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JUNEAU, ALASKA

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WILDLIFE RESEARCH UNIT STUDIES

David R. Klein, Leader

Volume VIII

Annual Project Segment Report
Federal Aid in Wildlife Restoration
Projects W-13-R-2, Jobs B-5 and C-7; W-14-R-2, Job G-5
W-15-R-2, Jobs M-7, N-2, and Q-4

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WORK PLAN SEGMENT REPORT
FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT: W-13-R-2 TITLE: Alaska Wildlife Investigations

WORK PLAN: B TITLE: Upland Birds

JOB NO. 5 TITLE: The Effect of Logging on Blue Grouse

PERIOD COVERED: July 1, 1966 to June 30, 1967

ABSTRACT:

Observation of the summer habitat of blue grouse in southeastern Alaska indicated that the hens with chicks were living at low elevations while the males and possibly the juveniles were living near tree line.

The summer foods of the hens and chicks were predominantly Vaccinium (V. ovalifolium and V. alaskensis) berries and moss (Polytrichum sp.) sporangia. No difference between chick and hen food habits was noted.

OBJECTIVES:

To investigate the ecology of the blue grouse in relation to logged and unlogged areas.

TECHNIQUES:

The study was initiated on July 12, 1966 on Mitkof Island, Southeast Alaska. I spent the first three weeks becoming familiar with the flora of the region and locating habitats occupied by blue grouse during the summer. Following this, logged and unlogged areas on Mitkof Island, Kupreanof Island, and the mainland were visited with the intention of selecting study sites and viewing cutovers of various ages. Observations taken during these visits were utilized to outline, roughly, the course of vegetational succession following logging. Grouse were searched for in these various habitats, and specimens were collected for plumage observations and a food habits study.

Graduate student Finn Sandegren and I spent December 19 to 28, 1966, in Petersburg attempting to observe the blue grouse in their winter habitat. We also planned to collect more specimens for the food habits segment of the study.

FINDINGS:

Observations of the blue grouse during July, August, and early September indicated that the females with broods were utilizing mature stands of timber at low elevations and roadsides, while the male grouse (and possibly the juveniles) were utilizing timber stands within 100 meters of timberline (approximate elevation: 830 m). No male grouse were observed at low elevations, and only one female grouse (without chicks) was observed near timberline. Brood size seemed to be fairly large, varying from two to five chicks, with the majority of the broods being near the upper figure.

Seven specimens, two adult females and five chicks, were collected. The weights of the five chicks varied between 210 and 510 grams. This weight range between chicks collected during the same week indicates there may be a three to four week variation in nesting and hatching dates.

Examination of the crop contents and observations of birds feeding indicated that berries of Vaccinium spp. (V. ovalifolium and V. alaskensis) and sporangia of the moss Polytrichum sp. were the major food items for the hens and chicks during the summer. In addition to these items, needles and twigs of Tsuga heterophylla and Picea sitchensis, fronds of polypodiaceous ferns, and leaves of ericaceous shrubs were also utilized. Only one insect was noted. Examination of the gizzards indicated that hard seeds were retained and used as grit. (Although the sample size was small, no difference was noted between the food of the hens and that of the chicks.)

Vegetational observations on logged and unlogged areas were utilized to lay the groundwork for next summer's work. The prominent vegetation of the unlogged areas was Picea sitchensis, Tsuga heterophylla, and smaller numbers of Chamaecyparis nootkatensis. The understory vegetation consisted of Cornus canadensis, Vaccinium spp., Menziesia ferruginea, Oplopanax horridus, Lysichitum americanum, and Dryopteris linnaeana. Following cutting, there was a marked response to the changed conditions; both Cornus canadensis and Rubus pedatus became very abundant. In addition, Vaccinium spp., Menziesia ferruginea, Rubus spectabilis, R. parviflorus, Oplopanax horridus, Sambucus racemosa, and Viburnum edule showed increased height and density. Alnus rubra was well represented in areas where the topsoil was lost. Picea sitchensis and Tsuga heterophylla seedlings began to appear in numbers, especially on the hillsides.

Approximately ten years after cutting, Vaccinium spp., Menziesia ferruginea, Oplopanax horridus, Rubus spectabilis, and R. parviflorus had formed a dense cover approximately one to two meters high. Picea sitchensis and Tsuga heterophylla were common and had also grown to a height of one to two meters.

In the oldest cuttings (1930), the vegetation consisted of a dense stand of Picea sitchensis and Tsuga heterophylla, with an understory of Vaccinium spp. and Menziesia ferruginea.

When we arrived in Petersburg on December 19, there was only a small amount of snow on the ground at low elevations. Pertinent literature and talks with local residents indicated that the grouse would probably be found in groups feeding in large Sitka spruce and western hemlock trees. In years of deep snow accumulation, they have also been found on the beaches at sea level. Since the birds may remain in a single tree for several days, and it is impractical to locate the birds in the trees by visual observations, we decided to search the ground under the trees for accumulated droppings.

No birds were located. This was probably due to the alternate periods of rain and snow which would have obscured the accumulated droppings. In addition to this, birds

are not very numerous in the area, and local residents and Alaska Department of Fish and Game personnel indicated that they had not observed any grouse during the winter. This may indicate that they were living on the high ridges.

SUBMITTED BY:

Rodney S. Brown
Graduate Student

APPROVED BY:

David R. Klein
Leader, Alaska Cooperative Wildlife Research Unit

WORK PLAN SEGMENT REPORT
FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT: W-13-R-2 TITLE: Alaska Wildlife Investigations

WORK PLAN: C TITLE: Waterfowl

JOB NO. 7 TITLE: Ecology of the Emperor Goose

PERIOD COVERED: July 1, 1966 to June 30, 1967

ABSTRACT:

During the summers of 1965 and 1966, the nesting ecology of the emperor goose was studied on the Yukon-Kuskokwim Delta near Chevak. Most nests were located beside ponds where the principal plant cover was either Carex spp. or Elymus mollis. The nests had an average clutch of 5.5 eggs, an incubation period of 24 to 27 days, and with one exception, hatching was completed by July 6. Approximately 70% of the initial eggs produced young; avian egg predation was primarily restricted to jaegers.

Aerial and ground surveys in 1965 and 1966 indicated little change in brood size during July and August. In late July, 1966, the average brood size was 4.0 young. But aerial surveys conducted in late August and early September on the Kuskokwim Delta averaged only 2.4 young per brood while counts on the Alaska Peninsula found 2.6 young per brood. Possible causes for this variation in brood size are discussed.

Ecological studies of the emperor on its wintering grounds at Izembeck Bay, Alaska were conducted. The main predator of these geese on the wintering grounds was the bald eagle. The principal food source utilized by the emperors in the Izembeck Bay area was Zostera marina; on the nesting grounds Carex spp. was the most important food item.

OBJECTIVES:

To investigate the nesting and winter ecology of the Emperor Goose (Philacte canagica).

TECHNIQUES:

Within the 5.7 square mile study area along the Kolomak River, a total of 28 emperor goose nests was located by a systematic search beginning on May 30, 1966. Upon location of each nest, a numbered, small plastic marker was placed three feet to the east of the site for positive identification. Each marker was concealed among the vegetation to lessen the chance of nest predation. An estimation of the hatching date for each clutch was accomplished by placing the eggs in water and recording their relative displacement as developed for pheasants by Westerkov (1950). Measurements with calipers were taken for only those eggs initially present, since each clutch was at least within one or two eggs of being complete. Each nest was visited every four days in most instances and concealed with vegetation subsequent to examination.

During the brooding season, extensive use was made of boats to make brood counts and to secure growth and development data. Air surveys were also conducted with a U. S. Fish and Wildlife Service Cessna 180. Classification of goslings was based on Gollop and Marshall's (1954) system of plumage development.

For food habit studies, 24 emperors were collected on the breeding grounds from May through August, 1966. Crops were also secured from Izembek Bay on the Alaska Peninsula, and from Adak Island in the Aleutian Islands. The crop contents were analyzed by the volume displacement method.

FINDINGS:

Nesting:

Habitat: Emperors, along with Canada geese (Branta canadensis) and white-fronted geese (Anser albifrons), prefer nesting sites several miles inland from the Bering Sea, often utilizing habitat as far inland as the tidal influence prevails. The coastal fringe with its sparse vegetation is principally used by the black brant (Branta nigricans).

The habitat utilized most frequently by emperor geese for nesting consists primarily of grasses. The species of grass among which the majority of the emperor nests were found on the study area was beach-rye (Elymus mollis). Sedge (Carex spp.) occurs throughout the area but its larger forms are mainly confined to the circumference of the ponds and potholes. Short Carex, one to three inches high, is interspersed with the grasses but is dominent only along the river and slough banks where large numbers of geese congretate to feed and loaf.

Much of the region consists of both small and large brackish-water ponds, four to one hundred feet in diameter, which have average depths of three to five feet. Periodic flooding from the sloughs transecting the flatlands maintains, in many of these ponds, a constant water level during the summer months.

