THE BREEDING BIOLOGY OF ROSS'S GOOSE IN THE PERRY RIVER REGION, NORTHWEST TERRITORIES

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ABSTRACT

Studies of a nesting colony of Ross's Geese at Arlone Lake, in the Perry River region, N.W.T. during the summers of 1963 and 1964 are described. A review of the explorations, climate, vegetation, fauna and Eskimos is presented. A history of the Ross's Goose in the Perry River region is discussed.

The following factors in the biology of Ross's Goose are discussed: arrival dates, nest initiation, incubation, post-nuptial movements, mortality, predation, productivity and competition.

Sight reports of Ross's Geese during the spring migration of 1964 are correlated with the northward movement of the 40 F isotherm. The possible advantage of this migration-control mechanism is discussed.

No courtship behaviour was observed during the study period at Arlone Lake suggesting that such activities are completed farther south. Ross's Geese use islands for nesting, presumably as a defense against mammalian predators. Highest nest densities were found in the mixed-birch-rock and open areas which provide both cover and grazing areas.

Eggs are laid every 1 1/2 days with a resultant 8 to 9 day egg-laying period. Clutch sizes, which average 3, may be controlled by the short Arctic season. Late nesters lay smaller clutches. Only 93 frost-free days are available to complete the reproductive phase. In 1963 and 1964 the Ross's Geese utilized over 80% of this period.

The high degree of attentiveness during the incubation period results in maximum hatching success. Mortality and predation is generally low on the nesting islands. Productivity was estimated from counts of 1 week old and younger broods. Most losses in 1964 occurred in the United States.

Goslings are polymorphic with gradations between yellow and gray. A differential mortality against female goslings occurs during the first 3 weeks of life. It

is suggested that a large influx of Lesser Snow and Blue Geese would be detrimental to the Ross's Geese during the reproductive phase.

It was concluded that the population of Ross's Geese nesting at Arlone Lake in 1963 and 1964 was not subjected to excessive limiting factors.

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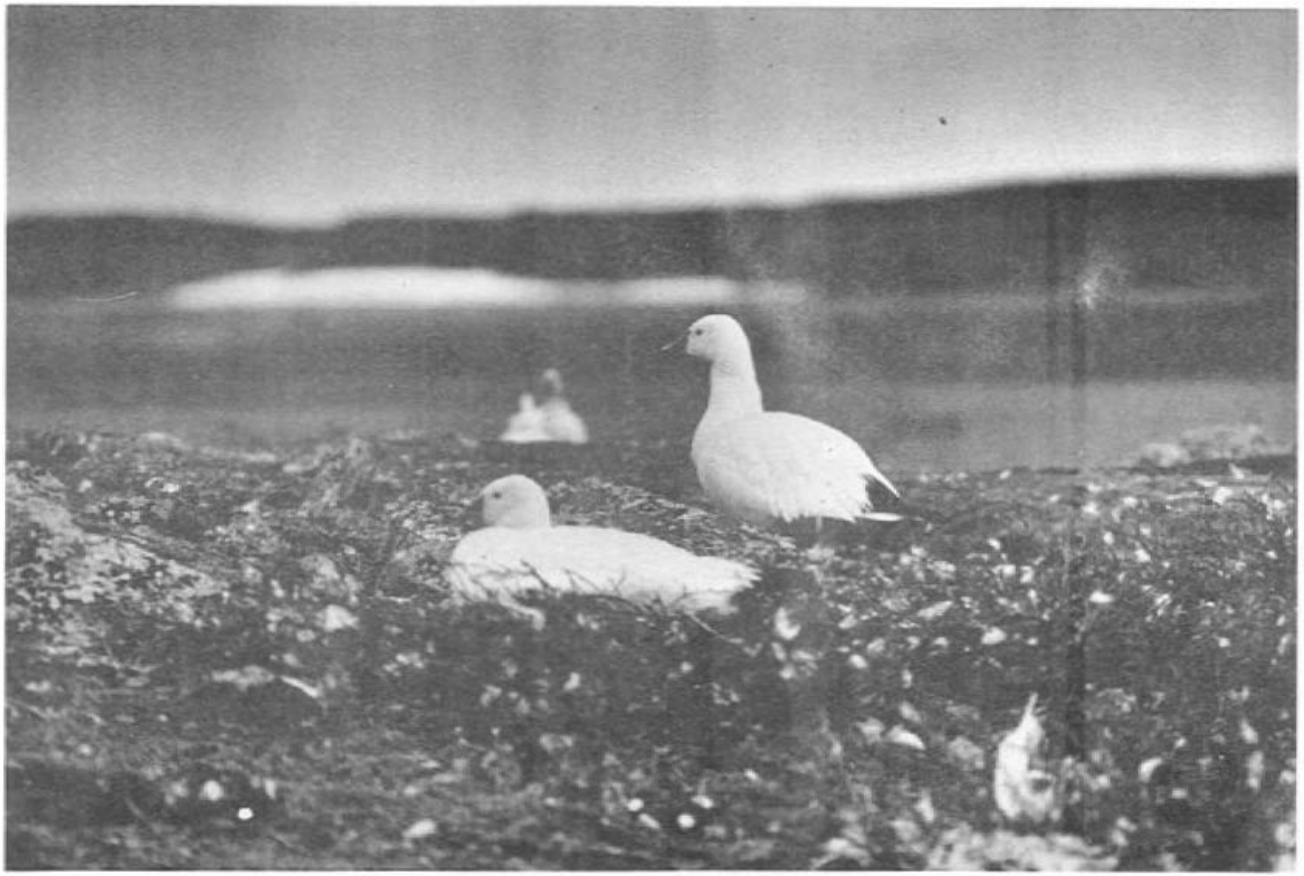


Ross's Geese nesting at Arlone Lake, N.W.T.

TABLE OF CONTENTS

	Page
LIST OF TABLES	
LIST OF FIGURES	
LIST OF PLATES	
INTRODUCTION	1
Previous exploration	3
Recorded history of the Ross's Goose in the Perry River region	7
Breeding distribution of Ross's Goose	9
Population status of Ross's Goose	10
STUDY AREA	13
METHODS	29
Reproductive biology of Ross's Goose	29
Habitat analysis	30
Post-breeding biology of Ross's Goose	31
RESULTS	32
Reproductive biology of Ross's Goose	32
Arrival	32
Nesting	39
Egg-laying period	46
Incubation period	59
Hatching period	64
Post-breeding biology of Ross's Goose	68
Brood count analysis of productivity	70
Physical attributes	74
Interspecific relationships	80
Parasitism	80

Predation 80

Competition with the Lesser Snow Goose 84

Banding operations 87

DISCUSSION 88

SUMMARY 98

BIBLIOGRAPHY 101

APPENDIX 1. Representative flora from Arlone Lake Study area .. 105

2. Avian phenology chart Perry River, N.W.T. 1963 and 1964 106

3. Mammals observed in the Perry River region, N.W.T. 1963 and 1964 110

4. Common and Kogmiut names of fish observed at Perry River, N.W.T. 1963 and 1964 111

5. Ross's Goose nest history card 112

6. Ross's Goose collection data form 113

7. Food habits 114

LIST OF TABLES

Table I.	Location and number of Ross's Goose observations from 1960 aerial surveys	12
Table II.	Temperature data (F) from Perry River region, 1963	25
Table III.	Distribution of flora types at Arlone Lake N.W.T. 1963, 1964	26
Table IV.	Dimensions of nests in relation to Habitat (measurements in inches)	41
Table V.	Comparison of nest cover and potential coverage of the 4 major habitats on Arlone Lake islands	42
Table VI.	Density of nests in each major habitat on islands (per 1000 sq. ft.)	42
Table VII.	Clutch sizes of Ross's Goose from Arlone Lake, 1963 and 1964	53
Table VIII.	Clutch size of Ross's Geese in relotlan to date of first egg	54
Table IX.	Clutch size in relation to habitat 1964	56
Table X.	Egg depletions from complete clutches, Island D, Arlone Lake June 17 and 18, 1964	57
Table XI.	Egg additions to completed clutches, Island C, Arlone Lake June 18, 1964	58
Table XIIa.	Fate of 351 eggs in 93 nests, 1964	67
Table XIIb.	Fate of 230 eggs in 59 nests, 1964	67
Table XIII.	Brood size data from the 1964 migration of Ross's Geese	72
Table XIV.	Physical measurements of Ross's Geese	77
Table XV.	Sex ratio of newly hatched Ross's Geese	78
Table XVI.	Color combinations of 1 day-old Ross's Geese Broods observed at Arlone Lake, N.W.T., 1963	79
Table XVII.	Color combinations of 1 day-old Ross's Geese Broods observed at Arlone Lake, N.W.T., 1964	79
Table XVIII.	Extensity of helminth infections of Ross's Geese collected during 1963 and 1964.	81
Table XIX.	Number of avian predator nests recorded at Arlone Lake, N.W.T. 1963 and 1964 seasons	83

Table XX. Nesting densities of the Lesser Snow Geese at Arlone Lake nests per 1000 sq. ft. 85

Table XXI. Results of food analysis of 26 Ross's Goose ventriculi collected in the Perry River region 1963 and 1964 115

LIST OF FIGURES

Figure 1.	Northwest Territories, Canada	6
Figure 2.	Winter population estimates of Ross's Goose in California	11
Figure 3.	Map of the Perry River showing location of study	14
Figure 4.	Map of Arlone Lake, N.W.T. showing position of nesting islands used by Ross's Geese	17
Figure 5.	Migration-phenology pattern of Ross's Goose, 1964, based on 12,531 sightings	34
Figure 6.	Gonad weight changes of Ross's Geese during the breeding season, 1963 and 1964	37
Figure 7.	Extent of Ross's Goose reproductive phase in relation to frost-free period, Perry River region, N.W.T., Canada	38
Figure 8.	Frequency of egg-laying in Ross's Goose, 1963 and 1964	47
Figure 9.	Ross's Goose nesting territories	51
Figure 10.	Ross's Goose nesting territories	51
Figure 11.	Clutch size frequency of Ross's Geese nesting at Arlone Lake, N.W.T. 1963 and 1964	55
Figure 12.	Hatching frequency of Ross's Goose, 1964	65
Figure 13.	Productivity of Ross's Geese from clutch and brood counts, 1963 and 1964	71
Figure 14.	Weight changes of Ross's Geese during 1963 and 1964 seasons	75

