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SEASONAL MOVEMENTS OF ELK

by

Jack E. Alexander

Final Report
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FINAL REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Jack E. Alexander		
Project Nos.:	W-17-3 and W-17-4	Project Title:	Big Game Investigations
Job No.:	13.1R	Job Title:	Seasonal Movements of Elk
Period Covered:	June 1, 1970 through June 30, 1972		

SUMMARY

Elk populations, home range size, movements and habitat preference were studied on Afognak and Raspberry islands from September, 1970 to August, 1972. During this two-year period, 47 elk were captured; 24 in September, 1970 and 23 in September and October, 1971. These elk were marked and released after the collection of specific biological information. Of this total, 43 were equipped with transistorized-oscillating radio transmitters.

A mean coefficient of association of 0.51 suggests relatively stable elk herds in which only limited exchange of animals between herds occurs. No exchange of tagged elk between herds or movements into new areas were noted during the two years of this study.

Home range sizes varied with seasons and habitat types. Annual home range sizes computed for nine distinct elk herds varied between 13.7 and 39.4 square miles and averaged 22.8 square miles. Winter home ranges were considerably smaller, ranging from 1.2 to 7.3 square miles and averaging 3.2 square miles. Placement and availability of favorable habitat and exposure appeared to influence size of home ranges.

In general, elk exhibited a high preference for mature spruce habitat during all seasons of the year. Of the 294 observations of radio-marked elk over the two-year period, 43 percent were made in spruce, 34 percent in grass-alder communities and 22 percent on alpine habitat.

CONTENTS

BACKGROUND

Roosevelt elk (*Cervus canadensis roosevelti*), which were introduced into Alaska, are restricted in distribution to Afognak and Raspberry islands in the Kodiak Archipelago, and perhaps Revillagigedo Island in the Southeast Panhandle. They are of considerable interest to a large number of Alaskan hunters, however. The status of elk populations has been the subject of much local concern over the past several years because of population declines on Raspberry Island and the southern portions of Afognak Island. The future of these elk populations is in question for two reasons: (1) exponential population increases occurred following introduction and were followed by rapid declines, and (2) the effects of future large-scale logging operations on winter habitat and elk populations are unknown. High densities during peak elk populations may have produced irrevocable changes in the plant composition of critical winter ranges in some areas, thereby permanently reducing carrying capacity. In order to allay public apprehension, assure habitat protection and maintain huntable numbers of elk, studies to assist in the development of progressive management plans were conducted.

Little is known regarding the delineation of various populations and subpopulations and the movements between these elk populations on Afognak Island. Home ranges of Roosevelt elk in general are poorly represented in wildlife literature. Harper (1966) and Schwartz (1943) suggested that Roosevelt elk are fairly sedentary and normally do not move great distances. Troyer (1960), basing his conclusions upon results of aerial surveys, felt Afognak elk do not move in excess of ten miles from summer to winter ranges. Brown (1965) reached similar conclusions in Washington on the basis of a very limited number of observations of 70 tagged elk over a four-year period.

OBJECTIVES

To delineate the various populations and subpopulations of elk inhabiting Afognak Island and determine their seasonal movements.

PROCEDURES

Elk were located and captured on alpine ranges during late September of 1970 and 1971. Immobilizing drug was administered with "Cap-Chur" powder projection equipment (Palmer Chemical and Equipment Co., Douglasville, Georgia) fired from a Bell 206A Turbo helicopter. Two forms of succinylcholine chloride (Sucostrin; E. R. Squibb and Sons, New York and Anectine; Burroughs, Wellcome & Co., Tuckahoe, New York) in concentrations of 50 mg/cc were used to immobilize the elk. Dosages of 30-40 milligrams were administered to adults, no attempts were made to capture animals less than 15 months of age. Hyaluronidase (Haver-Lockhart Laboratories, Kansas City, Missouri), in concentrations of 1500 n.f. units, was used to reduce induction time, thereby reducing the latent period of the succinylcholine chloride. When possible, two animals were injected in rapid succession; the helicopter was then moved a short distance away and used to keep the injected elk together and in the open until immobilized. Elk were weighed with a 2,000 pound capacity scale and cargo net slung beneath the helicopter when and where circumstances permitted. All captured elk were ear marked with numbered metal ear tags and colored Dayglo Saflag streamers (Safety Flag Company of American, Pawtucket, Rhode Island). Elk were also marked with a four-inch wide canvas collar to which nylon flagging had been sewed for color coding (Denver Tent Company, Denver, Colorado). The collar was attached by fastening overlapping ends with a "pop" rivetool, (USM Corp., Reading, Pennsylvania). Neck collars in combination with ear tags made individual recognition from low-flying aircraft possible. Twenty-three elk, three or four from each of the major herds inhabiting the southwestern, interior and northern portions of Afognak Island were fitted with radio transmitters. The transistor-crystal controlled transmitters and their method of construction are similar to these described by Verts (1963) but modified to fit elk. Circuit design and components of the transmitters were changed in 1971 to conform with those developed by Seidensicker, et al. (1970) in order to take advantage of less critical tuning procedures. A diode receiver and multimeter were used to predict signal range and battery drain. The transmitters used in this project have a maximum range of about eight miles and a theoretical battery life of 12-18 months. Their components were mounted on a circuit board and batteries were enclosed inside a one-inch continuous plastic hose. The hose was then filled with liquid styrofoam (Tital Polyfoam, Titon Chemicals, Inc., Seattle, Washington). As the styrofoam set the hose became a rigid ring that could be slipped over the elk's head. All collared elk in the same herd were on the same radio frequency but oscillation rates were varied, making it possible to recognize individuals. Tracking of elk was accomplished with the aid of a military surplus R-388 receiving unit on loan from the Bureau of Sport Fisheries and Wildlife and later a Davidson model "W" tracking receiver (Davidson Electonics, Minneapolis, Minnesota).

The receiving unit was carried aboard a Cessna 185 aircraft, with external antenna mounted between a wing and tail strut. Observations were made by flying at about 1,500 feet above the ground through herd areas and monitoring a selected frequency until a signal was detected. Ever-tightening circles were then flown, reducing audio gain and sensitivity of the receiver until animals were located. Once observed, the number, sex, and positive identification of animals in the herd were determined by flying as low and slowly as possible. Pilot ability contributed significantly to the number of observations, particularly when elk inhabited densely timbered areas. The type of habitat elk were associated with, slope and aspect were also noted.

Observations were made at irregular intervals varying from two weeks to two months. The inhospitable nature of the region's maritime climate made more frequent and regular observations impossible. For example, unusually severe weather conditions prevailed during the winter and spring seasons of 1972, permitting an average of only one tracking flight per month.

Standard body measurements, including the total length, girth and length of hind foot, were recorded. Reproductive status of each captured female was determined by examination of the udders. Winter and annual home ranges were calculated for each of the elk and its associated herd observed more than seven times. The method consisted of connecting all outside points of observations and calculating the area of the enclosed polygon with the aid of a polar planimeter. Due to the irregular coastal outline and precipitous mountain slopes, areal measurements are only approximate.

FINDINGS

Capture and Marking Success

During 1970 and 1971, 47 elk were captured; 24 in June, August, September and December, 1970 and 23 in September and October, 1971. These elk were marked and released after collecting specific biological information. Of these, 43 were equipped with transistorized-oscillating radio transmitters. Radio frequency and collar marking for elk tagged in 1970 and 1971 are listed in Table 1.

The elk, generally in herds of 50-100 animals, were located by searching alpine areas of Afognak Island with the aid of a helicopter. Once located, several animals were separated from the herd, injected with immobilizing agent and prevented from rejoining the herd or entering the timber by skillful maneuvering of the helicopter. Capture success using this technique averaged 1.8 elk per hour of flying. Tag numbers and locations of all captured elk are presented in Table 2.

In 1970, 50 percent of the darted elk appeared unaffected when injected with Sucostrin, however this proportion was reduced to 14 percent in 1971 when Anectine was substituted. The increase in capture

Table 1. Radio Number, Frequency and Neck Band Colors of 47 Tagged Elk, 1970 and 1971.

Radio Designation and Frequency*	Sex	Age	Date	Remarks	Repro. Status
H 30.07 MH_z	F	Mat.	9/27/70	White collar, orange ear streamers	Lactating
No radio	M	1.5	9/27/70	White collar, orange ear streamers	
I 30.07 MH_z	F	Mat.	9/27/70	White collar/red stripe, orange ear streamers	Lactating
O 30.05 MH_z	F	Mat.	9/27/70	Orange collar/yellow tape, orange ear streamers	
N 30.05 MH_z	F	Mat.	9/27/70	Orange collar, pink ear streamers	Lactating
T 30.25 MH_z	F	Mat.	9/30/70	Yellow collar/red bars, lime ear streamers	Dry
U 30.25 MH_z	F	1.5	9/30/70	Yellow collar, pink ear streamers	Dry
P 30.19 MH_z	F	Mat.	9/28/70	Yellow collar #15	Lactating
S 30.22 MH_z	F	Mat.	9/30/70	Yellow collar, orange ear streamers	Lactating
V 30.22 MH_z	F	Mat.	9/30/70	White collar	Lactating
R 30.19 MH_z	F	Mat.	9/30/70	Orange collar, orange ear streamers	Lactating
Q 30.19 MH_z	F	Mat.	9/30/70	Orange collar	Lactating
W 30.19 MH_z	F	Mat.	12/31/70	No collar	Lactating
F 30.06 MH_z	F	Mat.	9/27/70	Yellow/blue stripe	Lactating
G 30.06 MH_z	F	Mat.	9/27/70	Yellow/blue stripe collar w/red bars	Lactating
K 30.07 MH_z	F	Mat.	9/30/70	White collar/red stripe	Lactating
M 30.23 MH_z	F	Mat.	9/30/70	Collar white/red stripe	Lactating
L 30.24 MH_z	F	Mat.	9/20/70	Collar white/red stripe	Lactating
B 30.19 MH_z	F	Mat.	6/8/70	Radio taped red	Pregnant
C 30.24 MH_z	M	Mat.	6/8/70	Blue collar	
D No radio	M	Mat.	6/8/70	Yellow collar	
E 30.19 MH_z	F	1.0	6/8/70	White collar	
A 30.20 MH_z	M	Mat.	6/8/70	Orange collar	
X No radio	F	Mat.	8/10/70	Blue collar	Lactating

* Some radio designations and frequencies were used in both 1970 and 1971 on different animals.

Table 1. (cont'd.) Radio Number, Frequency and Neck Band Colors of 47 Tagged Elk, 1970 and 1971.

Radio Designation and Frequency*	Sex	Age	Date	Remarks	Repro. Status
I 30.24 MH_z	F	1.4	9/27/71	No collar, silver ear streamers	
K 30.24 MH_z	F	Mat.	9/27/71	No collar, silver ear streamers	Lactating
L 30.24 MH_z	M	Mat.	9/27/71	Yellow collar/black bars, lime left ear streamers, pink right ear streamers	
J 30.24 MH_z	F	Mat.	10/2/71	No collar, silver left ear streamer, pink right ear streamer	
E 30.23 MH_z	F	Mat.	10/2/71	Yellow collar/blue bars, silver and lime ear streamers	
P 30.21 MH_z	M	Mat.	10/4/71	Yellow collar, orange ear streamers	
F 30.20 MH_z	F	Mat.	10/2/71	Yellow collar/blue bar, no ear streamers	
M 30.21 MH_z	F	Mat.	9/30/71	Yellow collar/orange right ear streamer	
N 30.21 MH_z	F	Mat.	9/30/71	Yellow collar/pink ear streamers	
O 30.21 MH_z	F	Mat.	9/30/71	Yellow collar/orange ear streamers	
None	M	Mat.	10/2/71	Yellow collar/silver ear streamers	
Y 30.25 MH_z	M	Mat.	10/2/71	No collar, red ear streamers	
X 30.25 MH_z	F	Mat.	10/2/71	No collar, silver ear streamers	
W 30.25 MH_z	F	Mat.	10/2/71	White collar/red bar, pink ear streamers	
V 30.25 MH_z	F	Mat.	10/2/71		
D 30.23 MH_z	F	Mat.	10/2/71	Orange collar/lime ear streamers	Lactating
C 30.23 MH_z	F	Mat.	10/27/71	No collar, pink ear streamers	
R 30.22 MH_z	F	Mat.	10/4/71	White collar/pink and lime ear streamers	
G 30.20 MH_z	F	Mat.	9/30/71	White collar/lime ear streamers	
H 30.20 MH_z	F	Mat.	10/2/71	No collar/silver ear streamers	Lactating
A 30.20 MH_z	M	Mat.	10/2/71	Yellow collar/pink and orange ear streamers	
T 30.22 MH_z	F	Mat.	9/30/71	No collar, pink ear streamers	
S 30.22 MH_z	F	Mat.	9/30/71	No collar, silver ear streamers	

* Some radio designations and frequencies were used in both 1970 and 1971 on different animals.