Densities: Only a small portion of the approximate 20,000 square miles of the Yukon-Kuskokwim Delta are utilized annually by nesting geese and brant. Aerial surveys in 1949 showed that in the Delta region, the breeding population varied from 36 to 44 waterfowl per square mile. Emperors comprised only 3% of this population, but along the coastal strip from Hooper Bay to Nelson Island, an area of 600 square miles which was surveyed separately, emperors formed 7.6% of the breeding population (Spencer 1949).

Nesting Dates: During the years when spring arrives early on the breeding grounds, the emperors begin incubation well before the end of May. Spring was fairly late in 1966, and from the number of eggs already present and their stage of incubation, it was determined that several nests were initiated in late May (Table 1).

The white-fronted goose apparently is the first of the three geese species to begin nesting. Within the study area, the white-fronts began incubation several days prior to the emperors, so that their nesting was well underway by the end of the first week in June. Several cackler nests were observed with incubation in progress by June 5, but the majority of their broods did not come off until approximately one week after the emperor hatch.

Table 1. Approximate dates for onset of emperor nesting, based on start of egg laying

Date	No. of Nests
May 30	2
June 1	1
2	1
3	3
4	2
5	3
6	3
7	3
8	1
9	2
Total	21

Nest Site: The emperor may build its nest in one of several habitat types. Within the study area, 15 of the 28 emperor nests were located beside ponds less than 30 feet in diameter. These locations afforded greater concealment because the vegetation was taller and denser than that of other habitats.

Only one emperor nest occurred on an islet. Emperors and white-fronts generally confined their nest building to the mainland while the majority of the cacklers utilized islets.

Unlike black brant, emperor geese are not gregarious nesters, but several pairs may nest in close proximity to each other. In two instances, three emperor nests were found within 150 yards, while two other nests were only 50 feet apart.

The emperors, white-fronts and cacklers all exhibit tolerance towards one another. While the nests of these various species of geese appeared to be interspersed, the nests of emperors showed the greatest degree of scattering throughout the study area. Twice, emperor and white-front nests were found within 50 feet of each other. In another area, a cackler and emperor had build nests approximately 75 feet apart.

Incubation:

The Egg: Distinguishing the eggs of the emperor from those of other geese on the Delta is difficult, as the eggs closely resemble, in size and color, those of the white-front and cackler. Egg measurements for the three species overlap too much for definite identification to be made in many cases from size alone. The average size for 138 emperor eggs was 80.5 x 52.4 mm. The four extremes measured were: longest, 80.7 x 54.5 mm; shortest, 68.0 x 49.0 mm; widest, 79.5 x 56.0 mm; and narrowest, 68.0 x 49.0 mm. Bent (1962) determined the average dimensions for 109 white-front eggs to be 79.0 x 52.5 mm and Kessel et al. (1964) found the average size for 40 cackler eggs to be 72.9 x 50.1 mm.

Clutch Size: The number of eggs initially laid usually ranges between three and eight, and averages between four and six eggs per nest (Table 2). Based on 21 nests within the study area, a correlation was found between clutch size and the date the first egg was laid. For those nests which were not located prior to the onset of incubation, the total egg complement plus the average incubation period, 24 days, was subtracted from the date of hatching to determine the starting date of egg laying. On this basis, it was found that the earlier nesting began, the larger the clutch that was laid (Table 3).

Incubation Period: The incubation period was obtained for six emperor nests, those which were found prior to completion of the clutch. Of these nests, four hatched on the 24th day and two on the 27th day of incubation.

Phenology of Hatching: Due to the late start in nesting in 1966, few young were produced before the first days of July. In past years, when the snows have receded from the nesting grounds before mid-May, broods have been observed before the last week of June. However, in 1966 the first emperor young were not seen until June 30. By July 6, with one exception, incubation was completed (Table 4).

Table 2. Clutch size observations of the emperor goose, Yukon-Kuskokwim Delta, Alaska

Year	Location	Clutch Size Frequency 1	2	3	4	5	6	7	8	9	10	Totals Clutches	Eggs	Eggs/Clutch
1960	Igiak Bay[1]		1	1	1		1	1			1	6	32	5.3
1963	Igiak Bay[1]		2	3	2	3		3				13	57	4.4
1964	Kashunuk River and Old Chevak[1]			1	3	4						8	35	4.4
1965	Kashunuk River area			4		1	1					6	23	3.8
1966	Kolomak River (Igiak Bay)			2	6	7	7	1	5			28	154	5.5
	Baird Inlet[2]					3	1		1			5	29	5.6
	Kashunuk River area[2]				4	6	1		1			12	60	5.0
Average for 1966														5.4
Overall Average														5.0

[1]Alaska Nest Record Scheme, University of Alaska, College, Alaska.

[2]Dr. Calvin Lensink, U. S. Fish and Wildlife Service, Bethel, Alaska (in corresp. 1966).

Table 3. Comparison of emperor clutch size from 21 nests with date of egg laying

Date of Laying	No. Eggs/Clutch
May 30 - June 3	8-7
June 1 - 6	6
June 4 - 8	5
June 7 - 9	4-3

Table 4. Chronological distribution of the emperor hatch

Date	No. Nests Hatched	Percent Nests Hatched	Cumulative Percent Hatched
June 30	1	4.8	4.8
July 1	1	4.8	9.6
2	0	--	9.6
3	6	28.6	38.2
4	4	19.0	57.2
5	5	23.8	81.0
6	3	14.3	95.2
7	0	--	95.2
8	0	--	95.2
9	1	4.8	100.2

Nesting Success: Of the 28 females who had nests located on the study area, 21 were successful in bringing off broods. Of the 154 eggs laid, 70% (107) hatched to produce young (Table 5).

Over 50% of the unhatched eggs were destroyed by predation. Parasitic jaegers (Stercorarius parasiticus) are thought to be primarily responsible for this, although gulls may also have been involved. Red foxes (Vulpes fulva) were accountable in only one instance. The next most common factor contributing to egg mortality was the death of embryos. In each case, the eggs were partially developed and it was noted that all were approximately two weeks old when they died.

Only one nest was abandoned. In this case, all of the eggs contained dead embryos. The female continued incubation on the nest at least until July 2, but a further check two days later revealed the abandonment. All of the embryos had died approximately one week prior to this time.

Behavior: No nesting territories appear to be established by emperor geese. Emperors as well as cacklers and white-fronts were able to pass close to an occupied nest without an apparent arousing of the residents. In one case on June 7, a female was incubating while the male was feeding a few feet away in spite of the fact that another pair of emperors plus a pair of cacklers stood within 10 feet of the nest. No antagonism was observed between any of the individuals.

During incubation, the female remains on the nest throughout the day. When approached, she presses close to the nest with her head and neck outstretched and low to the ground. It is possible to approach to within 30 feet of a nest before the female takes flight.

As the nesting season progresses, the males spend less time at the nest and tend to congregate with other emperors on the feeding grounds. Only periodically do they return to the vicinity of the nest. But, by the time the eggs have pipped, the male stays close to his mate; both sexes aid in the raising and protection of the young.

The degree of orange-red staining on the head is indicative of the emperor's habits. The stain is obtained from the large concentrations of iron oxide (Fe_2O_3) in the small ponds. Once nesting has begun and larger bodies of water become available, the males tend to lose, to some degree, the deep coloration on the white portions of the head and neck. This is not true for the female, however, since she spends so much of her time away from water once incubation has begun. Thus, it is often possible to distinguish the sexes on the basis of staining on the head; at least for the nesting emperors.

Nest and Egg Losses:

Avian: Although nest losses can be attributed to both avian and mammalian predators, the former are by far the more important. Twenty-five percent of the nests were unsuccessful in producing young. Of this total, 17.8% were robbed by jaegers. Occasionally, jaegers were observed consuming eggs from cackler, white-front and emperor nests.

Table 5. Nesting success for emperor geese, Kolomak study area, 1966

Nest No.	Hatching Date	No. Laid	Egg Fate: Missing	Broken	Abandoned	Predation	Infertile	Dead Embryo	Hatched
1	6/30	7	1	1				1	4
2	7/1	6						1	5
3	7/3	8				2			6
4	---	4				4			0
5	7/3	6						1	5
6	7/3	8	2						6
7	7/5	6						1	5
8	---	4	2			2			0
9	7/9	4							4
10	7/6	5							5
11	7/3	5							5
12	7/5	6		1					5
13	7/4	5							5
14	---	4				4			0
15	---	6				6			0
16	7/3	3							3
17	7/6	5							5
18	7/4	8							8
19	7/3	5							5
20	---	3				3			0
21	7/5	8							8
22	---	6				6			0
23	7/4	8						3	5
24	---	4			4				0
25	7/4	5						1	4
26	7/5	6	1						5
27	7/6	4							4
28	7/5	*5							5
Totals		154	6	2	4	27	0	8	107

*Nest located just prior to hatching.

The effect of human intrusion on a nesting area is very apparent. Jaegers and gulls continually follow any person moving about and readily spot eggs vacated by a flushed bird. This occurrence was not common while examining emperor nests, however, since the average emperors allow one to approach within 20 yards before taking flight. The nests were covered with vegetation after they were examined; this procedure is believed to have kept egg losses from predation to a minimum.