LIST OF PLATES

Plate 1.	Morainal deposits in the Perry River region, N.W.T.	15
Plate 2.		18
Plate 3.		19
Plate 4.	Habitat maps of Ross's Goose nesting islands, Arlone Lake, N.W.T.	20
Plate 5.		21
Plate 6.		22
Plate 7.	Snow and ice conditions at Arlone Lake, early June	23
Plate 8.	Mixed habitat	44
Plate 9.	Rock habitat	44
Plate 10.	Birch habitat	45
Plate 11.	Open habitat	45
Plate 12.	Defense posture of Ross's Goose	49
Plate 13.	Destroyed eggs around a hyperclutch nest of Ross's Goose	59
Plate 14.	Incubating posture of Ross's Geese	62

INTRODUCTION

The Ross's Goose, Anser rossii Cassin, is North America's smallest and rarest Arctic-nesting goose. During the early 1950's concern for the species' survival was shown because of the low numbers reported on migration through the Canadian Prairie Provinces and on the wintering grounds in California. The lack of knowledge concerning its breeding habits made management procedures subjective and inefficient. Investigations were undertaken in a nesting area so that productivity and general habits could be ascertained.

In the spring of 1963, the author initiated a preliminary study of Ross's Goose in the Perry River region, N.W.T. The main objectives of the study were:

(1) to study the reproductive biology of the Ross's Goose on the nesting grounds.

(2) to study the post-breeding biology of the Ross's Goose.

(3) to study interspecific relationships existing on the nesting areas.

Activities were confined to Arlone Lake, N.W.T. (67°22'N, 102° 10'W) in the Perry River region and to the mouth of the Perry River. This region constitutes the traditionally reported nesting ground, although in recent years smaller colonies have been reported from the Hudson and James Bay area (Barry and Eisenhart 1958, Cooch 1954, MacInnes and Cooch 1963) and Banks Island (Barry 1960b, Manning et al 1956). Arlone Lake, according to the Kogmiut Eskimos, was the location of a well established nesting colony, so much so that it received the name "Pikiulik" which means 'nesting lake'. Gavin (1945) reported the presence of a Ross's Goose colony at Arlone Lake as early as 1937.

Data on previous ornithological work in this area are sparse. Biological survey work was carried out by Mr. Angus Gavin during his stay in the area from 1937 to 1941 (Gavin 1945, 1947). A scientific investigation of the geography, birds and mammals was executed in 1949 (Hanson et al 1956) and in 1962 a waterfowl

banding crew studied the potential of the area for goose banding (MacInnes and Weske 1962).

Previous exploration

The region adjacent to the Perry River lies in one of the least explored areas of the Canadian north. Samuel Hearne (1795) was the first whiteman to penetrate the interiors of the western Keewatin and eastern Mackenzie districts in an effort to find the mouth of the Coppermine River. Hearne's first two trips, 1769 and 1770, into the barren regions were short and he did not get far north from his base point at Churchill, Manitoba. The third expedition, 1770 and 1771, followed the wooded areas of the treeline far south of the barrens. The narrative of his journey contains many notes of natural history and in his closing chapter the author gives a detailed account of many of the animals with which he came in contact during his years in the north.

Coptoin George Back (1836) explored and described the area surrounding the Great Fish River (Back's River) during the years 1833 to 1835 (Fig. 1). His main contribution lay in the description of the region north-east of Pelly and Garry Lakes. The maps he constructed of the region as for as Montreal Island (67° 51'N, 96° 25'W), at the mouth of the Bock River remained the only ones until 1948 (Baird 1949). Although Bock's primary purpose for going into the north was to find the lost party of Captain John Ross (1829-1833), he kept natural history notes of many of the regions traversed. Preble (1908) states that Back did not encourage the collection of natural history specimens and that Mr. Richard King's (surgeon and naturalist of the expedition) medical duties kept him away from much of this type of work. However, the flora and fauna described by King, although not original (see Pennant Arctic Zoology, London, 1792-5), gave insight into the existing flora and fauna of the regions explored.

The coast of the Queen Maud Gulf, into which the Perry River flows, was mapped by Thomas Simpson between 1837 to 1839 as far east as the Castor and Pollux Rivers on Boothia Peninsula. Unfortunately he did not penetrate into the area south of the Queen Maud Gulf.

The first whiteman to travel into the region immediately adjacent to the

Perry River was David T. Hanbury in 1902. Part of his expedition proceeded north from Lake Pelly following the Ti-her-uak River (Armark) to the mouth. The route he followed was 30 to 40 miles east of the then unknown Perry River. Hanbury (1904) describes this region as follows:

"The river (Armork) flowing to the north after leaving Ti-her-yuok Lake traverses a very sterile area which here justifies the name Barren Lands. No vegetation is to be seen except a few blades of grass here and there, while rocks, both fragmentary and in situ are everywhere to be seen. Small shoal lakes with sandy bottoms are formed by widenings of the river".

Hanbury's descriptions and maps of the area were original.

Angus Gavin was the first whitemon to penetrate into the immediate territory drained by the Perry River. He acted as post manager for the Hudson's Bay Company of Flagstaff Island, N.W.T. (67° 48'N, 102° 16'W) from April 1937 to July 1941. Gavin (1945) says of the region:

"To the south lay an unmapped and unexplored territory lying between the coast and Back's River. I made my first journey into the interior in March 1938 when I accompanied hunters of a tribe of Caribou Eskimos to the Garry Lakes, returning alone obout two weeks later. This wos a traverse of 85 miles, and, I am told, is the first penetration of the territory by a white man".

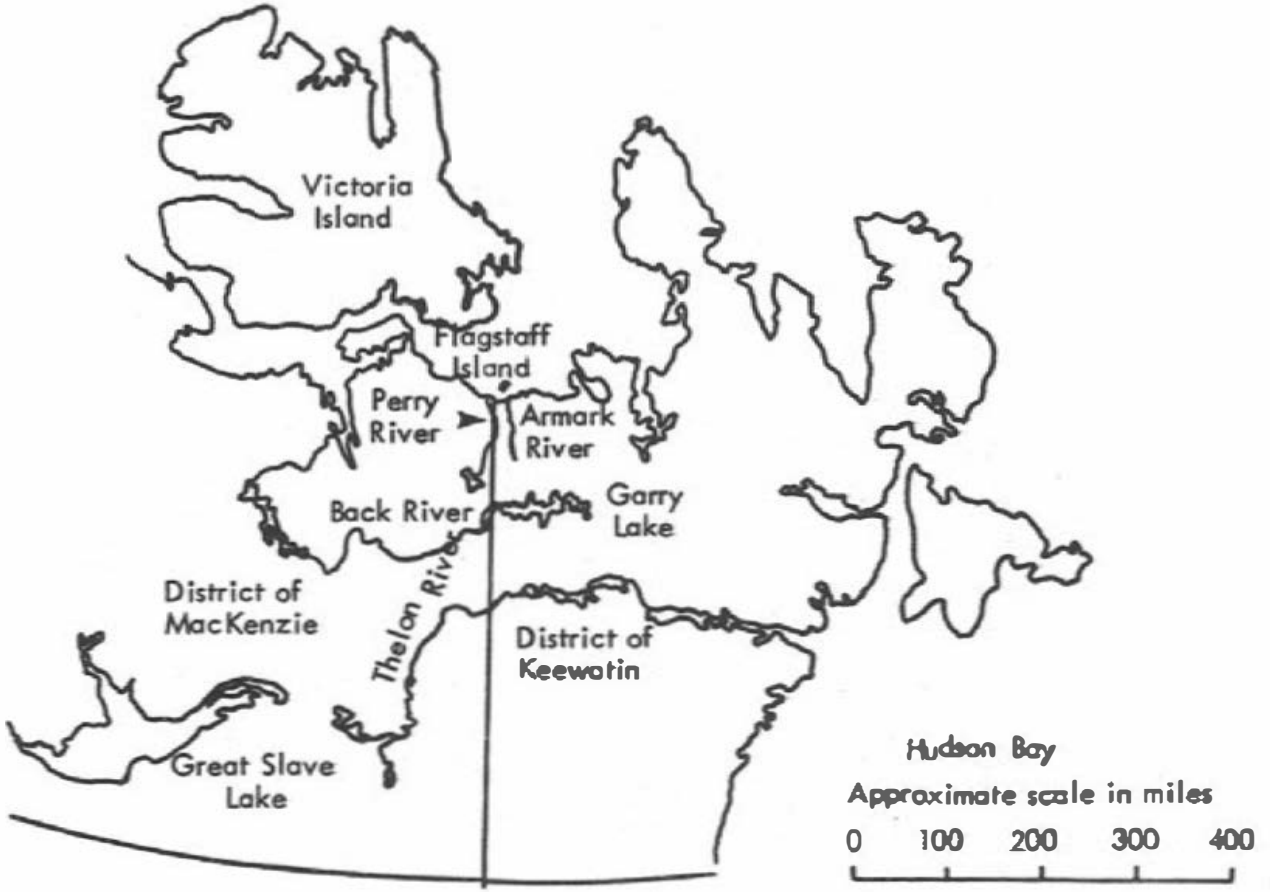
Gavin made other inland trips, up to 30 miles, during the summers of 1938 and 1941, taking notes on the geology, geography, climate, flora and fauna of the region (Gavin 1945, 1947).