Table 2. Tag Number and Tagging Location of 47 Elk Captured in 1970 and 1971.

Number*	Sex	Ear Tag Numbers Left	Ear Tag Numbers Right	Location	Remarks
	F	10920	10921	Paramanof Cape	
N	F	10919	10918	Paramanof Cape	
H	F	10910	10911	Raspberry Island	
J	M	10916	10917	Raspberry Island	
I	F	10912	10914	Raspberry Island	
T	F	10930	10931	Duck Mountain	
U	F	10934	10933	Duck Mountain	
P	F	10909		Danger Mountain	
S	F	10928	10929	N.W. Danger Bay	
V	F	10936	10935	Kitoi	
R	F	10927	10926	West Paramanof Mt.	
Q	F	-	-	West Paramanof Mt.	
W	F	10949	10950	Waskanareska	Died 2/20/71
F	F	-	-	Litnik Mountain	
G	F	10904	10905	Afognak Lake	
K	F	10906	10907	Malina Lake	Died 4/21/71
M	F	10925	10924	Steep Creek-Malina	
L	F	10922	10923	Steep Creek-Malina	
B	F	-	-	Raspberry Strait	
C	F	18		Head Danger Bay	Died 6/25/70
D	M	22	21	Head Danger Bay	
E	F	-	-	Kitoi	Died 6/12/70
A	M	25		Tonki	Killed 10/5/70
X	F			Paramanof Mt.	Killed 9/10/70

* The same letters were assigned to different elk in 1971.

Table 2. (cont'd.) Tag Number and Tagging Location of 47 Elk Captured in 1970 and 1971.

Number*	Sex	Ear Tag Numbers Left	Right	Location	Remarks
I	F	11000	10999	Tonki Bay	
K	F	10997	10998	Little Tonki	
L	M	10959	10960	Tonki Cape	
J	F	10955	10956	Tonki Cape	
E	F	10968	10967	Driver Bay Raspberry Island	
P	M	10978	10979	Driver Bay Raspberry Island	
F	F	10958	10957	Driver Bay Raspberry Island	
M	F	-	10892	Paramanof Mountain	
N	F	10988	10987	Paramanof Mountain	
O	F	10986	10985	Paramanof Mountain	
	M	10983	10984	Paramanof Mountain	Killed 9/18/72
Y	M	10980	10981	Waskanareska	
X	F	10965	10966	Litnik Mountain	
W	F	10961	10962	Waskanareska	
V	F	10963	10964	Waskanareska	Killed by brown bear 5/18/72
D	F	10993	10994	Paramanof Peninsula	
C	F	10995	-	Paramanof Peninsula	
R	F	10971	10072	Olympic Peak	
G	F	10952	10951	SW Waterfall Lake	
H	F	10954	10953	Two miles south of Waterfall Lake	
A	M	10969	10970	Olympic Peak	
T	F	10991	10992	Duck Mountain	
S	F	10990	10989	Duck Mountain	
	F	-	-	Kitoi	Died (result of overdose)

* The same letters were assigned to different elk in 1970.

rate and decrease in percent of escaping elk are attributed to the less variable reactions of stressed elk to Anectine. Dosages of 25 mg. per animal in 50 mg/cc solutions were ineffective, while 40 mg. proved fatal. Dosages of 33-35 mg. in combination with the enzyme hyaluronidase resulted in the immobilization of 24 of 28 injected elk and produced the most desirable effects in terms of induction time and reactions to the drugs. However, the period of immobilization was often very short (Tables 3 and 4). Similar dosages were used for mature animals of both sexes. Average time to collapse was 7.8 minutes (range 3-18 minutes) and immobilization periods averaged only 13.4 minutes (range 3-45 minutes). Often, on approach, elk would attempt to rise and manual restraint would be required in order to place the collar on the animal. In many cases, it was impossible to complete the tagging and measuring process. The reaction of males to the same dosage was exaggerated in comparison to that of the females. Bulls often were immobilized for 45 minutes to one hour.

For reasons yet to be determined, transmitters failed to operate as anticipated. Several possible reasons are being explored. Knight (pers. comm.) found transmitter life to be greatly extended once satisfactory casing for the radio was developed. Available resources, time and money prevented the development of what I consider a satisfactory casing. Hines (1970) found that flexing of the collars had broken solid copper stripping that was being used as antennas. One such collar, found in June, 1971, was nearly broken in half as the result of considerable flexing and corrosion. Proud (1969), after tests and correspondence with the Mallory Battery Company, indicated that shorter-than-expected battery life could result from low current drain causing mercury shorts inside the cells. Radio V was recovered in May, 1972 when the elk was killed by a brown bear (*Ursus arctos*). Examination of the transmitter revealed a variable tuning capacitor had rusted away. Only 12 of the 23 radios continued to operate after eight months.

Grouping Patterns

Information relating to the nature and extent of herd breakup was collected coincidental to data on individual and herd movements. Because of extensive population declines and resulting small sample sizes, 1971 and 1972 group observations were pooled.

Changes in average elk group sizes found in this study were similar to those observed by Schwartz (1943) in Washington and Harper (1971) in Oregon. Rapid changes in mean group sizes of Afognak Island elk were observed to occur with seasonal changes and calving and rutting activities. Mean group sizes decreased progressively through the winter-spring period (Fig. 1), attaining their smallest size in May. Harper and Swanson (1970) and Knight (1970), in studies of *C. c. nelsoni*, observed similar declines presumably in response to calving and migration activities. After calving, elk began to congregate into larger groups as they began an upward movement to their summer alpine ranges. Rapid declines in mean group sizes again occurred with the onset of the August-September rutting season, followed by an immediate increase to a high for the year in November. A third decline to near the level of the

Table 3. Drug Dosages and Reactions of Elk Injected with Sucostrin, 1970

Sex	Age	Dosage	Minutes to Collapse	Minutes Immobilized	Remarks
F	Mat.	90 mg.	5	35	
M	1.5	65 mg.	5	55	Need respiration
F	Mat.	25 mg.	22	0	Had to be restrained
F	Mat.	25 mg.	5	10	
F	Mat.	20 mg.	8	25	
F	Mat.	32 mg.	5	25	
F	1.5	32 mg.	7	25	
F	Mat.	90 mg.	3	45	
F	Mat.	33 mg.	13	15	
F	Mat.	32 mg.	8	15	
F	Mat.	32 mg.	7	10	
F	Mat.	32 mg.	20	0	Had to catch & restrain
F	Mat.	35 mg.	3	30	Poor physical condition
F	Mat.	75 + 75	1	25	
F	Mat.	50 + 50	4	20	
F	Mat.	25 mg.	0	0	No effect
F	Mat.	30 mg.	0	0	No effect
F	Mat.	35 mg.	0	0	No effect
F	Mat.	35 mg.	0	0	No effect
F	Mat.	35 mg.	0	0	No effect
F	Mat.	65 mg.	5		Died
F	Mat.	90 mg.	7		Died
F	Mat.	55 mg.	3		Died, broken neck
F	Mat.	90 + 90	6		Died
F	Mat.	32 mg.	1	30	Required respiration for 10 minutes
F	Mat.	33 mg.	7	15	
F	Mat.	32 mg.	4	15	
F	Mat.	20 mg.	5	10	
M	Mat.	15 mg.	5	15	
M	Mat.	15 mg.	5	19	
F	1.0	20 mg.	20	10	
M	Mat.	25 mg.	5	10	
F	Mat.	80 mg. (2)	0	0	No effect
F	Mat.	40 mg.	0	0	No effect
F	Mat.	50 mg.	0	0	No effect
F	Mat.	35 mg.	0	0	No effect
F	Mat.	25 mg.	0	0	No effect
F	Mat.	32 mg.	0	0	No effect
F	Mat.	25 mg.	0	0	No effect
F	Mat.	32 mg.	0	0	No effect

Extremes 1 - 22 min.
Mean - 7

Extremes 0 - 55 min.
Mean - 21.8

Table 4. Drug Dosages and Reactions of Elk Injected with Anectine, 1971.

Sex	Age	Dosage	Minutes to Collapse	Minutes Immobilized	Remarks
F	1.4	35 mg.	5	13	
F	Mat.	35 mg.	6	13	
M	Mat.	35 mg.	5	15	Rested for 45 minutes
F	Mat.	35 mg.	7	8	
F	Mat.	35 mg.	4	8	
M	Mat.	35 mg.	4	15	Rested for approximately one hour
F	Mat.	35 mg.	18	10	
F	Mat.	35 mg.	8	3	
F	Mat.	34 mg.	6	15	
F	Mat.	34 mg.	7	10	
M	Mat.	34 mg.	8	8	Rested for approximately 50 minutes before being able to stand
M	Mat.	35 mg.		45	
F	Mat.	35 mg.	12	8	
F	Mat.	34 mg.	7	10	
F	Mat.	34 mg.	14	20	
F	Mat.	32 mg.	9	14	
F	Mat.	31 mg.	13	10	
F	Mat.	35 mg.	9	20	
F	Mat.	34 mg.	7	13	
F	Mat.	35 mg.	4	14	
M	Mat.		8	18	
F	Mat.	32 mg.	9	17	
F	Mat.	34 mg.	7	3	
F	Mat.	34 mg.			Hit but escaped in dense timber
F	Mat.	40 mg.	3		Died in 5 minutes
F	Mat.	30 mg.			20 Min. no effect
F	Mat.	32 mg.			20 Min. no effect
M	Mat.	35 mg.			18 Min. no effect

Extreme time to immobilization 3-18 min.

Mean time to immobilization 8 min.

Extreme period of immobilization 3-45 min.

Mean time of immobilization 13 min.

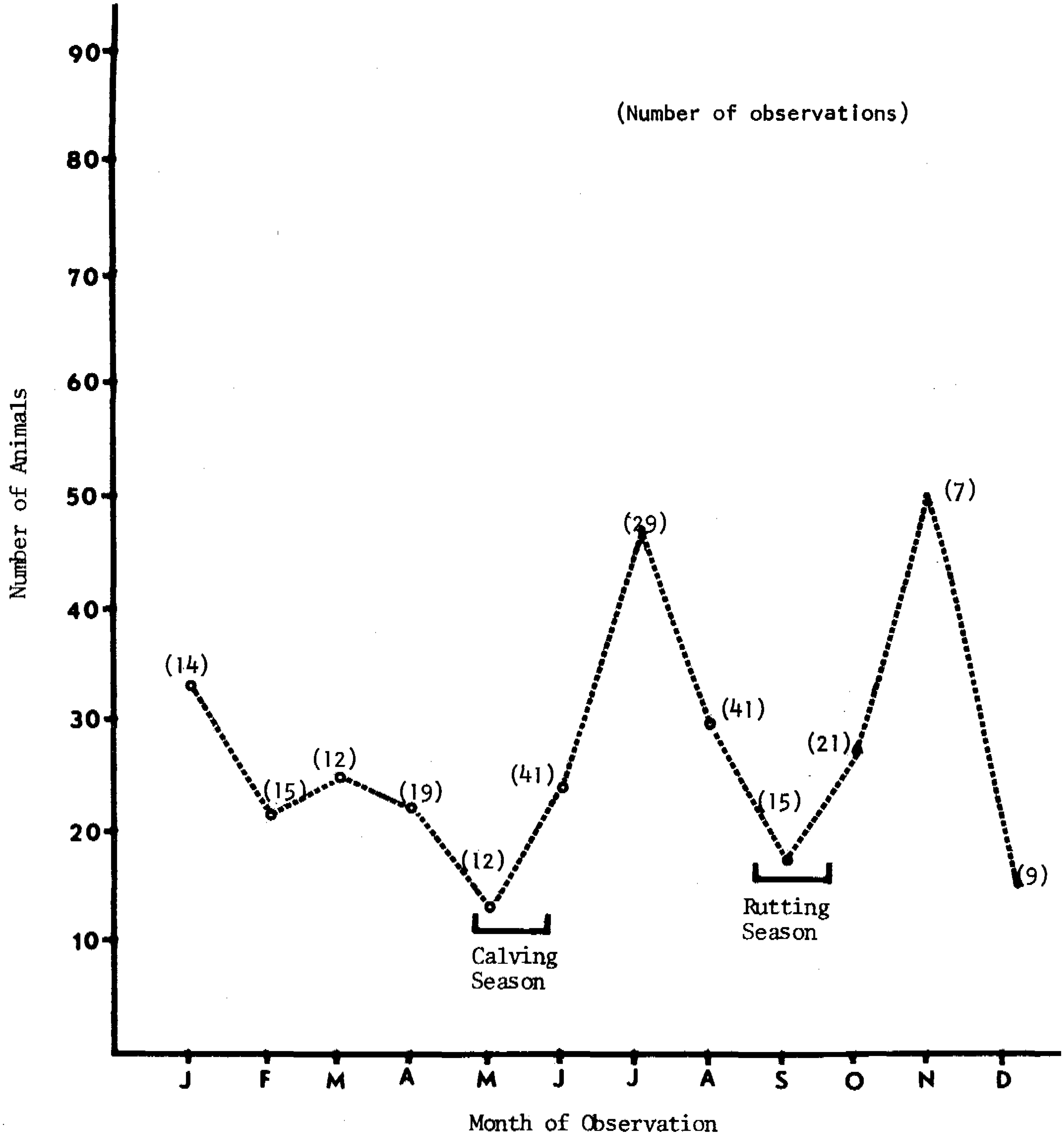


FIGURE 1 .--Average group size of elk observed on Afognak Is., 1970-72.

calving period low occurred in December, presumably in response to increasing snow depth.