Mammalian: Of lesser importance are the potential mammalian predators on nesting emperors; the red and arctic foxes (Alopex lagopus), mink (Mustela vison), and weasel (Mustela sp.). In the Kolomak study area, only the red fox appeared to be a threat to nesting waterfowl; there were no signs of the other three predators in the area. Frequently each week, a red fox was observed moving through the area. On June 22, a fox discovered one of the emperor nests, killed the female, and ate the eggs.

Throughout much of the emperor nesting habitat, fox trails are numerous and indicate the regular routes followed by foxes hunting for waterfowl and their nests.

Broods:

Growth and Development: Of the three species of geese common to the Yukon-Kuskokwim Delta, the emperors are the last to attain flight. The preflight period for emperors is approximately 48 days. Nelson and Hanson (1959) list the preflight period for cackling geese as 42 days. White-front fledglings were much in evidence almost a week earlier than the cacklers.

During the preflight period, the young geese gain rapidly in size and weight. By the time they are capable of flight, the goslings may weigh nearly as much as an adult. The weights obtained for six goslings with their age in days, based on an assumed hatching date of July 4, are given in Table 6.

After mid-July, the parent emperors undergo their postnuptial molt and become flightless. This period corresponds with the development of the goslings so that the adults regain their power of flight at approximately the same time that the young become fledged. However, the non-breeders are flying throughout August, having begun their molt about the first week of July.

Brood Size: At the time of hatching on the study area, the average brood size determined from the success of the 21 nests was 3.8 young per brood. This figure closely agrees with that obtained from ground brood counts made along the Kolomak River during the first two weeks in July. An aerial survey conducted at the end of the month showed no great difference in brood size (Table 7).

The results of the brood observations made in the Old Chevak area during July, 1966, concurred with those on the Kolomak River. However, in August the number of young per brood differed from the July observations. Theoretically, the average brood size for August should have been smaller than that of July. This deviation can probably be explained by the fact that in August a much smaller sample, which was nonrepresentative, was obtained due to the movements of the broods inland from the sloughs and rivers.

Table 6. Comparison of age with body weight for emperor goslings during preflight period

Age in Days	Sex	Body Weight in Pounds
18	Female	1.0
23	Female	2.0
29	Female	2.2
39	Male	3.3
44	Female	4.5
44	Male	4.3

Table 7. Results of ground brood surveys for emperor geese during July and August, 1965-66

Date	Location	Brood Size Frequency								Grouped Geese Paired		Totals		
		1	2	3	4	5	6	7	8	Adults	Young	Broods	Young	Yg/Br
1966														
6/30-7/13	Kolomak River	7	12	18	24	21	9	2	3			96	378	3.9
7/17-7/27	Old Chevak area	2	9	7	17	12	3	1	1	8	34	60	236	3.9
7/29	Lower Kolomak and lower Kokechik Rivers (Aerial)	1	3	8	9	4	3			2	7	35	142	4.0
Totals: July												191	756	4.0
8/2-8/17	Old Chevak area		1	7	2	9	5			7	28	31	134	4.3
Totals: July and August												222	890	4.0
1965														
7/1	Kokechik River area (Aerial)[1]		6	3	6	5	1					26	91	3.5
6/30-7/3	Tutakoke River[1]		1	3	1	1						6	20	3.3
7/25-7/30	Old Chevak area		2	2	2	5		1	1	5	22	13	80	4.4
Totals: July												50	191	3.8
8/11-8/17	Old Chevak area		1	2	4	4						11	44	4.0
Totals: July and August												61	235	3.8
7/1-8/10	Nunivak Island (South side)[2]											8	--	3.8
1964	Clarence Rhode NWR[3]											106	414	3.9
1963	Clarence Rhode NWR[3]											15	54	3.6
1961	Clarence Rhode NWR[3]											42	159	3.7

[1]Calvin J. Lensink, Fish and Wildlife Service, Bethel, Alaska (in corresp. 1965).
[2]U. S. Fish and Wildlife Service (1965a).
[3]U. S. Fish and Wildlife Service (1965b).

In 1965, the average brood size for July and August closely followed that of 1966. But a considerable difference occurred between the results obtained in late July and those obtained earlier in the month. Once again, the problem may have been a nonrepresentative sample.

For comparison, the number of young per brood recorded during 1961 and 1963-64 were included. These observations are also in agreement with those found on the Kolomak River and at Old Chevak (Table 8).

Brood surveys were also conducted along the Bering Sea coast. In 1966, Dr. Calvin Lensink and Jim Geerdts of the U. S. Fish and Wildlife Service and I took emperor brood counts on July 16 from Etolin Strait to the south side of Kokechik Bay. The average number of young per brood compared favorably with those results obtained from ground observations in the Old Chevak-Kokechik River areas (Table 8).

This coastal survey was also undertaken in 1965 by Dr. Lensink and myself covering much the same areas. However, the brood counts were not made until July 28, about two weeks later than in 1966. For this reason, almost all of the broods recorded were gathered in flocks, making individual counts impossible in many instances. Also, large numbers of adults were associated with the young; undoubtedly this was due to the fact that early molters (immatures and unsuccessful breeders) were gathered with the brooders. Therefore, the average brood size for the larger groupings of emperors was omitted and only individual and double broods (four adults) were considered (Table 8).

By the end of August and early September of 1966, few emperor broods were seen along the Bering Sea coast. Aerial surveys during this period showed a definite decrease in brood size; broods were recorded only when two adults could be identified with young of the year (Table 9).

Brood Predation:

Avian: Of the potential avian predators on the breeding grounds of the emperor goose, the glaucous gull (Larus hyperboreus) has, by far, the greatest effect on brood mortality. The greatest loss to emperor goslings occurs when the young become separated from the adults. Due to the gull's size, only one or two swallowing motions are necessary to devour the prey.

The protective nature of the adults towards their broods reduces the effect of avian predation on the goslings. When approached by gulls or jaegers, both adults move the goslings in close to them and often jump towards the aggressors to divert the attack from the goslings to themselves.

While the young geese are one or two weeks old, jaegers also pose a threat to their existence. The jaeger is considerably smaller than the glaucous gull, but in one instance a jaeger was observed carrying off an emperor gosling which it had just captured. This was the only time that predation on young emperors by jaegers was observed.

Table 8. Results of aerial brood surveys along the Bering Sea coast, 1965-66

Date	Location	1	2	3	4	5	6	7	8	Grouped Geese Paired Adults	Grouped Geese Young	Broods	Totals Young	Yg/Br
July 13, 1966	Kokechik Bay (South side)	1	4	5	14	3	5					32	125	3.9
	Angyoyaravak Bay				3							3	12	4.0
	Lower Kashunuk River											0	--	--
	Lower Aphrewn River		2	1	1							4	11	2.8
	Hazen Bay											0	--	--
	Lower Manokinak River		1	2	2							5	16	3.2
	Aknerkochik River		1	1	1							3	9	3.0
	Lower Azun River	2	6	9	15	3	3					43	159	3.7
	Naskonat Peninsula		1	3	4	1						9	32	3.5
	Ningaluk River	1	6	3	8	2	4	1				25	95	3.8
	Baird Inlet (Northeast corner Nelson Island)											0	--	--
	Kolovinerak River		9	11	14	6	5	1		4	12	54	186	3.4
	Etolin Strait											0	--	--
Totals												174	645	3.7
July 28, 1965	Kashunuk River to Kolovinerak River													
	Single Broods		1	4	4		1					10	36	3.6
	Double Broods					2			2			4	13	3.2
Totals												14	49	3.5

Table 9. Results of aerial brood surveys between the Kokechik River and Baird Inlet during fledgling period, 1966 (Calvin J. Lensink, Fish and Wildlife Service, Bethel, Alaska in corresp. 1966)

Date	Location	Brood Size Frequency 1	2	3	4	5	6	7	8	Broods	Young	Young/Brood
August 23	Clarence Rhode NWR South Unit Coast; Nelson Island	3	1	7	2					13	34	2.6
	Clarence Rhode NWR North Unit Coast	2	1		2					5	12	2.4
	Kokechik River area			3		1				4	14	3.5
Totals										22	60	2.7
September 9	Kashunuk River	2	2							4	6	1.5
	Kashunuk River to Aphrewn River									0	--	--
	Aphrewn River to Manokinak River	1		1						2	4	2.0
	Manokinak River		2							2	4	2.0
	Azun River									0	--	--
	Ningaluk River									0	--	--
	Newtok			1	1					2	7	3.5
	Baird Inlet to Chevak (Inland)	2	4		1					7	14	2.0
	Manokinak River		2							2	4	2.0
Totals										17	35	2.1
Totals for both surveys										39	95	2.4

Human disturbance on the breeding grounds also affects the numbers of geese killed by avian predators. Broods feeding along river and slough banks separate and scatter when disturbed by boats. Brood losses result because the adult emperors make no attempt to keep the goslings at their side.

