiak and Kulukak drainages have been documented. This increase may be due to a population increase in the study area (possibly due to mild winters the past several years) resulting in younger animals dispersing out of the area. Movement by younger animals would not be documented by the tracking flights. Other possibilities include a southerly movement from either the upper lakes in the Wood-Tikchik State Park or from the Aniak River drainage.

BACKGROUND

Little written information is available on moose abundance on or near the Togiak National Wildlife Refuge (TNWR) prior to the 1970s. Generally it is believed that moose populations have historically been at low densities in areas of southwestern Alaska, and that moose populations have expanded their range and increased in number in this region during the 20th century (Joe Chythlook, pers. comm.; Machida 1987; Van Daele 1992). Adequate moose habitat on TNWR exists primarily in riparian zones along river drainages. While no substantive studies have been conducted, it generally appears that vegetation along the major river drainages on the refuge (particularly the Togiak River) could support larger moose populations than currently exist (Taylor 1990; Van Daele and Hinkes, pers. comm.).

The Alaska Department of Fish and Game (ADFG) has set hunting regulations for moose in Game Management Unit (GMU) 17 since statehood. From 1956 through 1981, hunting regulations for subunit 17A (located on refuge lands) permitted the harvest of a single bull moose (ADFG files). However, throughout most of the 20th century, there has been a general disregard for moose hunting regulations by area residents. In areas capable of supporting more moose, low densities have been attributed to heavy hunting pressure on moose moving into these areas, limiting growth before populations capable of sustaining a harvest can become established (Taylor 1990).

In 1972, ADFG began surveying moose in GMU 17 (ADFG Files). In 1981, the first major survey of subunit 17A (including the Togiak River drainage) was

conducted. During 5.5 survey hours, only three moose were observed, resulting in the Board of Game's decision to close the hunting season in this subunit (Taylor 1990). Additional surveys were conducted in 1982 and 1984; moose densities were estimated to be at very low levels, probably less than 0.1 moose/mi^2 (Taylor 1985).

During the winter of 1982-1983, a moose census was conducted in a large portion of subunit 17C. Taylor (1984) estimated the moose density for subunit 17C to be 0.66 moose/mi^2. A similar census was conducted in the eastern portion of subunit 17B in 1987; moose density was estimated to range from 0.6-1.3 moose/mi^2. Throughout the 1980s, subsequent surveys of these subunits showed a trend of increasing moose numbers. This increase was attributed to mild winters, low predation rates by wolves, the availability of the Mulchatna Caribou Herd to residents of Nushagak River villages, and fewer incidences of illegal take by these residents. The moose population in subunit 17A continued to remain at very low levels, probably due to illegal harvests by residents from the Togiak River drainage (Taylor 1984).

In 1988, ADFG and TNWR biologists examined factors that contributed to the continued low densities of moose in subunit 17A. Despite habitat capable of supporting higher numbers, densities in 17A remained low, while moose populations in adjacent 17C steadily increased throughout the 1980s. During this time there were high numbers of moose taken illegally by residents of the Togiak River villages. It was assumed that moose were immigrating from subunit 17C (off refuge lands) into subunit 17A (on refuge lands), and were being taken illegally before a viable population could be established. This led to the study proposal to radio-collar and track moose along the northwestern portion of GMU 17C and the adjacent eastern boundary of TNWR to determine distribution of moose, seasonal movements, and westward expansion into the Togiak River drainage in subunit 17A.

OBJECTIVES

1. Determine production rate, recruitment, and mortality of radio-collared moose.

2. Determine annual immigration rate of moose to the TNWR, determine if this immigration is permanent or seasonal, and determine which areas adjacent to the refuge are most significant for producing moose.

3. Provide village residents with summary of data collected; educate refuge residents on the importance of protecting immigrating moose until a viable population can be established; provide representatives of each village with opportunities to participate in field work associated with this project.

STUDY AREA

The study area is located approximately 50 kilometers northwest of Dillingham, along the eastern border of Togiak NWR and the western border of Wood-Tikchik State Park (Fig. 1). It is approximately 1,800 km^2 and includes Sunshine Valley; Youth, Killian, and Ice creek drainages; and the Weary River Drainage.

Vegetation in the study area primarily consists of stands of spruce and cottonwood, and a mix of deciduous shrubs (willow, alder, birch). Typically, cottonwood stands and deciduous shrubs dominate the higher elevations of the creek and river drainages. The mouths of the creeks and rivers, and the areas around the lakes consist mainly of spruce stands. In most areas, the land adjacent to the waterways is dominated by either cottonwood stands or deciduous shrubs, or both.

METHODS

Capture and Radio-Collaring

The capture operation began on 6 March 1989. During the first four days of the capture (6-9 March), ADFG and USFWS staff travelled on two snow machines from Dillingham to the Killian and Youth Creek drainages. USFWS Biologist/Pilot and an observer flew in the refuge's Cessna 185 on wheels/skis. On the 10th and 11th of March, and 4th and 7th of April, the capture operation was staged off a small pond along upper Killian Creek. Snow machines and sleds were left at the pond, and people were shuttled back and forth to Dillingham in the refuge plane.

Moose were first located by the pilot and observer. Using VHF radios, the pilot directed biologists on snow machines to the moose. The animals were darted by the passenger on the first snow machine; the second snow machine carried supplies and provided support. Four milligrams of carfentanil were used to immobilize each animal; dart location was in the hip and rump area. Twelve cc's of naloxone were administered as the antagonist.

Thirty-two moose were captured and radio-collared. Two moose died of capture myopathy (1 male, 1 female); the collars were recovered and placed on other animals. After the recollaring a total of 22 female and 8 male moose were collared.

Aerial Surveys/Radio-Telemetry

Radio-collared moose were located using fixed-wing aircraft equipped with two Telonics tracking antennas, using standard radio-tracking techniques. Data collected during each survey include weather conditions (cloud cover, wind speed and direction, precipitation, and temperature); light type and intensity; snow age and condition; and turbulence. Attempts were made to observe each radio-collared animal. Data collected during these observations include collar frequency, number, sex, age, number in group, location, and presence or absence of calves (Fig. 2). Locations of moose were recorded on a 1:250,000 topographic map with the aid of Loran or GPS coordinates.

Trend Count Surveys

Aerial surveys of trend count areas in 17B and 17C were conducted by ADFG and USFWS to sample the sex and age composition of the moose population and to collect data on the population trend in representative portions of the unit. Optimal survey periods are from 15 November through 30 December. During this time moose are usually established on their winter ranges, and bulls still retain their antlers. The number of trend count surveys has been limited over the years by poor weather conditions, snow cover, and aircraft availability. No trend count areas have been established in subunit 17A; however, reconnaissance flights were conducted of the Togiak drainage.

Data Storage and Analysis

Maps and survey data sheets are kept on file at the TNWR headquarters in Dillingham. Moose observations and summary data are stored on Refuge computers using Lotus 123 software.

RESULTS AND DISCUSSION

The ages of 30 radio-collared moose were estimated by incisor wear and ranged from 2 to 10 years old. The time from darting with carfentanil to immobilization ranged from 2 to 11 minutes. Animals responded within 1 to 6 minutes after intramuscular injection of naloxone. Respiration rate ranged

from 6 to 52 breaths/minute, heart rate from 70 to 180 beats/minute, and body temperature from 100 to 108 degrees Fahrenheit (Table 1).

Twenty-four radio-tracking surveys were conducted between March 1989 and February 1994. Most flights were conducted during the first three years of the study (five flights each in 1989 and 1991, nine flights in 1990); in 1992, three tracking flights were flown. Only one tracking survey was conducted in 1993 and in 1994. Appendix I lists all data collected during the tracking flights.

Calf Production and Recruitment

Twenty-two radio-collared females were monitored to determine calf production and survival. Twenty-one of these females produced at least one calf (Table 2); the female that produced no calves was found dead (probably killed by a bear) within one month of being collared.

Moose calving in southwest Alaska typically occurs from 20 May to 5 June (Taylor, pers.comm.). Time of peak calving of radio-collared moose was not determined due to a lack of surveys during the calving period. In 1989, 64.3% (9/14) of the radio-collared females observed produced calves, for a calf:100 females ratio of 71. Eleven percent of the calves produced were twins. In 1990, 70.0% (14/20) of the females observed produced calves, for a calf:100 females ratio of 115. Of the calves produced, 64.3% were twins. In 1991, 80.0% (12/15) of the females observed produced calves, for a calf:100 females ratio of 133; 66.7% of the calves produced were twins (Table 3).

Franzmann and Schwartz (1985) believe that twinning rates can be valuable in evaluating moose habitat, and suggest that the importance of using twinning rates has been underestimated. However, they caution that factors such as post-natal mortality and the age structure of the population may depress twinning rates. Intensive aerial searches of the calving areas during the peak calving period is one way to avoid the effects of post-natal mortality.

Very few radio-tracking surveys were conducted during the first two weeks of June. To determine the number of calves produced, a history of each female was created using all data collected from the time of calving through the following April. Therefore, our production and twinning rates are minimum numbers and may be affected by peri-natal and post-natal mortality. The twinning rates for females producing calves in 1990 and 1991 (64.3% and 66.7%, respectively) are high compared to the rate observed in 1989 (11%). Although sample sizes are small, the high twinning rates in 1990 and 1991 suggest that moose had sufficient food resources during those years (Franzmann and Schwartz 1985). In light of this, it is unlikely that the low twinning rate in 1989 is a reflection of poor food resources. The lack of a June calving survey in 1989 may have resulted in fewer observations of twins that year. Also, while the 1990-1991 and 1991-1992 winters were relatively mild, the 1988-1989 winter was more severe and may have affected the condition of female moose giving birth in the summer of 1989. Severe winter weather may result in low twinning rates (Albright and Keith 1987).

Minimum recruitment rate was determined by comparing the number of calves observed in spring with the number of radio-collared females observed. In 1989, the number of calves surviving until their first spring:100 females ratio was 50. In 1990 and 1991, minimum recruitment rate was higher, with 75 and 73 calves:100 females, respectively.

Adult Mortality

The average annual mortality of radio-collared moose with known fates was 12.2%. As of February 1994, 13 radio-collared moose had died; eight others either died or slipped their collars, and two moose have been missing since

1989 and 1990. Five moose were alive and their collars still active during the last survey. The status of two moose, last relocated in June 1993, is unknown (Table 4). Five of the eight male moose that were collared died during the first two years of the study; a sixth male either died or slipped his collar in June 1989. Twelve collars have been recovered to date.

Causes of mortality are largely unknown. Two male moose were killed by hunters (one was an illegal harvest), and evidence suggested that four moose were killed by bears. The significance of human harvest and bear predation on moose in the study area is unknown. Wolves have been sighted infrequently in the study area. No wolf-killed moose were observed during any fall surveys between 1980 and 1990, or during radio-tracking flights in the study area. Wolf predation has likely been far less significant in this area than predation by brown bears.

Trend Count Surveys

In 1987, the moose population in subunit 17C was estimated to be 1400 - 1700 moose; this estimate was based on extrapolations from the 1983 moose census of this unit (Taylor 1990). A total of five trend count surveys were conducted in the study area from November 1989 through November 1993; three surveys were flown of the Sunshine Creek drainage and two of the Weary River drainage (both in subunit 17C). Survey data suggest that the number of moose in this subunit has been increasing since the extrapolated estimates of the population were made in 1987. It is expected that the current moose population in subunit 17C probably meets the management goal of about 1750 moose (Van Daele in prep.).

Composition data collected during the trend count surveys show that bull:cow ratios in subunits 17B and 17C have remained consistently high. Calf production and survival have fluctuated between areas and years, but they have generally been good to excellent (Van Daele in prep.).

During reconnaissance flights of the Togiak and Kulukak River drainages, four and six moose were observed in 1991 and 1992, respectively. However, in January 1994, 84 moose were observed during extensive surveys of the Togiak and Kulukak river drainages.

Distribution and Movements

Seasonal movements observed from survey data were subtle; there were no obvious, well defined movements during calving or rutting. As a result, we opted to examine tracking flight data by dividing up the year into four seasons based on general moose behavior and movements. We considered winter the months of November through March, when moose generally move into their winter range and feed on deciduous shrubs (primarily willow). Spring (April and May) is typically characterized by movements into calving areas, increasing day length, and a feeding shift to new leaves and buds. Calving begins in late spring and is completed during the first month of summer. During the summer months, June through August, moose rely heavily on aquatic vegetation. Autumn (September and October) is characterized by males exhibiting rutting behavior and the rut.

Distribution maps were created for 25 of the 30 radio-collared moose (20 females and 5 males) (App. II). Moose ranged from the northern end of Amakuk Arm in the north to the upper Wood River (south of Lake Aleknagik and east of Nunavaugaluk Lake) in the southeast to the Kulukak River in the west. The majority of the moose, however, were concentrated in Sunshine Valley; Youth, Killian, and Ice creek drainages; and the Weary River drainage. Fifteen of the collared moose were always relocated in this concentration area. Five other moose were located in the concentration area the majority of the time. Two moose were never relocated in the concentration area during the tracking flights: female #13 remained north of the concentration area on the north end

of Lake Nerka and female #36 moved west of the concentration area and was located along the Kulukak and Ongoke rivers. Female #43 was mostly observed east of the concentration area around Lake Nerka, and female #41 frequented the Lake Nerka-Sunshine Valley area. One female (#10B) usually remained south of the concentration area, on the east and south sides of Nunavaugaluk Lake.

Two moose were never located during a summer survey; female #36 was located along the Kulukak and Ongoke rivers during the fall, winter and spring months. Male #31 was located either in the Killian or Youth creek drainages on 14 of the 17 fall, winter and spring surveys. However, he was never located during any of the seven summer surveys.

General seasonal movements showed moose to be more widely dispersed during June and September-October (Figs. 3-4). During January and April, moose tended to concentrate along Killian and Youth Creek, and in Sunshine Valley (Figs. 5-6).

Contrary to expectations, tracking flights did not show a pattern of moose immigrating to the Togiak drainage, and thus an annual immigration rate could not be calculated. Only one moose (female 164.430) was relocated west of the main concentration area (refer to Appendix II, frequency 4430).

Through 1992, moose numbers in the Togiak River drainage remained low while moose numbers in adjacent areas steadily increased (Van Daele in prep.). In autumn of 1993 there were reports of an increase in the number of moose along the Togiak River (Hinkes, pers. comm.). Surveys in January 1994 documented large increases in the number of moose in the Togiak and Kulukak river drainages; many of the moose observed were young animals. It is unknown where these moose came from. Possibilities include a southerly movement from either the upper lakes in the Wood-Tikchik State Park or from the Aniak River drainage. Another possibility is that a population increase in the concentration area may result in a westward expansion by younger animals, while the older animals (which would include the radio-collared moose) may be residents of the area and less likely to leave their traditional areas (Roussel et al. 1975, Lynch 1976). A recent trend toward young animals dispersing out of the study area would not have been documented by the tracking flights since offspring were not radio-collared. Home range was not calculated because of the small number of tracking flights.

Mild winters (Albright and Keith 1987), good food resources (Franzmann and Schwartz 1985), and low numbers of predators (Gasaway et.al 1992) are all factors which may have contributed to an increase in the number of moose in the concentration area.

Sporadic efforts were made to educate refuge residents on the importance of protecting moose until a viable population is established. Representatives from each village were not involved in field work associated with this project.

RECOMMENDATIONS

1. Develop an interagency study plan to capture and radio-collar moose in the Togiak River drainage. This will be the best way to determine where moose from this area are moving to. Efforts should be made to collar young animals so their movements can be tracked. Follow up the collaring with an intensive aerial survey schedule, so enough data can be collected to better determine movements and home range.

2. If poaching is a concern, regular meetings should be scheduled in the villages to discuss reasons for the current restrictions, the benefits to be gained by allowing the moose population to grow, and to communicate survey results to local residents. Determine if agency goals are consistent with goals of local residents. Develop an education program in the schools in which moose biology, population dynamics, and management are discussed. Make sure the commitment in the villages and in the schools is a long-term, well planned out effort to maximize program effectiveness.

3. To collect more complete information on calving and to accurately compare twinning rates between populations, intensive surveying should be conducted during the calving period using standardized techniques.

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Table 1. Capture and immobilization data for radio-collared moose, southwest AK, 1989.

Date	Collar Freq	Collar Num	Sex	Est Age	Cond index	Capture Drug	Dose	Time to Immobil	Hit Area	Dist	Depth of Tranquilization	Resp Rate	Heart Rate	Temp	Antagonist	Dose	Injection to standing	Loc'n Given	Stand Time	St	Remarks	W/ Calf
03/06/89	4700	34	F	2	7	Carfentanil	4MG	5	LEFT HIP	3					Naloxone	12CC	3	IM	3:41	N		0
03/07/89	4950	32	M	4	5-6	Carfentanil	4MG	4	RT LOWER LEG	3	HEAD UP, MOUTH OPEN	24		103	Naloxone	12CC	4	IM	12:51	N		0
03/07/89	5090	11	F	7	7	Carfentanil	4MG	5	RIGHT REAR	5	LIGHTLY SEDATED	52	168	108	Naloxone	12CC	4	IM	3:50	N		1
03/07/89	5050	12	M	3	6	Carfentanil	4MG		LEFT RUMP	4	LAYING ON SIDE	24	108		Naloxone	12CC	2	IM	2:04	N		0
03/07/89	4390	10A	F	4	7	Carfentanil	4MG	3	L BK RUMP	5	HEAD UP	32	124	108	Naloxone	12CC	4	IM	3:10	N	Dead	1
03/08/89	5180	7	M		5	Carfentanil	4MG		RUMP	1	HEAD UP, LOOKED GOOD				Naloxone	12CC	2	IM	1:32	N		0
03/08/89	4790	33	M	5	5	Carfentanil	4MG	6	RIBS	5	HEAD UP	24		108	Naloxone	12CC		IM		N		0
03/09/89	4320	45	M	6	5	Carfentanil	4MG	4		4	HEAD DOWN, DEEP	24		106	Naloxone	12CC	2	IM	3:03	N		0
03/09/89	4260	37A	M	3	5	Carfentanil	4MG	9	RIGHT RUMP	3		20	78	105	Naloxone	12CC	2	IM	1:56	N	Dead	0
03/09/89	4430	36	F	7	6	Carfentanil	4MG	3	LEFT RUMP	5	HEAD UP, ALERT	24		108	Naloxone	12CC	3	IM	12:05	N		0
03/10/89	4870	30	F	4	6-7	Carfentanil	4MG	8	RIGHT RUMP	3	HEAD UP	16	70		Naloxone	12CC	2	IM	3:03	N		0
03/10/89	4120	3	F	6	7	Carfentanil	4MG	6	LEFT RIBS	4	PROSTRATE,TONGUE OUT	28	88		Naloxone	12CC	3	IM	3:35	N		0
03/10/89	4070	1	F	7	7	Carfentanil	4MG	6	LEFT RUMP	1	HEAD UP, TREMORS	18		105	Naloxone	12CC	3	IM	4:35	N		0
03/10/89	4930	4	F	5	7	Carfentanil	4MG	3	RIGHT RUMP	2		28	176	104	Naloxone	12CC	6	IM	4:26	N		0
03/10/89	4240	9	F	5	6-7	Carfentanil	4MG	6	RIGHT HIP	2	HEAD UP, MOUTH OPEN			104	Naloxone	12CC	2	IM	11:46	Y		1
03/10/89	4170	2	F		6	Carfentanil	4MG	7	RIGHT HIP	2	HEAD UP, ALERT				Naloxone	12CC	3	IM	2:06	N		1
03/10/89	4020	31	M	5	5-6	Carfentanil	4MG	4	LEFT HIP	3	HEAD UP, ALERT	20	112	105	Naloxone	12CC	3	IM	12:41	N		0
03/11/89	4740	29	F	4	7	Carfentanil	4MG	4	HIP	4		14	72	104	Naloxone	12CC	2	IM	3:38	N		2
03/11/89	4280	44	F	6	7	Carfentanil	4MG	4	RIGHT RIBS	4	LIGHT	16	70		Naloxone	12CC	4	IM	3:35	N		1
03/11/89	4720	43	F	8+	7	Carfentanil	4MG	2	RIGHT RUMP	4	HEAD UP, ALERT	20		105	Naloxone	12CC	3	IM	2:58	N		0
03/11/89	4890	40	F	10	6	Carfentanil	4MG	4	RIGHT RUMP	1	HEAD UP, ALERT	14	180	102	Naloxone	12CC	2	IM	4:20	N		0
03/11/89	4210	13	F	4	6	Carfentanil	4MG	4	RIGHT RUMP	1	LIGHT,HEAD UP	12		100	Naloxone	12CC	5	IM	11:40	N		1
03/11/89	5030	39	M	6	5	Carfentanil	4MG	3	RIGHT RUMP	2	HEAD UP	8	144	101	Naloxone	12CC	3	IM	12:05	N		0
03/11/89	4670	14	F	4	6	Carfentanil	4MG	4	RT.LEG	4	ALERT,RESTLESS			102	Naloxone	12CC	1	IM	12:48	N		1
03/11/89	4350	8	F	6	5	Carfentanil	4MG	11		2	HEAD DOWN,MOUTH OPEN			104	Naloxone	12CC	1	IM	1:01	N		1
04/04/89	4260	37B	F	6	6	Carfentanil	4MG	3	LEFT HIP	1	LYING PROSTRATE	6	76	100	Naloxone	12CC	4	IM	2:42	N	Recollar	
04/04/89	4100	35	M	4	5	Carfentanil	4MG	3	RIGHT HIP	1	HEAD UP	18	132	102	Naloxone	12CC	2	IM	3:27	N		
04/04/89	4390	10B	F	7	6	Carfentanil	4MG	4	RIGHT HIP	4	PRONE IN WATER			106	Naloxone	12CC	4	IM	4:04	N	Recollar	
04/07/89	5010	6	F	5	6	Carfentanil	4MG	4	RIGHT HIP	2	HEAD UP	10	136	103	Naloxone	12CC	4	IM	11:32	N		
04/07/89	5110	5	F	10	6	Carfentanil	4MG	3	RIGHT HIP	2	HEAD UP	12	140	101	Naloxone	12CC	2	IM	12:01	Y		
04/07/89	4850	41	F	10	6	Carfentanil	4MG	2	RIGHT HIP	1	1/2 STANDING IN SNOW	26	106	104	Naloxone	12CC		IM		N		
04/07/89	5160	42	F	10	6	Carfentanil	4MG	3	VULVA	2	HEAD UP, MAD	20	180	105	Naloxone	12CC	2	IM	1:52	N		

Cond Index = Condition Index (1-10), Time to Immobil = Time (minutes) from dart hit until moose immobilized, Dist = Disturbance (1-5), Injection to Standing = Time (minutes) from injection until moose standing, IM = Intramuscular, Recollar = Collar reused

Table 2. Number of calves observed with radio-collared moose, southwest AK, 1989-1993.