In the summer of 1949 the first scientific party into the Perry River region centred its activities around the geography, birds and mammals (Hanson et al 1956). The results of this investigation shed new light on the habits and occurrences of various plant and animal species and brought up to date the available maps of the area. Hitherto unmarked topographic features were placed on the National Topographic Map Series 1953, produced by the Department of Mines and Technical Surveys. Hanson et al. (1956) say of the regian:

"In view of the scant attention given by exploring parties to the country lying between the Back River and the orctic coast, it is not surprising that maps of this area in 1949 were sketchy. The course of the Perry River was indicated by dotted lines and our bubble sextant observations showed that its mouth was about 15 miles farther west than shown, placing it in the District of Mackenzie instead of the District of Keewatin".

Subsequent investigations in the Perry River region have been primarily ornithological, consisting of a waterfowl banding potential study (MacInnes and Weske 1962), and the present investigation.

Figure 1. Northwest Territories, Canada.



NORTHWEST TERRITORIES, CANADA

Recorded history of Ross's Goose in the Perry River region

The Ross's Goose was first reported by Samuel Hearne in 1770 from observations he made during his attempts to find the Coppermine River. His report of large flocks was amazingly close to the main nesting area at Perry River, and it is unfortunate that no one took his words seriously until after the actual discovery.

Cartwright (1940) states that it may have been on the second or third attempt that Hearne saw the flocks of "Horned Wavey", but judging from the dates it was probably the second attempt in 1770.

Clarke (1940) realized Hearne's words bore value when he said: "In the interior we have from Hearne as good a hint as any yet available". The Indians during their summer travels saw almost everything there was to see on the land but no one ever reported finding the nest of the Ross's Goose. Part of the problem was the lack of exploration between the Back River and the Arctic coast, which "have been travelled by no whiteman in summer".

The species was not described for science until almost a century after Hearne's report when, in 1861, John Cassin named it Anser rossii in honour of Bernard Rogan Ross, Chief Factor of the Hudson's Bay Company at Fort Resolution, Great Slave Lake. Ross was so honoured because he sent specimens to Cassin between the years 1859 and 1861.

Following the formal naming of the species the location of the nesting grounds became the subject of speculation for many decades. During the years, [illegible] 1861-66 Roderick Ross MacFarlane, manager of the Hudson's Bay Company post at Fort Anderson, induced many of the officers of the Mackenzie District to participate in the search and interrogate the natives as to where the Ross's Goose nested (Cartwright, 1940). MacFarlane postulated that it probably nested along with the larger numbers of Lesser Snow Geese on the islands to the north of the North American continent. He says:

"I have always regretted that I was unable, owing to the abandonment of the post, summer 1866, to carry out my intention of devoting at least two seasons to a personal exploration of the breeding grounds of this (Ross's Goose) and some other birds which are

believed to resort to Liverpool Bay and the 'Eskimo Lakes' and thence also to the Delta of the Mackenzie River".

Sergeant Charles Mackenzon of the Royal Canadian Mounted Police, Cambridge Bay, gave the first indication that Perry River might be the location of the nesting grounds. He obtained information from his association with the Kogmiut Eskimos. Stimulated by Mackenson's suggestion, Mr. Charles E. Gillham of the United States Department of the Interior, Fish and Wildlife Service, flew over the Perry River region in 1938. While on this flight he observed what he thought were Ross's Geese. He says (Kortright 1960):

"From the air the writer (Gillham) could see countless large white birds in these marshes; whether they were swans, Snow Geese or Ross' Geese only time will prove".

Gillham planed to return to the same region in 1939, this time to specifically search for Ross's Geese. Unfortunately the project was abandoned due to the untimely death of the pilot.

On June 30, 1938 Angus Gavin, manager of the Hudson's Bay Company post at Perry Island started out to find the nesting grounds. His account of the successful journey is published in The Beaver of December 1940. Gavin's route took him 8 miles up the Perry River from the mouth then 15 miles south-east along a small tributary of the Perry to a small lake (now called Discovery Lake, 67° 33'N, 101° 49'W).

Gavin (1940) says:

"On entering the lake, we could see them (Ross's Geese) flying all over the place. The lake was long and narrow, and studded with two or three hundred reefs of varying shapes and sizes up to about 500 by 50 yards. One of the islonds nearest us wos covered with the white dots of the nesting birds. Through the glasses they reminded us of ptarmigan in winter garb. As we approached they rose in large flocks over our heads, loudly protesting at our invasion of their domoin. Others took it very philosophically, and not until we had actually landed did they get off their nests".

In a discussion of Gavin's accomplishments Cartwright (1940) states:

"There is something singularly appropriate---a sort of poetic justice--- in the fact that the solution to the lost remaining ornithological enigma of North America--the whereabouts of the nesting grounds of Ross's Goose---should be accomplished by officers of the Hudson's Bay Company.

Breeding Distribution of Ross's Goose

The distribution of nesting colonies of Ross's Geese has not yet been completely established. Prior to 1938 the only known colonies were located in the restricted Perry River region. Soper (1952) states that the Perry River region presumably accommodates all the Ross's Geese in existence. Snyder (1957) remarks that the known summer range is restricted to the interridge country inland from the coast in the Perry River area. Amadon (1938) said the species exhibits o relict distribution in that it was once more widespread. MacInnes and Cooch (1963) support this idea and postulate that this may have resulted through exclusion from other areas by the larger, more aggressive Anser caerulescens. Hanson et al (1956) made no mention of other possible nesting grounds.

Samuel Hearne (1795) made the first mention of Ross's Geese in the area 200 miles northwest of Churchill, Manitoba. Small numbers have subsequently been reported nesting in the Hudson and James Bay area in 1953 (Cooch 1954), Boas River Delta on Southampton Island in 1956 (Barry and Eisenhart 1958), and McConnel River and Boas River in 1960 and Boas River in 1961 (MacInnes and Cooch 1963). A total of 33 individual Ross's Geese have thus been reported so far from these areas. Colonies have been observed on Banks Island, N.W.T. (Manning et al 1956 and Barry 1960b) and at various points along the Queen Maud Gulf from the Ellice River to Sherman Inlet (Barry 1960b).

The increase of reports of nesting Ross's Geese from areas other than the Perry River might at first indicate that the species was penetrating new areas. MacInnes and Cooch (1963) explain the situation in the eastern Arctic as follows:

> "It is not safe to assume that this represents a recent eastward extension of Ross's Goose range from the Perry River area. In view of Hearne's old records it is more likely that a very small population has always been present in the eastern Arctic, and that the recent increase in the number of observations merely reflects increased activity by ornithologists, particularly in the North".

Probably the same conclusion can be reached in considering those reports from the western Arctic, based on reports from Banks Island, N.W.T. Höhn

(1959) say that there is strong evidence that some Ross's Geese migrate on a more westerly route to breeding grounds which have not yet been discovered.

If future investigations uncover additional nesting colonies or individuals from the eastern and western extremities of the Canadian Arctic as well as the large area along the Queen Maud Gulf the species cannot be considered any longer as one of North America's relict species. This is particularly encouraging in view of the sparse investigations that have taken place in the central Arctic.

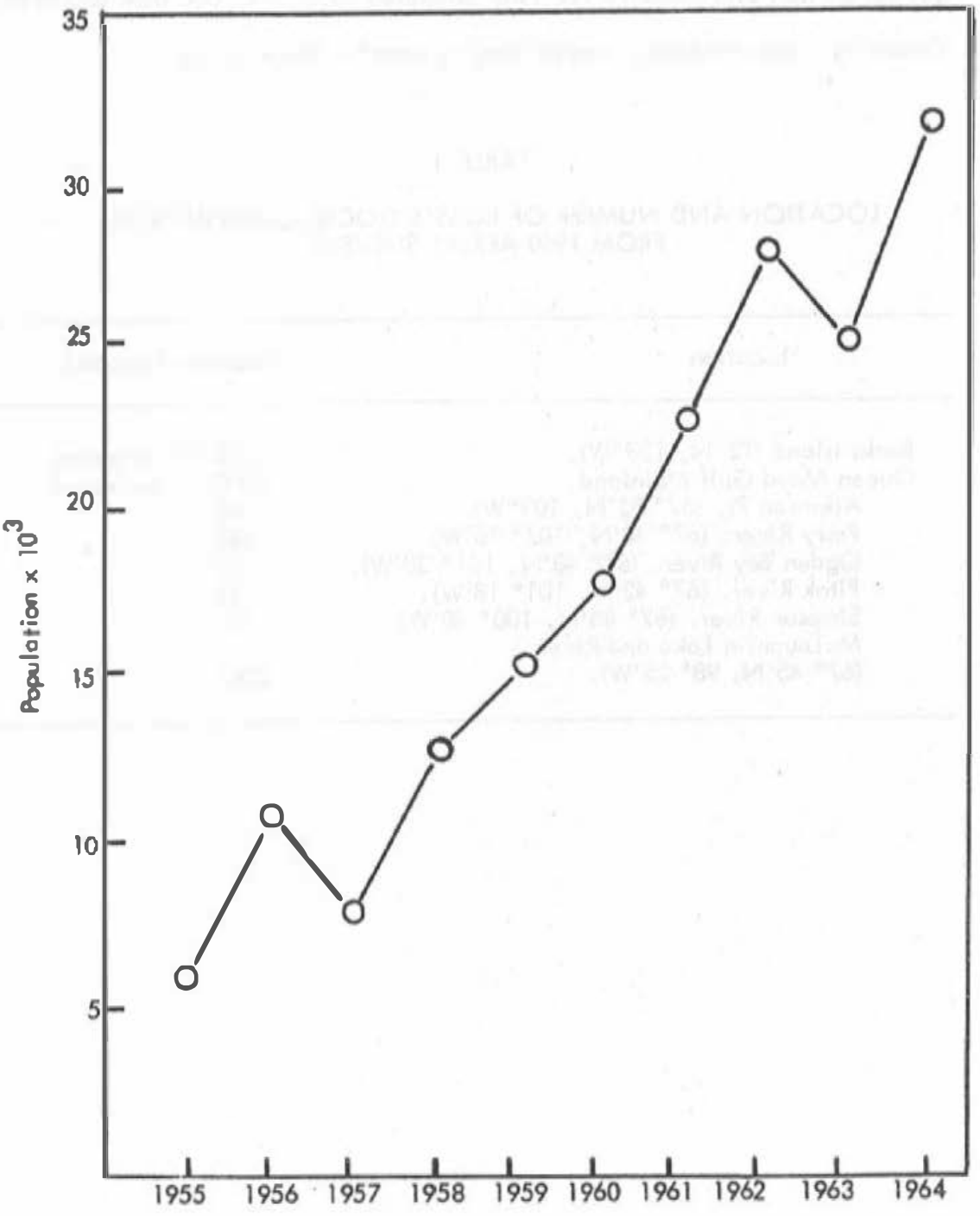
Population Status of Ross's Goose

Over the past two decades there has been an apparent increase in the total number of Ross's Geese (Fig. 2). Hanson et al (1956) were the first to count Ross's Geese along the Queen Maud Gulf and estimated 2000 in 1949 between the Perry River and the Simpson River, N.W.T.