Mammalian: No emperor brood losses from red fox were recorded in the Kolomak River or Old Chevak areas. Red foxes were observed on only three occasions in the vicinity of Old Chevak; their sparse numbers may, in part, be due to the close proximity of the area to the villages of Chevak and Hooper Bay.

Post Brood Season:

Family Groups: As emperor geese move onto the wintering grounds, family groups appear to be still intact. Each group may retain its entity throughout the winter months until spring, when the disintegration of the intrafamily bond occurs.

The fall migration of emperor geese was at its peak at Izembek Bay during the last week of September, 1966. Robert Jones, Jr., Manager, and Palmer Sekora, Assistant Manager, Aleutian Islands National Wildlife Refuge, Cold Bay, recorded family sizes between September 15 and October 19, 1966. These data are considerably below the young per brood data obtained in July and early August on the breeding grounds.

Presently, only postulations can be made to account for the foregoing discrepancy. Scott et al. (1955:87) proposed "that family flocks of [Canada] geese observed in the autumn are essentially a random assortment of young resulting from loose brood bonds on the nesting grounds." If this statement is true, although it is believed to be otherwise by Hanson (1965), the same may follow among emperor geese.

A second hypothesis is that large losses occur on the breeding grounds as a result of drives of flightless birds by natives. Klein (1966), however, gives evidence for only limited drives; those on a large scale apparently are not being held between Baird Inlet and Hooper Bay.

Renesting is a third possibility. But the fact that the brood results obtained on the breeding grounds in early September agree with those recorded at Izembek Bay tends to eliminate this assumption from consideration. Further research is needed to determine the actual factor responsible for the apparent brood size reductions.

Predation:

Avian: The bald eagle (Haliaeetus leucocephalus) appears to be the greatest potential predator to the emperor goose on the wintering grounds. Murie (1940) found the bald eagle to be well-distributed throughout the Aleutian Islands, and that 86% of its diet consisted of avifauna. Although the study was conducted during the summer months, the remains of two emperor geese were found, each in a different eagle nest. In December, I occasionally observed one or more eagles gathered on the ice at Izembek Bay feeding on the carcass of a waterfowl, but because of the distance, specific identification of the prey was not possible.

Only one direct emperor kill was observed. On December 31, an eagle surprised some 200 geese, causing them to take flight. One bird that lagged behind was caught in mid-air; after which the eagle dropped to the ice with its prey. It was immediately joined by three other eagles.

Mammalian: Throughout the Aleutian Chain, the blue phase of the arctic fox is abundant. However, little data is available to determine the extent that emperor geese or even waterfowl are utilized in this fox's diet.

Mating: As with other geese, emperors probably pair for life. The initial pair bond appears to be formed during spring migration or while the immatures are on the breeding grounds. Family disintegration occurs in the wintering areas or during migration and many of the non-breeding geese are observed to be paired in early June after nesting has commenced.

Prior to family disintegration, there is a noticeable change in behavior among the adults. Each group becomes intolerant of the others and drives off any intruder which approaches. Then, as occurred in Izembek Bay during the last week of February, 1966, the small flocks begin to congregate in one mass. Migration to the breeding grounds follows.

Food Habits:

Breeding Grounds: A total of 24 emperor goose crops was collected on the breeding grounds between May 30 and August 17, inclusive. In the 12 crops obtained in late May, June and early July, the leaves of sedge (Carex spp.) far exceeded any other plant species as a major food source during the incubation period (Table 10).

Between the latter part of July and mid-August, 12 additional crops were secured from young as well as from adults. Once again, sedge was the principal food item, although green algae was also utilized to some degree.

By August, berries are available to the waterfowl; emperors apparently do not eat them to the extent that the Canada geese do. Only one crop contained berries; these being crowberries (Empetrum nigrum). Crowberry seeds were present in three crops.

Stomach analyses by Cottam and Knappen (1939) confirm that the emperor's diet is largely plant material. They examined stomachs from 14 geese collected near Hooper Bay and found that approximately 90% of the diet was vegetable food.

Wintering Grounds: U. S. Fish and Wildlife Service personnel collected a total of 18 emperor geese from Izembek Bay, and the crops of 17 of these specimens were suitable for food analysis. Eelgrass (Zostera marina) is very abundant in this bay and by far serves as the principal food item in the emperor's diet (Table 11).

Stomachs were also obtained from Adak Island, Aleutian Islands. Four crops collected in March, 1966, by Lt. Charles Smith, contained primarily sea lettuce (Ulva spp.), although one bird had fed almost exclusively on barnacles (Balanus sp.). Although one stomach was essentially empty, a trace of barnacle was present in it. In four gizzards collected in October by Lt. James Beers, sea lettuce was the only food item present (Table 12).

Table 10. Foods of emperor geese from the Kolomak River (66-1 through 66-12) and Old Chevak (66-13 through 66-24) in May-August, 1966. Volume and occurrence of each food item expressed in percentages

Stomach No.	Date Collected	Age	Sex	Carex spp. Vol.	Juncus sp. Vol.	Empetrum nigrum Vol.	Chlorophyceae Vol.	Plant Fiber Vol.	Gravel Vol.
66-1	5/30	Adult	M				86	6	8
66-3	5/31	Adult	M	33				67	
66-4	6/15	Adult	F	50		Trace[1]			50
66-5	6/13	Adult	M	100					
66-6	6/26	Adult	M	100					Trace
66-7	6/26	Adult	F					12	88
66-8	6/26	Adult	M	40				40	20
66-9	7/1	Adult	M	67				7	27
66-11	7/8	Adult	M	100					
66-12	7/11	Adult	F	100					
66-13	7/21	Immature	F	100					
66-14	7/21	Adult	F					100	
66-15	7/27	Immature	F	87					13
66-16	7/27	Immature	M	10			50	40	
66-17	7/27	Immature	F	10	88			2	
66-18	8/2	Adult	M	50		30[1]		20	
66-19	8/12	Immature	M	5		50[2]	43		
66-20	8/12	Adult	M	30				70	
66-21	8/12	Adult	F				100		
66-22	8/17	Adult	F			Trace[1]			
66-23	8/17	Immature	M	100					
66-24	8/17	Immature	F	100					
Percentage Volume to Total Volume				51.9	2.9	18.3	19.2	6.1	2.6
Frequency Occurrence				77.3	4.5	9.1	22.7	45.4	27.3

[1] Seeds
[2] Berries

Table 11. Foods of emperor geese, Izembek Bay, Alaska in October and November, 1966. Volume and occurrence of each food item expressed in percentages

Stomach No.	Date Collected	Age	*Zostera marina* Vol.	Gravel Vol.
66-25	10	Immature	100	Trace
66-26	10	Adult	100	Trace
66-27	10	Adult	100	Trace
66-28	11/1	Immature	Trace	Trace
66-29	10/27	Immature	100	
66-30	11/1	Adult	100	Trace
66-31	10/27	Immature	100	
66-32	10/27	Adult	100	
66-34	10	Immature	100	
66-35	10	Immature	Trace	100
66-36	11/1	Immature	100	
66-37	10	Adult	100	
66-38	10	Adult	100	
66-39	11/1	Adult	100	Trace
66-40	11/1	Immature	100	Trace
66-41	11/1	Adult	Trace	
66-43	10/27	Adult	100	
Percentage Volume to Total Volume			90.5	9.5
Frequency Occurrence			82.4	5.9

Table 12. Foods of emperor geese, Adak Island, Alaska in March and October, 1966. Volume and occurrence of each food item expressed in percentages

Stomach No.	Date Collected	Age	Sex	*Balanus* sp. Vol.	*Ulva* sp. Vol.	Undetermined Plant Fiber Vol.	Gravel Vol.
66-43	3	Adult	F	96		4	
66-44	3	Adult	F		100		
66-45	3	Adult	F	Trace		Trace	
66-46	3	Adult	M		100		
66-47[1]	10/27	Adult	F				100
66-48[1]	10/27	Immature	F		100		Trace
66-49[1]	10/27	Immature	M		100		Trace
66-50[1]	10/27	Immature	M		100		Trace
Percentage Volume to Total Volume				11.5	77.5	0.5	10.5
Frequency Occurrence				12.5	62.5	12.5	12.5

[1]Gizzard analyzed; crop empty.

Utilization by Natives:

According to Klein (1966), the cackler and white-fronted geese receive the majority of the hunting pressure on the Yukon-Kuskokwim Delta since they are distributed more widely than the emperors. But, in the region between Goodnews Bay and Newktok, the emperor is taken to a greater extent in the spring.

On August 13, 1966, during an aerial brood survey within the study area, three Eskimo boats containing geese were observed on the Kolomak River. It was estimated that several hundred birds had been killed, most of which appeared to be emperors. By waiting until mid-August, the natives were able to capture flightless young geese almost the size of adults.

During the fall, fewer geese are harvested than in the spring. Klein (1966) has estimated that the spring kill involves approximately 6,500 emperors while the fall kill involves 1,700. Based on these figures, 6% of the spring population and 1% of the fall population of emperor geese are killed annually by the natives of the Yukon-Kuskokwim Delta. This annual kill by Eskimos does not presently appear to be detrimental to the species.