Collar Number	DATE																	
	4/89	11/89	1/90	2/90	3/90	4/90	6/90	7/90	8/90	10/90	2/91	4/91	6/91	10/91	1/92	4/92	6/92	6/93
164.070		0					2	2		2		1	1	1	1	1	0	0
164.120							2	2		2		2	1	1	1	1		
164.170		0					1	1		1		1	0		0		2	0
164.210	1					1				0	2	1						
164.240		1					2			2		2	0		0		0	
164.260										2								
164.280	1	1			1				1	1		2			0	2	2	
164.350					0			0		1				1	0		2	
164.390	1	2			2		2	0										
164.430		0								1		1		2		2		
164.670		1	1				0			0		0	2					
164.700								0		1		1		2	2			
164.720							0	0		0		2						
164.740		1		1						0			2	0	0	1		
164.850		0						1		0		0						
164.870		1			1	1				0		0	0	0	0	2		
164.890	1																	
164.930		0				1	0	0		0		0	2	2	2		0	
165.010						1	0			0			0	0				
165.090	2	0					1	0		0		2	0		0	1		
165.110							0			0			1	2	1	1	0	1

Table 3. Reproduction, recruitment, and calf survival of radio-collared moose, southwest AK, 1989-1991.

PARAMETER	YEAR		
	1989	1990	1991
Females observed	14	20	15
Females w/calves	9	14	12
%Females w/calves	64.3%	70.0%	80.0%
Single calf	8	5	4
Twins	1	9	8
% Twins	11.0%	64.3%	66.7%
Total calves	10	23	20
Total calves:100 Females	71	115	133
Total twins: 100 Females w/calves	11	64	67
Minimum recruitment[1]	50	75	73

[1]Minimum recruitment = # calves in spring: 100 Females

Table 4. Deployment and current status of radio collars on adult moose, southwest Alaska, March 1994.

Collar Number	Collar Color	Date Collared	Sex	Age	Animal Status	Collar Status	Remarks
31	Orange	3/10/89	M	5	Alive	Active	2/7/94, Killian Creek
1	Orange	3/10/89	F	7	Alive	Active	6/11/93, Youth Creek
2	Orange	3/10/89	F		Alive	Active	2/7/94, Killian Creek
9	Orange	3/10/89	F	5	Alive	Active	2/7/94, Killian Creek
44	Orange	3/11/89	F	6	Alive	Active	2/7/94, Sunshine Valley
34	Orange	3/6/89	F	2	Alive	Active	6/11/93, Ice Creek
5	Orange	4/7/89	F	10	Alive	Active	2/7/94, Sunshine Valley
37B	Orange	4/4/89	F	6	Unk.	Unk.	Missing since 10/90
40	Orange	3/11/89	F	10	Unk.	Unk.	Missing since 6/89
35	Orange	4/4/89	M	4	Mort.	Recov.	Hunter kill, 12/89
3	Orange	3/10/89	F	6	Mort.	Recov.	Dead 6/93, recovered 7/9/93
13	Orange	3/11/89	F	4	Mort.	Recov.	Dead 5/91, recovered 10/29/92
45	Orange	3/9/89	M	6	Mort.	Recov.	Found dead, last heard 8/90
8	Orange	3/11/89	F	6	Unk.	Active	Dead or slipped since 6/93, Sunshine Valley, not re
10B	Orange	4/4/89	F	7	Mort.	Recov.	Dead 6/91, recovered 10/29/92
36	Orange	3/9/89	F	7	Mort.	Active	Dead 6/93, Ongoke River, not recovered
14	Orange	3/11/89	F	4	Mort.	Recov.	Last heard 6/91, recov., date unk.
43	Orange	3/11/89	F	8+	Unk.	Recov.	Dead or slipped 6/91, recov 4/20/92
29	Orange	3/11/89	F	4	Unk.	Active	Dead or slipped since 6/92, Sunshine Valley, not re
33	Orange	3/8/89	M	5	Unk.	Active	Dead or slipped since 6/93, Killian Creek, not reco
41	Orange	4/7/89	F	10	Mort.	Recov.	Prob bear kill 6/91, recov. 10/29/92
30	Orange	3/10/89	F	4	Unk.	Active	Dead or slipped since 6/93, Youth Creek, not recov
4	Orange	3/10/89	F	5	Unk.	Active	Dead or slipped since 6/93, Youth Creek, not recov
32	Orange	3/7/89	M	4	Mort.	Recov.	Hunter kill (illegal) 1/90
6	Orange	4/7/89	F	5	Mort.	Active	Dead 4/20 (confirm 6/93), Youth Creek, not recov.
39	Orange	3/11/89	M	6	Mort.	Recov.	Prob bear kill 10/90, recov. 10/29/92
12	Orange	3/7/89	M	3	Unk.	Active	Missing since 6/89, heard 1/31/92, upper Sunshine Dead or slipped, not recovered
11	Orange	3/7/89	F	7	Unk.	Active	Dead or slipped since 6/92, Killian Creek, not reco
42	Orange	4/7/89	F	10	Mort.	Recov.	Prob bear kill 5/89
7	Orange	3/8/89	M		Mort.	Recov.	Prob bear kill 5/89

Mort. = Mortality, Unk. = Unknown, Recov. = Recovered

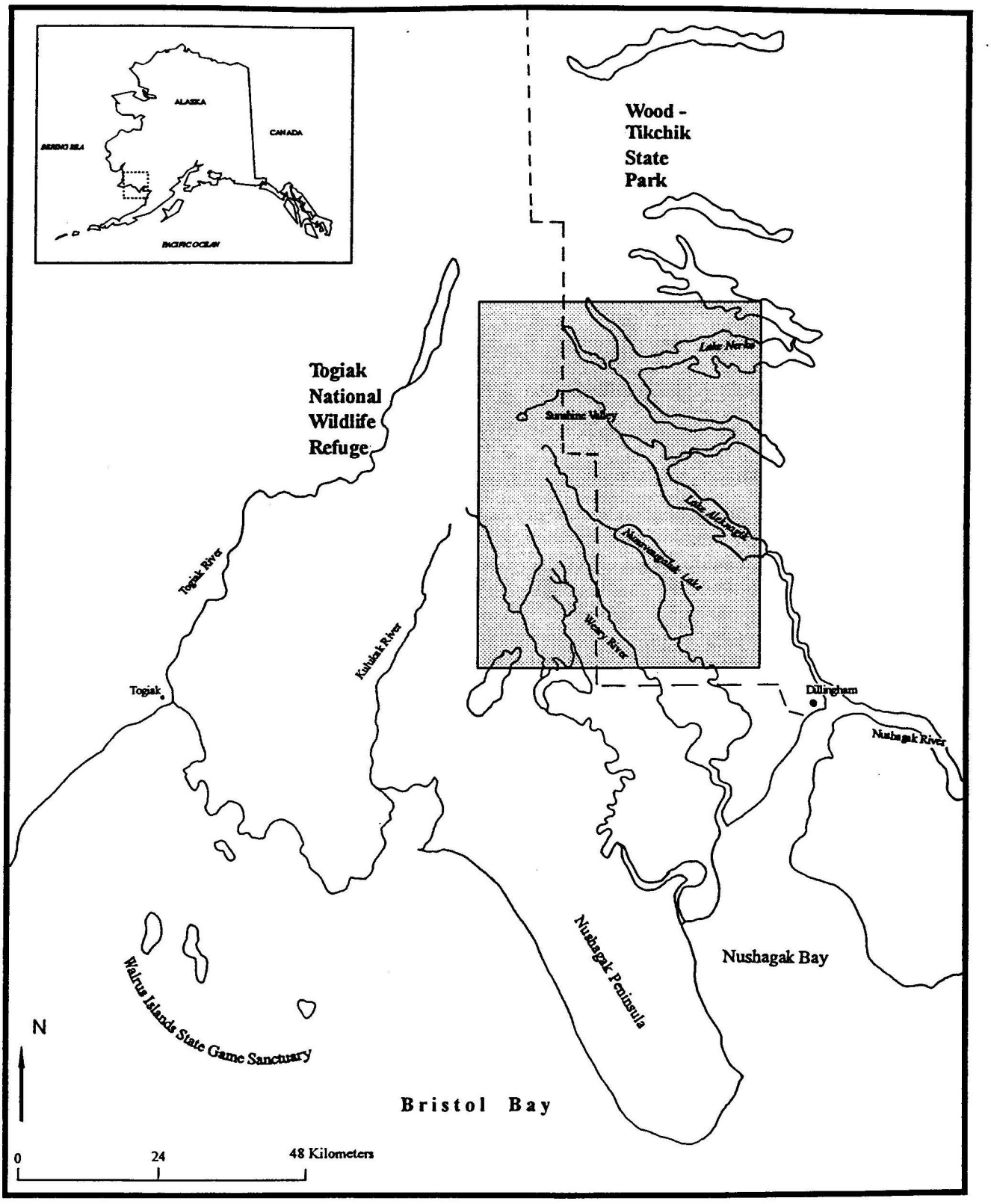

Figure 1. Location of moose study area, southwest Alaska.

Figure 2. Survey form for moose radio-telemetry flights, southwest AK.

Flight #:_____ Date:_____ Study Area/GMU:_____ Species:_____ Aircraft:_____
Pilot:_____ Observers:_____ Start Time:_____ Stop Time:_____
Wind Speed:_____ Direction:_____ Precip:_____ Temp:_____ Turb:_____ Cloud:_____
Light Type: bright____ flat____ Light Intensity: high____ medium____ low____
Snow Age: fresh____mod____old____ Snow Cond: complete____veg showing____bare____
Remarks:_____

Obs	Radio	Composition						Location			
Num	Freq	Total	Male	Fema	Calf	Yrlg	Uncl	Elev	Time	Latitude	Longitude	Remark
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												

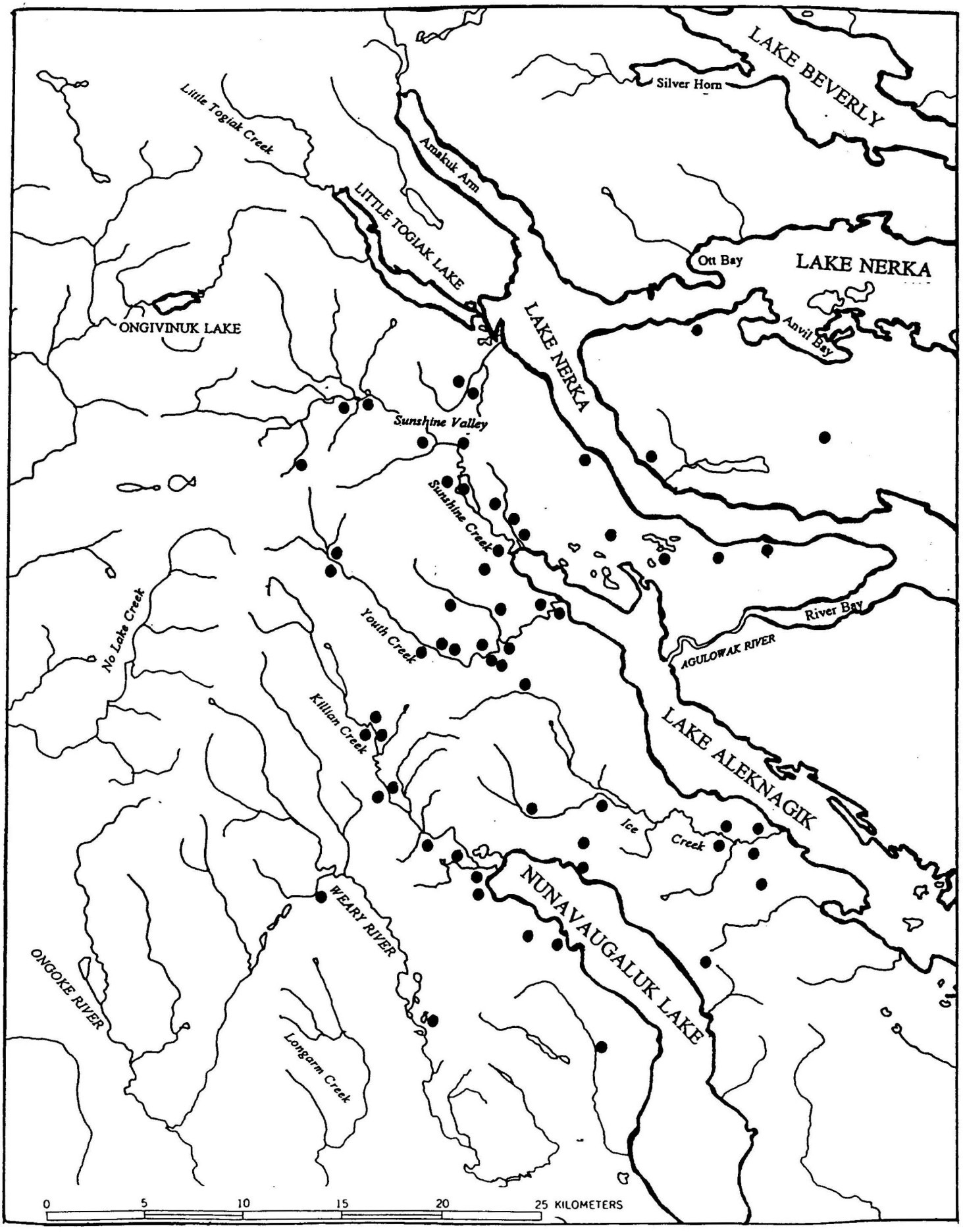

Figure 3. Location of radio-collared moose during June 1990 - 1993, southwest AK.

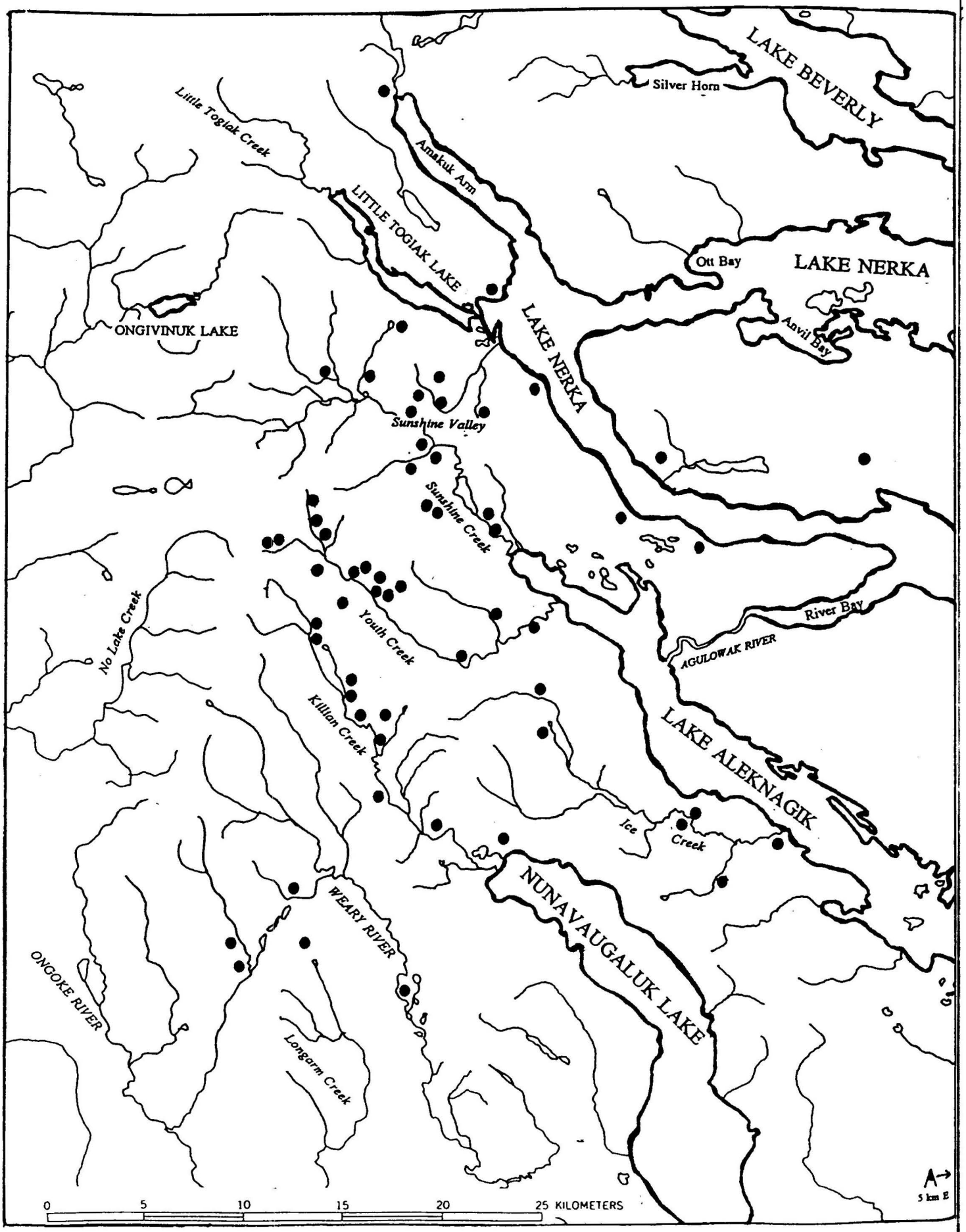

Figure 4. Location of radio-collared moose during September and October 1989 - 1991, southwest AK.

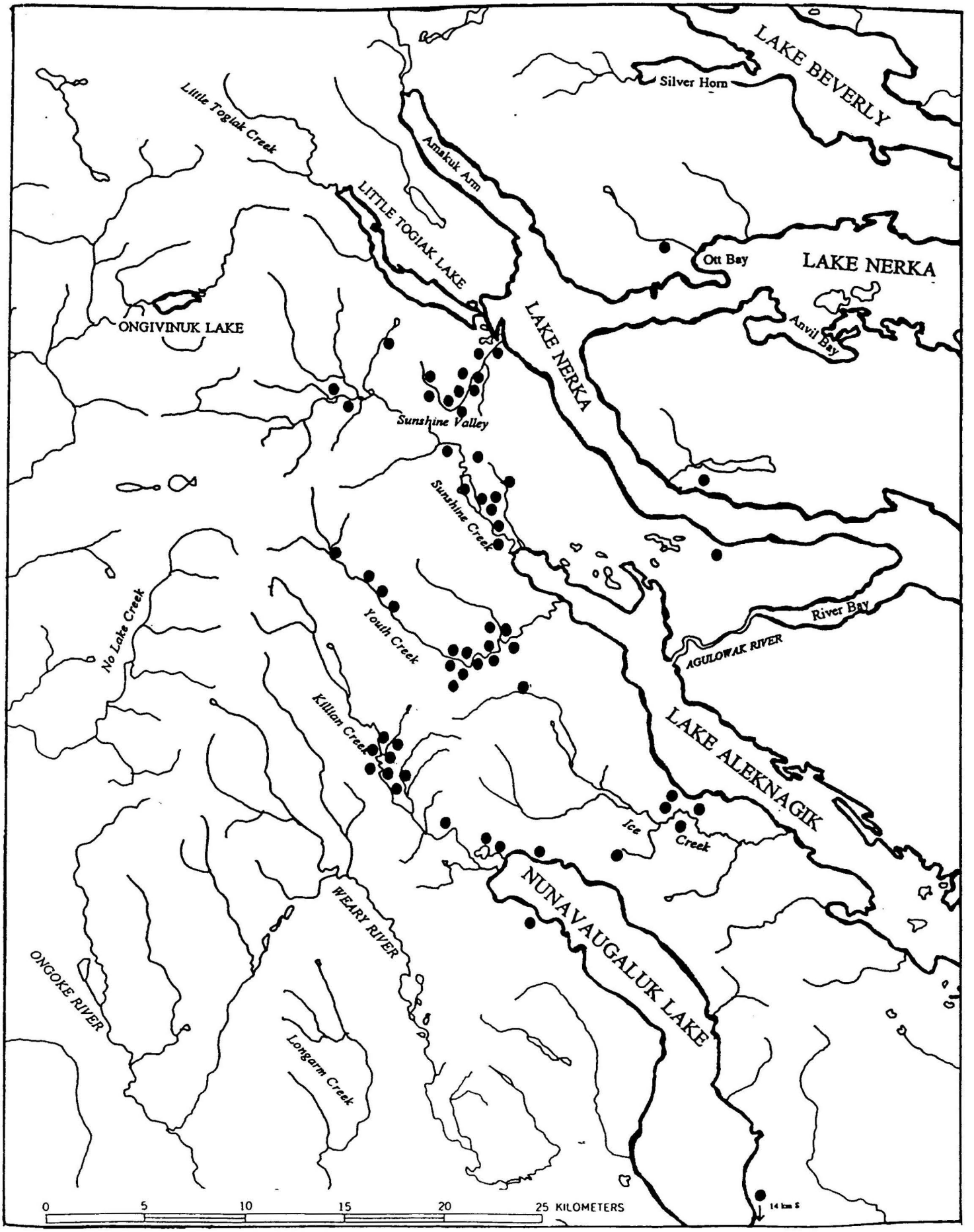

Figure 5. Location of radio-collared moose during January 1990 - 1992, southwest AK.