Seasonal changes in mean group sizes did occur with changes in habitat use patterns. The largest group sizes recorded were during the summer period when the elk were in open alpine areas. Conversely, the smallest mean group sizes occurred during the winter period when elk were closely associated with mature spruce (*Picea sitchensis*) habitat where visability is restricted. However, these changes in group sizes should be attributed to seasonal changes in habits, not observability. Radio-marked elk generally made possible the location and counting of associated animals regardless of habitat type. In addition, actual breakup of animals into smaller groups occurred during the September breeding season while the majority of animals were readily observable on alpine ranges.

No large concentrations of elk (100-150) were observed on alpine ranges during the July-August period of 1971 and 1972 as had been observed in previous years. The probable reasons are: (1) elk herds were reduced to approximately one-half their 1970 size by heavy mortality occurring during the 1971 and 1972 winters, and (2) phenology of the season may have altered the "normal" seasonal distribution of elk. Snowfall each winter was in excess of 160 inches as compared to a previous eight-year average of 70 inches. Approximataly one-half of the total snowfall in 1971 occurred during the critical period of March and April (Fig. 2). The summer season of 1971 was retarded approximately six weeks and in some alpine areas, grasses and forbs did not develop normally as a result of unseasonably cold weather.

Life History

Attempts were made to weigh and collect standard measurements from each captured elk. Difficulties were encountered in weighing animals, because of the extremely short period of immobilization. Measurements consisting of girth, hind foot length and total length were compared to those of Roosevelt elk on the Olympic Peninsula of Washington. Mean measurements from 43 animals indicate that body size of Afognak elk may be somewhat larger. Schwartz (1943) found an average body length of 98 inches for males and 92 inches for females for Olympic Peninsula elk. The average body lengths of elk measured during this study were 103.2 for males and 96.4 for females (Table 5).

Herd Identities

A total of 272 observations of 32 radio-marked elk were made over a two-year period. These observations were used to determine the identities and movements of major elk herds. Table 6 lists nine individual herds, approximate herd boundaries, current population status and trend, as determined by five previous trend counts and home range size of these herds. Fig. 3 shows the approximate location of areas used by each herd.

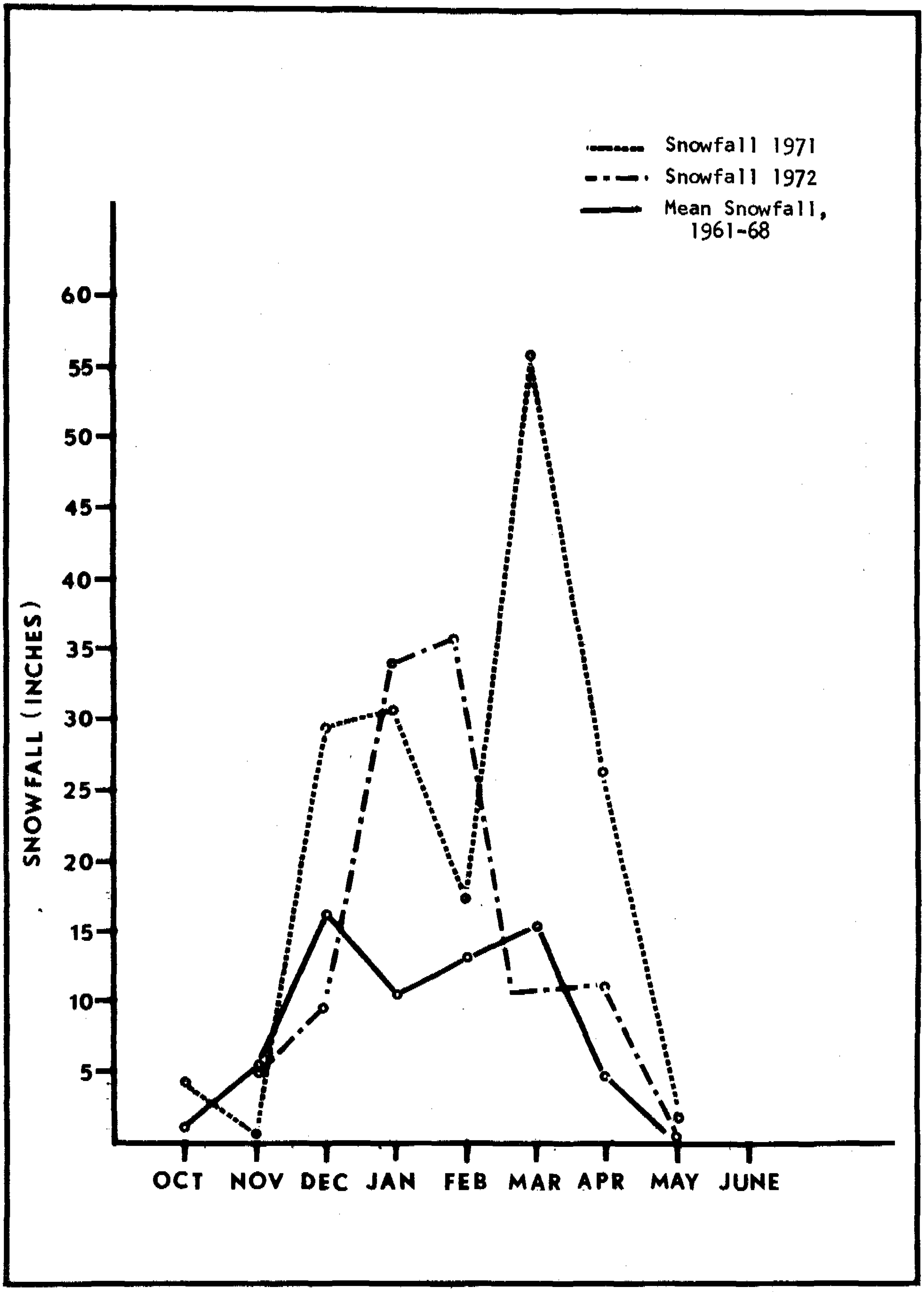


Fig. 2. Monthly snowfall for years 1971, 1972 and 1961-68 mean Afognak Island.

Table 5. Body measurement of 50 elk, yearlings and older, captured in 1970 and 1971.

Number	Age	Height of Shoulder	Girth	Hindfoot	Total Length	Weight
Males						
	Mat.			29		1,200
C	Mat.		68	28	104	
D	Mat.		74	29	105	860
A	Mat.					
J	1.5		64	27		
Y	Mat.		72		102	
L	Mat.		68	27	99	
A	Mat.		72		107	
Z	Mat.		64	26	102	
P	Mat.		69	27	104	
Mean			68.8	27.5	103.2	
Females						
M	Mat.					
O	Mat.		72	27	101	
N	Mat.		68	26	99	
H	Mat.		68		103	
G	Mat.		67		98	
R	Mat.		72	27	97	
D	Mat.		72	27	99	
C	Mat.		70	25	102	
J	Mat.		70	26	98	
K	Mat.		72	25	100	
I	1.4			24	95	
T	Mat.					
S	Mat.					
X						
	Mat.		70	26	95	
W	Mat.		72	26	100	
F	Mat.				97	
E	Mat.		64	27	100	
	Mat.		70	26	94	960
	Mat.	60	66	26	90	
	Mat.		64	27	95	
	Mat.	55	64	25	87	
	Mat.	61	66	25	96	
P	Mat.		64	25	92	660
S	Mat.		67	26	98	
V	Mat.		68	27	99	
R	Mat.		66		93	

Table 5. (cont'd.) Body measurement of 50 elk, yearlings and older, captured in 1970 and 1971.

Number	Age	Height of Shoulder	Girth	Hindfoot	Total Length	Weight
Females						
F	Mat.		74		104	
W	Mat.			28	92	
G	Mat.		69	27	89	
K	Mat.	60	71	25	89	
M	Mat.		70		96	
K	Mat.	61	68	27	93	
U	1.5		58	23	93	
T	Mat.	56	68	26	97	
I	Mat.	54	63	27	99	
H	Mat.	57	71	26	96	
N	Mat.		66	27	96	
O	Mat.		68		105	
E	1.5	44	50	24	94	
Mean		56.4	67.5	25.9	96.4	

Table 6. Herd Boundaries, Home Range Size and Population Trend of Nine Major Herds Inhabiting Afognak Island

Herd	Approximate Herd Boundaries	Home Range mi^2	Maximum Herd Numbers[2/]	Estimated Herd Sizes[2/]	Population Trends[3/]
<u>Herds in areas of limited timber growth</u>					
Tonki	Tonki Peninsula east of Swartz Lake	25.4	284[b/]	120	Stable
Paramanof Peninsula	Paramanof Peninsula east to King Lake	23.7	116[d/]	50	Decreasing
Malina	Cape Nuviliak Peninsula to Malina Cape-Malina Peninsula	13.7	222[a/]	0	Absent
Raspberry Island	Entrance to Onion Bay on Raspberry Cape to Windy Point	22.2	230[c/]	45	Decreasing
<u>Herds in areas of major timber growth</u>					
Raspberry Strait	Muskomee Bay-Afognak Lake to Litnik Mountains and Raspberry Strait	39.4	225	60	Decreasing
Waterfall	Waterfall Bay-Waterfall Mountain to Kazakof Peak and Delphin Bay	29.4	110[e/]	75	Decreasing
Kitoi	Headwaters of Kitoi Bay to Long Lake	14.1	41[d/]	25	Decreasing
Duck Mountain	Cape Kostromitnof to Selezen Bay to Duck Mountain	19.2	138[d/]	50	Decreasing
Paramanof Mountain	Paramanof Mountain and bays west of King Lake	18.5	95[d/]	25	Decreasing