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SUBMITTED BY:

Philip C. Headley
Graduate Student

APPROVED BY:

David R. Klein
Leader, Alaska Cooperative Wildlife Research Unit

WORK PLAN SEGMENT REPORT
FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT: W-14-R-2 TITLE: Alaska Wildlife Investigations

WORK PLAN: G TITLE: Marine Mammals

JOB NO. 5 TITLE: Breeding and Maternal Behavior Among the Steller Sea Lion

PERIOD COVERED: July 1, 1966 to June 30, 1967

ABSTRACT:

No breeding activity was observed in the Marmot Island rookery from July 19 to August 24, 1966. At this time, sea lion pups were skillful swimmers but usually kept close to the shore of the island. However, pups occasionally were seen taking long swims accompanied by a cow. Ten pups weighed on July 30 averaged 63.5 pounds (range 38 to 85 pounds). On June 27, 79 pups dead from unknown causes were found by Alaska Dept. of Fish and Game personnel. During the rest of the time in the field, only three more dead pups were discovered.

OBJECTIVES:

To investigate aspects of the breeding biology and behavior of the sea lion with particular emphasis on the timing of breeding in relation to parturition. The behavior of cows and pups on breeding rookeries as related to pup desertion and survival, frequency of nursing and development of pups will also be studied.

TECHNIQUES:

The animals were observed from an elevated place with a 20x spotting scope and 7 x 50 binoculars. A 35 mm Edixa camera with 50 and 240 mm lenses was used for the census photography. A .358 magnum rifle was used to collect adult sea lion specimens.

FINDINGS:

On my arrival at Marmot Island on July 19, the sea lions were very shy and left for another part of the island as soon as disturbed. This shyness was probably caused partly by the previous pup harvest in the study area and partly by the loose territoriality of the adults and strong swimming ability of the pups at this time. With the exception of one copulation, no breeding activity, territorial fights between bulls, or parturition was observed. Noteworthy is the fact that during this study period large numbers of nursing yearlings were observed.

During July and early August, groups of big bulls were seen hauled out separately from the part of the rookery where the cows and pups were to be found. Throughout this time the pups were skillful swimmers and spent much time in the water. Several times cows were seen taking off for swimming tours accompanied by a pup.

These tours varied in range from 100 to 2,000 m. The cow and pup usually swam side by side diving and surfacing simultaneously. During seven of these cow-pup swims occurring on July 28 and 30, the dives were timed. The average time for the dive of each pup was 13, 11, 10, 8, 7, 7, and 5 seconds.

An estimate of approximately 8,000 to 10,000 adult sea lions on Marmot Island was made on August 10 between 2:00 and 4:00 PM.

On June 27, the first count of dead pups was made; 79 dead pups were found along a 2,000 m part of the short on the east coast of the Island which was accessible without using a boat. These pups probably had died during the time between parturition and the time of the count. No definite cause of death was determined.

SUBMITTED BY:

Finn Sandegren
Graduate Student

APPROVED BY:

David R. Klein
Leader, Alaska Cooperative Wildlife Research Unit

WORK PLAN SEGMENT REPORT
FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT: W-15-R-2 TITLE: Alaska Wildlife Investigations

WORK PLAN: M TITLE: Bear

JOB NO: 7 TITLE: Ecology of the Black Bear

PERIOD COVERED: July 1, 1966 to June 30, 1967

ABSTRACT:

Hunting pressure on black bear in the Prince William Sound area, Alaska, was considerably lower during the 1966 fall hunting season than during the 1966 spring season. Concern over pelt quality and the presence of other game species reduced hunter pressure on black bear. Fall hunters required fewer days to kill their bear than did spring hunters although the dense fall foliage was expected to increase hunting effort. This increased fall hunter success reflects the seasonal change in black bear food habits; many bears had moved onto the open mud flats where they were most vulnerable to hunters. Based on individual food preferences, the black bear population can be divided into three classes: salmon feeders near sea level, salmon and berry feeders at 250 to 1,000 feet, and berry feeders at the higher elevations from 1,000 to 2,500 feet.

OBJECTIVES:

1. To refine aging techniques and determine the sex and age structure of the hunter harvest.

2. To determine productivity within the population on the basis of observations and through examination of reproductive tracts.

FINDINGS:

Hunting pressure was considerably less in the 1966 fall black bear season than during the 1966 spring season. This lack of hunter interest may have been due to a combination of factors. During September, silver and pink salmon were still available in the bays, so sport fishing occupied many would-be hunters. Based on conversations with hunters during this fall season, it appeared that there was considerable concern over the condition of black bear pelts. Although most bears were in good condition, there were hunters who were reluctant to engage in several days of hard work for what they felt might be an inferior hide. In addition, there seems to be a psychological (or perhaps physical) barrier to hunting at this time of year. The availability of other game at this time apparently has much to do with the small harvest; many hunters cannot also find time for a fall bear hunt.

Although there was considerably fewer fall bear hunters than spring hunters, it appears that there was an overall increase in hunter success. However, judging from the hunter success of the earlier season, this would appear unusual. In the spring hunt, there was a sharp drop in the number of bear shot after the

foliage emerged. Since the fall vegetation is as dense or denser than the spring vegetation, it would seem logical that more hunting days would be required per bear. Actually, the number of days it took to obtain a bear was cut by a third.

The reason for the increase in hunter success and the drop in total hunter days, the two being quite closely related, was the change in the food habits of the bears. In the spring, bears were feeding mostly on skunk cabbage and new grass, which put them in fairly heavy cover. But, in the fall, a considerable part of the bear population fed on salmon in the open flats where the streams entered Prince William Sound. Except for those animals killed along the roadside, most bears were killed in the stream flats areas. Hunters who placed themselved strategically on a point overlooking these open areas usually killed black bear.

I feel that the bears killed near the beach are a segregated part of the population. Bears have been observed at all altitudes up to 2,500 feet, but individuals are often seen in the same general location day after day, perhaps not varying their elevation more than 200 to 300 feet. Based on individual food preference, it appears that the population can be divided into at least three classes; those that spend a majority of their time feeding on salmon and are consequently near sea level; those which feed occasionally on salmon, but prefer berries at higher elevations (250 to 1,000 feet depending on terrain); and those which predominantly prefer berries. The majority of the berries, mostly blueberries (Vaccinium uliginosum), grow above the alders (Alnus sp.) at elevations of 1,000 to 2,500 feet. There may be some bears which overlap all of these zones or change locations as the season progresses, but most of the individuals which I observed were fairly static in their areal movements.

In the fall of 1966, 16 hunters took 14 bears for a success percentage of 87.5. However, only 12 hunters actually killed bears, so the true individual hunter success was 75%. This figure is high, and I feel certain that there were several hunters I was unable to contact who failed to shoot a bear. The true individual hunter success was probably near 65%.

These 14 bears were taken during 31 days of hunting, for an average of one bear killed for every 2.2 days of hunter effort. It required 37 days for the 16 hunters to kill the 14 bears, for an overall average of 2.6 hunter days per bear.

SUBMITTED BY:

Carl Grauvogel
Graduate Student

APPROVED BY:

David R. Klein
Leader, Alaska Cooperative Wildlife Research Unit

WORK PLAN SEGMENT REPORT
FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT: W-15-R-2 TITLE: Alaska Wildlife Investigations

WORK PLAN: N TITLE: Sheep

JOB NO: 2 TITLE: Dall Sheep Lamb Survival

PERIOD COVERED: July 1, 1966 to June 30, 1967

ABSTRACT:

A combined aerial-ground census was the best method for censusing the Dall sheep population on Surprise Mountain, Kenai National Moose Range, Alaska. In 1966, lambs constituted 26% of the total sheep population; in late August the population had a ratio of 54 lambs per 100 ewes. The 39 yearlings present indicated 83% survival of the 1965 lamb crop. During the 1965-66 winter, lamb mortality appeared slight, but in late Nobember ice-covered vegetation created harsh conditions for sheep feeding in areas blown free of snow.

OBJECTIVES:

To investigate the annual production and extent and nature of mortality during the first year of life of an isolated Dall sheep population in the Kenai National Moose Range.

FINDINGS:

Field studies on Surprise Mountain were initiated on July 14, 1966. A lamb-ewe ratio (late August) of 54:100 was obtained. Early summer yearling counts showed a survival of over 80% of the 1965 lamb crop. Total population and composition counts were obtained through the coordination of ground and aerial observations via air to ground communication. The summer work was terminated on August 28th.

Six days were spent on Surprise Mountain in late November. At that time, the sheep were experiencing harsh conditions with a layer of ice covering vegetation in areas blown free of snow. Sheep activity was concentrated at timberline on the north side of the mountain. Rutting activity was observed and there was no evidence of lamb mortality.

Ten days were spent on Surprise Mountain in mid-March. Sheep were found to be concentrated on south-facing slopes and cliffs where early snow melt had exposed forage vegetation. Although no total count was obtained, indications were that winter mortality of lambs had been light. We camped for several days (3/15 - 3/17) below the eastern end of the Skilak cliffs to observe sheep using the steep south-facing meadows and cliffs in the area. During the observation period, the sheep were continuously using the area, varying in numbers from about 40 - 110. The most lambs counted at one time was 27.