In 1952 it was believed that the total number was still 2000 and decreasing (Lloyd 1952). By 1958 estimations indicated that the population was over 10,000 (Munro 1958). Since 1955 annual counts of Ross's Geese have been undertaken each February on the wintering grounds in California by the United States Department of the Interior Bureau of Sports Fisheries of Wildlife.

In July and August of 1960 Canadian Wildlife Service biologists surveyed the Central Canadian Arctic in an effort to count Ross's Geese on the major nesting colonies. The survey extended from the Anderson River (69° 45'N, 129° 00'W) on the west, along the coast of the Queen Maud Gulf to Sherman Inlet (68° 00'N, 98° 21'W) on the east. A total of 9000 Ross's Geese were observed at inland points all along the Gulf and more than 200 on Banks Island (see Table 1). These numbers represent a value considerably less than the estimate made on the wintering grounds in the spring of 1960 (Fig. 2). Barry (pers. comm.) says that at the time of the survey (16th - 22nd August, 1960), most of the geese had completed their postnuptial moult and were able to fly. Consequently many of the birds were then located a considerable distance from the nesting sites.

Figure 2. Winter population estimates of Ross's Goose in California.


35
30
25
20
15
10
5
Population x 10^3
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964

Figures obtained from California aerial surveys for 1963 and 1964 show that the number now stands in the vicinity of 32,000. This is in part substantiated by Mr. A. Dzubin who in the fall of 1962 estimated 35,000-40,000 from counts made at Kindersley, Saskatchewan, a major staging area for Ross's Geese.

TABLE I

LOCATION AND NUMBER OF ROSS'S GOOSE OBSERVATIONS FROM 1960 AERIAL SURVEYS

Location	Number Reported
Banks Island (72°N, 123°W).	200 (+) estimated
Queen Maud Gulf Mainland.	9000 estimated
Atkinson Pt. (67° 55'N, 103°W).	48
Perry River. (67° 42'N, 102° 15'W).	282
Ogden Bay River. (67° 40'N, 101° 30'W).	12
Pitok River. (67° 42'N, 101° 18'W).	22
Simpson River. (67° 45'N, 100° 40'W).	101
McLaughlin Lake and River (67° 45'N, 98° 25'W).	2365

STUDY AREA

Location and Topography

The Perry River drains a part of the Canadian or Hudson Bay Precambrian Shield. Its mouth lies at position 68°N 102°W, about 75 miles north of the Arctic Circle (Fig. 3). It is immediately west of the Mackenzie-Keewatin border. This region is part of the vast area called the "Barren Grounds" so often mentioned in the literature. At the close of the Tertiary Period the Canadian Shield, an area of approximately two-million square miles, was uplifted unequally and warped into the familiar approximate saucer shape, with a central depression in the Hudson Bay area. The Torngat Mountains of the Ungova Section of northern Labrador are the highest region in the Laurentian Province, and the broad Hudson Bay coastal plain section is the lowest. Intermediate is the Keewatin section, the western boundary of which is located at the contact of the typical Precambrian rocks of the shield with the Paleozoic and Mesozoic rocks of the plains (Kimble et al 1954).

The terrain from the Arctic coast inland to Arlone Lake is monotonously flat and wet in summer. It is relieved only by the presence of morainal deposits or Wholeback Hills (Plate 1) as described by Hanson et al (1956). North to north-west glacial movement in the past is clearly evident by the scars and frost cracks exposed on these Precambrian outcroppings, by the north-south flow of the many, almost parallel rivers which drain the region, and by the north-south running axes of the numerous lakes.

The hills are often formed completely of gravel deposits, but more commonly are solid rock. The height of these hills does not usually exceed 100 feet, although Hanson et al. (1956) recorded one to be as high as 800 feet just north of MacAlpine Lake at position 66° 46'N, 102° 35'W.

Inbetween the hills are valleys and wide stretches of tundra, more specifically according to the classification of Kendeigh (1961), grass tundra. This area is typified

Figure 3. Map of the Perry River showing location of study area.


OGDEN BAY
102°
WINTER ISLAND
CABIN
67°40'
LEE
ISLAND
GAVIN
RIVER
LAINE CREEK
MANN
ISLAND
DISCOVERY LAKE
PERRY RIVER
MAIN
CAMP
ARLONE LAKE
(MAIN STUDY AREA)
4 MILES

Plate 1. Morainal deposits in the Perry River region, N.W.T.

by the presence of tussocks which are formed from the effects of frost heaving. Baird (1964) described their formation as resulting from differential frost heaving in the predominantly wet mineral soil. The tussocks are one or more feet in diameter and height with a core of heaved mineral soil and a tuft of rhizomes and leaf bases on the top and sides.

The Perry River drains primarily from MacAlpine Lake (66° 40'N, 102° 15'W). Important tributaries enter via an unnamed river at position 66° 57'N 102° 6'W, Laine Creek (67° 36'N 102° 9'W) and the Govin River (67° 38'N 102° 5'W). During the spring runoff innumerable temporary streams empty into the Perry River. The volume of water discharged has been calculated at 10^6 cubic feet per minute and the maximum depth is approximately 15 feet. The velocity varies from 1 to 2 miles per hour (Hanson et al. 1956).

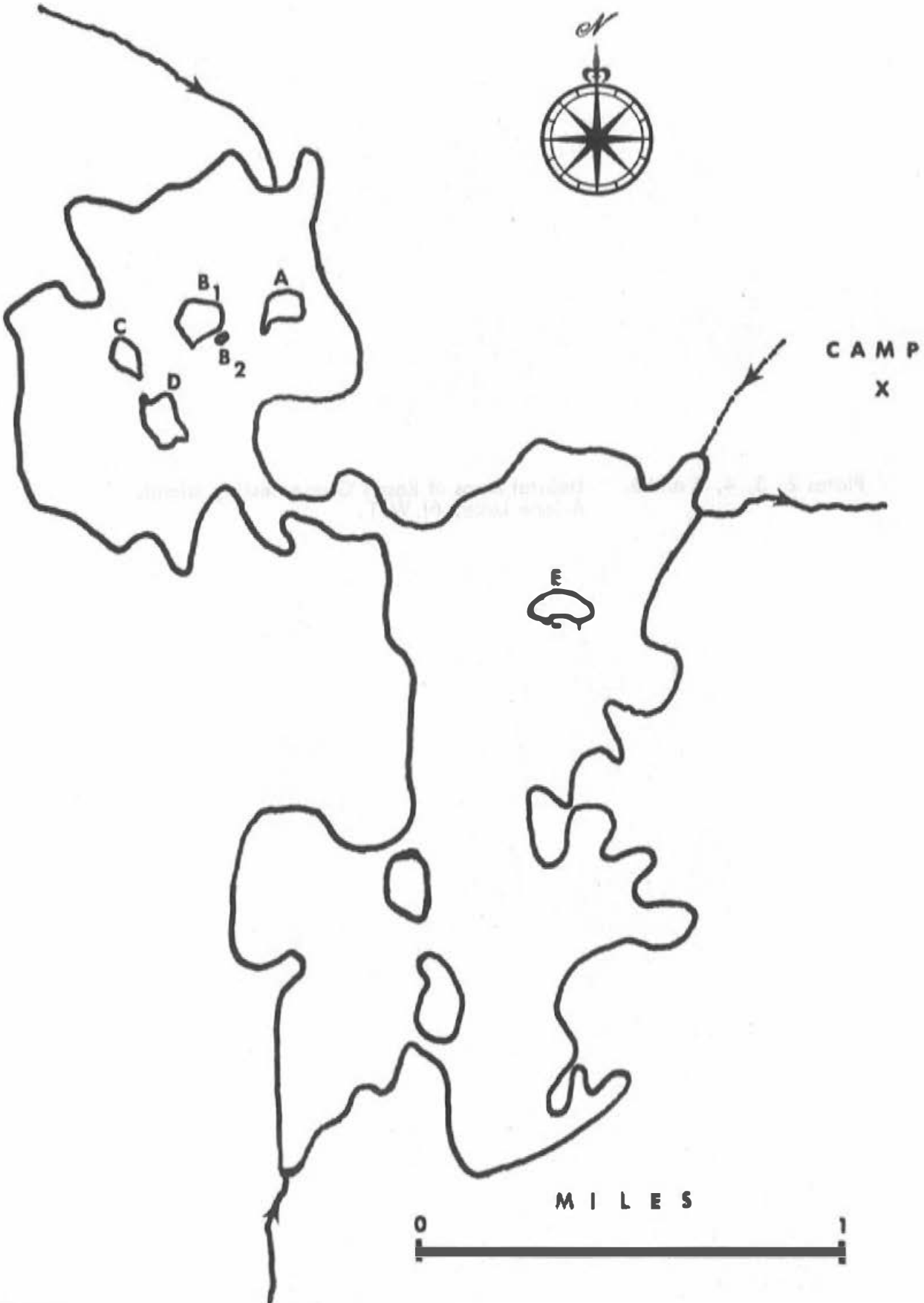
Arlone Lake (67° 22'N 102° 10'W) is about 24 miles south of the mouth of the Perry River. It has a maximum width of 1 mile and maximum length of 2 miles (Fig. 4). The greatest recorded depth is 9 feet 5 inches with an average depth of only 3 feet 9 inches. It contains 7 islands, 5 of which are used by nesting Ross's Geese (Plates 2, 3, 4, 5 and 6).