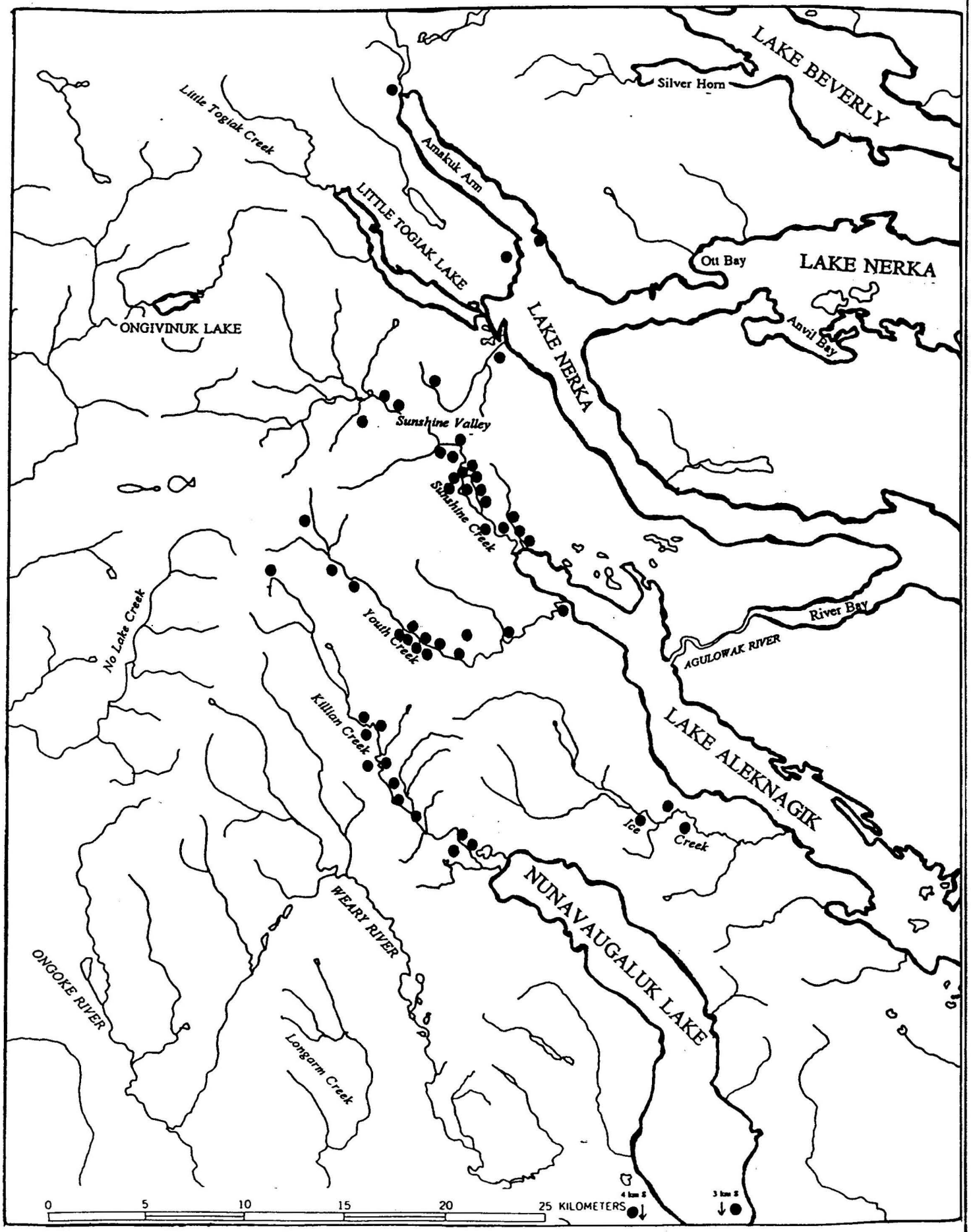

Figure 6. Location of radio-collared moose during April 1990 - 1992, southwest AK.

Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
1	3	7	89	1		1			59 21.3	159 10.8	4390	
1	3	9	89	1	1				59 12.1	159 13.9	4260	
1	3	9	89	1		1			59 17.9	159 05.3	4700	
1	3	9	89	1		1			59 13.3	159 08.8	4430	
1	3	9	89	1	1				59 13.4	159 14.5	4320	
1	3	10	89	1		1			59 32.9	159 06.5	4170	
1	3	10	89	1	1				59 21.3	159 10.8	5050	
1	3	10	89	1	1				59 24.9	159 08.8	4790	
1	3	10	89	1		1			59 21.3	159 10.8	5090	
1	3	11	89	1		1			59 32.1	159 12.5	4350	
1	3	11	89	1	1				59 24.9	159 08.8	5180	
1	3	11	89	1		1			59 24.9	159 04.8	4070	
1	3	11	89	1		1			59 32.9	159 06.5	4210	
1	3	11	89	1	1				59 24.3	159 14.0	4020	
1	3	11	89	1		1			59 30.2	159 12.5	4720	
1	3	11	89	1		1			59 25.6	159 08.5	4120	
1	3	11	89	1	1				59 31.2	159 07.7	5030	
1	3	11	89	1		1			59 25.4	159 09.0	4870	
1	3	11	89	1		1			59 29.9	159 09.8	4890	
1	3	11	89	1		1			59 31.2	159 12.1	4670	
1	3	11	89	1		1			59 29.8	159 11.0	4740	
1	3	11	89	1		1			59 24.6	159 04.1	4930	
1	3	11	89	1		1			59 29.8	159 11.0	4280	
1	3	11	89	1		1			59 23.4	159 12.9	4240	
1	3	11	89	1	1				59 21.3	159 10.8	4950	
2	4	3	89	1	1				59 24.2	159 06.5	5180	
2	4	3	89	1	1				59 22.8	159 12.1	4950	
2	4	3	89	1	1				59 24.1	159 05.8	4790	
2	4	3	89	1				1	59 14.2	159 13.1	0	
2	4	3	89	1				1	59 17.4	159 10.4	0	
2	4	3	89	1		1			59 27.5	159 13.7	4930	
2	4	3	89	1		1			59 24.7	159 04.2	4870	
2	4	3	89	1		1			59 23.7	159 05.6	4700	
2	4	3	89	1		1			59 24.7	159 04.2	4120	
2	4	3	89	1		1			59 23.8	159 05.2	4070	
2	4	3	89	1	1				59 20.2	159 18.4	4020	
2	4	3	89	1		1			59 23.3	159 08.8	4240	
2	4	3	89	Capture mortality, collar retrieved, placed on female moose					59 18.4	159 10.8	4260	
2	4	3	89	1	1				59 15.6	159 15.8	4320	
2	4	3	89	Capture mortality, collar retrieved, placed on female moose					59 22.8	159 12.1	4390	
2	4	3	89	1		1			59 10.6	159 13.1	4430	
2	4	5	89	1		1			59 31.7	159 12.6	4720	
2	4	5	89	3		1	2		59 25.3	159 14.5	5090	2
2	4	5	89	2		1	1		59 30.5	159 07.8	4890	1
2	4	5	89	1		1			59 31.0	159 12.3	4740	
2	4	5	89	1	1				59 32.1	159 06.5	5030	
2	4	5	89	1		1			59 31.0	159 12.3	4670	
2	4	5	89	2		1	1		59 18.4	159 12.2	4390	1
2	4	5	89	2		1	1		59 34.5	159 01.1	4210	1
2	4	5	89	1		1			59 21.3	159 20.1	4260	
2	4	5	89	2		1	1		59 29.9	159 08.4	4280	1
2	4	5	89	1		1			59 30.7	159 06.0	4350	
3	4	18	89	1		1			59 29.8	159 08.1	4240	
3	4	18	89	1		1			59 28.8	159 08.1	4720	
3	4	18	89	1		1			59 29.8	159 08.1	5160	
3	4	18	89	1		1			59 29.2	159 04.6	5110	

SUR# = survey number MON = month YR = year UNCLS. = unclassified

Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
3	4	18	89	1		1			59 19.5	158 51.6	5010	
3	4	18	89	Mortality, possible bear kill							5180	
3	4	18	89	Mortality, possible bear kill							5160	
4	9	26	89	2	1	1			59 27.7	159 14.5	4930	
4	9	26	89	1		1			59 28.4	159 57.1	4720	
4	9	26	89	1		1			59 29.9	159 54.9	4850	
4	9	26	89	1		1			59 24.2	159 05.3	4870	
4	9	26	89	1		1			59 18.4	159 14.2	5090	
4	9	26	89	1	1				59 20.3	158 53.4	4950	
4	9	26	89	1		1			59 19.8	158 53.3	5010	
4	9	26	89	1	1				59 32.1	159 12.4	5030	
4	9	26	89	1		1			59 30.5	159 05.5	5110	
4	9	26	89	1		1			59 31.2	159 07.4	4670	
4	9	26	89	1		1			59 22.4	159 00.6	4700	
4	9	26	89	1	1				59 16.2	159 17.3	4100	
4	9	26	89	1	1				59 10.7	158 34.8	4790	
4	9	26	89	2		1		1	59 27.7	159 53.5	4210	
4	9	26	89	1	1				59 22.8	159 10.2	4020	
4	9	26	89	1		1			59 25.5	159 01.7	4120	
4	9	26	89	1		1			59 22.3	159 10.1	4170	
4	9	26	89	1		1			59 29.8	159 08.4	4740	
4	9	26	89	1		1			59 19.5	159 02.6	4240	
4	9	26	89	1		1			59 16.1	159 17.0	4260	
4	9	26	89	1		1			59 28.6	159 06.7	4280	
4	9	26	89	1		1			59 15.7	159 08.9	4390	
4	9	26	89	1		1			59 31.9	159 01.6	4350	
4	9	26	89	1	1				59 19.7	158 48.8	4320	
5	11	29	89	1		1			59 24.7	159 03.6	4700	
5	11	29	89	1		1			59 31.6	159 10.5	4850	0
5	11	29	89	5	2	3			59 29.5	159 54.4	4720	
5	11	29	89	3		2	1		59 24.2	159 05.5	4740	1
5	11	29	89	1	1				59 25.7	159 09.8	4790	
5	11	29	89	1		1			59 26.3	159 10.5	4930	0
5	11	29	89	2		1	1		59 26.3	159 11.3	4870	1
5	11	29	89	2		2			59 31.1	159 04.8	5110	
5	11	29	89	2	1			1	59 22.3	159 00.2	4950	
5	11	29	89	1	1				59 25.2	159 02.7	5030	
5	11	29	89	1		1			59 21.2	159 09.9	5090	0
5	11	29	89	4	2	2			59 24.5	159 05.1	5010	
5	11	29	89	3		1	2		59 20.3	159 08.5	4390	2
5	11	29	89	2		1	1		59 28.9	159 05.5	4670	1
5	11	29	89	1		1			59 28.9	159 12.3	4170	0
5	11	29	89	1	1				59 25.9	159 09.9	4020	
5	11	29	89	1		1			59 16.1	159 35.2	4430	0
5	11	29	89	1	1				59 15.1	159 18.1	4100	
5	11	29	89	4	1	2		1	59 27.1	159 12.8	4120	
5	11	29	89	1		1			59 26.0	159 10.3	4070	0
5	11	29	89	1		1			59 35.9	158 40.5	4210	
5	11	29	89	21		1		20	59 22.4	159 10.3	4260	
5	11	29	89	2		1	1		59 31.1	159 09.5	4280	1
5	11	29	89	2	1			1	59 20.0	158 53.8	4320	
5	11	29	89	21		1		20	59 24.9	159 04.0	4350	
5	11	29	89	2		1	1		59 19.9	159 07.9	4240	1
	12		89	Mortality, hunter kill							4100	
6	1	7	90	1	1				59 28.9	159 06.0	4950	
6	1	7	90	1	1				59 24.8	159 05.6	4790	

SUR # = survey number MON = month YR = year UNCLS. = unclassified

Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
6	1	7	90	4	1	2		1	59 24.3	159 05.6	4870	
6	1	7	90	1		1			59 29.8	159 05.6	4930	
6	1	7	90	1		1			59 21.2	159 10.0	5090	
6	1	7	90	1		1			59 29.8	159 04.6	5010	
6	1	7	90	3	3				59 31.9	159 05.4	5030	
6	1	7	90	2		2			59 30.2	159 06.8	5110	
6	1	7	90	2	1	1			59 29.1	158 53.2	4720	
6	1	7	90	1		1			59 31.9	159 05.6	4740	
6	1	7	90	10		1		9	59 31.6	159 07.2	4850	
6	1	7	90	1		1			59 28.5	159 03.4	4700	
6	1	7	90	2		1	1		59 31.2	159 06.1	4670	1
6	1	7	90	3	1	2			59 35.6	158 54.5	4210	
6	1	7	90	1		1			59 29.8	159 05.6	4070	
6	1	7	90	4		1		3	59 17.7	159 02.0	4390	
6	1	7	90	1		1			59 29.8	159 05.6	4120	
6	1	7	90	1		1			59 29.8	159 05.6	4170	
6	1	7	90	2		1		1	59 19.1	159 01.7	4240	
6	1	7	90	10		1		9	59 22.1	159 10.3	4260	
6	1	7	90	1		1			59 28.4	159 04.7	4280	
6	1	7	90	1	1				59 20.4	158 54.2	4320	
6	1	7	90	1	1				59 29.8	159 05.6	4020	
6	1	7	90	1		1			59 32.3	159 04.5	4350	
7	2	5	90	3				3	59 27.5	159 02.8	0	
7	2	5	90	2				2	59 35.5	159 03.1	4210	
7	2	5	90	2				2	59 29.3	159 54.6	0	
7	2	5	90	2		1		1	59 28.1	158 54.0	4720	
7	2	5	90	1		1			59 27.9	159 03.1	4850	
7	2	5	90	1		1			59 27.3	159 03.3	4070	
7	2	5	90	1				1	59 27.2	159 03.2	0	
7	2	5	90	3		1		2	59 27.9	159 03.0	4930	
7	2	5	90	4		1		3	59 27.9	159 02.9	5010	
7	2	6	90	2		1		1	59 28.6	159 04.7	4670	
7	2	6	90	3	1			2	59 29.1	159 05.3	0	
7	2	6	90	2				2	59 29.5	159 05.6	0	
7	2	6	90	1		1			59 29.4	159 05.4	4280	
7	2	6	90	2				2	59 28.7	159 05.1	0	
7	2	6	90	2				2	59 29.0	159 05.1	0	
7	2	6	90	2		1	1		59 28.8	159 04.5	0	
7	2	6	90	2		1	1		59 30.5	159 06.8	4740	1
7	2	6	90	1		1			59 16.2	158 09.4	4390	
7	2	6	90	1	1				59 17.7	158 49.2	4320	
7	2	6	90	5				5	59 32.4	159 05.3	0	
7	2	6	90	5				5	59 28.9	159 04.9	0	
7	2	6	90	4	1	1	1	1	59 30.4	159 06.8	0	
7	2	6	90	6		2	2	2	59 30.5	159 06.5	0	
7	2	6	90	1		1			59 21.3	159 09.1	5090	
7	2	6	90	3				3	59 24.7	159 04.1	0	
7	2	6	90	6	1			5	59 25.4	159 03.9	4020	
7	2	6	90	7	2			5	59 21.7	159 08.5	0	
7	2	6	90	3	2	1			59 20.8	159 08.6	0	
7	2	6	90	2		1		1	59 26.4	159 11.1	4870	
7	2	6	90	1		1			59 19.5	159 05.1	4260	
7	2	6	90	5				5	59 30.7	159 07.1	0	
7	2	6	90	2		1		1	59 21.4	159 07.7	4240	
7	2	6	90	1		1			59 24.9	159 04.9	4170	
7	2	6	90	3	1			2	59 25.2	159 03.8	4790	

SUR # = survey number MON = month YR = year UNCLS. = unclassified

Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
7	2	6	90	1				1	59 26.2	159 10.4	0	
7	2	6	90	4		1		3	59 28.0	159 04.6	4700	
7	2	6	90	1		1			59 30.7	159 07.5	4350	
7	2	6	90	5				5	59 31.0	159 08.3	0	
7	2	6	90	2				2	59 28.3	159 04.4	0	
7	2	6	90	1				1	59 30.5	159 07.3	0	
7	2	6	90	5	2			3	59 30.4	159 07.1	0	
7	2	6	90	2		2			59 30.3	159 07.4	0	
7	2	6	90	1		1			59 28.1	159 03.2	4120	
7	2	6	90	3		3			59 28.5	159 04.7	5110	
7	2	6	90	Mortality, hunter kill							4950	
8	3	16	90	4		2	1	1	59 31.1	159 08.7	0	
8	3	16	90	2		1	1		59 31.5	159 10.3	0	
8	3	16	90	9		1		8	59 30.9	159 08.4	4670	
8	3	16	90	10		2		8	59 30.8	159 08.0	4740	
8	3	16	90	2				2	59 30.7	159 07.5	0	
8	3	16	90	2		2			59 30.4	159 06.5	0	
8	3	16	90	1				1	59 30.5	159 07.3	0	
8	3	16	90	2		1	1		59 30.4	159 07.4	0	
8	3	16	90	2				2	59 30.3	159 07.3	0	
8	3	16	90	3		1	1	1	59 30.3	159 07.0	0	
8	3	16	90	4		1		3	59 30.3	159 06.5	4850	
8	3	16	90	22				22	59 31.4	159 11.4	0	
8	3	16	90	5		1		4	59 31.6	159 10.8	4350	0
8	3	16	90	3		1	2		59 08.8	158 53.3	4390	2
8	3	16	90	7				7	59 31.6	159 11.4	0	
8	3	16	90	2	1			1	59 40.3	159 09.2	5030	
8	3	16	90	3		2	1		59 30.1	159 06.4	0	
8	3	16	90	2				2	59 08.5	158 53.1	0	
8	3	16	90	1				1	59 08.7	158 53.0	0	
8	3	16	90	1	1				59 17.2	158 50.7	4320	
8	3	16	90	1				1	59 27.9	158 53.0	0	
8	3	16	90	1				1	59 37.6	159 04.4	0	
8	3	16	90	5				5	59 31.5	159 06.5	0	
8	3	16	90	1		1			59 28.1	158 53.5	4720	
8	3	16	90	4				4	59 29.3	158 54.4	0	
8	3	16	90	2		1		1	59 34.7	159 03.9	4210	
8	3	16	90	3				3	59 32.4	159 05.2	0	
8	3	16	90	3		1	2		59 30.2	159 06.0	0	
8	3	16	90	13	2	1		10	59 25.0	159 08.1	4170	
8	3	16	90						59 25.0	159 08.1	4020	
8	3	16	90						59 25.0	159 08.1	4790	
8	3	16	90	3		2	1		59 26.4	159 10.9	4870	1
8	3	16	90	1				1	59 25.8	159 10.0	0	
8	3	16	90	2		1	1		59 28.7	159 05.1	0	
8	3	16	90	1		1			59 28.8	159 03.2	5010	
8	3	16	90	3		1	1	1	59 21.3	159 10.2	0	
8	3	16	90	1				1	59 24.6	159 07.0	0	
8	3	16	90	2				2	59 24.8	159 03.8	0	
8	3	16	90	7		1		6	59 19.4	159 05.8	4260	
8	3	16	90	1		1			59 20.2	159 07.6	4240	
8	3	16	90	5				5	59 20.8	159 09.4	0	
8	3	16	90	2		1		1	59 21.3	159 09.4	5090	
8	3	16	90	2				2	59 24.6	159 04.2	0	
8	3	16	90	2		1	1		59 25.2	159 08.6	0	
8	3	16	90	3				3	59 24.6	159 04.0	0	

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Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
8	3	16	90	3				3	59 27.3	159 02.7	0	
8	3	16	90	3		1	2		59 28.8	159 03.5	0	
8	3	16	90	6		3	1	2	59 28.9	159 05.1	4280	1
8	3	16	90						59 28.9	159 05.1	4930	
8	3	16	90	1		1			59 28.1	159 04.1	5110	
8	3	16	90	1		1			59 29.0	159 03.5	4700	
8	3	16	90	2		1	1		59 27.2	159 03.2	0	
8	3	16	90	6		3	1	2	59 27.1	159 03.3	4120	
8	3	16	90						59 27.1	159 03.3	4070	
8	3	16	90	2				2	59 27.3	159 03.0	0	
8	3	16	90	1				1	59 27.4	159 03.2	0	
8	3	16	90	2				2	59 27.8	159 03.6	0	
8	3	16	90	2				2	59 28.1	159 04.5	0	
9	4	17	90	3		1		2	59 29.7	159 05.8	4670	
9	4	17	90	3				3	59 28.2	159 04.2	0	
9	4	17	90	1		1			59 29.2	159 05.5	4120	
9	4	17	90	4		1		3	59 29.4	159 06.1	4280	
9	4	17	90	1		1			59 29.0	159 06.2	4850	
9	4	17	90	1		1			59 27.8	158 53.7	4720	
9	4	17	90	4		1		3	59 29.9	159 06.0	4350	
9	4	17	90	2		1	1		59 31.1	159 03.6	4210	1
9	4	17	90	2	1			1	59 40.2	159 09.2	5030	
9	4	17	90	9		1		8	59 31.6	159 10.5	4740	
9	4	17	90	6		2	1	3	59 29.0	159 04.9	4930	1
9	4	17	90						59 29.0	159 04.9	4070	
9	4	17	90	2		1	1		59 26.0	159 01.0	5010	1
9	4	17	90	3		1		2	59 29.4	159 05.3	5110	
9	4	17	90	5		1		4	59 19.8	159 07.3	4240	
9	4	17	90	3				3	59 27.5	159 02.5	0	
9	4	17	90	2		1		1	59 08.1	158 52.0	4390	
9	4	17	90	1	1				59 15.7	158 51.0	4320	
9	4	17	90	1		1			59 19.4	159 05.5	4260	
9	4	17	90	1				1	59 19.6	159 06.7	0	
9	4	17	90	20				20	59 31.0	159 08.8	0	
9	4	17	90	2		1		1	59 21.2	159 09.0	5090	
9	4	17	90	5				5	59 21.2	159 08.5	0	
9	4	17	90	2		1	1		59 24.9	159 03.4	4870	1
9	4	17	90	4	1			3	59 25.2	159 08.6	4020	
9	4	17	90	3		1		2	59 27.5	159 02.5	4700	
9	4	17	90	3	1			2	59 24.6	159 07.3	4790	
9	4	17	90	1		1			59 25.5	159 09.3	4170	
10	5	21	90	1		1			59 28.6	159 06.3	4930	
10	5	21	90	1		1			59 23.2	158 45.4	4280	
10	5	21	90	1		1			59 28.9	158 57.6	4850	
10	5	21	90	1		1			59 27.9	158 54.8	4720	
10	5	21	90	1		1			59 35.4	158 34.0	4210	
10	5	21	90	1		1			59 29.7	158 58.2	4350	
10	5	21	90	1		1			59 29.7	159 06.2	4740	
10	5	21	90	1		1			59 29.9	159 05.6	4670	
10	5	21	90	1		1			59 26.7	159 05.0	4070	
10	5	21	90	1		1			59 19.0	158 55.5	4240	
10	5	21	90	1		1			59 24.6	159 03.5	4870	
10	5	21	90	1	1				59 24.4	159 04.9	4790	
10	5	21	90	1		1			59 25.1	159 03.8	4120	
10	5	21	90	1		1			59 29.7	159 05.5	5110	
10	5	21	90	1		1			59 25.7	159 09.7	4170	