On August 25, 1966, I was equipped with a small two-way radio while Refuge Manager Troyer flew cover with a Super-cub in an attempt to get a complete count of the population. In this manner the observer in the plane spotted the various bands of sheep and directed the ground observer to the bands. We believe this was the most accurate count obtained. The count indicated a population of 255 sheep, including 66 lambs. A number of attempts were made to determine the composition of the population. Calculations revealed 66 lambs and a minimum of 27 rams, with at least four legal rams remaining in the population (Six legal rams and one adult ewe were removed during the hunting season prior to the count.). Thus 123 sheep were classified as ewes 2 years old and older; however, the percentage of rams in the population appears extremely small and quite likely some yearling and 2 year old rams were classified as ewes. Late summer yearlings may be difficult to distinguish from ewes unless close observation is possible.

Lambs constituted 26% of the total population and, assuming that the 123 sheep classified as ewes is correct, this gives a ratio of 54 lambs per 100 ewes. The 39 yearlings present in the population represent a survival of 88% of the 44 lambs counted in the 1965 crop.

Additional ground and aerial counts made during the summer are useful in substantiating these figures. The results are summarized below:

Ground Counts:

				Rams			Totals	
Date	Ewes	Lambs	Yearlings	Less than 3/4	3/4+	Unclassified	Adults	Lambs
7/15/66	94	70	27	15	8	37	181	70
7/24/66	104	66	25	18	8	--	155	66

Aerial Counts:

			Rams			Totals	
Date	Ewes & Yearlings	Lambs	Less than 3/4	3/4+	Unclassified	Adults	Lambs
7/20/66	162	53	12	10	--	184	53

SUBMITTED BY:

Marsh Pitzman
Graduate Student

APPROVED BY:

David R. Klein
Leader, Alaska Cooperative Wildlife Research Unit

WORK PLAN SEGMENT REPORT
FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT: W-15-R-2 TITLE: Alaska Wildlife Investigations

WORK PLAN: Q TITLE: Musk Ox

JOB NO: 4 TITLE: Musk Ox Surveys

PERIOD COVERED: July 1, 1966 to June 30, 1967

ABSTRACT:

In 1965 and 1966 the population history and range interrelationships of muskox on Nunivak Island, Alaska, were studied. Range types of the island were described and mapped. Wet tundra, the most extensive range type on the island, covered about 57.5% of the area. The other vegetative types and their areas are: grass-browse, 23.4%; dry tundra, 14.2%; beach grass-forb, 0.4%; barren rock, 2.5%; and aquatic, 2.0%.

The muskox population has increased from the 1936 introduction of 31 animals to an estimated 620 animals in 1966. Loss on winter ice may be the major mortality factor affecting muskox. Nunivak muskox cows calve in successive years and a natal sex ratio of three males to one female is indicated. The average summer herd size was eight, while in winter it was eleven. Composition counts in 1966 indicate calves formed 21% of the population, yearlings 17%, subadults 10%, and adult cows 25%. The 1966 calf:adult cow ratio was 85:100.

Muskox concentrate on the narrow coastal fringe of Nunivak Island during winter, while in summer the herds disperse widely over the tundra. Primary winter use is restricted to the beach grass-forb and wet tundra types; in summer the grass-browse type is utilized. Presently, there is little competition between reindeer and muskox on winter ranges. Reindeer were introduced to Nunivak during the 1920's and since then they have increased rapidly and have experienced marked population fluctuations. In 1966 it was estimated that there were 8,000 reindeer on the island. The reindeer range was largely overgrazed by the mid-1940's and remains in poor condition today.

OBJECTIVES:

To determine the basic population dynamics and range interrelationships of the Nunivak Island muskox herd.

FINDINGS:

The Nunivak Island Range:

Nunivak Island range types were described superficially on the basis of dominance of one to several species, supplemented by physiognomic characteristics. Dominance was based on the proportion of the areal cover contributed by each species. Cover was determined by the use of line-point transects 100 feet in length. Point readings were made every six inches on most transects, with one reading taken per point. Points were assigned to the first species hit or to non-vegetative bare ground, rock,

or litter. Percentages of vegetative cover were determined by dividing the number of vegetative hits by the total number of points for each range type. Individual species cover percentages were obtained by dividing the number of hits on a species by the total number of vegetative hits for each range type. Transects were subjectively placed in relatively homogenous stands representing the various types, largely around the perimeter of the island. A range type map was prepared from U. S. Coast and Geodetic Survey aerial photographs of the island and appears in the thesis.

Range Types:

Wet Tundra: Wet tundra is the most extensive type on the island, covering 57.5% of the area or about 638,000 acres. It is present throughout the island, wherever low-lying or flat terrain impedes drainage. This type was divided into three subtypes.

Peat Mound Subtype: Occurring as dry mounds in waterlogged wet tundra areas, the peat mound subtype generally had a vegetative cover of dry tundra species which differed from that of the surrounding sedge-dominated wet tundra. The subtype is dominated by Rubus chamaemorus, with lichens (mostly Cladonia spp.), Ledum decumbens, mosses, Arctostaphylos alpina, Empetrum nigrum, and Vaccinium vitis-idaea also contributing to cover.

Tidal Wetland Subtype: This subtype occurs in areas subject to flooding by sea water, especially during fall storms. Species are adapted to saline conditions and differ from the typical wet tundra species. Cover is dominated by Carex spp. Elymus mollis, Poa eminens, Potentilla pacifica, and Stellaria humifusa are also important cover species.

Wet Tundra Subtype: The typical wet tundra subtype is one of the most uniform types on the island in terms of appearance and species composition. Carex aquatilis and Eriophorum angustifolium are the dominant cover species. Other important cover species include Salix spp. (including S. ovalifolia), Sphagnum spp., moss, Empetrum nigrum and Eriophorum scheuchzeri.

Dry Tundra: Dry tundra covers about 13.6% of the island or about 151,000 acres. It is most common in the interior poritons of the island and on the western tip.

Alpine Tundra Subtype: The alpine tundra subtype occurs at higher elevations, on numerous hills and mountains. Empetrum nigrum and Arctostaphylos alpina are the dominant cover species, but Dryas octopetala, Salix arctica, moss, Ledum decumbens, and Oxytropia nigrescens are also important cover components.

Dry Tundra Subtype: The dry tundra subtype is found on sloping terrain with good drainage, often where the soil depth is shallow. Empetrum nigrum is the dominant cover species. Other important cover species include Carex bigelowii, lichens (mostly Cladonia spp.), mosses, and Arctostaphylos alpina. This subtype has a varied character on different parts of the island depending on differential abundance of species. Lichen growths are much reduced in most dry tundra areas of the island. Only Cape Mendenhall and the Twin Mountains - Cape Corwin regions had substantial

growths. The presence of Spirea beauverdiana, Vaccinium uliginosum, and to a lesser extent Betula nana exilis had a similar pattern to that of lichens. These browse species are absent from the western third of the island, and are most abundant in the southeast quarter of the island.

Grass-browse: The grass-browse type is the second most abundant range type on the island covering 23.4% of the island or about 260,000 acres. It is divided into two subtypes.

Grass Hummock Subtype: The grass-hummock subtype is generally found along the edges of and intermingled with the wet tundra type, in drainage channels adjacent to dry tundra, or in broad areas where the mineral soil and water table are close to the surface. Typically dominated by Festuca altaica or Calamagrostis canadensis or both, other species including Empetrum nigrum, moss, Artemisia laciniatia, and Salix pulchra are important contributors to cover.

Riparian Grass-browse: The riparian grass-browse subtype is similar in species composition to the grass-hummock subtype, but its occurrence is restricted to the borders of streams and rivers. Calamagrostis canadensis dominates the cover with Salix spp. (primarily S. pulchra, S. alaxensis, and S. reticulata), moss, Festuca altaica and Sanguisorba sitchensis also important components.

Beach Grass-forb: The beach grass-forb type is limited to coastal sand dunes and strand areas of the island. It covers about 0.4% of the island or about 4,400 acres. Elymus mollis is the dominant cover species. A variety of transition vegetation associations exist between the Elymus-dominated dunes and adjoining types, where species including Festuca rubra, Calamagrostis canadensis, Artemisia arctica, Conioselinum benthami and Empetrum nigrum become important cover species.

Barren Rock: Barren rock, as a range type, covers about 2.5% of the island or about 28,000 acres. There are extensive areas of barren rock in the interior of the island in lava bed regions and on mountains and buttes. Vegetation cover ranges from a sparse crustose lichen cover on lava beds to a lithosol dry tundra vegetation.

Aquatic: Nunivak Island has a large number of small, shallow ponds and lakes which support aquatic vegetation. The number of species is low. Those most commonly found are Hippuris vulgaris, Ranunculus polasis, and Carex aquatilis. About 2.0% or 22,000 acres consist of this type.