1. Taken from maximum aerial trend counts

   a. 1961
   b. 1964
   c. 1965
   d. 1970
   e. 1971

2. 1972 trend counts plus sign indicating additional elk

3. Indicated from previous five year trend counts

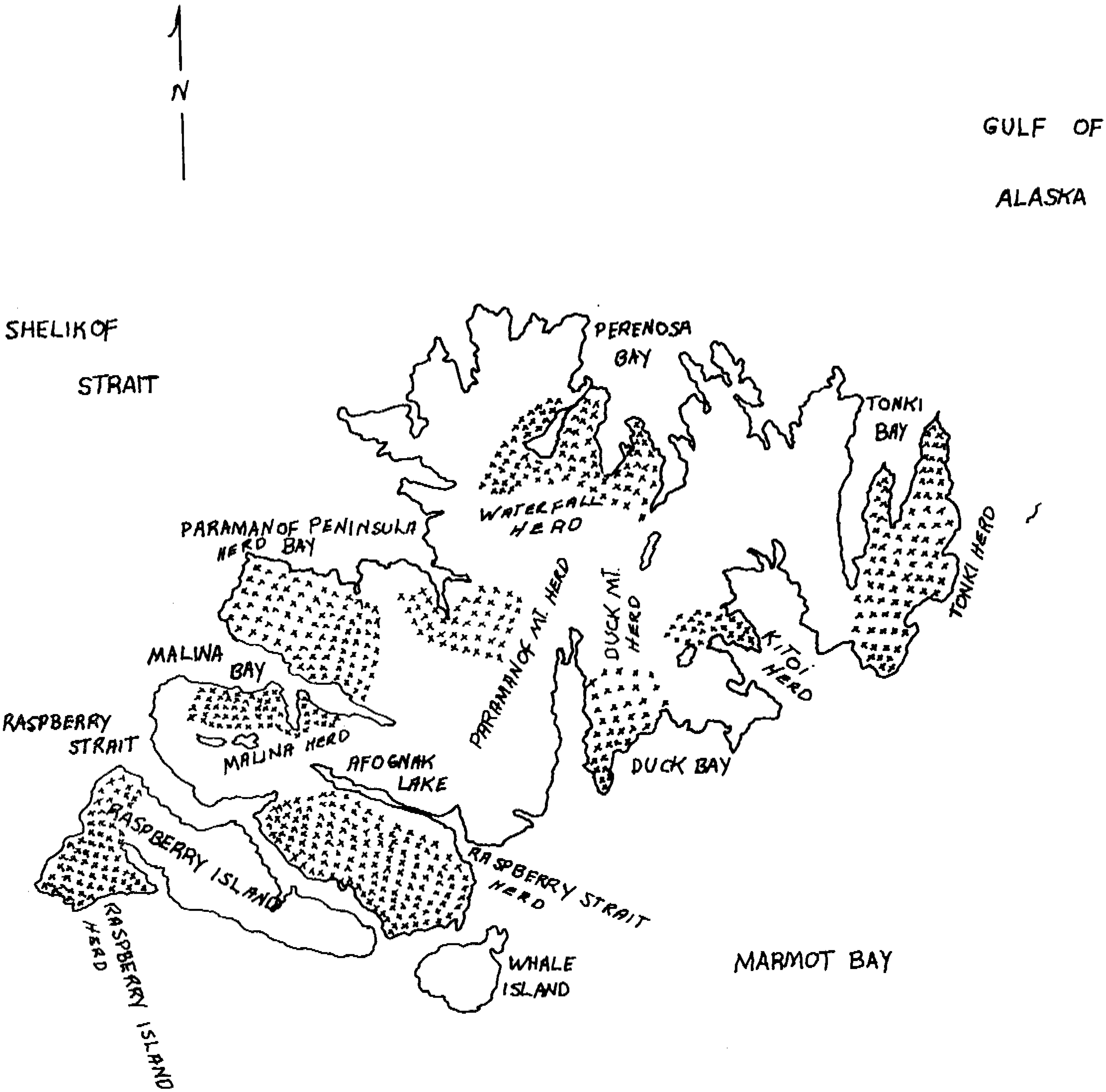


FIGURE 3. Approximate location of areas used by each of nine major elk herds. Afognak Island, 1970-1972.

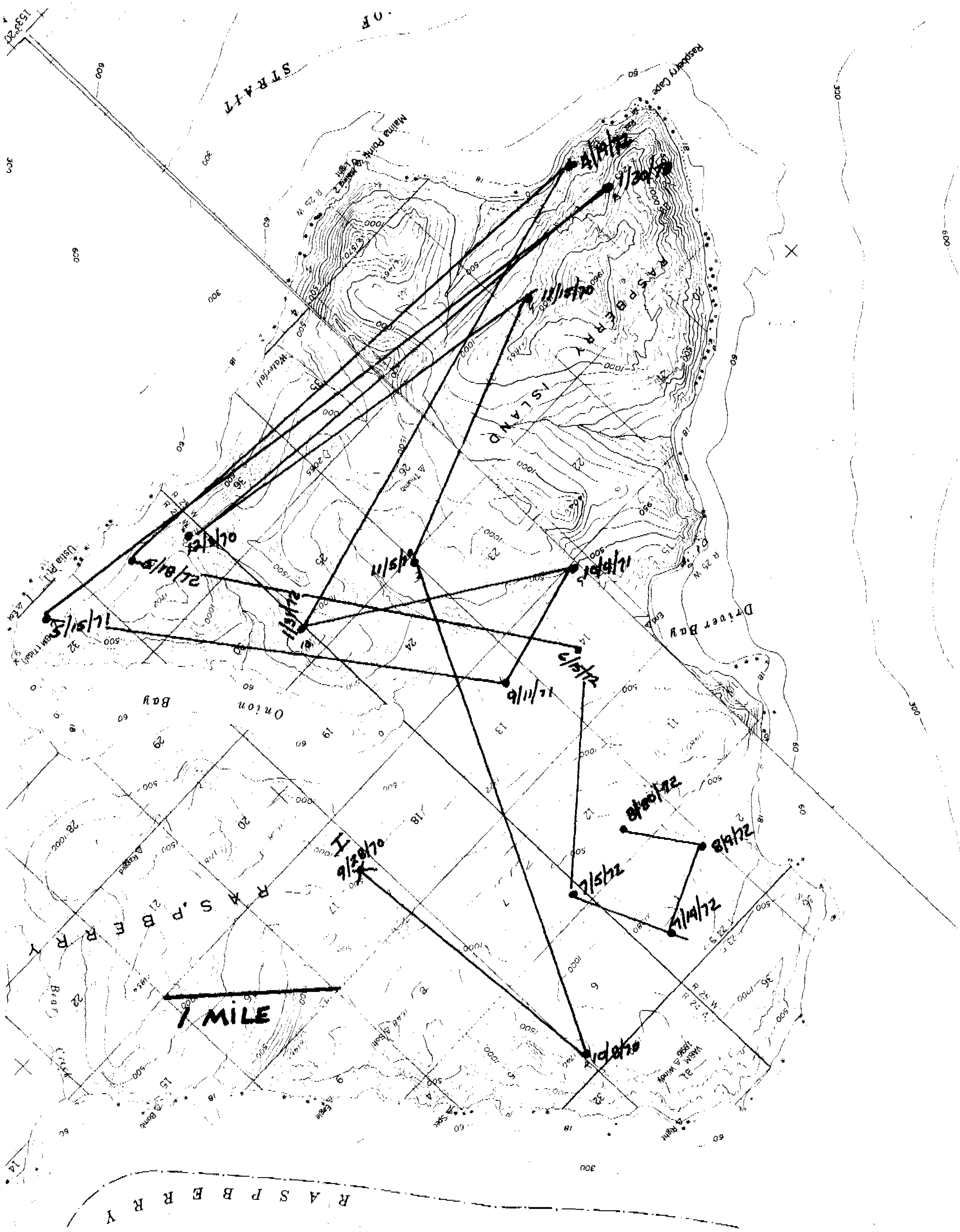
Many factors have been known to influence the seasonal movements and exchange of animals between herds. Harper (1971) concluded that seasonal movements and animal exchange between herds were influenced by terrain. Elk inhabiting steep, rugged terrain generally had the smallest home range and the least amount of herd interchange. Home range and degree of interchange were noted to increase as the terrain moderated. It is also probable that quality, quantity and placement of essential habitat and snowfall influence the seasonal movements of elk. Afognak Island topography is extremely rugged. Steep mountains often rise to near 3,000 feet elevation within one or two miles from sea level. Since all the major vegetation types utilized by elk can be found along the steep vertical rises, one would expect relatively limited seasonal and annual movements to be the rule.

Seasonal Movements

Elk movements and home ranges were divided into two distinct seasonal periods, winter-spring (December-April) and summer-fall (May-November). Winter movements of the nine major herds were determined by 101 observations and summer-fall movements by 171 observations of the 32 radio-tagged elk. These observations indicated there were variations in movements and home range sizes. Such variations may be the result of variations in habitat types, snow accumulation, seasonal abundance of vegetation and sex composition of the herds.

Fourteen tagged elk, four each from Raspberry Island (Fig. 4) and Paramanof Peninsula (Fig. 5) and three each from the Malina (Fig. 6) and Tonki (Fig. 7) peninsulas, provided 86 observations of elk inhabiting areas of limited timber growth. Calculated annual home ranges were 22.2, 23.7, 13.7 and 25.4 square miles, respectively, and averaged 21.2. Winter home ranges were calculated as 5.5, 1.8, 3.5 and 0.45 square miles, respectively, and averaged 3.2 square miles. The Raspberry Island and Paramanof Peninsula herds demonstrated similar movement patterns during both years of the study. Winter movements appeared restricted to the steep southeast-facing slopes adjacent to Kupreanof Strait and low valleys adjacent to the south slope of Paramanof Bay. Following the calving period a northerly movement into areas characterized by broad valleys and low ridges facing westward toward Shelikof Strait was noted. The Paramanof Peninsula herd also exhibited a movement from the north to the south side of the peninsula each year. Observations of tagged animals from the Malina herd were limited to the winter-spring period of 1971 due to the loss of the animals to the stress imposed by the previous winter. Summer utilization of westerly exposures was similar to that of the Raspberry Island herd; however, winter travels were restricted to the northwest shores of Malina Bay. The last of the Malina herd are believed to have died about the first of May, 1971.

Eighteen tagged elk, seven from Raspberry Strait, four from Duck Mountain, three each from Paramanof and Waterfall mountains and one from Kitoi, provided 186 observations of elk inhabiting timbered regions of Afognak Island. Annual home range size varied from 14.1 to 39.4 square miles and averaged 21.1 square miles. Winter home range sizes varied



(2)
(3)
(4)

Figure 4. Movements of elk I, Raspberry Island herd, September 28, 1970 to August 30, 1972. Raspberry Island.

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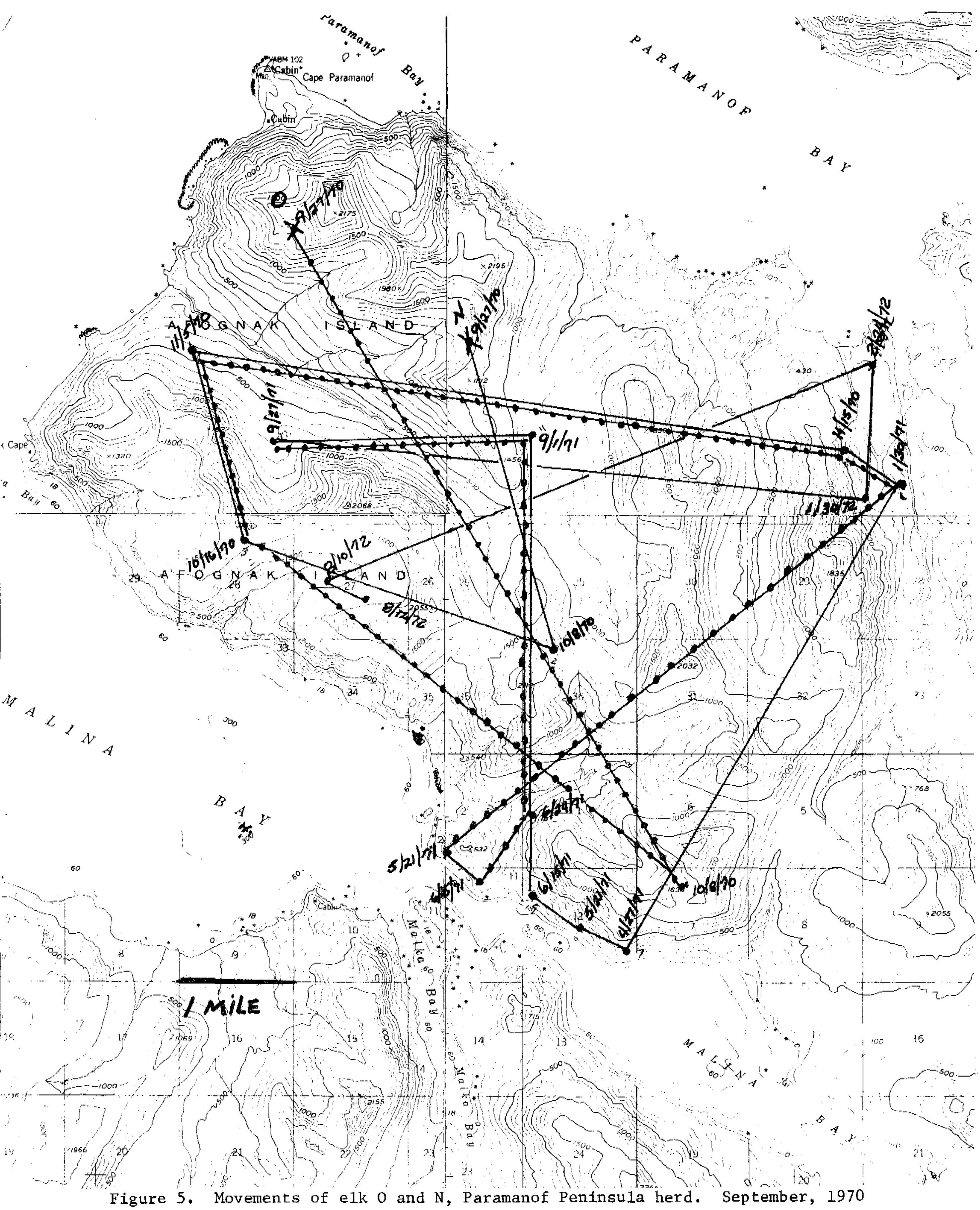