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Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
11	6	20	90	1		1			59 19.3	158 52.5	5010	0
11	6	20	90	1		1			59 27.3	158 52.6	4720	0
11	6	20	90	1		1			59 29.9	158 50.5	4700	
11	6	20	90	3		1	2		59 16.7	158 52.7	4240	2
11	6	20	90	3	1	1	1		59 18.1	158 50.2	4320	
11	6	20	90	1		1			59 14.6	159 07.7	4260	
11	6	20	90	1		1			59 28.1	158 57.2	4350	
11	6	20	90	1		1			59 27.6	158 49.4	4850	
11	6	20	90	3		1	2		59 24.8	159 03.6	4120	2
11	6	20	90	1		1			59 30.3	159 06.2	4670	0
11	6	20	90	1		1			59 25.6	159 00.1	4870	
11	6	20	90	1		1			59 31.8	159 05.4	4740	
11	6	20	90	2		1	1		59 16.6	159 00.2	4170	1
11	6	20	90	2		1	1		59 20.6	159 09.8	5090	1
11	6	20	90	3		1	2		59 16.7	159 01.9	4390	2
11	6	20	90	1		1			59 27.4	159 12.2	4930	0
11	6	20	90	1		1			59 27.9	159 03.0	5110	0
11	6	20	90	3		1	2		59 24.3	159 03.9	4070	2
12	7	12	90	1		1			59 25.4	159 04.1	4870	
12	7	12	90	1		1			59 25.7	159 09.8	4930	0
12	7	12	90	1	1				59 25.4	159 02.7	0	
12	7	12	90	3		1	2		59 26.1	159 08.4	4070	2
12	7	12	90	1	1				59 26.3	159 09.5	4790	
12	7	12	90	1		1			59 16.2	158 56.7	4240	
12	7	12	90	2		1	1		59 16.9	159 01.3	4170	1
12	7	12	90	1		1			59 14.8	159 08.5	4390	0
12	7	12	90	3		1	2		59 20.2	159 00.8	0	
12	7	12	90	1		1			59 20.9	159 00.5	4700	0
12	7	12	90	3		1	2		59 25.7	159 04.2	4120	2
12	7	12	90	1		1			59 19.5	159 13.3	5090	0
12	7	12	90	2		1	1		59 25.1	159 03.8	0	
12	7	12	90	2		1	1		59 29.5	158 37.4	4850	1
12	7	12	90	2		1	1		59 31.7	159 05.8	0	
12	7	12	90	1		1			59 30.2	158 37.5	4720	0
12	7	12	90	1		1			59 38.5	158 46.9	4210	
12	7	12	90	1	1				59 32.5	159 04.7	5030	
12	7	12	90	1		1			59 31.7	159 08.7	4670	
12	7	12	90	1	1				59 21.5	159 08.0	0	
12	7	12	90	2	1	1			59 31.9	159 07.9	4740	
12	7	12	90	1	1				59 38.2	158 44.5	0	
12	7	12	90	1		1			59 29.9	158 58.7	4350	0
12	7	12	90	1		1			59 28.9	159 04.9	5110	
12	7	12	90	2		1		1	59 30.4	158 37.5	0	
12	7	12	90	2	1	1			59 29.5	158 59.0	0	
13	8	15	90	1		1			59 29.6	158 58.9	4350	
13	8	15	90	1		1			59 31.9	159 05.7	4670	
13	8	15	90	1	1				59 33.1	159 04.2	5030	
13	8	15	90	1		1			59 28.9	158 41.5	4850	
13	8	15	90	1		1			59 30.0	158 41.8	4720	
13	8	15	90	1		1			59 17.0	159 16.3	4260	
13	8	15	90	1		1			59 36.6	158 39.5	4210	
13	8	15	90	1		1			59 28.7	159 04.8	5110	
13	8	15	90	1		1			59 30.6	159 06.9	4740	
13	8	15	90	2		1	1		59 29.0	159 16.2	4280	1
13	8	15	90	1	1				59 22.4	159 06.4	4790	
13	8	15	90	1		1			59 23.3	159 08.5	4930	

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Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
13	8	15	90	1		1			59 21.7	159 00.3	4170	
13	8	15	90	1		1			59 15.1	159 18.3	4390	
13	8	15	90	1		1			59 26.4	159 11.1	4870	
13	8	15	90	1		1			59 18.8	158 55.5	5010	
13	8	15	90	1		1			59 18.9	158 56.6	4240	
13	8	15	90	1	1				59 18.2	158 56.4	4320	
13	8	15	90	1		1			59 20.6	159 02.1	4700	
13	8	15	90	1		1			29 25.0	159 06.9	4070	
13	8	15	90	1		1			59 24.3	159 06.7	4120	
13	8	15	90	1		1			59 24.4	159 13.4	5090	
14	10	30	90	2		1	1		59 19.6	158 51.1	4700	1
14	10	30	90	2		1	1		59 30.4	159 07.3	4280	1
14	10	30	90	1		1			59 29.7	159 06.2	5110	0
14	10	30	90	Mortality, possible bear kill					59 33.1	159 10.2	5030	
14	10	30	90	1		1			59 30.2	158 43.4	4720	0
14	10	30	90	3		1	2		59 27.6	159 14.9	4070	2
14	10	30	90	2		1	1		59 06.1	159 34.7	4430	1
14	10	30	90	3		1	2		59 17.2	159 14.8	4260	2
14	10	30	90	1		1			59 28.3	159 04.2	4740	0
14	10	30	90	1		1			59 31.8	159 06.8	4670	0
14	10	30	90	1		1			59 29.9	159 08.5	4850	0
14	10	30	90	1		1			59 34.3	159 04.0	4210	0
14	10	30	90	1		1			59 27.1	159 12.8	4870	0
14	10	30	90	2		1	1		58 28.9	159 08.1	4350	1
14	10	30	90	9	1			8	59 25.1	159 14.0	4020	
14	10	30	90	13		1		12	59 23.7	159 11.8	5090	0
14	10	30	90	3		1	2		59 19.7	159 07.0	4240	2
14	10	30	90	1		1			59 26.9	159 12.1	5010	0
14	10	30	90	1		1			59 26.5	159 09.9	4930	0
14	10	30	90	2		1	1		59 27.8	159 12.4	4170	1
14	10	30	90	3		1	2		59 26.3	159 11.5	4120	2
14	10	30	90	Mortality, exact date unknown							4320	
16	2	7	91	3		1		2	59 32.8	159 04.8	4850	
16	2	7	91	1		1			59 28.5	159 07.2	4280	
16	2	7	91	5	1			4	59 20.7	158 55.4	4790	
16	2	7	91	3		1	2		59 33.2	159 04.8	4210	2
16	2	7	91	3		1		2	59 27.7	158 53.5	4720	
16	2	7	91	3		1		2	59 31.6	159 08.5	4740	
16	2	7	91	3		1		2	59 06.5	159 45.5	4430	
16	2	7	91	3		1		2	59 31.3	159 06.7	4350	
16	2	7	91	1		1			59 20.0	158 55.0	4700	
16	2	7	91	3		1		2	59 31.7	159 09.5	4670	
16	2	7	91	4		1		3	59 18.9	159 04.2	4240	
16	2	7	91	2		1		1	59 07.3	158 54.2	4390	
16	2	7	91	1		1			59 19.8	159 06.8	4170	
16	2	7	91	2		1		1	59 19.1	159 04.7	5090	
16	2	7	91	4		1		3	59 27.8	159 04.4	5110	
16	2	7	91	2		1		1	59 23.6	159 02.7	4070	
16	2	7	91	3		1		2	59 25.7	159 04.2	4870	
16	2	7	91	2		1		1	59 24.7	159 03.8	4120	
16	2	7	91	3		1		2	59 27.6	159 03.3	5010	
16	2	7	91	2		1		1	59 25.3	159 04.0	4930	
17	4	4	91	16		1		15	59 31.2	159 08.5	4350	
17	4	4	91	1		1			59 29.5	159 05.5	4740	
17	4	4	91	4		1		3	59 28.2	159 03.6	5110	
17	4	4	91	3		1		2	59 29.9	159 05.8	4670	0

SUR # = survey number MON = month YR = year UNCLS. = unclassified

Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
17	4	4	91	1		1			59 27.8	159 03.1	5010	
17	4	4	91	3		1	2		59 29.9	159 11.9	4280	2
17	4	4	91	2		1	1		59 35.1	159 02.1	4210	1
17	4	4	91	3		1	2		59 27.5	158 52.3	4720	2
17	4	4	91	3		1		2	59 29.7	158 58.2	4850	0
17	4	4	91	3		1	2		59 26.4	159 11.2	4120	2
17	4	4	91	2		1	1		59 26.8	159 12.3	4070	1
17	4	4	91	3		1	2		59 21.3	159 12.2	5090	2
17	4	4	91	6		2		4	59 25.8	159 09.8	4930	0
17	4	4	91						59 25.8	159 09.8	4870	0
17	4	4	91	2		1	1		59 03.6	159 47.3	4430	1
17	4	4	91	3		1	2		59 20.6	159 09.7	4240	2
17	4	4	91	5		4	1		59 21.4	159 09.6	0	
17	4	4	91	4		2	2		59 22.7	159 10.8	0	
17	4	4	91	7	1	4	2		59 21.7	159 10.2	4170	1
17	4	4	91	3		2	1		59 21.7	159 08.6	0	
17	4	4	91	3		1	1	1	59 20.3	158 55.0	4700	1
17	4	4	91	3	1	1	1		59 25.9	159 14.5	4020	0
17	4	4	91	3	1	1	1		59 20.2	158 53.5	4790	
17	4	4	91	1		1			59 07.6	158 56.1	4390	
18	5	15	91	3		1		2	59 30.5	159 05.2	4350	
18	5	15	91	3	1	2			59 19.8	159 12.0	4020	
18	5	15	91	1		1			59 19.0	159 03.7	4170	
18	5	15	91	1		1			59 19.1	159 04.1	4240	
18	5	15	91	3	1	2			59 18.9	159 04.1	5090	
18	5	15	91	2		1		1	59 26.0	159 10.5	4930	
18	5	15	91	1		1			59 25.3	159 01.5	4120	
18	5	15	91	1		1			59 16.6	159 08.5	4390	
18	5	15	91	1		1			59 25.5	159 01.5	4070	
18	5	15	91	1		1			59 25.5	159 01.0	5010	
18	5	15	91	1	1				59 19.8	158 55.5	4790	
18	5	15	91	1		1			59 20.3	158 55.6	4700	
18	5	15	91	1		1			59 26.3	158 57.3	4870	
18	5	15	91	1		1			59 29.0	158 52.0	4850	
18	5	15	91	Mortality					59 33.5	158 52.0	4210	
18	5	15	91	1		1			59 28.1	159 01.8	5110	
18	5	15	91	1		1			59 28.0	159 02.5	4670	
18	5	15	91	1		1			59 28.2	159 02.5	4740	
19	6	5	91	1	1				59 19.7	158 48.8	4790	
19	6	5	91	1		1			59 19.7	158 48.7	4700	
19	6	5	91	1		1			59 19.3	158 48.8	5010	0
19	6	5	91	Mortality or shed collar					59 29.7	158 45.0	4720	
19	6	5	91	1		1			59 29.6	158 59.0	4350	
19	6	5	91	1		1			59 27.3	158 59.0	4280	
19	6	5	91	3		1	2		59 31.7	159 11.3	4670	2
19	6	5	91	2		1	1		59 27.7	159 03.4	5110	1
19	6	5	91	3		1	2		59 27.7	159 05.5	4930	2
19	6	5	91	2		1	1		59 24.8	159 04.4	4120	1
19	6	5	91	1		1			59 25.7	159 04.1	4870	
19	6	5	91	1				1	59 25.4	159 03.3	4070	0
19	6	5	91	1		1			59 18.5	159 05.0	5090	0
19	6	5	91	2	1	1			59 19.6	159 07.0	4240	0
19	6	5	91	3		1	2		59 28.7	159 05.2	4740	2
19	6	13	91	1		1			59 19.0	159 13.0	5090	0
19	6	13	91	1		1			59 24.9	159 04.3	4870	0
19	6	13	91	2		1	1		59 24.5	159 03.0	4070	1

SUR # = survey number MON = month YR = year UNCLS. = unclassified

Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
19	6	13	91	1		1			59 22.2	159 10.4	4170	0
19	6	13	91	Mortality, possible bear kill							4850	
19	6	13	91	Mortality							4390	
20	10	23	91	4	1	1	2		59 08.5	159 39.8	4430	2
20	10	23	91	2		2			59 25.9	159 07.4	5010	0
20	10	23	91	3		1	2		59 22.7	159 00.7	4700	2
20	10	23	91	2	1	1			59 24.6	159 07.0	4790	
20	10	23	91	4		4			59 32.5	159 07.5	4740	0
20	10	23	91	3		1	2		59 29.0	159 06.2	5110	2
20	10	23	91	2		1	1		59 32.2	159 10.5	4350	1
20	10	23	91	2		1	1		59 26.6	159 09.7	4120	1
20	10	23	91	2		1	1		59 26.0	159 09.9	4070	1
20	10	23	91	1		1			59 21.0	159 09.6	4170	
20	10	23	91	1		1			59 26.4	159 09.1	4870	0
20	10	23	91	2	1	1			59 23.4	159 11.4	4240	
20	10	23	91	2		2			59 22.9	159 11.0	5090	
20	10	23	91	1		1			59 25.0	159 12.8	4280	
20	10	23	91	3		1	2		59 27.9	159 13.6	4930	2
20	10	23	91	1	1				59 28.0	159 12.8	4020	
21	1	31	92	1	1				59 21.8	159 10.3	4790	
21	1	31	92	1		1			59 21.8	159 10.3	4280	0
21	1	31	92	1		1			59 21.8	159 10.3	4170	0
21	1	31	92	1		1			59 19.4	159 59.0	5010	
21	1	31	92	Mortality or shed collar					59 33.5	159 09.7	5050	
21	1	31	92	3		1	2		59 20.7	159 53.3	4700	2
21	1	31	92	1		1			59 31.5	159 12.0	4350	0
21	1	31	92	1		1			59 31.5	159 11.6	4740	0
21	1	31	92	2		1	1		59 28.1	159 04.0	5110	1
21	1	31	92	1		1			59 21.8	159 10.3	5090	0
21	1	31	92	3		1	2		59 26.0	159 10.5	4930	2
21	1	31	92	1		1			59 21.8	159 10.3	4240	0
21	1	31	92	1		1			59 25.0	159 03.6	4870	0
21	1	31	92	2		1	1		59 26.5	159 12.0	4070	1
21	1	31	92	1	1				59 27.4	159 13.6	4020	
21	1	31	92	2		1	1		59 26.8	159 13.4	4120	1
22	4	20	92	2		1	1		59 31.8	159 09.5	4740	1
22	4	20	92	1		1			59 28.2	159 04.2	4350	
22	4	20	92	1		1			59 25.5	159 07.5	5010	
22	4	20	92	3		1	2		59 25.2	159 09.9	4870	2
22	4	20	92	2		1	1		59 28.9	159 06.3	5110	1
22	4	20	92	2		1	1		59 25.2	159 09.9	4120	1
22	4	20	92	2		1	1		59 25.2	159 09.9	4070	1
22	4	20	92	1	1				59 19.2	159 06.1	4790	
22	4	20	92	3		1	2		59 22.7	159 12.7	4280	2
22	4	20	92	6	3	1		2	59 28.0	159 13.6	4930	
22	4	20	92	1		1			59 19.6	159 06.9	4170	
22	4	20	92	1		1			59 21.5	159 10.8	4240	
22	4	20	92	2		1	1		59 22.7	159 12.2	5090	1
22	4	27	92	3		1	2		59 19.2	159 26.2	4430	2
23	6	9	92	3		1		2	59 28.6	159 04.0	5110	0
23	6	9	92	3		1	2		59 23.6	159 02.3	4170	2
23	6	9	92	3		1	2		59 27.3	158 55.0	4350	2
23	6	9	92	Mortality or shed collar					59 30.8	159 07.5	4740	
23	6	9	92	1		1			59 20.5	158 57.1	4700	
23	6	9	92	1		1			59 27.5	159 05.4	4930	0
23	6	9	92	1		1			59 25.8	159 00.7	4120	

SUR# = survey number MON = month YR = year UNCLS. = unclassified

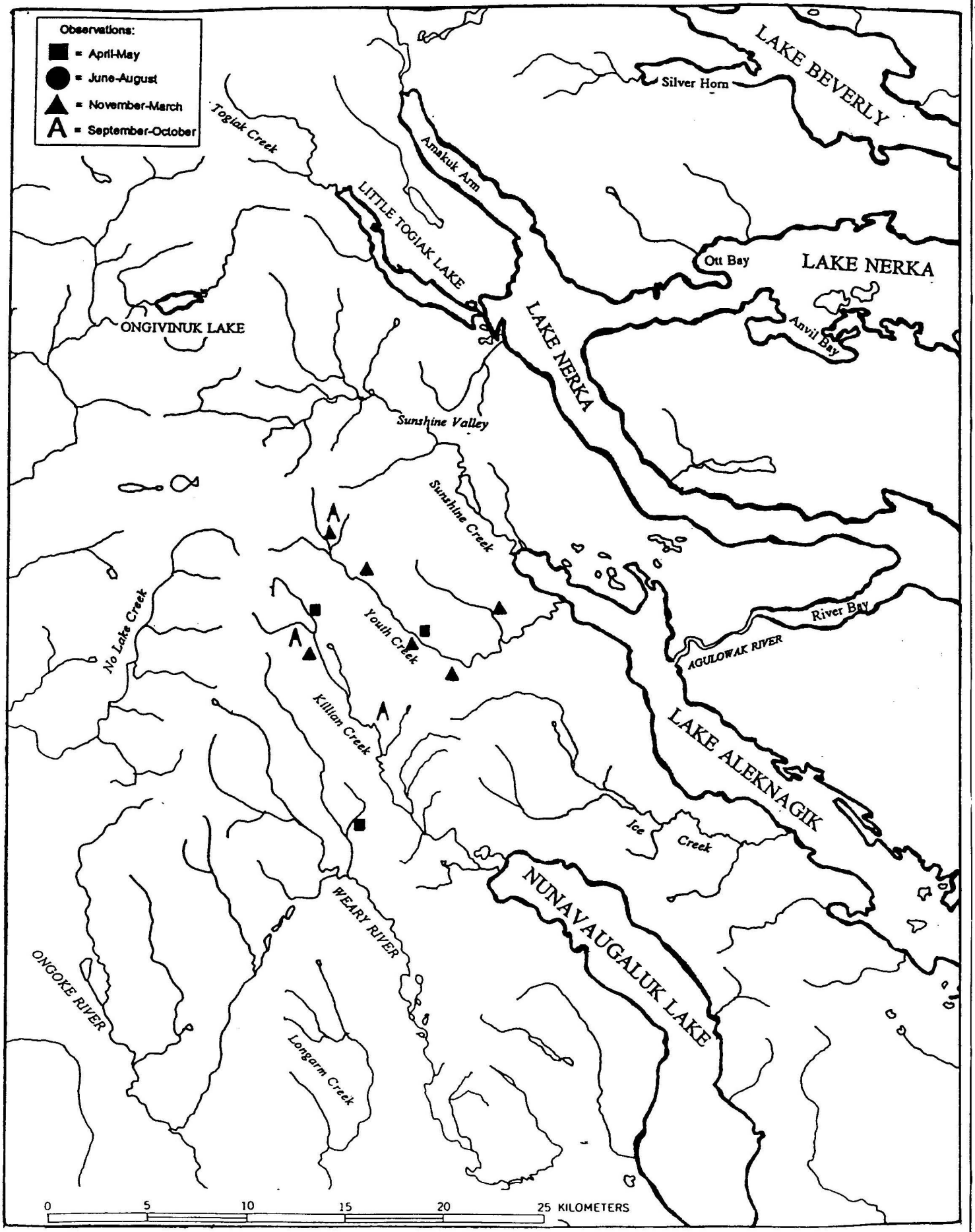
Appendix I. Radio-tracking survey data of radio-collared moose, southwest AK, 1989-1994.