The short arctic season may prevent an extensive growth of aquatic and emergent vegetation and aquatic fauna. In 1963 and 1964 bottom ice continually rose until the middle of July leaving little time for plant and animal growth water. The almost constant winds prevailing in the summer result in the water being continually turbid. At no time during either seasons of field work was the bottom visible despite the shallow nature of the lake.

The topography around Arlone Lake consists of glacial moraines and the extensive grass tussock or meadow tundra, numerous small lakes and temporary streams. The lake was still completely ice covered on 2nd June 1963 and 1st June 1964 (Plate 7), although 2 to 3 inches of water covered the ice in 1964. By 12th June 1963 and 15th June 1964 there was sufficient water to float the rubber boat. Prior

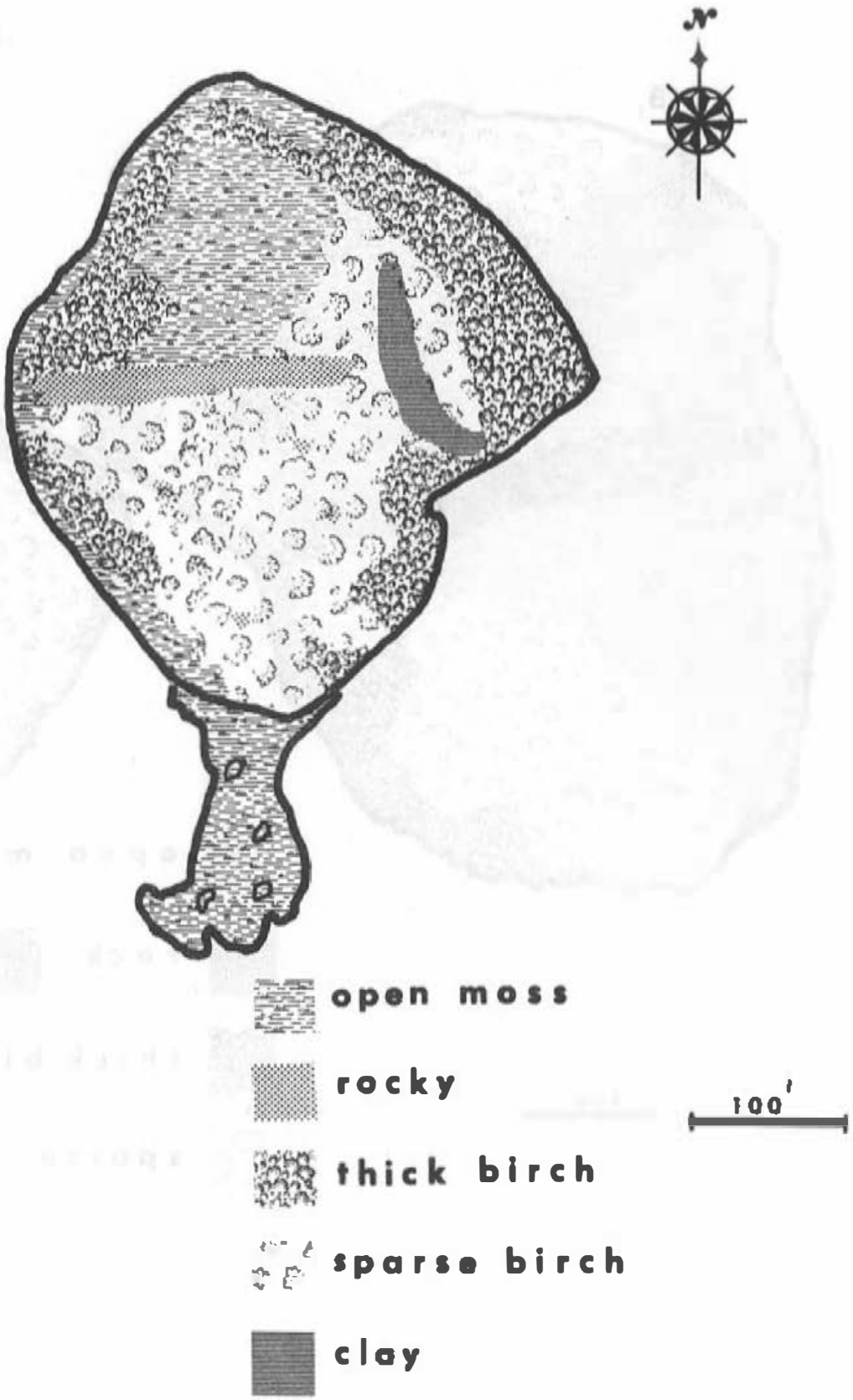
Figure 4. Arlone Lake, N.W.T. showing position of nesting islands of Ross's Geese.

ARLONE LAKE

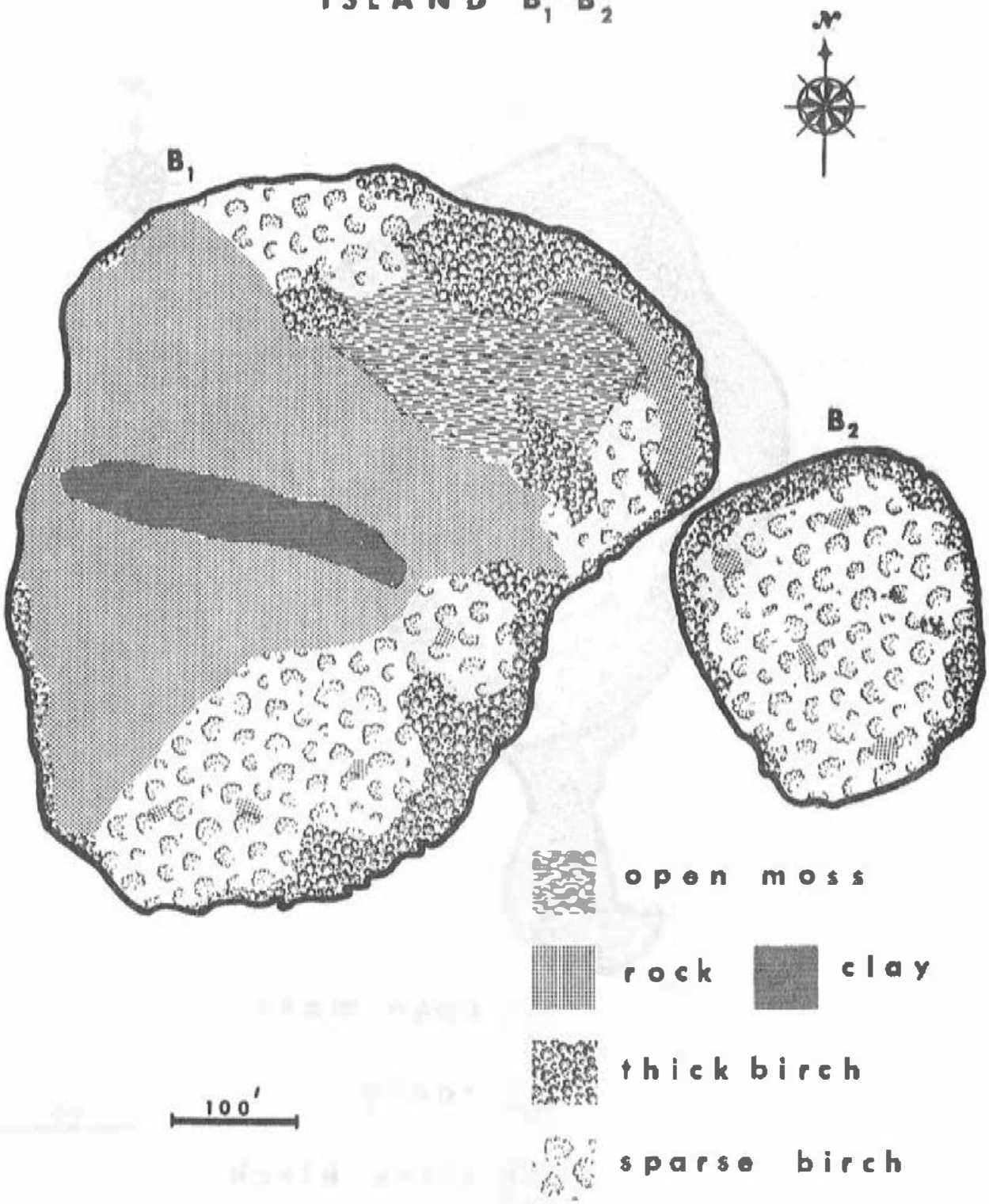


Plates 2, 3, 4, 5 and 6. Habitat maps of Ross's Goose nesting islands Arlone Lake, N.W.T.