Figure 5. Movements of elk O and N, Paramanof Peninsula herd. September, 1970 to September, 1971. Afognak Island

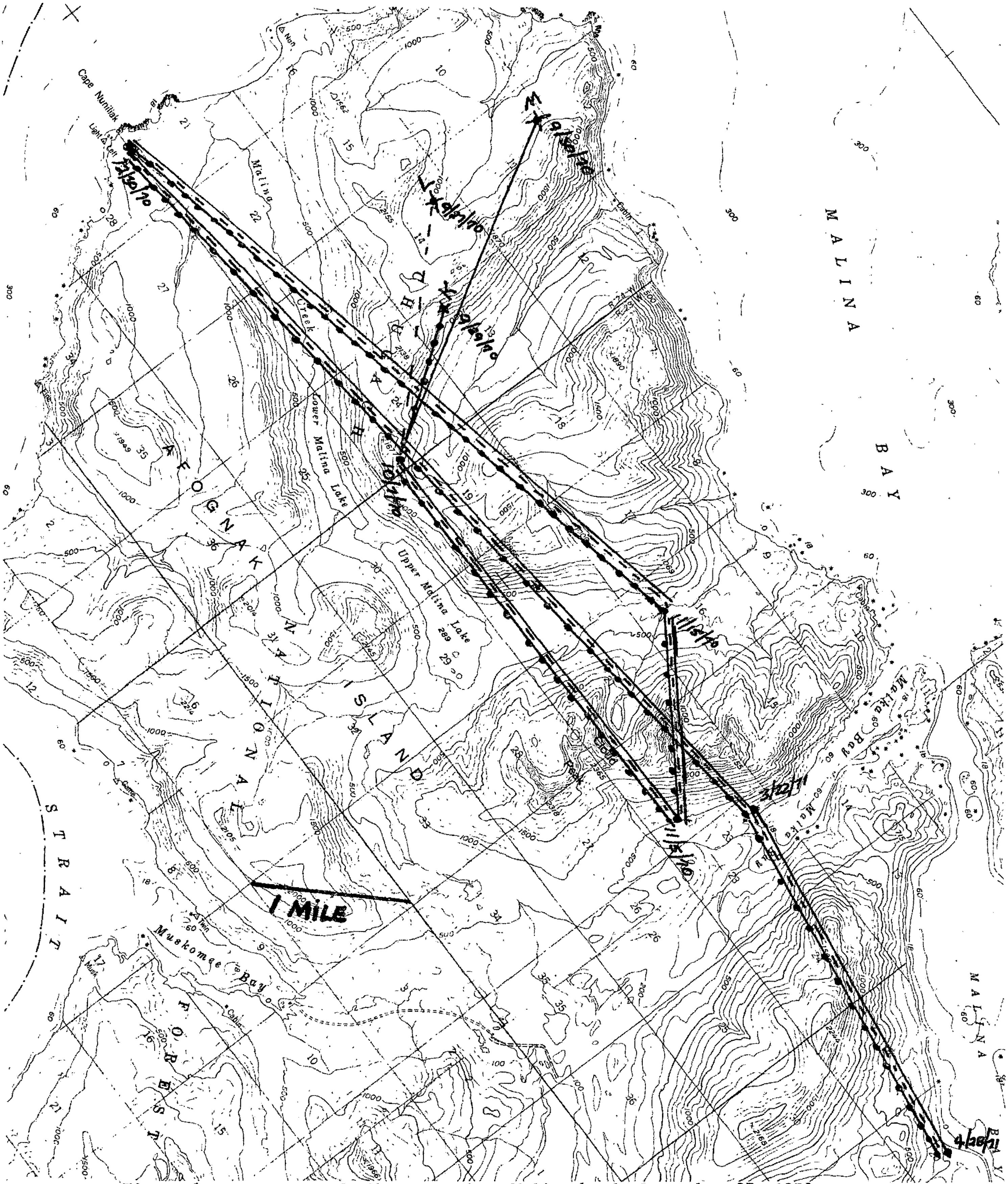

Figure 6. Movements of elk K, L and M, Malina herd, September 27, 1970 to April 28, 1971. Afognak Island.

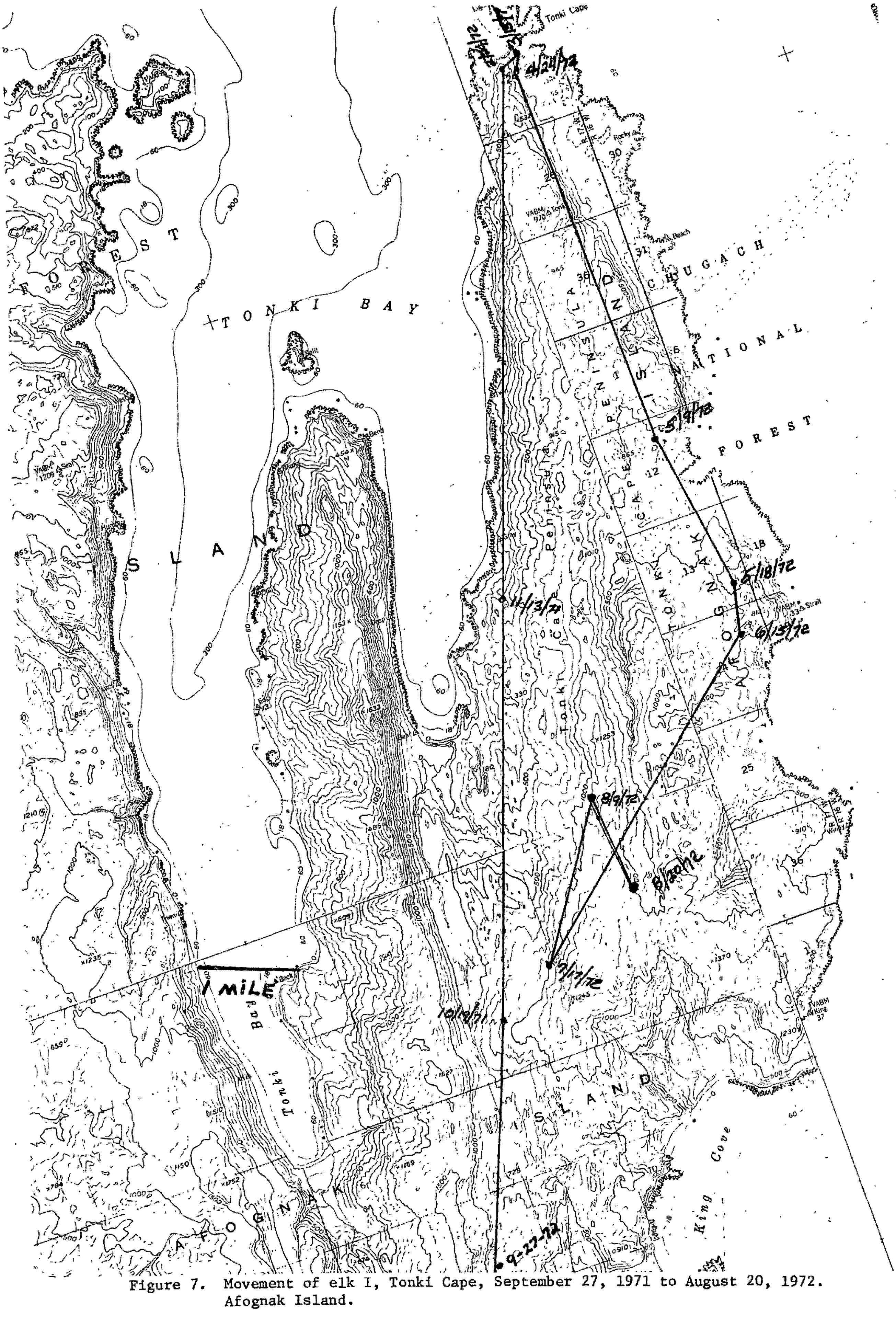

Figure 7. Movement of elk I, Tonki Cape, September 27, 1971 to August 20, 1972. Afognak Island.

from 1.2 to 3.9 square miles and averaged 3.2 square miles (Table 7). Habitat types did not appear to influence average size of annual and winter home ranges. Duck Mountain (Fig. 8) and Raspberry Strait (Fig. 9) herds demonstrated typical movement patterns for elk inhabiting timbered regions of Afognak Island. Winter movements were restricted to timbered south and southeast-facing slopes adjacent to beach fringes. Alder (*Alnus crispa*) covered hillsides above timberline with similar aspects provided intermediate spring range until the elk moved on to alpine ranges in late July. Movements from alpine areas to intermediate fall ranges with a northerly aspect generally occurs during early October.

The Paramanof (Fig. 10) and Waterfall (Fig. 11) mountain herds exhibited the most extensive seasonal movements. Winter ranges near Paramanof and Delphin bays were in excess of six miles from the summer ranges on Paramanof and Waterfall mountains. The Paramanof Mountain herd wintered in close proximity to the Paramanof Peninsula herd in 1971-72. Though no exchange of animals between herds was noted the possibility does exist.

The Waterfall herd wintered in areas adjacent to Delphin and Discovery bays. A limited number of observations from tagged elk (9) plus signs observed during tracking flights indicate that the major herd separates into numerous small groups that range extensively throughout the area. The Kitoi herd (Fig. 12) utilized similar summer and winter ranges during both years. Extensive use was made of the densely timbered Kitoi Peninsula during the winter period, followed by a shift in range to an area approximately four miles inland. The summer range, though densely timbered, does possess large alder and grass openings.

Movements of bulls older than two years are generally independent of the rest of the herd (Harper, 1971). This is generally the case with Afognak bulls (Fig. 7-A). However, it was not uncommon to observe bulls traveling with female and immature elk groups throughout the year. A tagged adult bull was observed with the Raspberry Strait herd during nine of 13 tracking flights, October to August, 1971-72. When adult males do accompany female groups their annual movements are considerably more extensive than those of solitary males. Minimum movements of females occurred in May and June, probably in response to parturition, and subsequent periods of early calf development.

Reduced herd movements were also noted in January, February and March particularly in the Tonki Cape, Waterfall and Kitoi herds. Snow accumulation far above normal during both years is believed to be the reason for reduced movements. Movements within an area of less than one square mile during this period were not uncommon. It appeared at times that the herd had become snow bound, as no noticeable movement could be observed between observations made nearly a month apart.

Habitat Preferences

For the purpose of determining habitat use and preference, the location of elk observations were subjectively classified into three

Table 7. Maximum, minimum and winter home range for 32 radio marked elk and associated herds, Afognak and Raspberry islands, 1970-72.

Herd	Elk	Sex	Maximum Distance Between Obs.	Observation Period	Minimum Distance Between Obs.	Observation Period	Winter Home Range mi²
Herds in areas of limited timber growth							
Tonki	I-71	F	5.00 miles	11/13/71-2/24/72	.25 miles	2/24/72-3/13/72	.75 sq. mi.
Tonki	L-71	M	1.00 miles	10/2/71-10/19/71	.25 miles	2/7/72-2/24/72	.30 sq. mi.
Tonki	J-71	F	5.00 miles	10/2/71-10/19/71	.25 miles	2/7/72-2/24/72	.30 sq. mi.
Paramanof Peninsula	C-71	F	3.25 miles	9/27/71-10/19/71	.25 miles	6/2/72-6/15/72	2.30 sq. mi.
Paramanof Peninsula	D-71	F	3.25 miles	9/27/71-10/19/71	1.00 miles	3/15/72-4/20/72	2.30 sq. mi.
Paramanof Peninsula	O-70	F	6.50 miles	9/27/70-10/8/70	.50 miles	11/15/70-1/30/71	1.30 sq. mi.
Paramanof Peninsula	N-70	F	5.50 miles	11/5/70-11/15/70	.50 miles	11/15/70-1/30/71	1.30 sq. mi.
Raspberry Island	F-71	F	4.50 miles	4/24/72-5/9/72	.50 miles	5/9/72-5/18/72	4.20 sq. mi.
Raspberry Island	H-70	F	5.50 miles	4/19/72-5/15/72	.75 miles	8/9/72-8/20/72	7.30 sq. mi.
Raspberry Island	I-70	F	5.50 miles	4/19/72-5/15/72	.75 miles	8/7/72-8/20/72	7.30 sq. mi.
				4/24/72-5/9/72	.50 miles	5/9/72-5/18/72	7.30 sq. mi.
Raspberry Island	E-71	F	4.50 miles				
Malina Peninsula	K-70	F	8.00 miles	12/30/70-3/22/71	1.75 miles	11/5/70-11/15/70	3.50 sq. mi.
Malina Peninsula	L-70	F	8.00 miles	12/30/70-3/22/71	1.75 miles	11/5/70-11/15/70	3.50 sq. mi.
Malina Peninsula	M-70	F	8.00 miles	12/30/70-3/22/71	1.75 miles	11/15/70-11/15/70	3.50 sq. mi.
Mean			5.25 miles		.76 miles		3.2
Elk herd in areas of major timber growth							
Raspberry Strait	F-70	F	3.50 miles	1/30/71-5/1/71	.50 miles	11/15/70-12/9/70	1.20 sq. mi.
Raspberry Strait	G-70	F	4.00 miles	9/27/70-10/8/70	2.00 miles	12/31/70-1/30/71	2.60 sq. mi.
Raspberry Strait	B-70	F	5.00 miles	6/18/70-6/13/70	1.00 miles	4/31/71-6/14/71	2.60 sq. mi.
Raspberry Strait	Y-71	M	5.00 miles	2/24/72-4/20/72	1.00 miles	5/9/72-5/18/72	3.20 sq. mi.
Raspberry Strait	V-71	F	4.00 miles	10/2/71-10/19/71	.75 miles	5/9/72-5/18/72	3.20 sq. mi.
Raspberry Strait	W-71	F	5.00 miles	2/24/72-4/20/72	.75 miles	5/9/72-5/18/72	3.20 sq. mi.