SUR #	MON	DAY	YR	TOTAL	MALES	FEMALES	CALVES	UNCLS.	LAT.	LONG.	COLLAR	W/ CALF
23	6	9	92	1		1			59 19.8	158 57.8	4240	0
23	6	9	92	1		1			59 25.3	159 02.3	4870	
23	6	9	92	1		1			59 29.4	159 14.8	4280	0
23	6	9	92	1	1				59 18.9	159 04.2	4790	
23	6	9	92	Mortality or shed collar					59 21.9	159 10.4	5090	
23	6	9	92	1		1			59 24.7	159 05.5	4070	0
24	6	11	93	Mortality, possible bear kill					59 26.0	159 01.0	4120	
24	6	11	93	1		1			59 20.7	159 01.4	4700	
24	6	11	93	3		1	2		59 31.0	159 12.1	4280	2
24	6	11	93	Mortality or shed collar					59 32.2	159 05.2	4350	
24	6	11	93	2		1	1		59 29.7	159 07.1	5110	1
24	6	11	93	1		1			59 25.2	159 08.4	4070	0
24	6	11	93	Mortality					59 25.0	159 06.4	5010	
24	6	11	93	1		1			59 18.8	158 59.3	4240	
24	6	11	93	Mortality or shed collar					59 26.9	159 12.3	4930	
24	6	11	93	Mortality or shed collar					59 26.9	159 12.3	4870	
24	6	11	93	1		1			59 21.1	159 10.1	5090	
24	6	11	93	1	1				59 18.9	159 05.1	4790	
24	6	11	93	Mortality					59 18.7	159 26.2	4430	
24	6	11	93	1		1			55 22.1	159 10.6	4170	0
25	2	7	94	4	1			3	59 23.0	159 12.2	4020	
25	2	7	94	3		1		2	59 19.1	159 05.6	4240	
25	2	9	94	2		1	1		59 30.7	159 07.5	4280	1
25	2	9	94	4		1		3	59 29.2	159 05.5	5110	

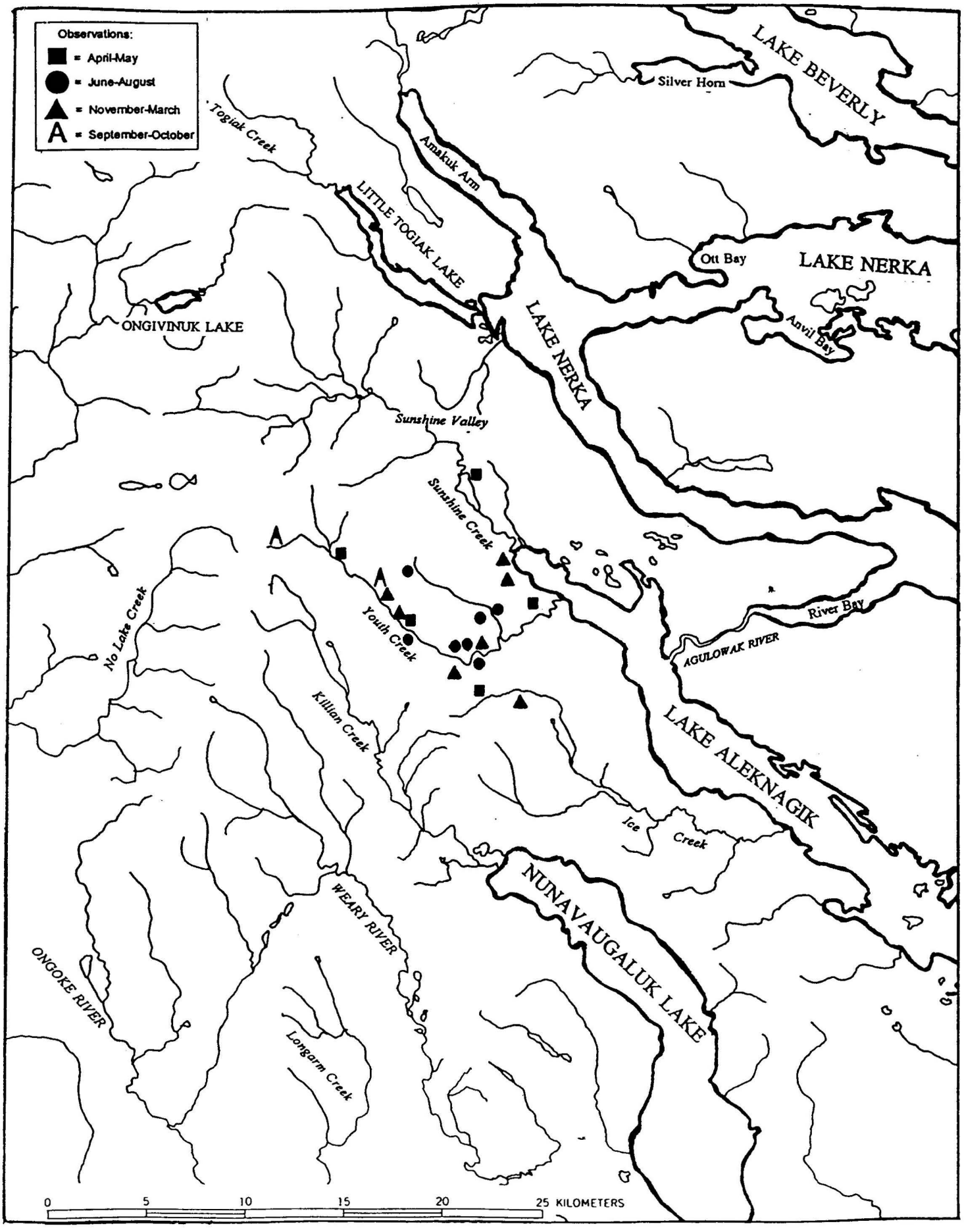
SUR# = survey number MON = month YR = year UNCLS. = unclassified

APPENDIX II

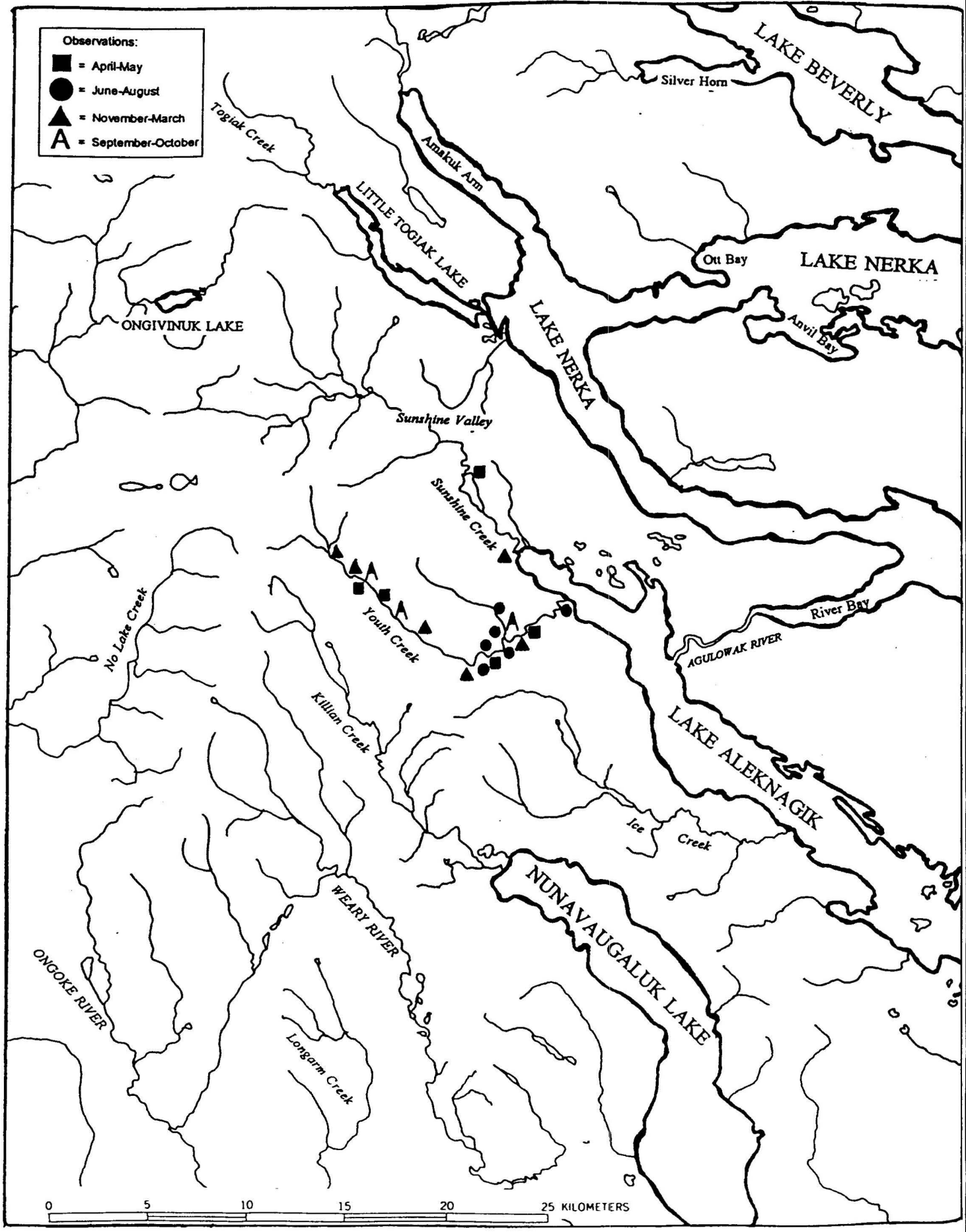
Distribution and Movements of Radio-Collared Moose Southwest Alaska, 1989 - 1994



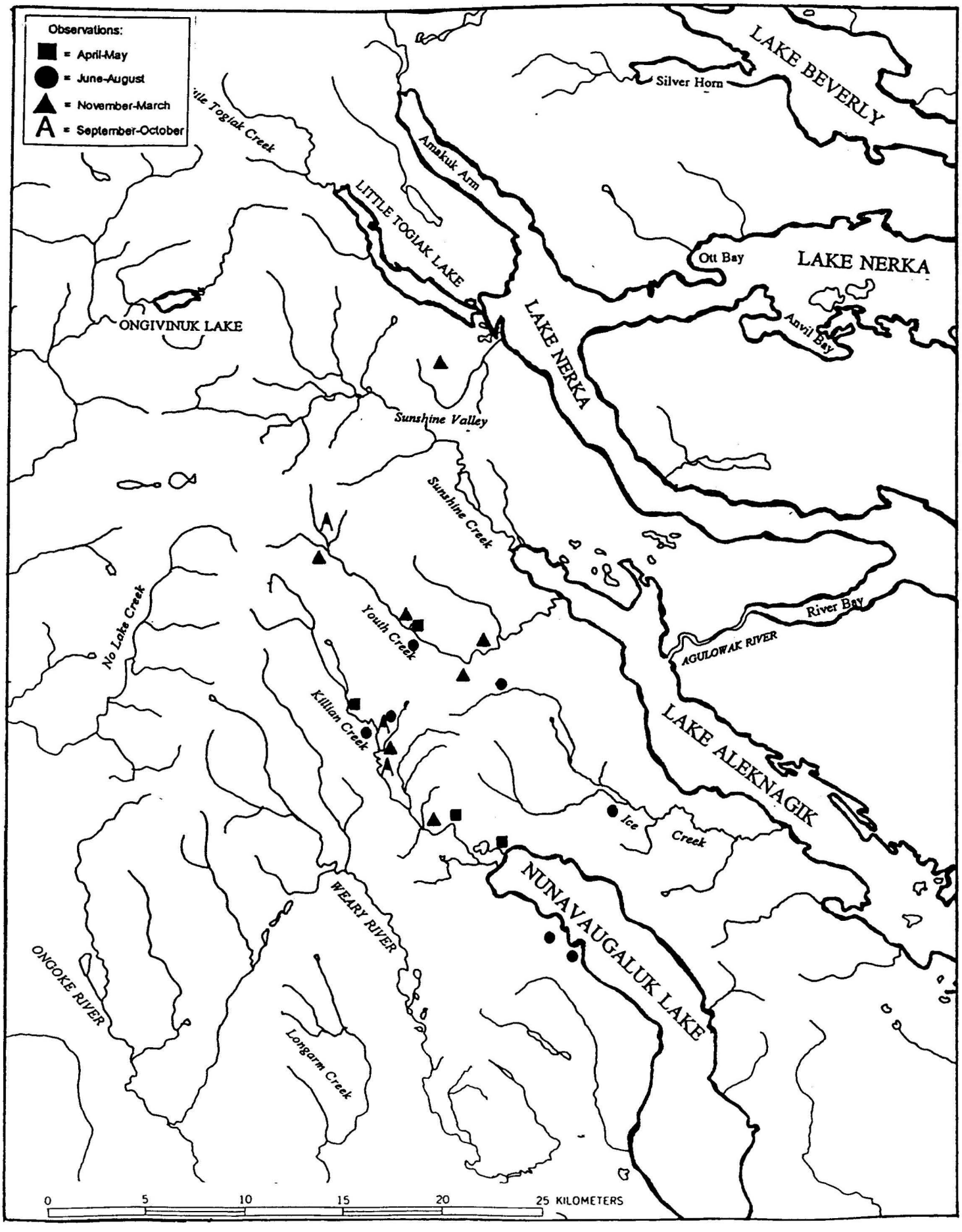
Map 1. Movements of adult male moose 4020, southwest Ak.



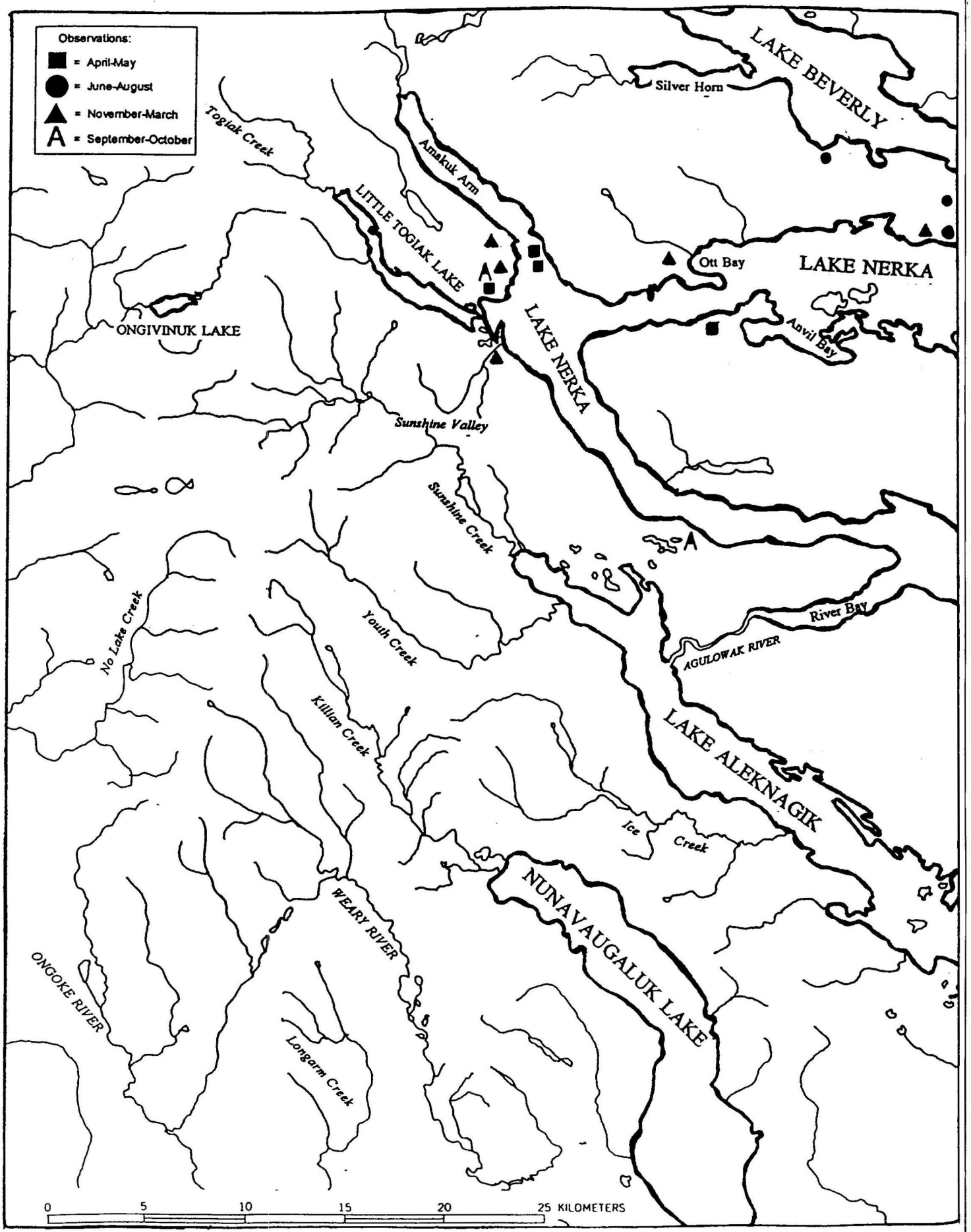
Map 2. Movements of adult female moose 4070, southwest AK.



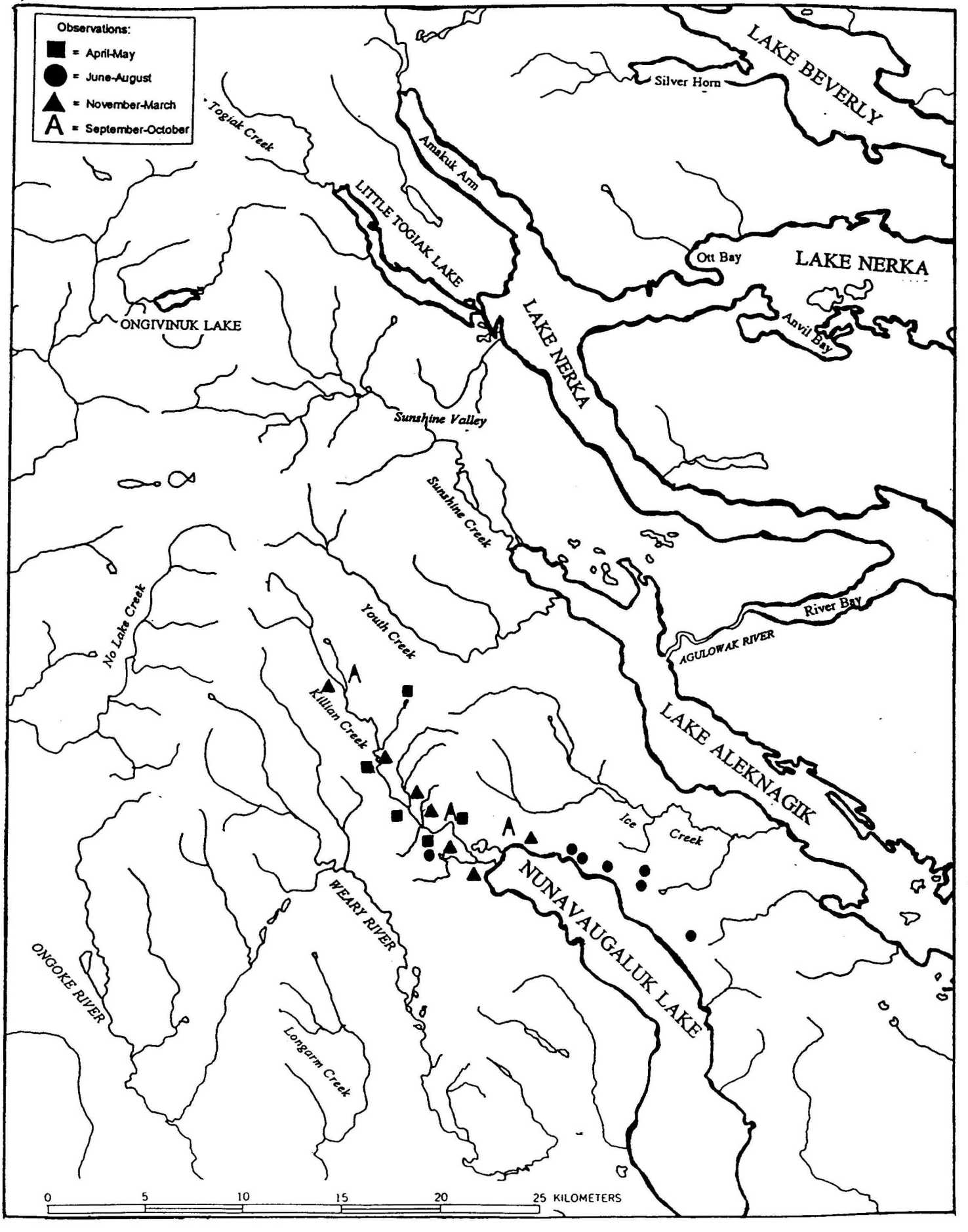
Map 3. Movements of adult female moose 4120, southwest AK.



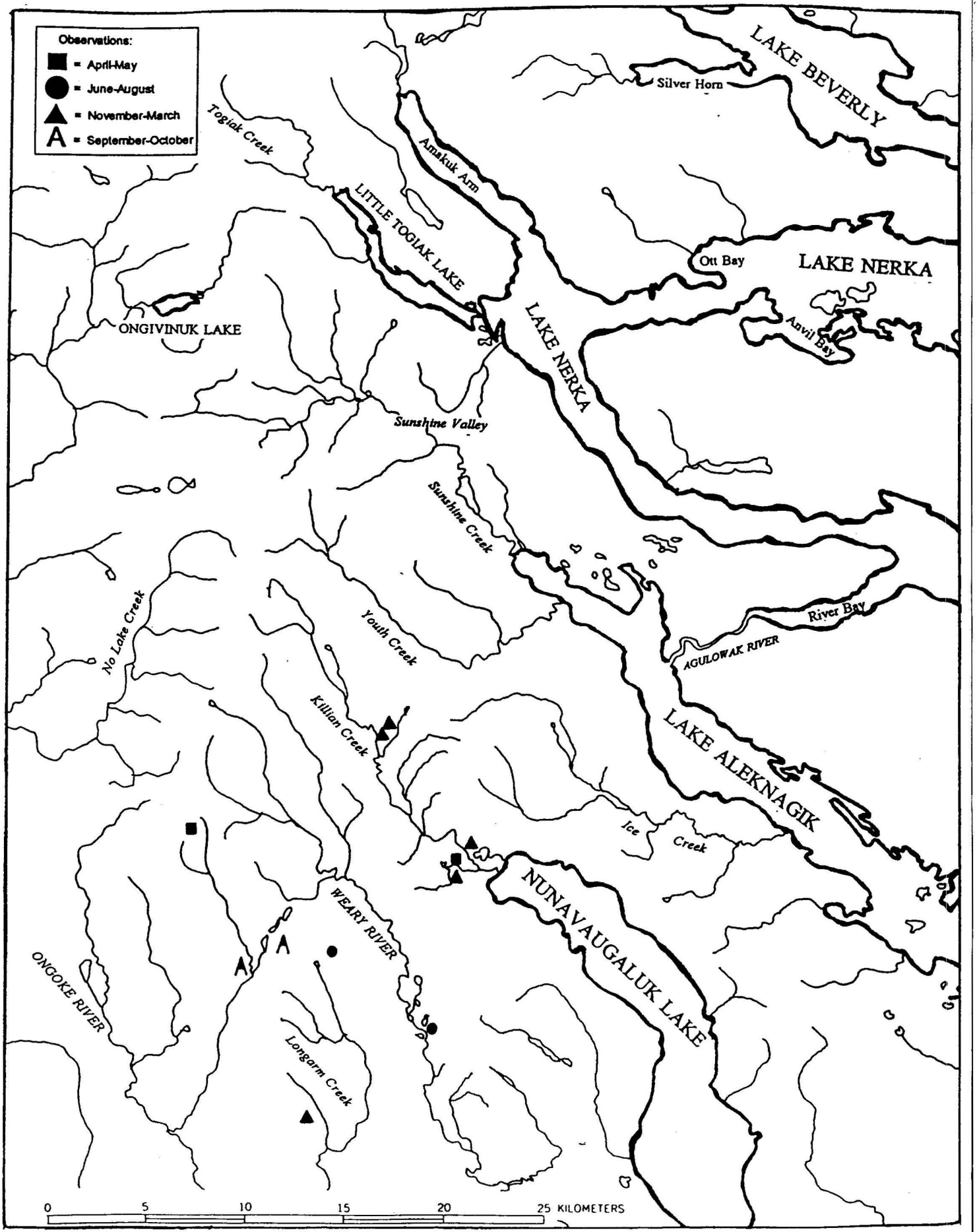
Map 4. Movements of adult female moose 4170, southwest AK.