Table 1 gives the cover percentages of species in the different vegetation types.

Muskox:

The Nunivak Island muskox (Ovibos moschatus wardi Lydekker) were introduced to the island in 1935 and 1936 by the U. S. Bureau of Biological Survey. The herd, numbering 31 animals at introduction, was obtained from Greenland. The introduction to Nunivak Island was the first in Alaska since the species was exterpated from Alaska in the latter 1800's.

Population Growth: Palmer (1938) reported a possible production of 10 calves in 1937 and 9 to 11 calves in 1938, or a total of about 50 muskox. Subsequent reports

Table 1. Cover percentages of species in vegetation types of Nunivak Island, Alaska

Species	WET TUNDRA			DRY TUNDRA		GRASS-BROWSE		BEACH GRASS FORB
	Peat Mound	Tidal Wetland	Wet Tundra	Alpine Tundra	Dry Tundra	Grass Hummock	Riparian Grass-browse	Beach Grass-forb
Lichens	20		T	5	12	4	T	
Lungwort							T	
Mosses	12		4	9	11	9	6	
Sphagnum spp.			8			T	T	
Lycopodium selago					T			
Equisetum arvense						T	3	
Equisetum spp.					T			T
Dryopteris oreopteris						T		
Betula nana exilis	2		T	3	2			
Campanula lasiocarpa				T	T			T
Arenaria peploides								T
Stellaria humifusa		5						T
Stellaria spp.					T		T	T
Achillea borealis							1	4
Arnica lessingii						T	T	
Artemisia arctica				T		2	1	3
A. laciniata				T	T	9	3	
Chrysanthemem arcticum		2	T				T	
Petasites frigidus			1			2	T	T
Senecio resedifolius					T			
Taraxacum spp.						T	T	
Cornus suecida							T	
Sedum roseum			T		1	2	4	
Cardamine pratensis						T	T	
Carex aquatilis			38				T	
C. atrata						T	1	

Table 1. (Continued)

Species	WET TUNDRA			DRY TUNDRA		GRASS-BROWSE		BEACH GRASS FORB
	Peat Mound	Tidal Wetland	Wet Tundra	Alpine Tundra	Dry Tundra	Grass Hummock	Riparian Grass-browse	Beach Grass-forb
C. bigelowii	T			3	12	4	2	
C. stylosa							T	
Carex spp.		63						
Eriophorum angustifolium			20				2	
E. scheuchzeri			4					
Empetrum nigrum	7		4	15	29	11	1	
Arctostaphylos alpina	8		T	14	7			
Ledum decumbens	16		1	8	3	T		
Loiseleuria procumbens				2				
Vaccinium uliginosum				1	3			
V. vitis idaea	6		T	3	1	T	T	
Corydalis pauciflora						T	T	
Geranium erianthum							2	
Alopecurus alpinus						T	2	1
Arctagrostis latifolia						4	T	
Calamagrostis canadensis	T		2		T	13	16	5
Elymus mollis		9			2			60
Festuca altaica					T	16	5	
F. brachyphylla					T			
F. rubra	17		T				3	6
Hierochloe alpina				4				
H. odorata					T		T	
Poa arctica					2			1
P. eminens		2						
Poa spp.			T		T	T	T	T
Pucinellia spp.		T			T			
Trisetum sibiricum				T	2		T	
Luzula campestris			T			T	T	

Table 1. (Continued)

Species	WET TUNDRA			DRY TUNDRA		GRASS-BROWSE		BEACH GRASS FORB
	Peat Mound	Tidal Wetland	Wet Tundra	Alpine Tundra	Dry Tundra	Grass Hummock	Riparian Grass-browse	Beach Grass-forb
L. nivalis				2	3			
Lathyrus maritimus					T			12
Oxytropis nigrescens				6	T			
Lloydia serotina				T	T			
Tofieldia coccinea				T				
Epilobium angustifolium						T	T	T
E. Latifolium							T	
Polemonium acutiflorum			T					
Polygonum viviparum				T	T	T	1	
Rumex arcticus			T				T	
Androsace chamajasme					T			
Primula tschuktschorum					T		T	
Trientalis europea						T	T	
Pyrola minor			T					
Aconitum delphinifolium					T		T	
Anemone narcissiflora				1			T	
Caltha palustris arctica							T	
Ranunculus pygmaeus			T					
Dryas octopetala				10				
Potentilla pacifica		T						
P. palustris			2				T	
Rubus arcticus						1	1	
R. chamaemorus	26		2			T	T	
R. stellatus						1	T	
Sanguisorba sitchensis						3	5	
Spirea beauverdiana			T			T	T	
Salix alaxensis							T	
S. arctica				9	T			
S. ovalifolia		2			T	T		
S. pulchra					8	4		

Table 1. (Continued)

Species	WET TUNDRA			DRY TUNDRA		GRASS-BROWSE		BEACH GRASS FORB
	Peat Mound	Tidal Wetland	Wet Tundra	Alpine Tundra	Dry Tundra	Grass Hummock	Riparian Grass-browse	Beach Grass-forb
S. reticulata					T	T	T	
Salix spp.			9				10	
Saxifraga punctata						1		
Lagotis glauca							T	
Pedicularis langsdorfii			T	T	T	T		
P. oederi							T	
P. verticillata				T				
Angelica lucida						3	2	1
Cnidium ajanense					T		T	2
Conioselinum benthami								1
Ligusticum hulteni				T			T	
L. multellinoides				T				
Valeriana capitata					T			
Viola langsdorfii						1	3	T
VEGETATIVE COVER	77	86	93	84	84	90	92	31
BARE GROUND, ROCK, LITTER	23	14	7	16	16	10	8	19

*Trace, less than one percent.

of numbers were largely inaccurate until 1947 when the U. S. Fish & Wildlife Service began making annual aerial surveys of the population. Table 2 represents the data obtained from these surveys. All counts have been complete except for the 1966 survey, when a small portion of the island was not censused. Population increases from 1948 to 1965 have averaged 12.9% per year.

Mortality: Fairly good records of muskox mortality on the island exist. Natives report dead animals and the annual aerial muskox surveys account for many records. It is estimated that about 220 animals have died since introduction; of these, 103 have been recorded, 36 of which have been ascribed to known causes of mortality. There are no muskox predators on the island other than man. Accidents cause most of the mortality, with losses on winter ice suspected to be the major cause of loss. Falls from cliffs, drowning, becoming mired in bogs, and man-caused mortality are other known causes of death. Recorded losses are shown in Table 2. Effects attributable to parasites and diseases have not been observed with Nunivak muskoxen.

Reproduction: Canadian muskox calve in alternate years, with cows breeding at four and five years of age (Tener 1965). Nunivak muskox calve in successive years and cows are breeding at three years of age, possibly earlier. Pedersen (1958) suggested that the variability in frequency of calving may be related to the nutritional condition of the cows. Muskox breed in August and calve in April and May. The gestation period is about eight months. The sex ratio at birth is unknown but a ratio of 3:1 in favor of males is suggested. There have been no confirmed cases of twinning on Nunivak Island.

The Population:

Herd Size and Composition: Muskox are gregarious animals usually found in herds. Solitary adult bulls in summer are an important exception. The largest herds are found in winter, averaging 11 animals. The largest herd seen contained 37 muskox. In winter, adult bulls join mixed sex and age herds or join into groups exclusively composed of bulls.

In spring the muskox disperse from winter concentration areas and the herds become smaller. Many of the adult bulls separate and become solitary as the summer progresses. By mid-July, mixed sex and age herds have only one adult bull. Summer herds average eight animals in size.

The composition of muskox herds encountered during the study was recorded whenever conditions of identification of all individuals in a group were favorable. Table 3 presenta a summarization of composition data for nuskox herds classified during the summers of 1965 and 1966.

Distribution: Since their introduction, the muskox have preferred western and southern portions of the island while avoiding central interior areas and wet tundra regions. The Twin Mountain - Cape Corwin region has become a major summer range in recent years.

In winter, muskox are concentrated on the coast of the island, primarily along the northwestern sea bluffs and southern sand dunes. Muskox tend to occupy points and projections of the coast and sometimes become stranded on small islands adjacent to the coast when connecting sea ice melts in spring.

Table 2. Muskox population counts 1936 - 1966*

Year	Adults, Subadults and Yearlings	Calves	Total Count	Recorded Loss
1936			31	1
1937		10?		
1938	41	9-11	50	
1945				2
1947			47-49	
1948	50	7	57	5
1949	57	8	65	1
1950	54	7	61	4
1951	60	16	76	2
1952	68	9	77	2
1953	75	15	90	3
1954	79	21	100	4
1955	97	19	116	4
1956	100	26	126	9
1957	118	25	143	2
1958	149	32	181	1
1959	167	39	206	6
1960	199	57	256	2
1961	224	69	293	3
1962	275	78	353	6
1963	333	73	406	9
1964	365	102	467	28**
1965	402	110	512	26**
1966	460	109	569***	16

*1936, 1937, 1938 figures from Palmer (1938); all other data from files of USFWS, Clarence Rhode National Wildlife Range, Bethel, Alaska.