Table 7. (cont'd.) Maximum, minimum and winter home range for 32 radio marked elk and associated herds, Afognak and Raspberry islands, 1970-72.

Herd	Elk	Sex	Maximum Distance Between Obs.	Observation Period	Minimum Distance Between Obs.	Observation Period	Winter Home Range mi^2
Elk herd in areas of major timber growth							
Raspberry Strait	X-71	F	5.00 miles	2/24/72-4/2/72	.75 miles	5/9/72-5/18/72	3.20 sq. mi.
Paramanof Mountain	N-71	F	6.25 miles	10/2/71-1/31/72	.25 miles	5/9/72-5/31/72	3.90 sq. mi.
Paramanof Mountain	M-71	F	6.25 miles	10/27/71-1/31/72	.25 miles	5/9/72-5/31/72	3.90 sq. mi.
Paramanof Mountain	0-71	F	6.25 miles	10/2/71-1/31/72	.25 miles	5/9/72-5/31/72	3.90 sq. mi.
Duck Mountain	T-71	F	6.00 miles	10/19/71-2/24/72	.25 miles	5/9/72-5/18/72	3.70 sq. mi.
Duck Mountain	S-71	F	6.00 miles	10/19/71-2/24/72	.25 miles	5/7/72-5/18/72	3.70 sq. mi.
Duck Mountain	T-70	F	5.75 miles	11/15/70-1/30/71	.75 miles	1/30/71-3/22/71	2.80 sq. mi.
Duck Mountain	U-70	F	4.50 miles	11/15/70-1/30/71	.75 miles	1/30/71-3/22/71	2.80 sq. mi.
Waterfall	R-71	F	8.00 miles	10/2/72-2/15/72	.00 miles	2/15/72-3/24/72	3.80 sq. mi.
Waterfall	G-71	F	10.50 miles	3/24/72-8/9/72	.00 miles	2/15/72-3/24/72	3.80 sq. mi.
Waterfall	H-71	F	6.00 miles	10/2/72-2/9/72	1.50 miles	2/15/72-3/24/72	3.10 sq. mi.
Kitoi Bay	V-70	F	6.50 miles	11/15/70-1/30/71	.75 miles	1/30/71-3/22/72	3.50 sq. mi.
Mean			5.75 miles		.65		3.2

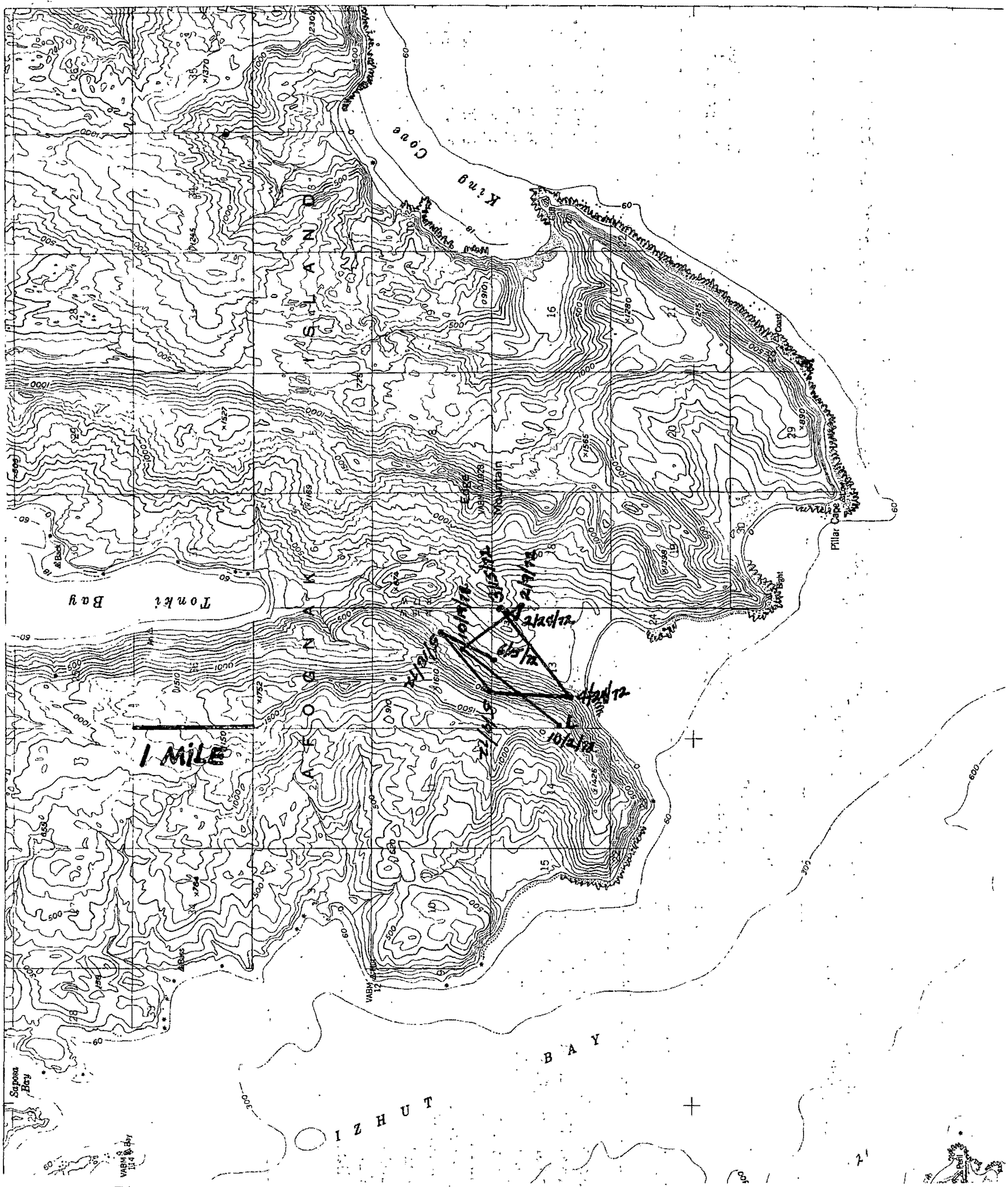

Figure 7-A. Movement of elk L males, Tonki Cape, October 2, 1971 to June 15, 1972. Afognak Island.

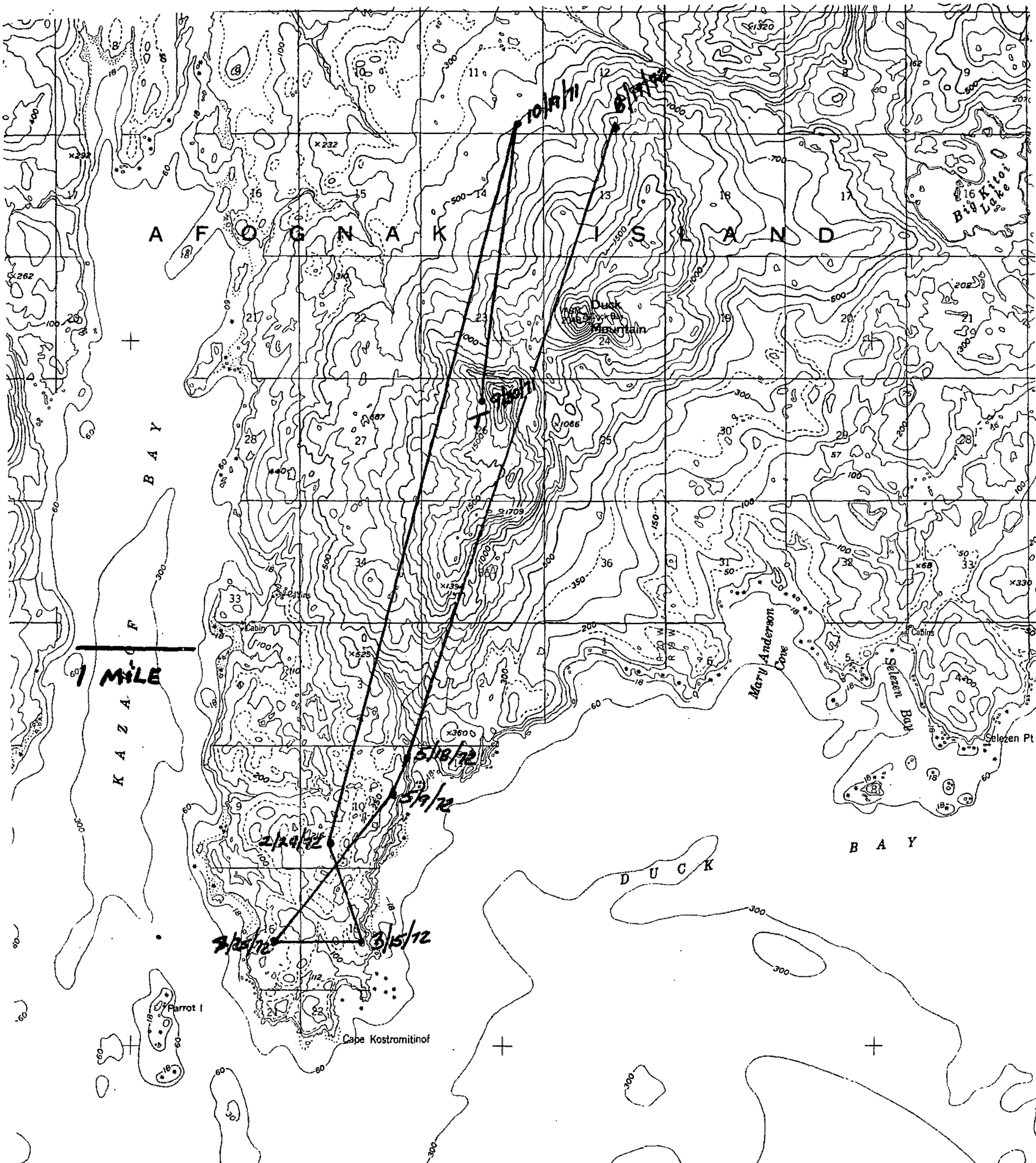

Figure 8. Movements of elk T, Duck Mountain herd, September 30, 1971 to August 17, 1972. Afognak Island.