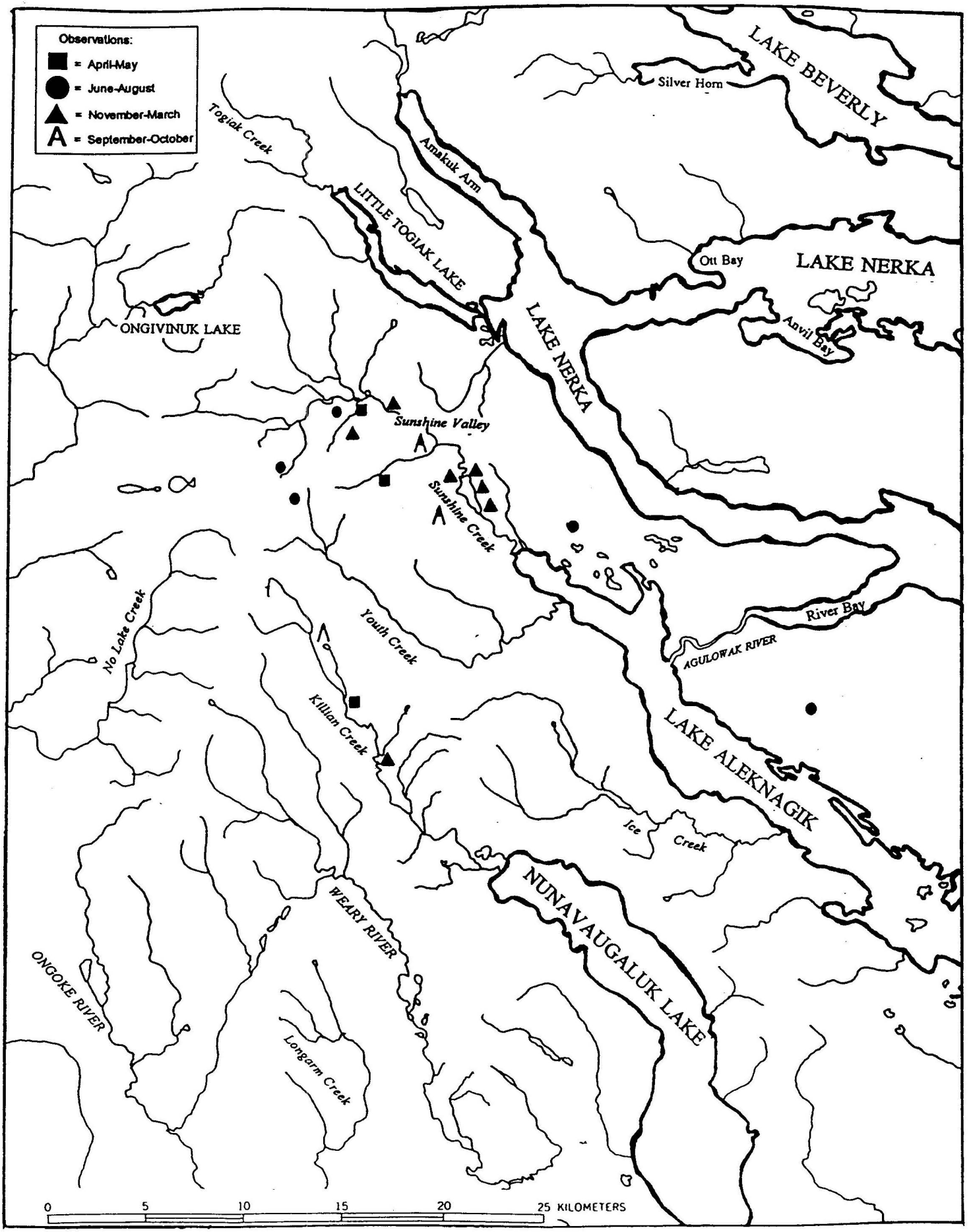
Map 5. Movements of adult female moose 4210, southwest AK.



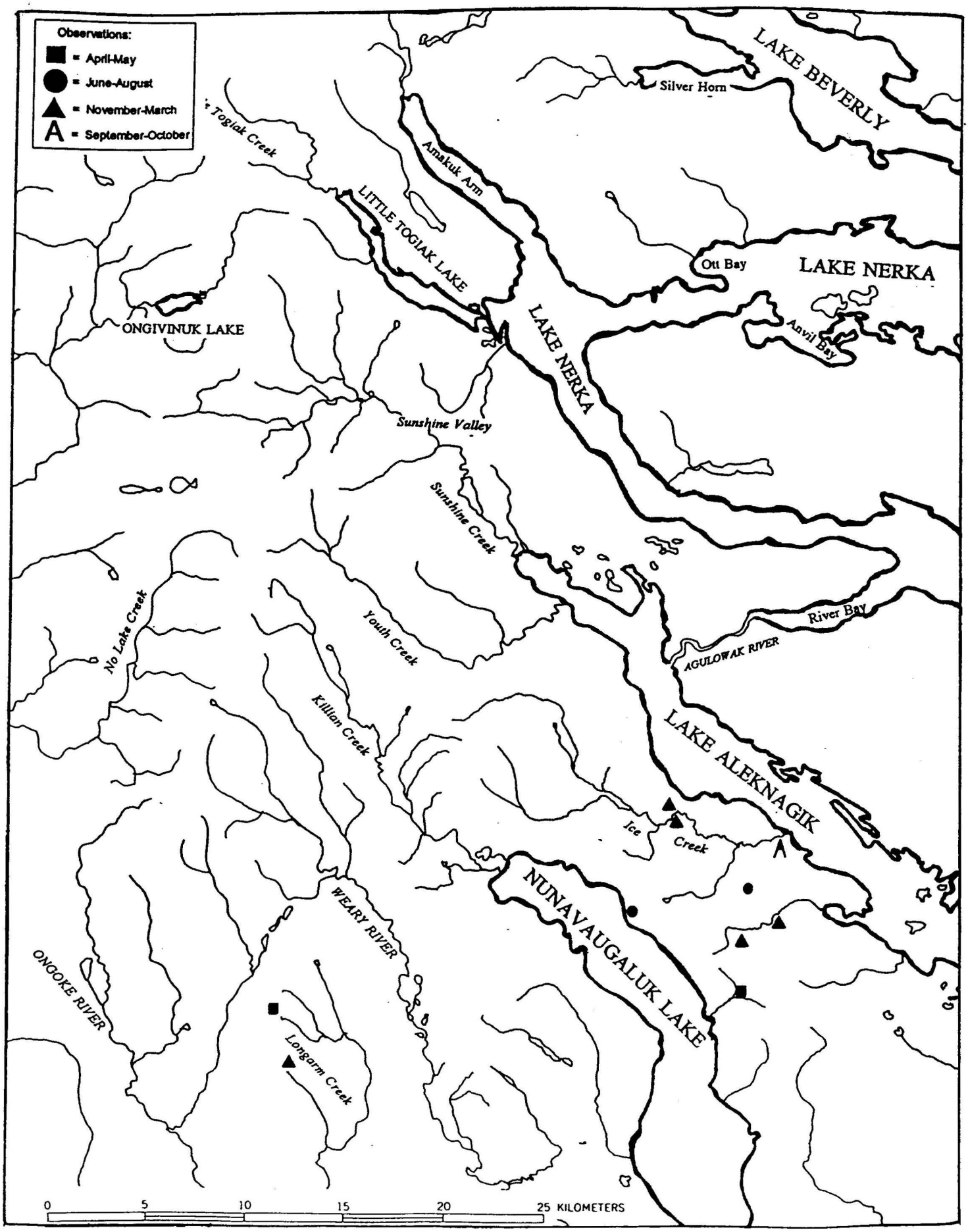
Map 6. Movements of adult female moose 4240, southwest AK.



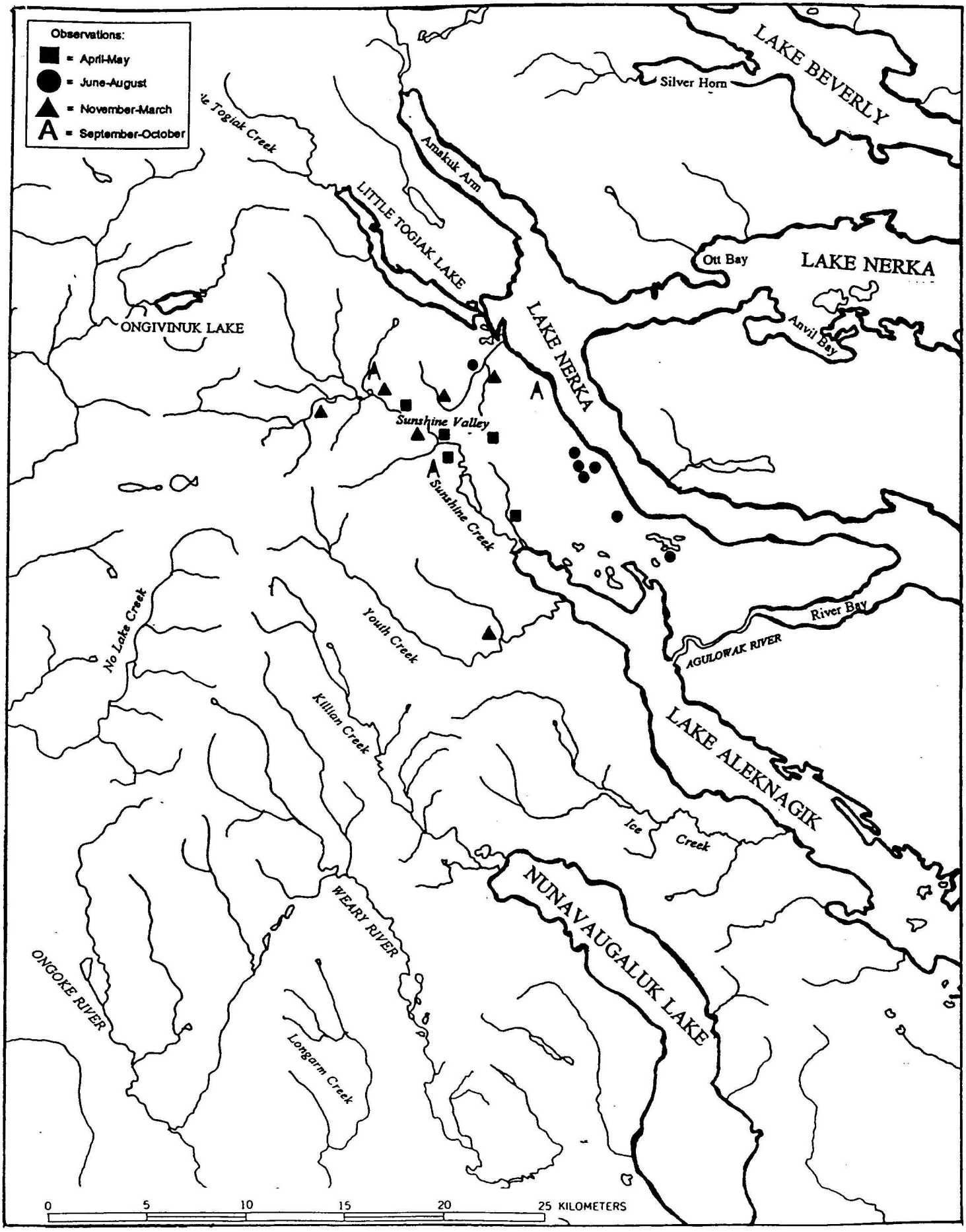
Map 7. Movements of adult female moose 4260, southwest AK.



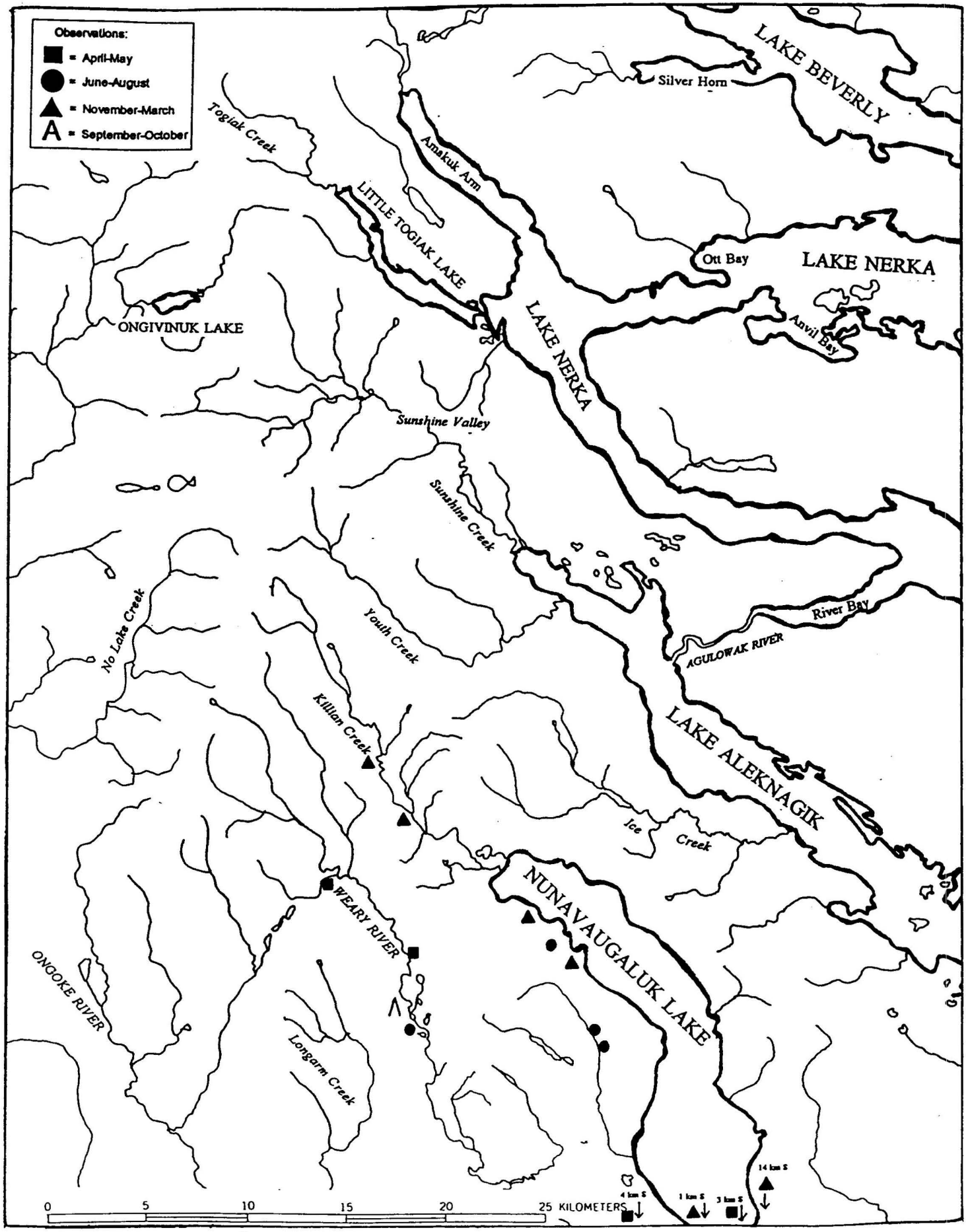
Map 8. Movements of adult female moose 4280, southwest AK.



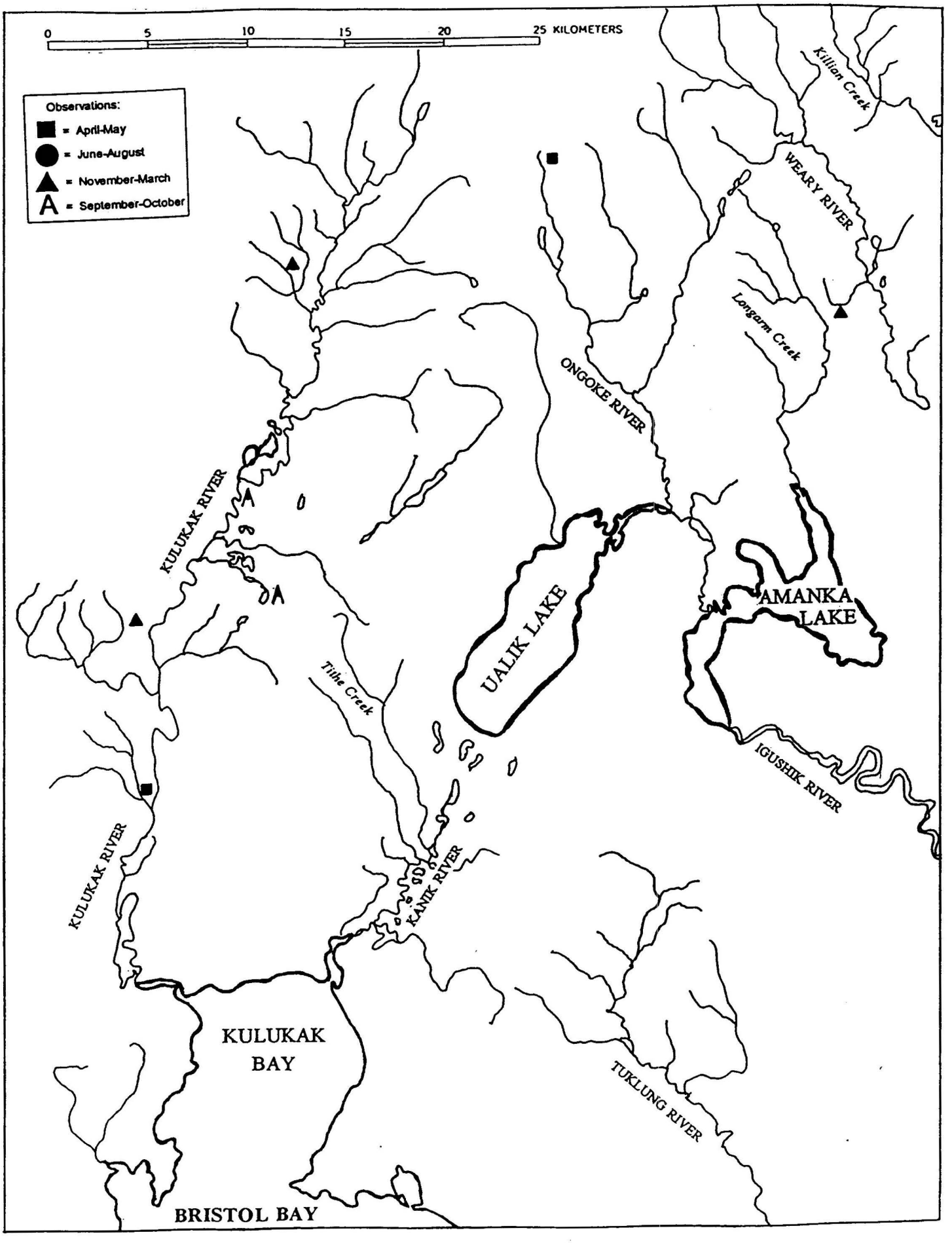
Map 9. Movements of adult male moose 4320, southwest AK.



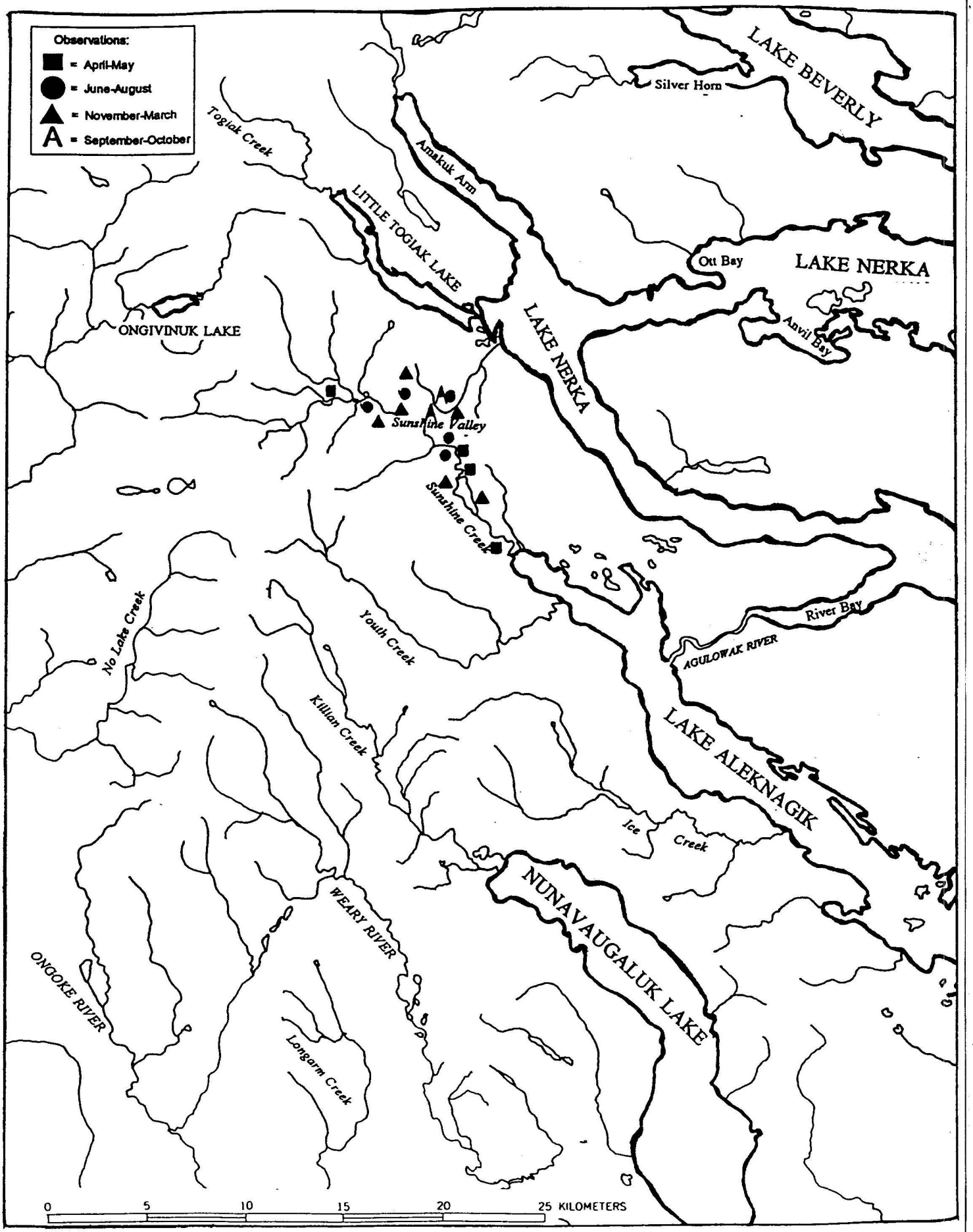
Map 10. Movements of adult female moose 4350, southwest AK.