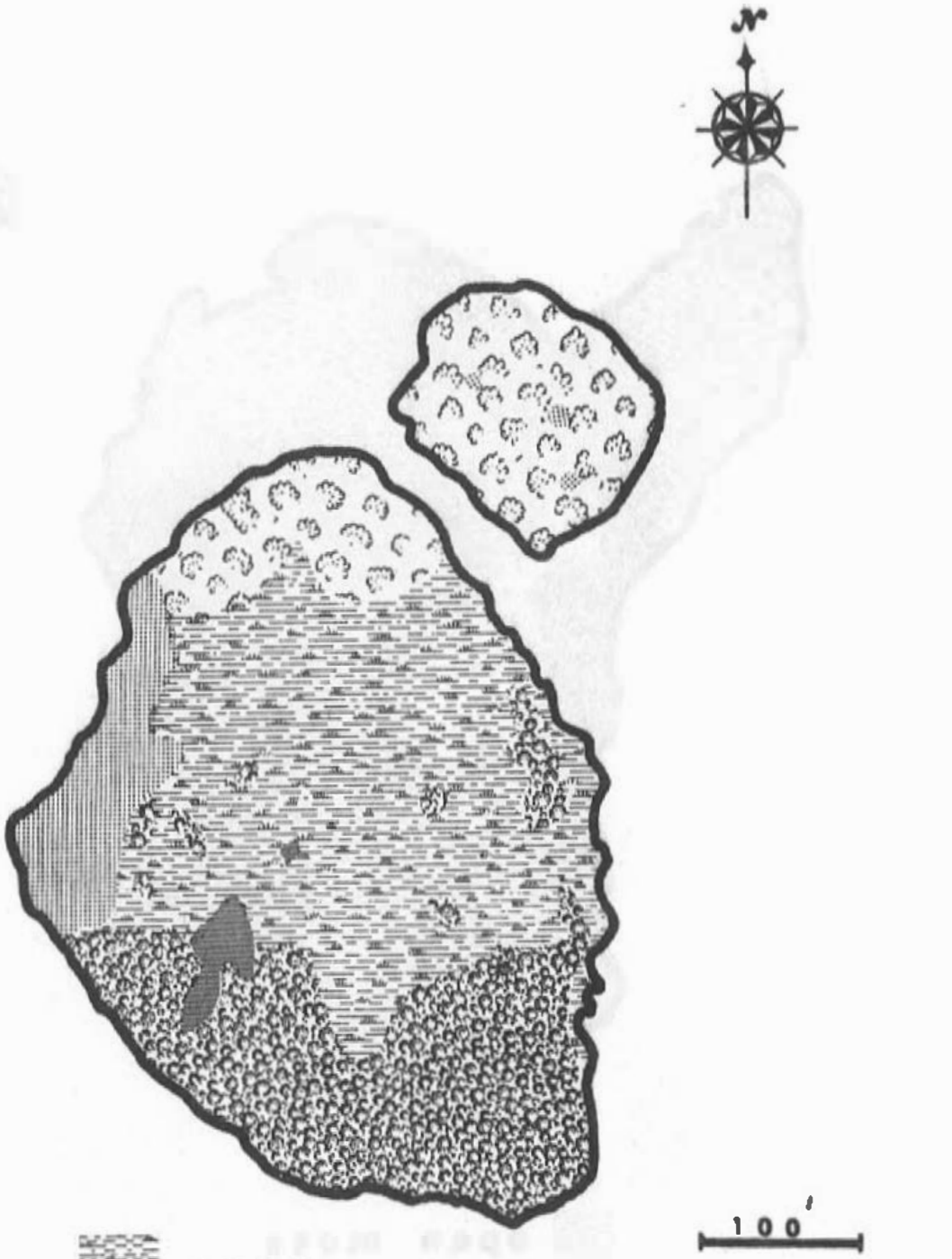
ISLAND A



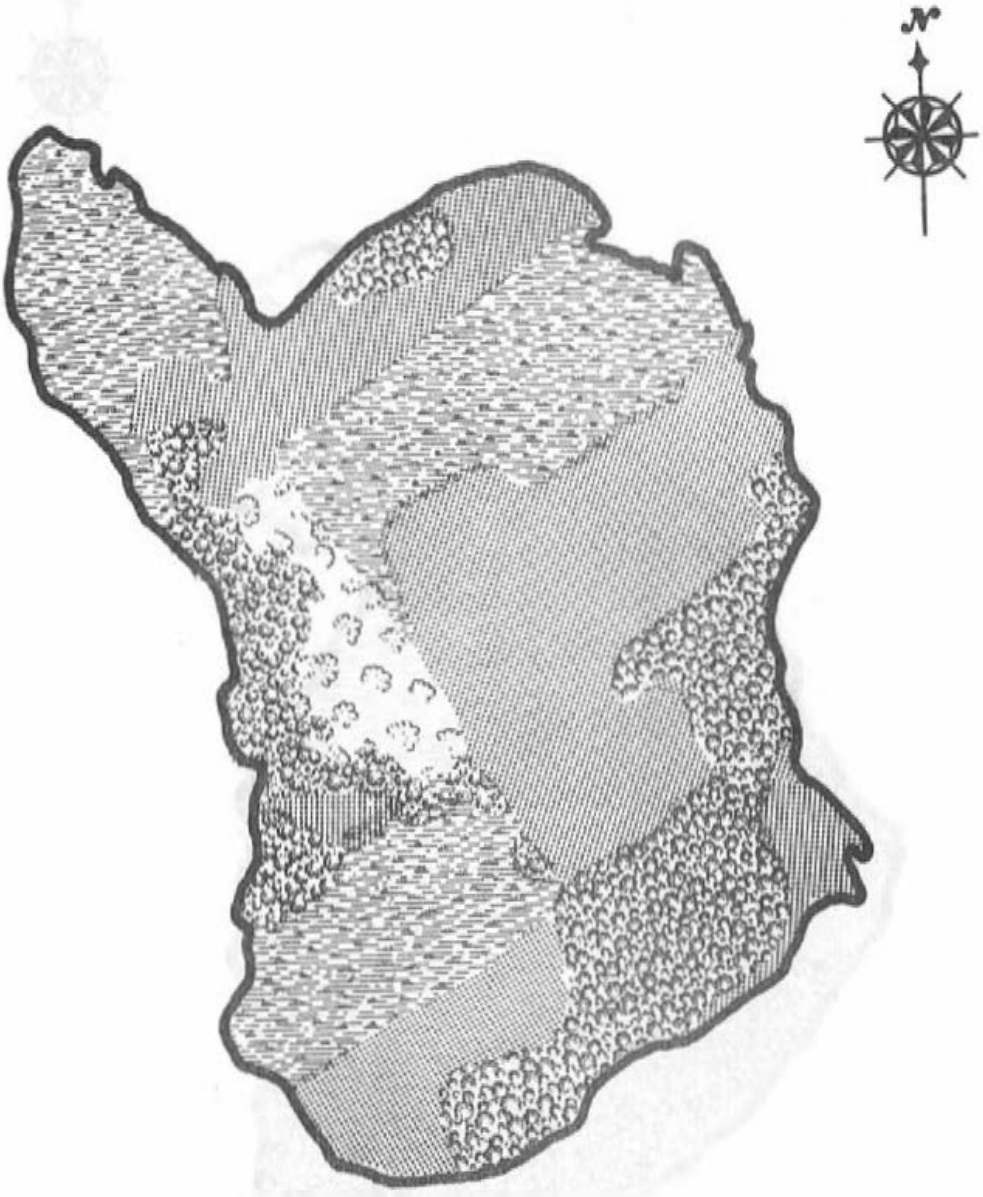
ISLAND B_1 B_2



ISLAND C



ISLAND D



ISLAND E

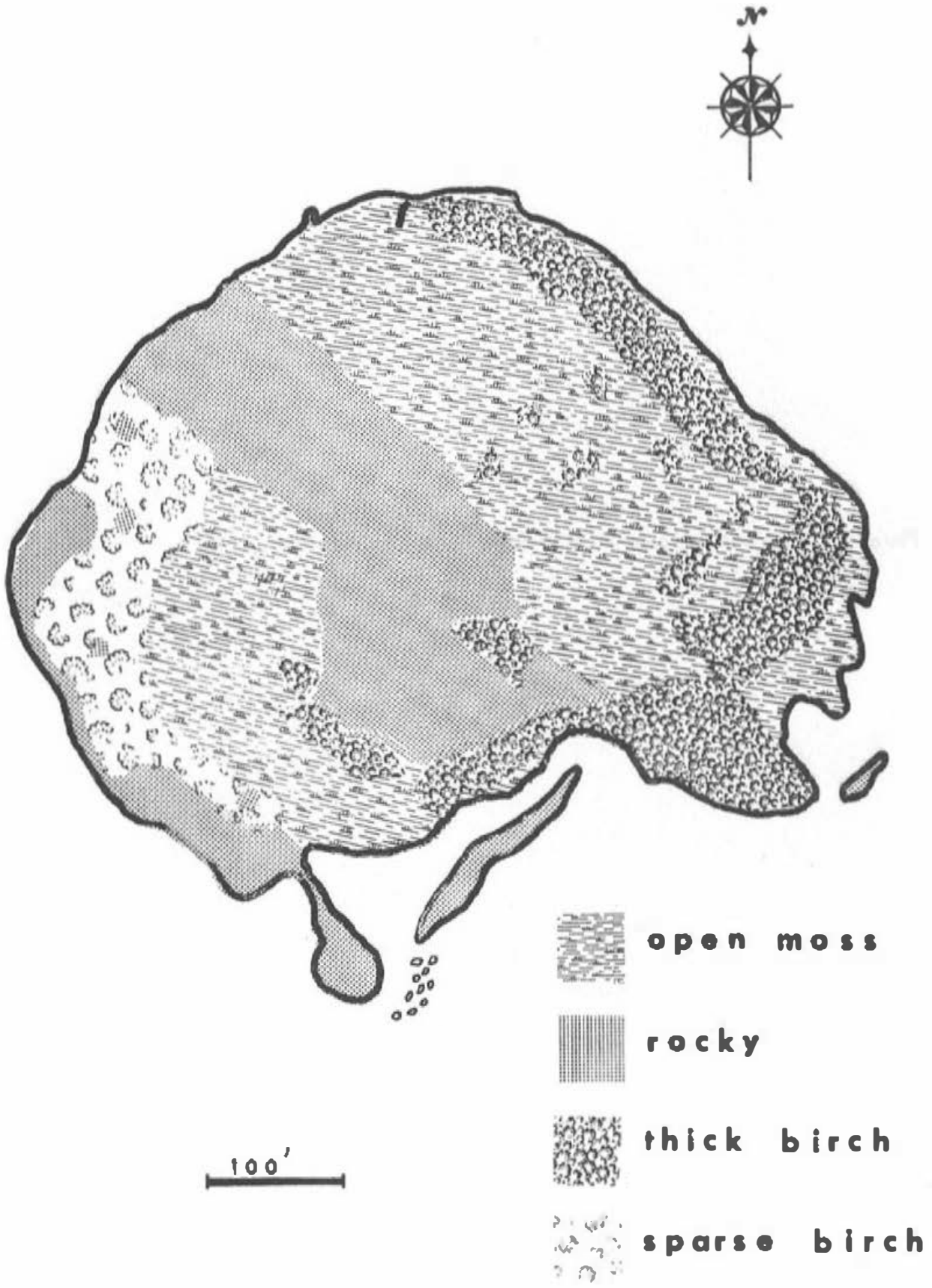


Plate 7. Snow and ice conditions at Arlone Lake, early June.

to this the ice was sufficiently solid so that we and other mammals were able to get to the islands from the mainland.