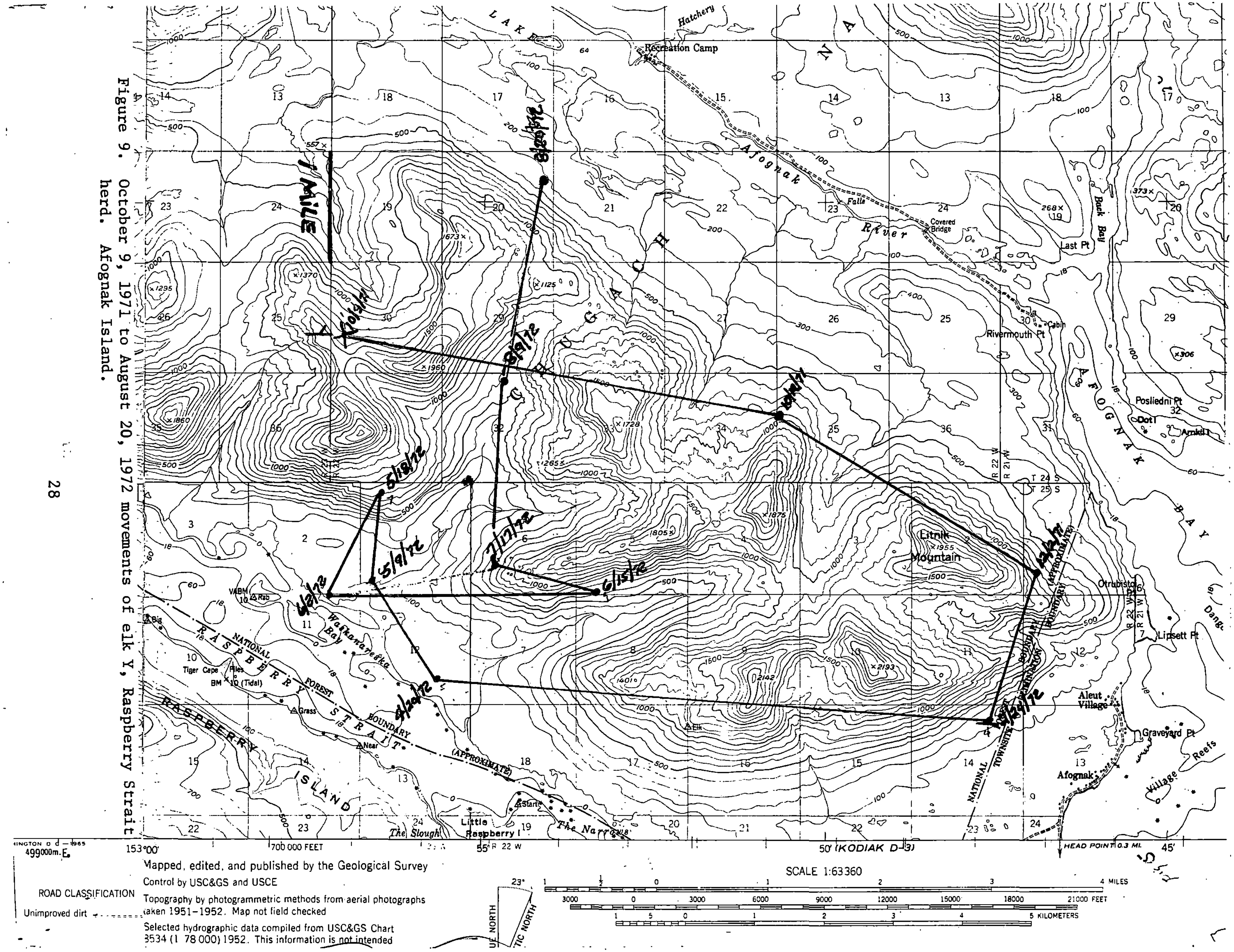

Figure 9. October 9, 1971 to August 20, 1972 movements of elk Y, Raspberry Strait herd. Afognak Island.

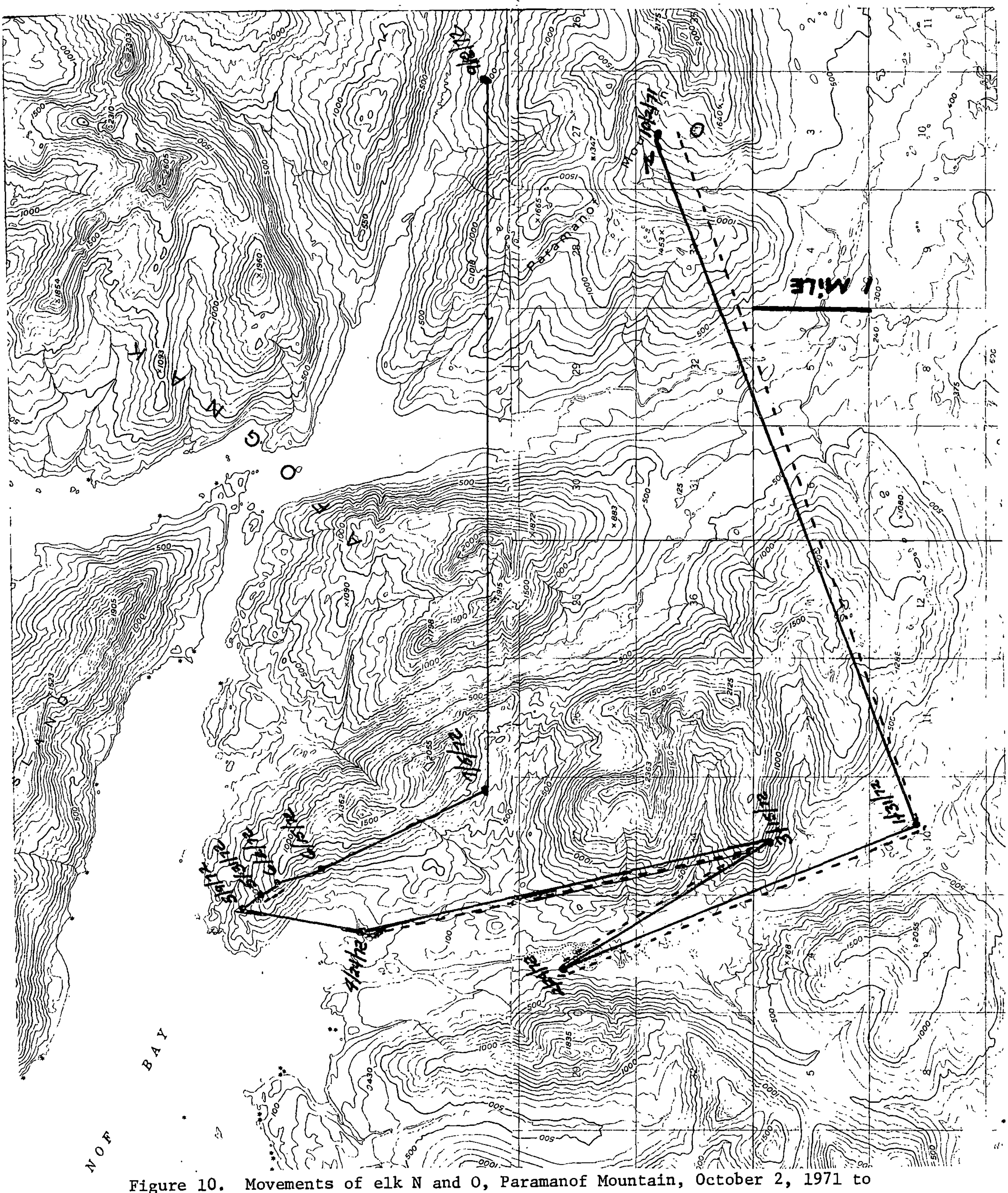

Figure 10. Movements of elk N and O, Paramanof Mountain, October 2, 1971 to September 18, 1972. Afognak Island.

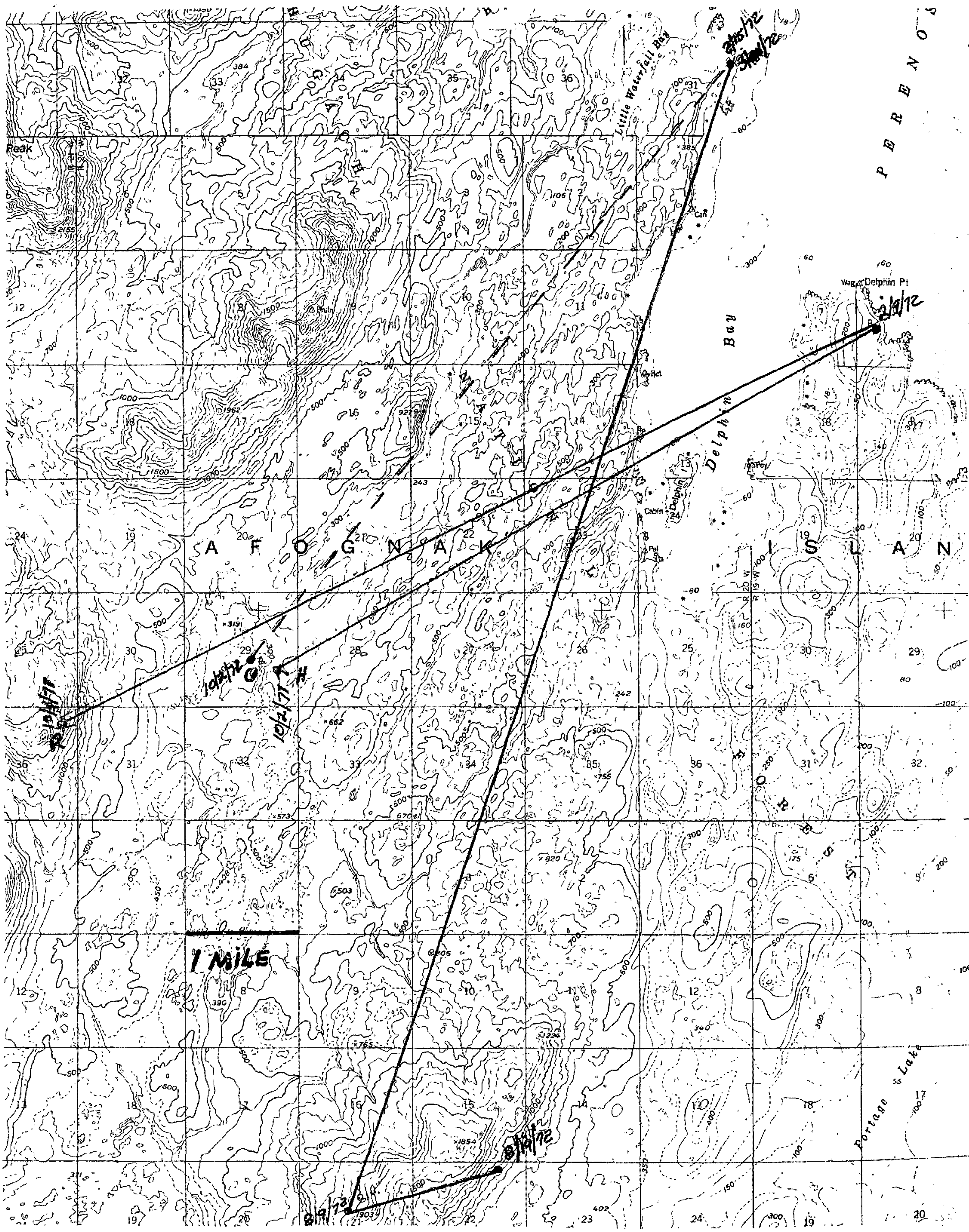

Figure 11. Movement of elk G, R, and H, Waterfall herd. October 4, 1971 to August 19, 1972. Afognak Island.