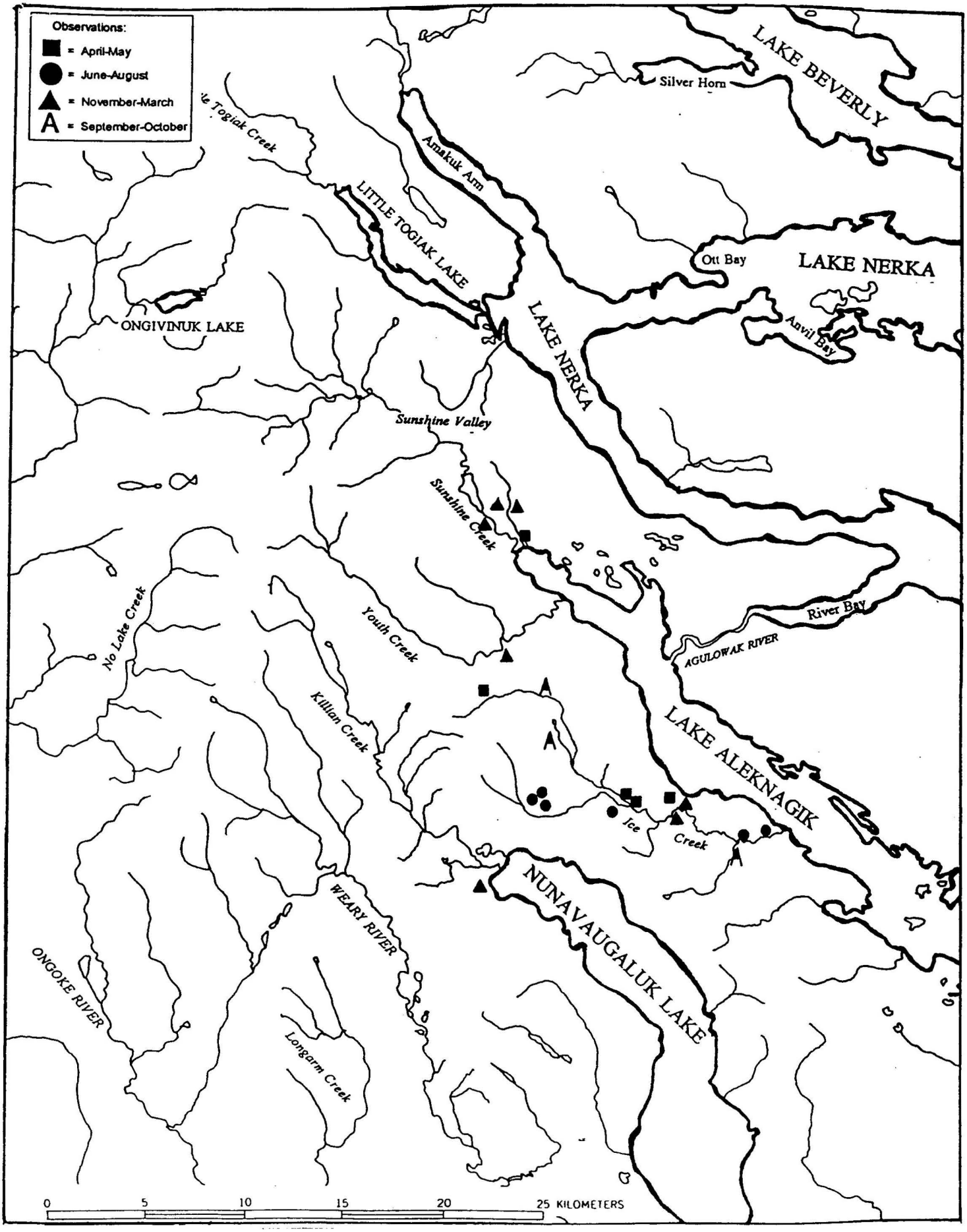
Map 11. Movements of adult female moose 4390, southwest AK.



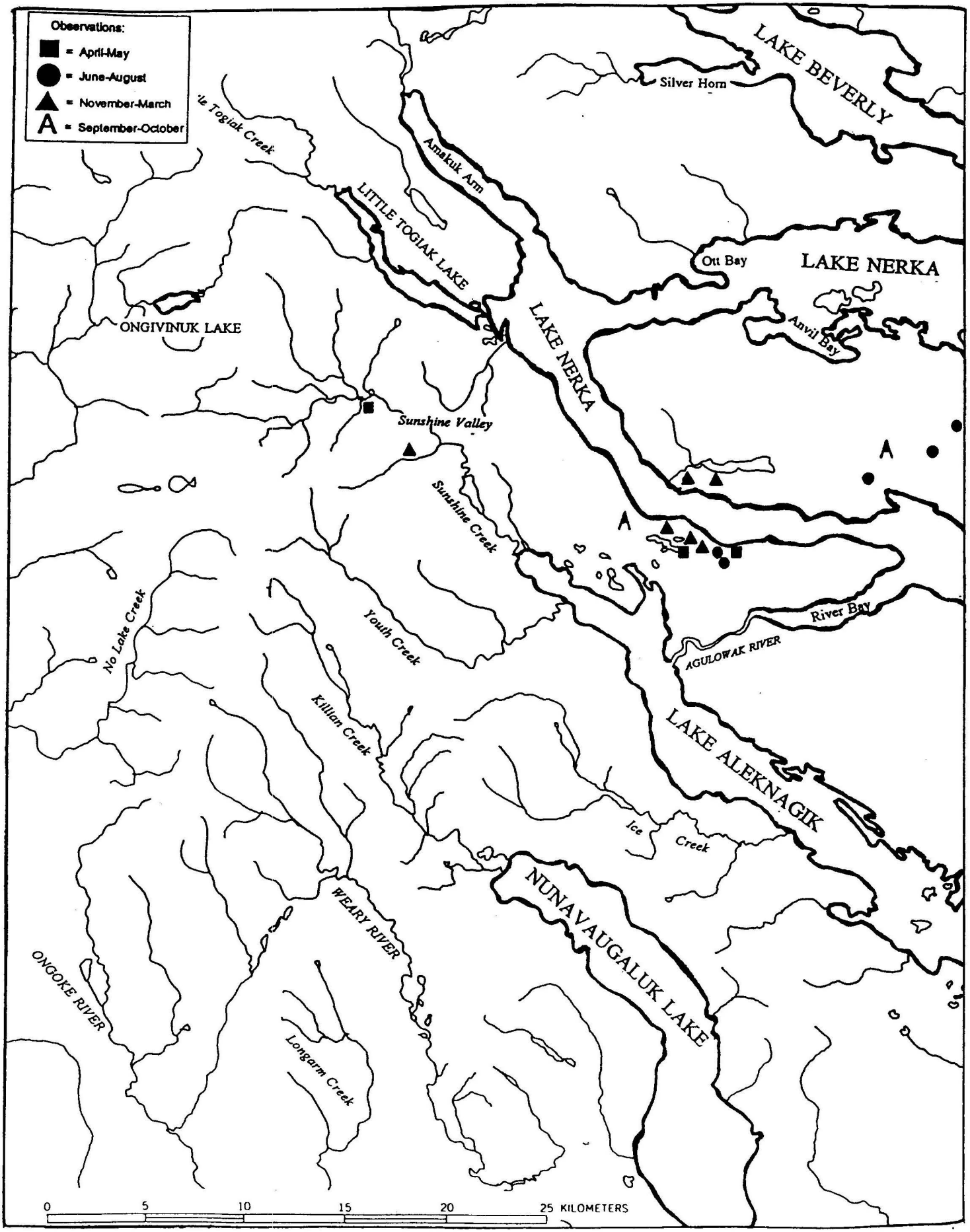
Map 12. Movements of adult female moose 4430, southwest AK.



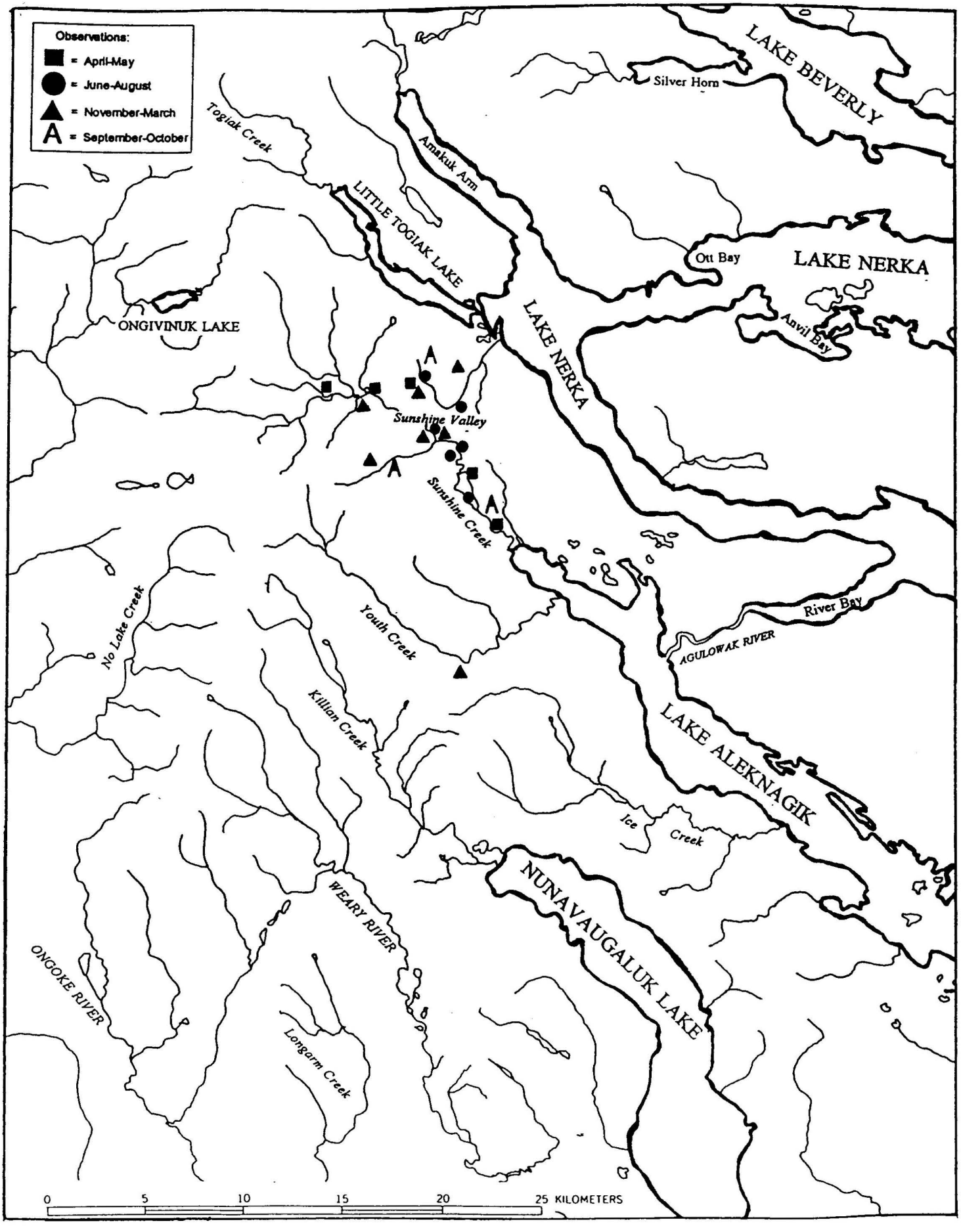
Map 13. Movements of adult female moose 4670, southwest AK.



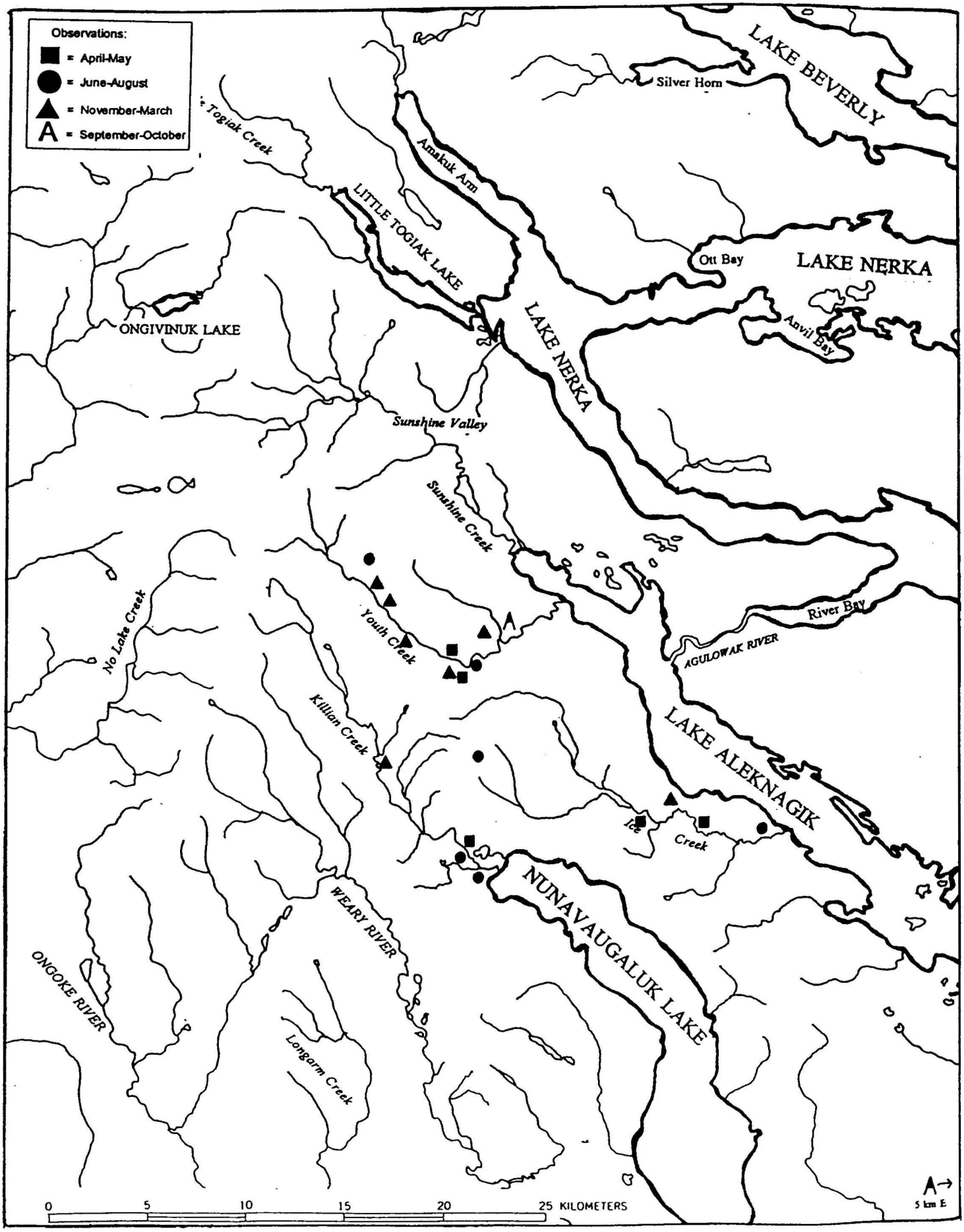
Map 14. Movements of adult female moose 4700, southwest AK.



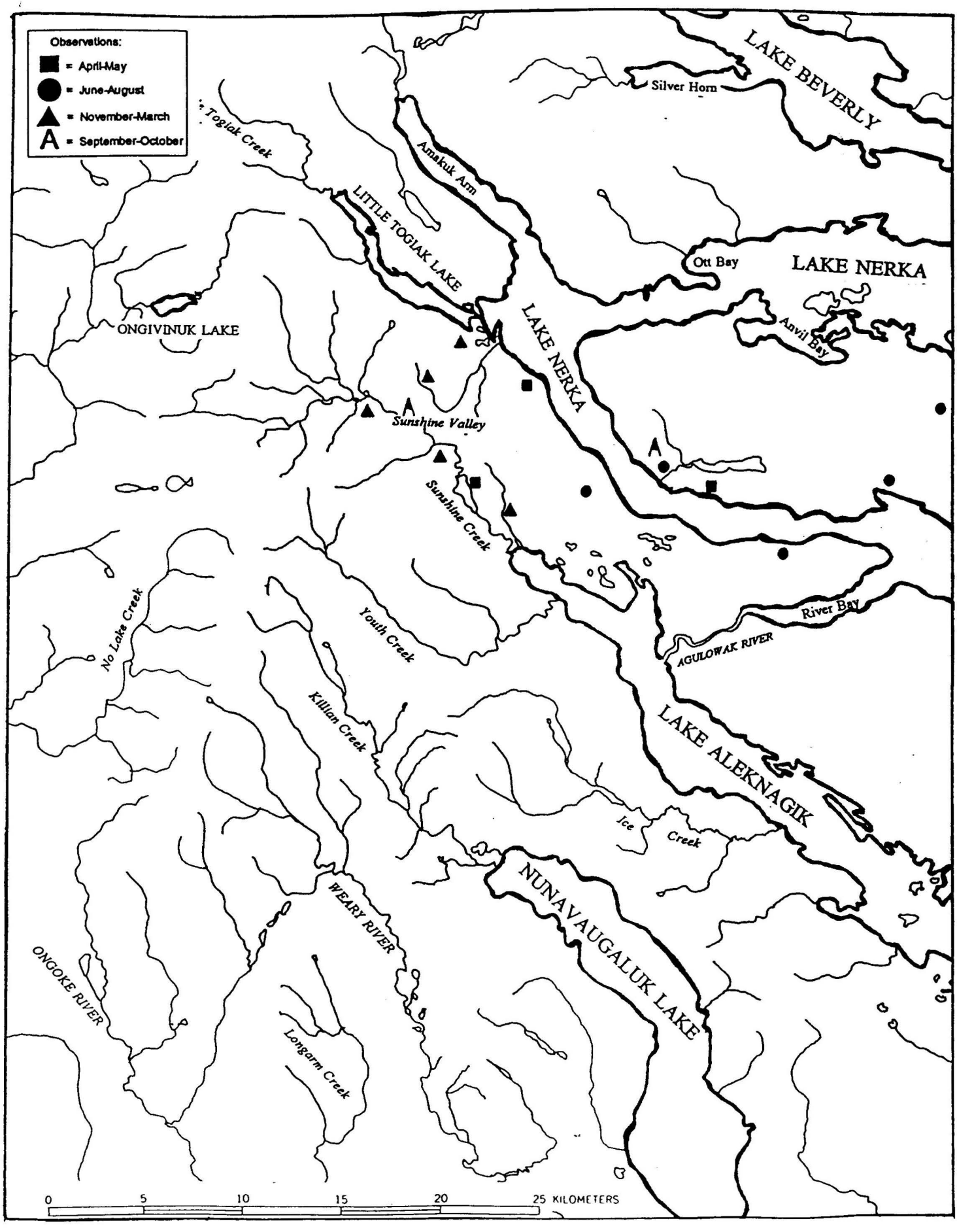
Map 15. Movements of adult female moose 4720, southwest AK.



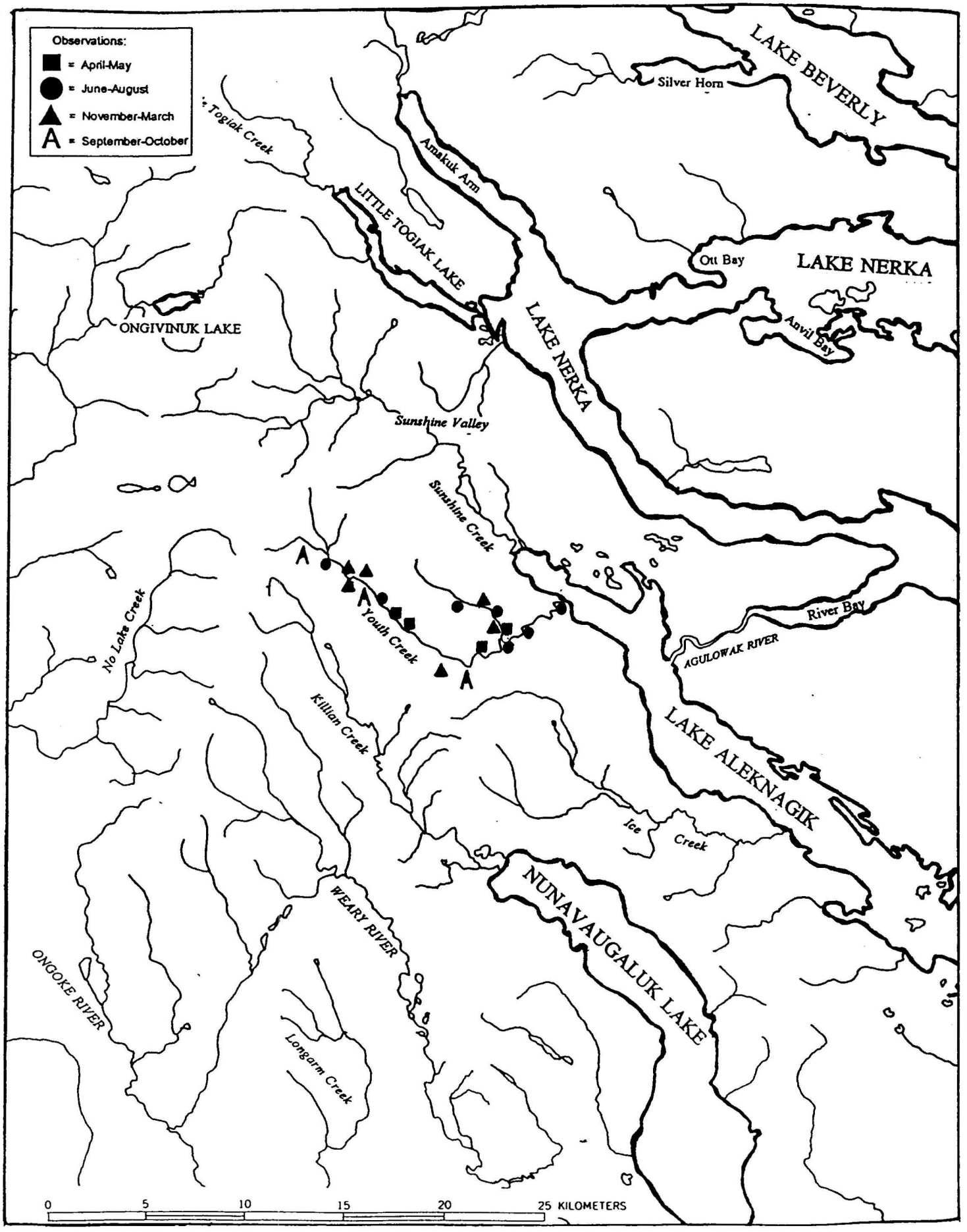
Map 16. Movements of adult female moose 4740, southwest AK.