**Includes removal of 23 calves in 1964 and 10 calves in 1965 by John Teal, Project Supervisor, Mushox Project, University of Alaska.

***Incomplete count.

Table 3. Composition of muskox herds classified during the summers of 1965 and 1966

	1965	1966
Solitary adult bulls	19*	25
Percentage solitary adult bulls	8*	8
Adult bulls, solitary or in groups	39*	52
Adult bulls in mixes sex and age herds	26	37
Total adult bulls	65*	89
Percentage adult bulls	26*	26
Adult cows	69	84
Percentage adult cows	28*	25
Population ratio, adult bulls to adult cows	94:100*	106:100
Herd ratio, adult bulls to adult cows	38:100	45:100
Calves	57	71
Percentage calves	23*	21
Ratio, calves to adult cows	83:100	85:100
Yearlings	36	56
Percentage yearlings	14*	17
Subadults	23	35
Percentage subadults	9*	10
No. of herds	30	28
No. of observations	28	68
Total no. in herds	211	284
Total no. of muskox	211 (250*)	336

*Figures extrapolated from more complete 1966 composition data.

In the summer, muskox are more widely distributed primarily along stream systems up to about 15 miles inland. In late summer, the herds become more scattered as they move out on the tundra before returning to the coast for winter.

Movement: Muskox are quite mobile in summer with herds often moving one to several miles in a day. Solitary bulls also wander extensively. Senile animals may remain in wintering areas after other muskox have left.

Range Relationships:

Summer Food and Habitat Preferences: The most important summer range type is the grass-browse type. Both the grass hummock and the riparian grass-browse subtypes have rapid annual vegetative growth, and the lush new vegetation attracts most of the muskox use in the summer. After departing from their winter ranges, the muskox move to the riparian zones along streams. Highest preference is shown for Salix pulchra. Other willows are important also, including S. alaxensis, S. reticulata and S. ovalifolia. In addition to the willows, heavy use is received by Calamagrostis canadensis, Festuca spp., Alopecurus alpinus, Carex spp., Equisetum arvense, and Rubus spp. The riparian grass-browse type is not as well developed on the west end of the island. Muskox in this region use Calamagrostis - Arctagrostis fringe pockets bordering wet tundra areas and along the bluffs. Green growth of Carex aquatilis in wet tundra is also used.

In late summer, muskox move onto the grass hummock subtype. Species utilized there are similar to riparian species. S. pulchra grows in the hummocks and continues to to receive heavy use. Other species include Angelica lucida, Arctagrostis latifolia, Calamagrostis canadensis, and Poa spp. Muskox also feed in dry tundra and alpine tundra when traversing them. Species taken include Empetrum nigrum, Arctostaphylos alpina, Betula nana exilis, Carex bigelowii, Hierochloe alpina, and Salix arctica. Use is directed to new growth.

Summer use is not intensive, since herds do not remain at one site for longer than one or two days. Use of the vegetation is quite light and comes at a time when maximum growth is occurring.

Winter Food and Habitat Preferences: Muskox winter range is confined to the perimeter of the island. It is selected more on the basis of its exposure to winds and the windswept feeding areas they provide, than on the basis of forage species present. Feeding is done in small craters pawed through snow of usually less than one foot in depth. Winter use occurs on two range types almost exclusively--wet tundra and beach grass-forb. One herd wintering on Muskox Mountain uses alpine and some dry tundra vegetation.

In wet tundra, species taken include Carex aquatilis, Eriophorum angustifolium, Luzula spp., moss (Hylocomium spp. and Sphagnum spp.), Petasites frigidus, Rubus chamaemorus, and Salix spp. On the beach grass-forb type, muskox use is concentrated on Elymus mollis and Elymus - Empetrum zones. Other species taken include Betula nana exilis, Festuca rubra, moss, and some lichens. The herd on Muskox Mountain take Empetrum nigrum, Salix reticulata, S. arctica, Carex spp., Dryas octopetala, Loiseleuria procumbens, and moss.

In spring, muskox in sand dune areas feed almost exclusively on new sprouts of Elymus before dispersing to summer ranges.

Winter use is much more localized and intensive in nature. Herds may feed in one location for several days or longer and remain at favorable sites for long periods. Where use is on Elymus in the dune areas or on Carex sp. in wet tundra areas, recovery of the vegetation in the feeding craters during the following growing season is usually very good. Browse species receiving use on dry tundra, alpine tundra, or on drier dune areas recover much more slowly. Empetrum nigrum is very susceptible to damage from browsing or trampling in winter. Recovery of Empetrum or other browse species may take several years or longer. Preferred wintering areas are used every year, and overuse is occurring in a few such locations. Small islands adjacent to the coast exhibit results of heavier muskox use than most other winter range.

Reindeer:

Population Growth: Reindeer were introduced to the island in 1920 when 81 animals were placed on the island. An additional 523 were added in 1928. Table 4 lists estimates of the reindeer populations since introduction. Although the accuracy of the figures is uncertain, the estimates do give an indication of population trends. The herd increased rapidly after introduction, reaching peak numbers around 1944 and then showed marked declines until the early 1950's, after which it began increasing again. The population reached a second high point in 1964 and may possibly be declining again.

The herd has been harvested since the 1920's. During the past decade about 2,000 reindeer have been slaughtered annually.

Range Use: During summer reindeer aggregate into large herds commonly numbering from several hundred to several thousand animals. Movements are extensive with herds traveling as much as 20 to 40 miles daily. Summer concentrations are found primarily in the south central and western areas of the island. Use is directed to sedges and grasses, and on new browse growth where encountered. Prostrate willows are an important food sought in wet tundra areas. Although grazing is not normally damaging to the range in summer, trampling can have a much more harmful effect, particularly when large numbers of reindeer are involved. Lichens fracture easily in summer and browse species may be damaged. Compacting of moist soil also results. The most apparent damage by trampling occurs on the western bluffs when reindeer movements are interrupted by the sea cliffs. At such places, the reindeer will move in a tight circle and trample the vegetation into the substratum. Recovery of such area takes many years.

In winter, the pattern of reindeer use changes. Reindeer winter primarily in the central and south central portions of the island, although scattered groups can be found in all areas of the island except for the immediate coast. The reindeer occur in small scattered herds which are more sedentary than summer associations.

Reindeer use is evident over much of the tundra. Much of the dry tundra and alpine tundra has been overgrazed, especially on the western part of the island. Lichen ranges are largely non-existent on the island with the exception of Cape Mendenhall, and the Twin Mountain region. The latter has received heavy use in recent years. Although lichens and browse are the preferred forage in winter, reindeer on Nunivak have turned to wet tundra species to maintain themselves.

Table 4. Population estimates of reindeer on Nunivak Island 1920-1966.

Year	Population Estimate	Source
1920	81	Palmer 1938
1923	310	Palmer 1923, Field Diary
1925	578	Palmer 1938
1938	12,000	Palmer and Rouse 1945
1944	30,000	Palmer and Rouse 1945
1945	7,000	Palmer 1945, Field Diary
1948	7-10,000	USFWS 1964
1950	5,165	USFWS Files, Bethel, Alaska
1951	5,000	USFWS 1964
1953	3,000	USFWS Files, Bethel, Alaska
1956	4,900	USFWS 1964
1957	7,000	USFWS 1964
1958	8-10,000	USFWS 1964
1959	12,000	USFWS 1964
1960	14,332	USFWS 1964
1962	12,000	USFWS 1964
1964	15,500	USFWS 1964
1965	10,000	USBIA verbal comm.[1]
1966	8,000	USBIA verbal comm.[1]

[1]Data from United States Bureau of Indian Affairs personnel.

Muskox-Reindeer Interrelationships: The character of the Nunivak Range has been altered by overuse by reindeer. The effects of this overuse on muskox are unknown. Up to the present time such effects have probably not been harmful to muskox, since muskox use vegetation characteristic of lower seral stages than reindeer on Nunivak winter ranges. However, with the loss of lichen ranges on the island, reindeer have come to depend on much the same type of winter forage as that which supports muskox. Winter ranges have usually been separate for the two species, so that little competition has resulted. Reindeer remains on most major sand dune areas indicate that reindeer have used this important muskox winter range in the past, probably during periods of high reindeer population levels. Now that the muskox population is larger and increasing rapidly, future use of the beach type by reindeer could result in serious competition.

With increases in the muskox population, preferred muskox wintering areas will receive progressively heavier use. The winter range has not expanded proportionately with population increases. Whether or not muskox will accept new winter range as the population increases is unknown. If not, intraspecific competition will result. If new winter range is accepted, there is the possibility of competition with reindeer in winter areas.

To determine carrying capacities for reindeer and muskox on Nunivak Island, studies are needed to determine forage preferences of muskox and reindeer, cover and composition percentages for forage species, extent of the areas used as winter range by both species, and range condition and trend. Effects of competition would serve to complicate the problem.

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SUBMITTED BY:

Gregory N. Bos
Graduate Student

APPROVED BY:

David R. Klein
Leader, Alaska Cooperative Wildlife Research Unit