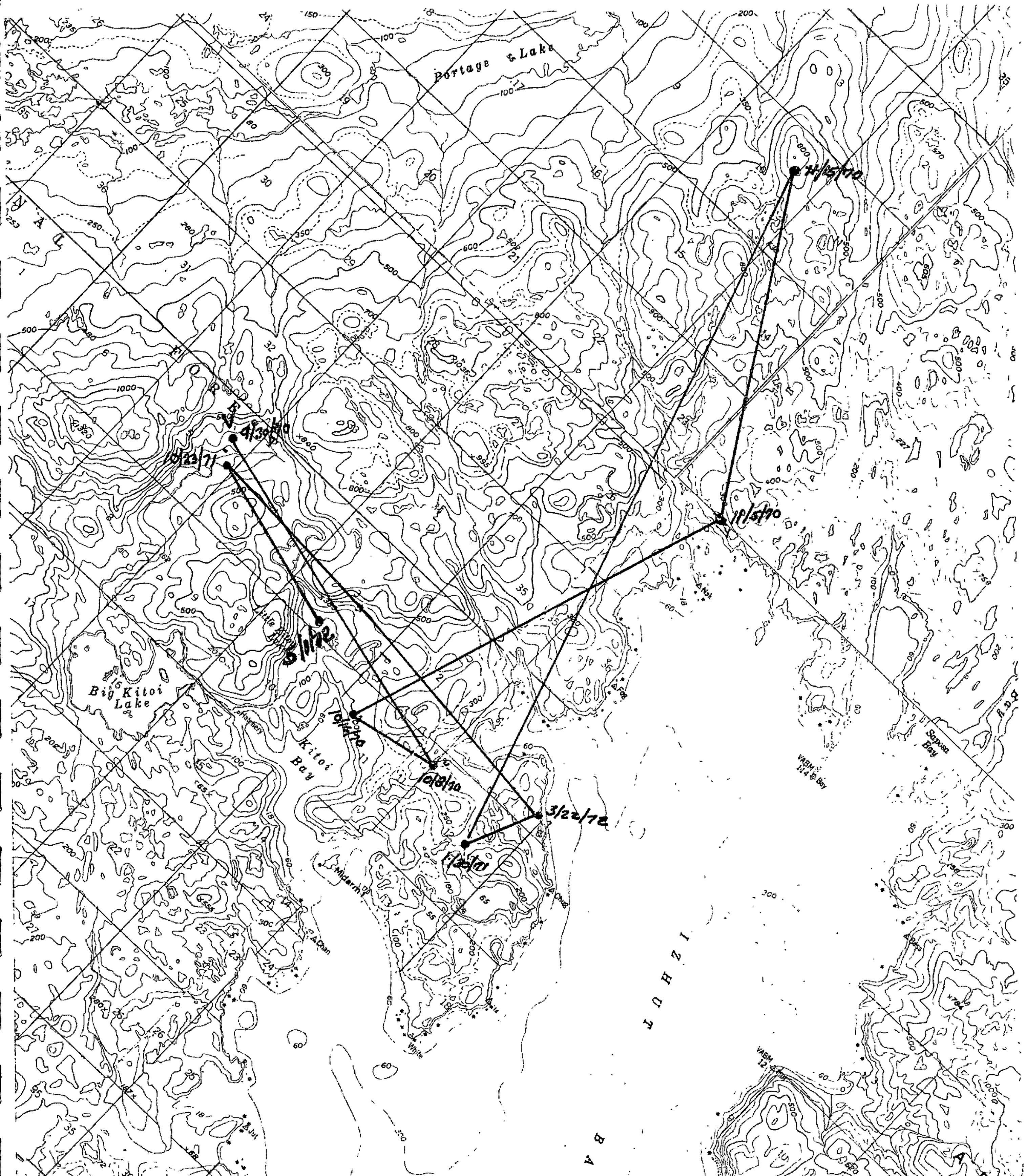

Figure 12. Movements of elk V, Kitoi Bay, September 30, 1970 to May 1, 1972.

major vegetation types; spruce, alder-grass and alpine. The frequency and percent of time tagged elk were observed in these categories were recorded. Elk behavior and subsequent use of habitat may be influenced by the time of day (Harper et al., 1967), (Bentley, 1959; unpublished master's thesis), therefore observation periods were varied between early morning and late afternoon. Because observations were few, the data from both years were pooled. Two hundred and ninety-four observations of 40 tagged elk and 3,685 observations of untagged elk were used to determine habitat use. Forty-three percent of the total sightings were made in spruce, 34 percent in grass-alder and 22 percent in alpine habitats.

Utilization of spruce-timbered areas by elk was greatest from December through March and decreased steadily thereafter. Alder communities were used more as herbaceous plants emerged in the spring and again as snow arrived on alpine ranges in the fall. Elk concentrations on alpine habitat were restricted primarily to the summer months of August and September. Notable exceptions were on Tonki and Raspberry capes where alpine vegetation extends almost to sea level and remains relatively free of snow during the winter months. Elk in these areas account for the February-March observations of animals on alpine habitat (Fig. 13).

Associations of Elk

The degree of association among elk is quantitatively expressed using the "formula for the coefficient of association" presented by Knight (1970). Using this formula, a value of 1.0 would indicate a perfect association. Though the total number of observations is limited there does appear to be a higher degree of association among elk of this study than found among Rocky Mountain elk (Knight, 1970) and Roosevelt elk in Oregon (Harper, 1971) as shown in Table 8. A strong association existed between females in most herds between seasons and between the two years of the study. The mean coefficient of association of 0.51 suggests a relatively stable elk herd in which only limited exchange of animals exists. A higher degree of association is suspected; however, the malfunction of radio transmitters, high mortality of tagged elk resulting from severe winters, loss of tags and poor observational conditions prevented positive identification of many tagged animals.

A tally of herd numbers and composition at each sighting provided insight into the group behavior of the major herds. Elk herds moved about their respective herd areas without major changes in composition or numbers. Seasonal break-ups did occur in response to rutting and calving activities during the spring and fall periods. Some herd break-up was also noted during the period of maximum snow accumulation. Commencing in June, group sizes increased as small bands merged and moved into the intermediate grass-alder and the alpine ranges where they remained as constant groups throughout the summer. Altmann (1960) reported that after a disturbance a group's components reformed into the same herd. Herd break-up caused by the use of a helicopter frequently occurred during tagging operations. Observations indicated that

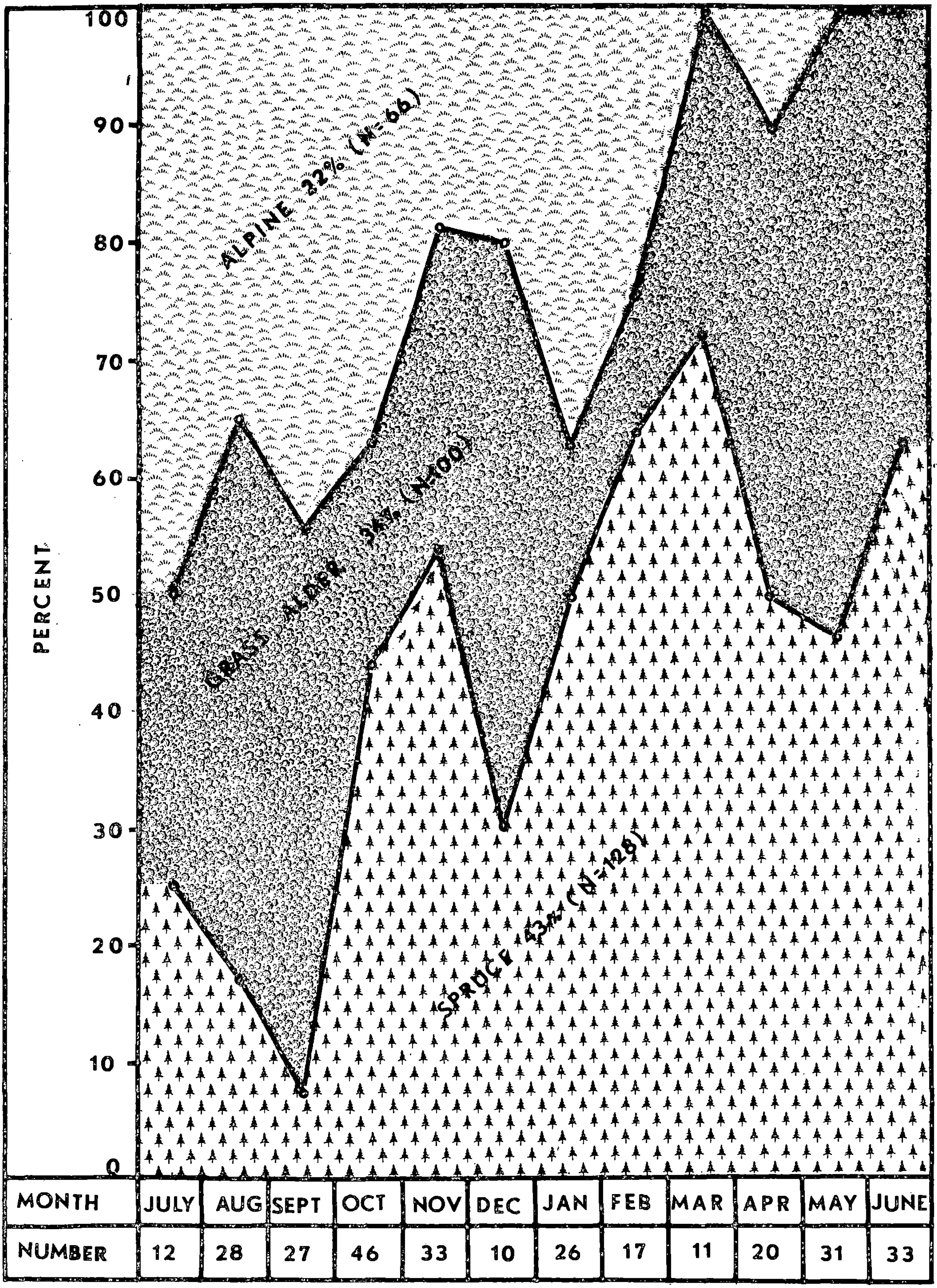

Figure 13. Seasonal changes in percent of observations of 40 radio marked elk made in different habitat types. Afognak Island, 1970-1972.

Table 8. Coefficients of Association for Radio Marked Elk on Afognak and Raspberry Island, 1971-1972.

Herd	Elk	Association With				
Tonki	I-7	J-71	K-71	L-71M		Mean
		.89	.24	.10		.41
Raspberry Island	F-71	P-71M	E-71	I-71	H-70	Mean
		.14	.95	.82	.82	.68
Raspberry Strait	W-71	Y-71M	X-71	V-71		Mean
		.64	.55	.01		.40
Paramanof Peninsula	D-71	C-71	N-70	O-70		Mean
		.50	.75	.53		.59
Paramanof Peninsula	N-71	O-71	M-71			Mean
		.08	.84			.46

individuals which were tagged in successive days and groups separated by the tagging operation had reformed into their original group within a few days and remained intact until the winter or calving break-up occurred. No exchange of tagged elk between herds was observed during the course of the study.

DISCUSSION

In general, elk exhibited a high preference for spruce timber habitat, which is used intensely during the winter and spring months regardless of snow depths. Schwartz (1943) inferred the importance of timber to elk in coastal areas of Washington. His observations indicated that elk showed a preference toward small islands of standing timber left after logging. The same preference for small stands of timber was noted on the southwestern portion of Afognak Island where large continuous stands of timber do not exist. Harper and Swanson (1970) found that elk use of openings, expressed in acres per elk, decreased as the distance from standing timber increased. With only a few exceptions during this study, elk were never observed more than a few yards from standing timber during the October-June period. The notable exceptions were on Raspberry Island and Tonki Cape where little timber exists on the winter range. Both areas are easterly facing capes extending into the ocean and are kept relatively free of snow accumulation by prevailing winds. Vegetation on the capes closely resembles that of the higher alpine regions. In general elk movements and home ranges on all areas of Afognak tended to be greater than that reported by Harper (1971) for Roosevelt elk in Oregon. This tendency toward larger home ranges may be the result of extended movements required by the greater distance between preferred seasonal habitats and exposures. Marked animals that survived both winters exhibited a tendency to return to the same summer, winter and calving areas each year. This tendency is probably the result of animals seeking the most favorable habitat within the herd area. Winter movements generally consist of travels parallel and adjacent to the beach line where snow depth is least. Although movement to new summer ranges was not restricted, tagged elk did not disperse, but apparently were limited by their ranging habits to traditional areas.

Large bulls are not generally found with the main herds at times other than the breeding season (Troyer, 1960; Harper, 1971). However, our observations indicated mixed bull-cow groups were common during all seasons. When such was the case, male movements were similar to those of the females and much greater than those of the solitary bulls.

CONCLUSION

This study confirmed past observations concerning the limited movements, dispersal and herd integrity of Afognak Island elk. The knowledge that discrete herds exist and herd consistency is maintained will assist in the development of a management plan directed at the manipulation of these herds. This study demonstrates the values of radio telemetry and aircraft to determine animal movements and habits in remote areas of dense habitat.

RECOMMENDATIONS

The apparent stability of Afognak elk herds and their tendency to utilize traditional ranges indicate the necessity for development and implementation of a management plan on an individual herd basis. Annual composition and trend counts and tabulation of harvest by established herds are essential components of such a management plan.

Logging and the subsequent development of access may warrant special considerations for both elk and habitat. Studies in other states have proven logging to be beneficial to elk populations through increased browse production. However, little is presently known concerning successional plant stages that may occur following logging on Afognak Island. Should browse production following logging be determined insufficient for elk maintenance, cooperative efforts should be taken to improve habitat conditions. Considerations should be given to the seeding of landings, skid roads and shoulders of primary and secondary roads with palatable grasses and perhaps imported browse species.

This study indicates that elk on Afognak Island prefer mature spruce habitat. Studies conducted by Harper (1966, 1971) and Harper and Swanson (1970) in Oregon and Schwartz (1943) in Washington also indicate a preference by elk for standing timber. Therefore it is further recommended that size of clear cut areas be made commensurate with good elk production. This would require small cut areas (less than 100 acres) with sufficient standing timber left adjacent to and surrounding the cut area to provide cover for elk. Narrow and irregular-shaped units would provide the maximum amount of edge.

It is also recommended that cutting programs be designed and conducted to prevent disturbance to elk calving and wintering activities. Areas that should receive particular considerations are wintering areas located on Cape Kazakof and at Waskanareska and Discovery bays.

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