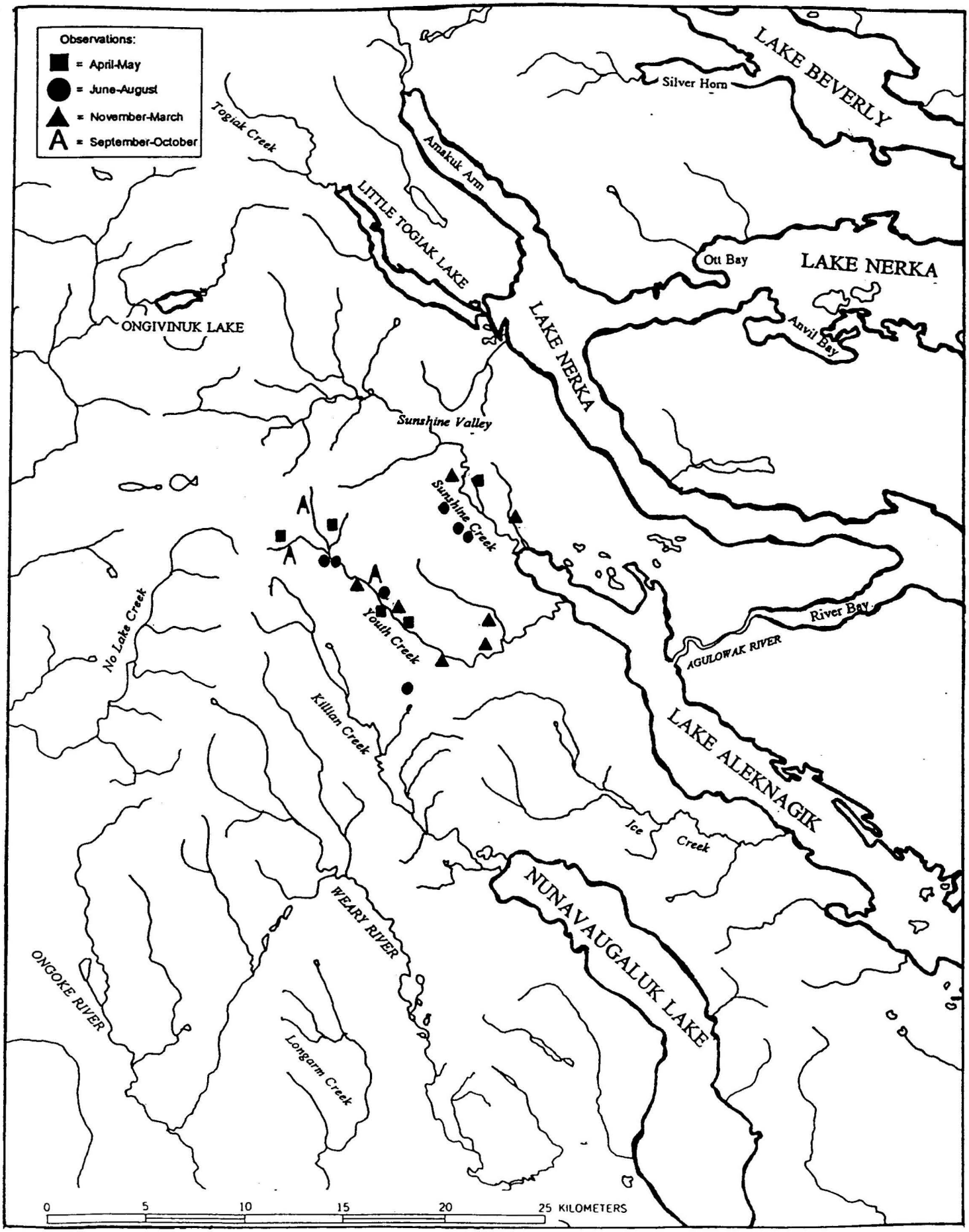
Map 17. Movements of adult male moose 4790, southwest AK.



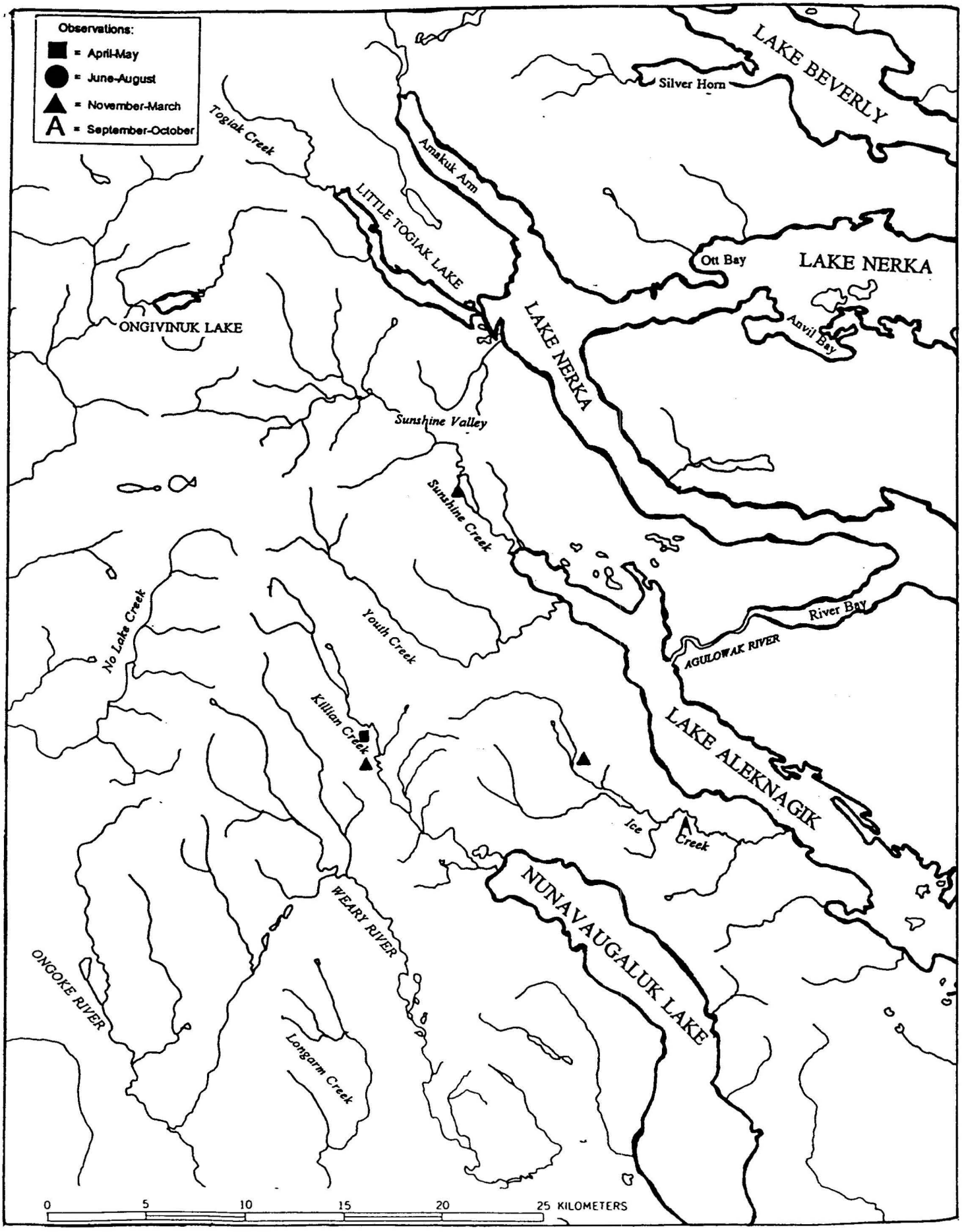
Map 18. Movements of adult female moose 4850, southwest AK.



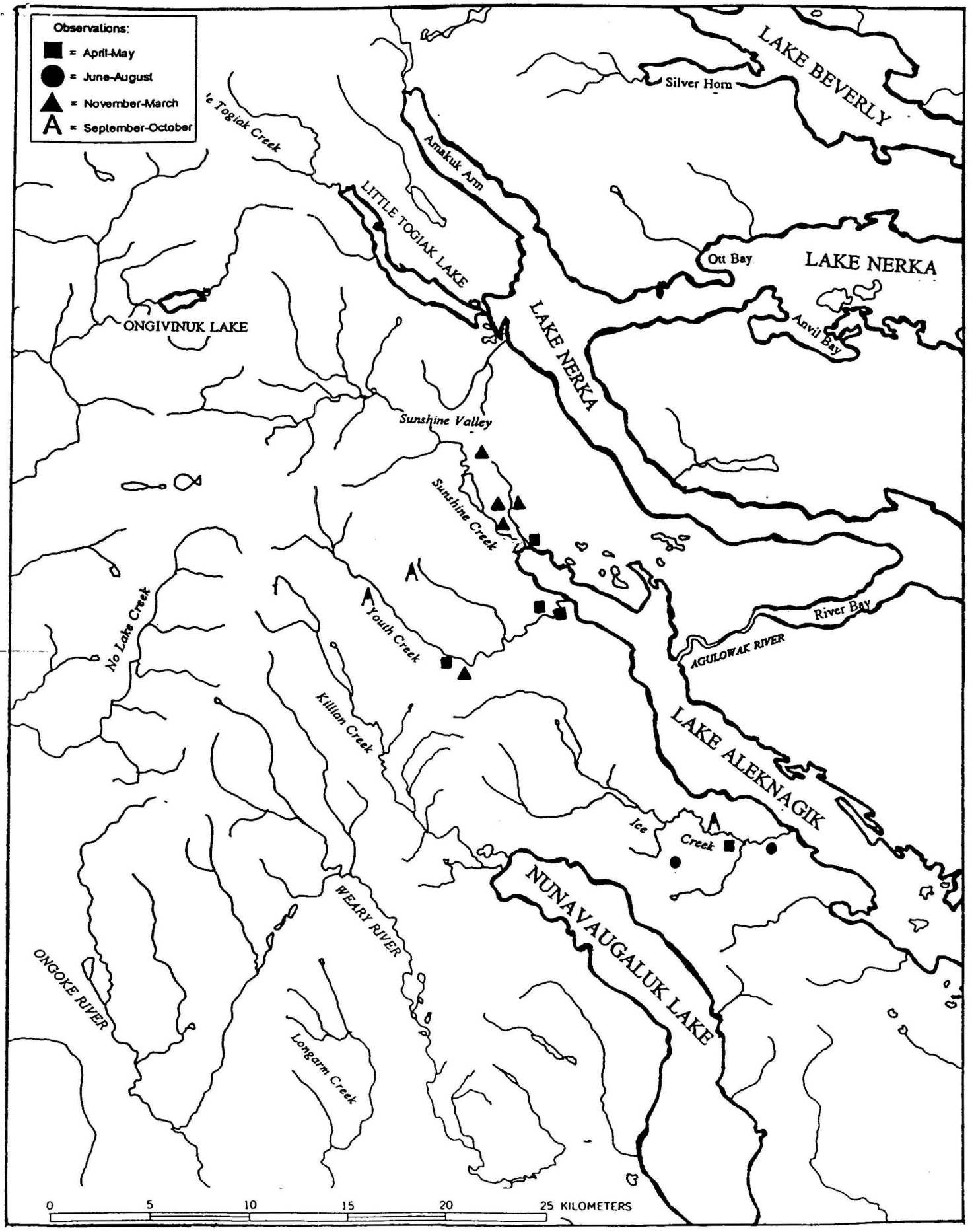
Map 19. Movements of adult female moose 4870, southwest AK.



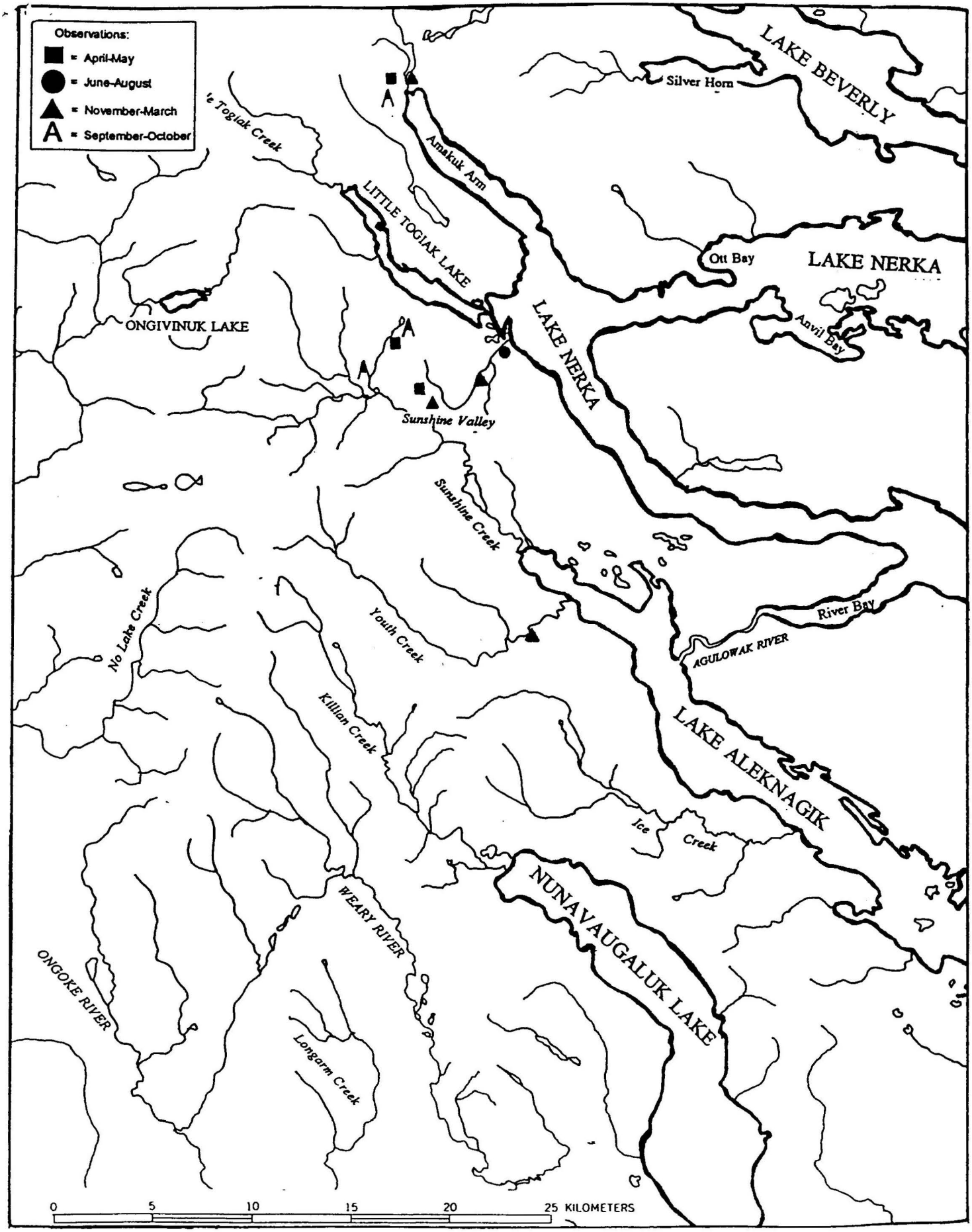
Map 20. Movements of adult female moose 4930, southwest AK.



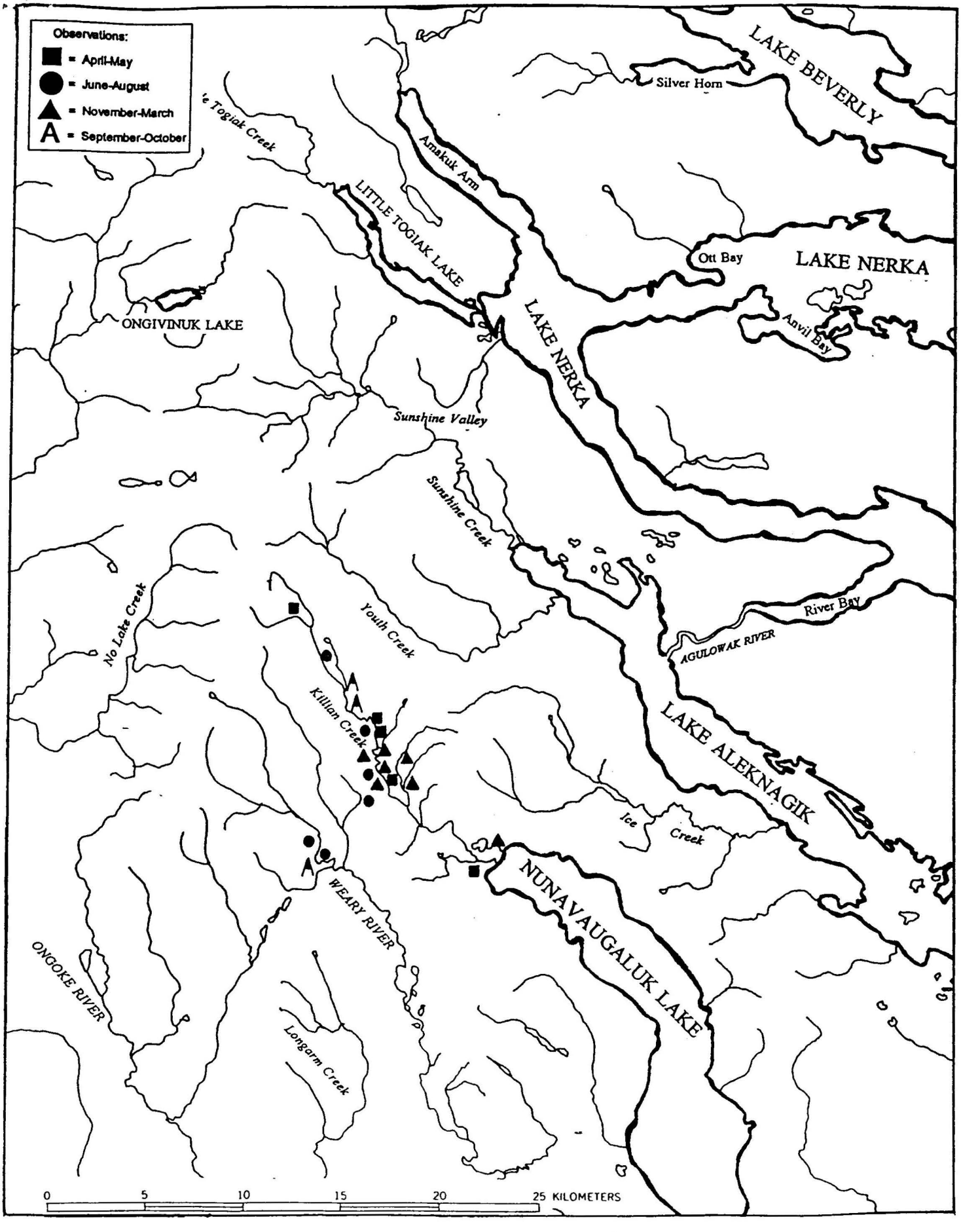
Map 21. Movements of adult male moose 4950, southwest AK.



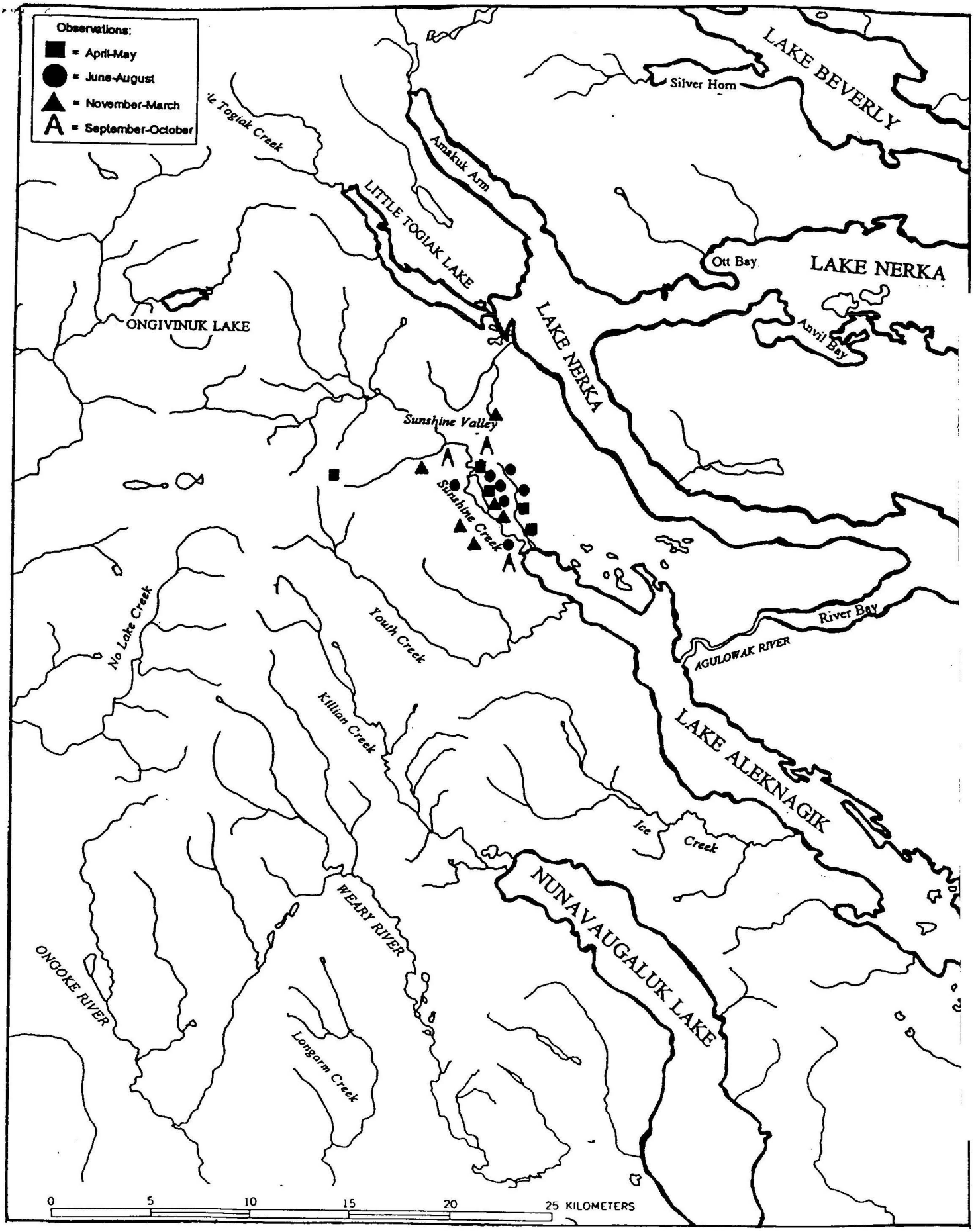
Map 22. Movements of adult female moose 5010, southwest AK.



Map 23. Movements of adult male moose 5030, southwest AK.



Map 24. Movements of adult female moose 5090, southwest AK.



Map 25. Movements of adult female moose 5110, southwest AK.