Climate

Gavin (1945) recorded -59 F as the coldest winter temperature. During the summer of 1963 we recorded 82 F on 30th June and 6th July. In 1964 the highest temperature was 89°F on July 10th (see Table II for summary of weekly temperatures).

It is not readily apparent that this region is influenced either by a continental or coastal climatic regime. Kimble and Good (1955) state that the strict classification of Arctic regions into continental and coastal regimes is not valid because of the extreme uniformity of the topography, this posing no barrier for both continental and coastal influences. The region of the study area is probably influenced to o great extent by continental air mosses approaching from the south and also by the onshore winds from the arctic islands to the north which bring cold air from the still frozen Arctic Ocean. The region appeared to be influenced therefore by both continental and coastal climates.

Vegetation

The vegetation of the study area most closely approximated Baird's (1964) dwarf shrub-heath tundra and the grassland tundra. The former is the most florally complex and colorful of the tundra areas being characterized by the predominance of Betula spp., Vaccinium spp., Cassiope spp. and Cladonia spp. The grassland tundra is characterized by the presence of frost-heaved tussocks of Eriophorum spp. and Carex spp. In the immediate area of Arlone Lake there were three major areas which were botanically distinguishable. These were the islands in the lake, the grassy or meadow tundra, and the glacial moraines. Representative floral samples were secured from each of these regions (Appendix I).

TABLE II

TEMPERATURE DATA (F) FROM PERRY RIVER REGION, 1963

Date	Max.	Min.	Mean	No. days above 32 F	No. days below 32 F	Range
June:			Arlone Lake			
3-9	56	20	34	7	5	20-56
10-16	72	33	48	7	0	33-72
17-23	74	32	46	6	0	32-74
24-30	82	33	54	6	0	33-82
monthly mean = 45.5 F						
July:						
1-7	82	35	54	7	0	35-82
8-14	74	35	54	5	0	35-74
			Mouth of Perry River			
15-21	65	34	48	5	0	34-65
22-28	80	36	56	7	0	36-80
monthly mean = 53 F						
August:						
1-4	69	33	50	4	0	33-69
5-10	76	37	54	6	0	37-76
monthly mean = 51 F						

TEMPERATURE DATA (F) FROM PERRY RIVER REGION, 1964

Date	Max.	Min.	Mean	No. days above 32 F	No. days below 32 F	Range
June:			Arlone Lake			
1-6	64	27	38	6	5	27-64
7-13	44	22	34	7	7	22-44
14-20	54	26	36	7	5	26-54
21-27	69	28	42	7	4	28-69
28-30	64	37	47	3	0	37-64
monthly mean = 39.4 F						
July:						
1-4	68	34	48	4	0	34-68
5-10	89	40	62	6	0	40-89
			Mouth of Perry River			
15-18	80	34	52	4	0	34-80
19-25	66	32	46	3	0	32-66
26-31	82	33	52	6	0	33-82
monthly mean = 52 F						
Aug:						
1-6	82	36	50	6	0	36-82

A total of 19 families is represented from our collections. These include 25 identified species and 6 unidentified species. The distribution of these is presented in Table III.

TABLE III

DISTRIBUTION OF FLORA TYPES AT ARLONE LAKE N.W.T.
1963, 1964

	Islands	I/T shored	Tundra	T/M shared	Moraine	M/I shored	T/M/I shared
Plants	20	3	14	3	14	5	2
Unique	9		6		2		

From this table it is clear that the islands have more species in common with the moraines than the grassy tundra. This may be explained by the similarity of substrate and altitude of the islands and moraines. Both are higher than the tussock tundra and have a rocky shallow soil in contrast to the deeper soil and permafrost of the tundra.

All the vegetation is dwarfed. The maximum height of the birch and willow is 3 feet with the majority of individuals being prostrate and clumped. These are characteristics of the vegetation in general and hence they are referred to as cushion plants. These morphological characteristics are attributed to at least two growth limiting factors in the area, wind chill and sparse precipitation. Two other well documented factors, that of low nitrogen content of the soil and the disruption of the soil by frost possibly act to reduce annual plant productivity in the study area (Baird, 1964). Wilson (1957) has shown that the annual growth increment of Salix arctica in Cornwallis Island, N.W.T. is about one-third the total plant weight whereas in temperate climates such a growth occurs in less than a week. It has been shown that the annual productivity of arctic flora in terms of weight of plant material per unit area is only one percent of that of temperate climate

regions (Wilson, 1957). In the study area a 10 year old birch stem had a basal diameter of 4.3 millimetres.

Fauna

The avifauna of the study area is poor when compared to the number of bird species in more temperate regions. The mammalian fauna is also impoverished. During the two study seasons 45 avian and 11 mammalian species were observed. Hanson et al (1956) recorded 47 species and 6 mammalian when his party was in the region in 1949. First observations of new species for both seasons are presented in Appendix 2. The commonest avian species in 1963 was the Lapland Longspur (Calcarius lapponicus), while the rarest of the observed was the Short-eared Owl (Asio flammeus). In 1964 the Lapland Longspur was again commonest with a noticeable lack of the Snowy Owl (Nyctea scandiaca). This lack is attributed to the scarcity of lemmings and red-backed voles in 1964. The most common mammal in the region in both years was the Brown Lemming (Lemmus trimucronotus) and the rarest of observed mammals was the Canadian Polar Wolf (Canis lupus) with only one sighted in two seasons (see Appendix 3). Aleksiuk (1964) summorizes the fauna observations made during 1963. The major differences noted in 1964 were the scarcity of Snowy Owls, Lemmings and Red-Backed voles and the abundance of the Arctic Fox (Alopex lagopus), with only one sighted in 1963 and ten in 1964.

Eskimos

The natives of the Perry River tribe are the Kogmiut or "Swan People". The Eskimo name for the Perry River is Koguak which means "the place of the swans". The Kogmiut are part of a larger group of Eskimos, the Ahiarmiuts, which includes those living on the shores of the Queen Maud Gulf. The Ahiarmiuts are part of a still larger group the Kitdlinermiut of Rasmussen, which takes in all the natives inhabiting the area between Bathurst Inlet and the south shores of Victoria Island and the shores of the Queen Maud Gulf (Hanson et al 1956).

The total native population from Hudson's Bay records at Perry River in 1963 was 77. Gavin (1945) reported 35 people living at Perry River between 1937 and 1941. Very little immigration or emmigration seems to occur within the Kogmiut. Only two families that were at Perry River in 1963 had moved when we arrived there in 1964, both because of sickness.

The Kogmiut are to a large extent one of the most primitive groups of Eskimos left in the Canadian Arctic (Pryde pers.comm.). Of the 77 people we met, only 6 could speak English with any skill and 2 had admittedly converted to a Christian religion.

Their pattern of life follows a strict routine governed by the seasons. In the spring the families converge and take part in the annual seal hunting. This occurs on the sea ice until the early part of June when the melting rivers make conditions on the ice too hazardous. Following this phase, fishing camps of 2 to 12 tents are set up usually along the estuaries of one of the 4 main rivers in the region, Ellice, Perry, Pitok and Armark. These camps are active throughout June when fishing is at an optimum. The fish listed in Appendix 4 are commonly caught in the nets and are either eaten right away or dried and saved for the winter season. Some of the fish are used for dog food, the chief constituent of the dog's summer diet.

By the middle of July interest has turned to caribou hunting. Regular hunting parties are not commonly organized by the Kogmiuts, instead each hunter in the family goes after his own needs. The hunting is sporadic throughout the summer until October, when trapping the Arctic Fox occupies each family's time until the following spring.

METHODS

Reproductive Biology of Ross's Goose

All field studies at Arlone Lake started prior to the arrival of the geese. Subsequently notes were kept on the approximate numbers of individuals arriving doily. This was accomplished by doily visits to each island.

A total of 301 nests were marked during the study (160 in 1963, 141 in 1964). Complete nest histories were kept from 67 nests in 1963 and 81 in 1964. In addition 93 nests from Island E served to furnish information of clutch size, nesting and hatching success, nest density and habitat preference.

Ten nests from Island C demonstrated the ability of the Ross's Goose to successfully incubate o hyperclutch. Fifty nests from Island D were used to determine the effects of depleting the clutch.

The 148 nests from which complete nest histories were obtoined were visited before 9 a.m. when conditions allowed. When conditions were inclement the visits usually took place later in the day. The histories dote from the laying of the first egg to the hatching of the lost one in the clutch.

Nests were marked with wooden stakes $1\frac{1}{2}$ feet long. All the eggs were marked with o soft lead pencil or with scarlet no il polish. A nest cord form was used to record nesting dotu in 1964 (Appendix 5).

The total number of nests in the colony wos counted twice each season, 18th - 22nd June and 3rd - 6th July, 1963; and 19th June and 4th July, 1964. During the 1964 counts notes were kept on the location of each nest.

Trapping of Incubating female Ross's Geese was attempted with a falconer's bow trap. Three females were trapped and marked in 1963 (26th June, 1st and 5th July). A total of 148 were marked later the some yeor during bonding operations at the mouth of the Perry River. Of these, 20 (10 pairs) were recorded on the Arlone Lake nesting ground in 1964.

Throughout both seasons notes were kept on behaviour of the geese. Two territories were marked out by placing four stakes at distances of 3 feet from the nest in north, south, east and west directions. Activities of the male and female were then recorded on graph paper for a period of two hours. The results of these observations were used to determine territory size.

A total of 72 Ross's Geese were collected on the study area, (28 in 1963 and 44 in 1964), 49 of these were adults and 23 were young. Data were recorded from each specimen on a standard form (Appendix 6).

Autopsies were done on 57 geese (40 adults and 17 young). All food and parasites collected were preserved for later identification. Records were kept on the color of each gosling when hatched in each brood. In addition, 192 day old goslings were caught by hand. Sixty-four were weighed to the nearest gram, sex and color phase noted. The sex and color phase were recorded of the remaining 128 goslings. Of the 192 goslings, 83 were leg-banded with a plastic, expandable band. The color of the band depicted sex and color phase of each gosling.

Following the departure of the geese from the nesting area, all unhatched eggs in the colony were broken. The number in the nest, habitat in which the nest was located and condition of the eggs (sterile, dead embryo or addled) was noted.

Habitat Analysis

Maps were constructed of each island by dividing them into two halves by a rope stretched along the longest axis of the island. Every 100 feet along this rope another rope was placed at right angles running to the shore. This formed a number of transects the length of which were known. These were then transferred to scale into graph paper.

The insular nesting grounds were divided into 4 major habitats: birch, in which Betula sp. predominated in o clumped or matted form; rock, primarily boulder piles and individual rocks on the open areas; moss, which was the only cover on the

rocky substrate, and mixed, in which the three former were interspersed.

Floral analyses were completed during the 1964 season. Coverage and frequency of represented plants were determined following the method described by Daubenmire (1959). All plants encountered during the analyses were pressed and dried for subsequent identificotion.

Post-breeding biology of Ross's Goose

Following the nesting season the study was continued at the mouth of the Perry River (67° 42'N, 102° 11'W) where a banding program was followed from 30th July to 10th August, 1963 and 11th July to 10th August, 1964. Concurrently, notes were kept on flock size and sex ratios. Through co-operation from the Canadian Wildlife Service population counts and brood sizes were obtained while Ross's Geese were on their fall migration through Kindersley, Saskatchewan (51° 27'N, 109° 10'W).

Meteorological data were collected from certain areas along the spring migration route in an attempt to correlate movements with weather conditions. United States Fish and Wildlife refuge managers located in the Pacific Flyway were alerted to watch for major concentrations of Ross's Geese in their respective areas during the spring of 1964. Fish and Game officials from the province of Alberta and Saskatchewan were sent letters requesting the same information.

REPRODUCTIVE BIOLOGY OF ROSS'S GOOSE

Spring Migration and Arrival

Dates The exact arrival dates of Ross's Geese on their arctic nesting grounds are not present in the literature. Hanson et al. (1956) recorded them at the junction of the Govin and Perry Rivers on 7 June, 1949; we however observed the geese earlier at Arlone Lake in 1963 and 1964.

In 1963 the first Ross's Geese (12) were sighted flying over Arlone Lake on 5 June. Canada Geese (Branta canadensis), Whitefronted Geese (Anser albifrons) and Lesser Snow Geese (Anser caerulescens) had been recorded earlier by 25 May, 1 June, and 3 June respectively (Appendix 2). The arriving Ross's Geese were inevitably in small flocks of two to 50 individuals and they were not in association with the Lesser Snow Geese. On 7 June, 50 white geese were seen on island B_1B_2, the majority of these being Ross's. Seventy Ross's Geese were seen on these same islands on 8 June. The peak arrival occurred on 8 June. Ross's Geese continued to arrive until the end of June when a total of 1538 nesting geese were present on the six nesting islands.

In 1964 the arrival of Ross's Geese followed much the same pattern with small flocks first appearing over Arlone Lake followed by a rapid build up of the population. The first Ross's Geese (19) were seen flying in a N.N.W. direction over our camp on 1 June. At this time we counted 45 Lesser Snow Geese in the vicinity of the lake but saw no white geese on the nesting islands. On 2 June, 19 Ross's and 25 Lesser Snow Geese were seen on island E. Extreme weather conditions on 3 June prevented our visiting the islands but on 4 June a large number of Ross's Geese had arrived. June 4 was considered to be the peak arrival date. By 9 June, 1812 Ross's Geese and 356 Lesser Snow Geese were present at Arlone Lake.

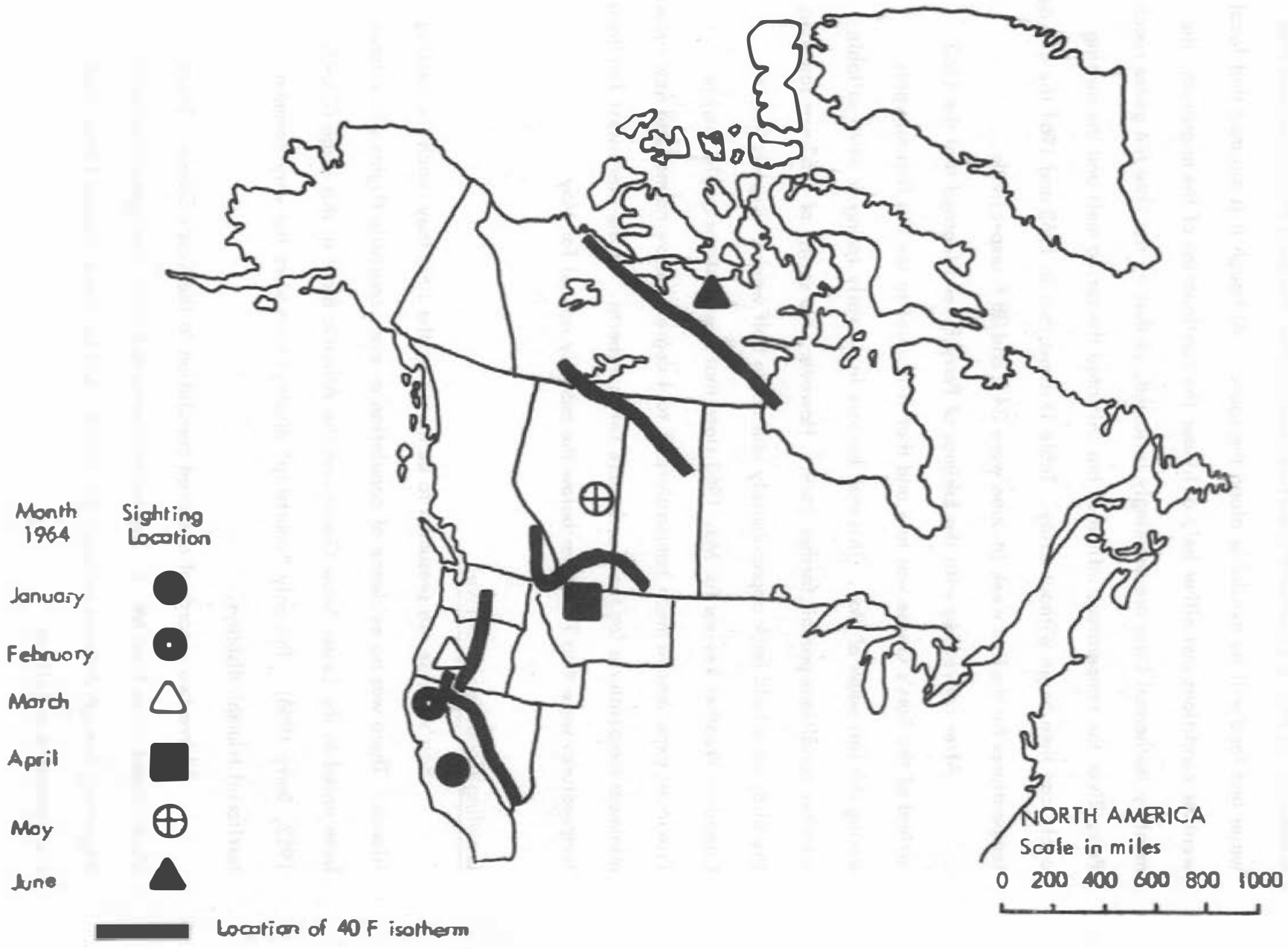
Correlation with Weather

Birds which migrate approximately 2300 miles from the wintering area to the Arctic require some external factor that will govern their movements so that they arrive on the nesting grounds when conditions will permit their successful nesting. Presumably one of the most efficient mechanisms by which o species can obtain such information is to follow a weather clue. This has been termed the phenological influence of weather on migration (Welty, 1962). Lincoln (1939) depicted the movements of various spring migrants in relation to spring temperatures and drew isochronal lines of migration which corresponded to certain isotherms. He described the spring movements of the Canada Geese, and stated that the northward migration keeps pace with the advance of the 35 F isotherm. Sowls (1955) has shown that the arrival of summer resident ducks into a region is greatly influenced by weather conditions. He states that the northward moving waterfowl push against o barrier that is giving way gradually, but inevitably. Sudden changes in the barrier result in appropriate movements in the population; when the barrier of cold air masses moves south, the migration sometimes retreats.

The isotherm of phenological theory was applied to the 1964 spring migration of Ross's Geese. This was done by mapping the spring isotherm advance monthly from the California wintering grounds to the Perry River nesting grounds (Figure 5). It was found that the prevailing isotherm in central California during the month of January was 40 F, and that the isotherm which persisted over the nesting area in June, 1964 was between 30 F and 40 F. The information on the migration includes reports of 12,531 Ross's Geese from the following locations. Merced and Willows, California; Burns, Lakeview andKlomoth Falls, Oregon; Charlo, Montana; Strathmore and Hayboy, Alberta.

The results are suggestive that the migration of this species does follow a particular spring phenology pattern. The geese arrive at each reported location

Figure 5. Migration-phenology pattern of Ross's Goose, 1964, based on 12,531 sightings.


Month 1964
Sighting Location
January
February
March
April
May
June
Location of 40 F isotherm
NORTH AMERICA
Scale in miles
0 200 400 600 800 1000

subsequent to the 32 F isotherm therefore assuring that the melt has started and that water and food will be available along the route. Although it is assumed that local weather conditions can either help or hinder the continuation of the migration, the monthly isothermal lines are seemingly followed, so that by the time the geese reach Perry River the temperature influence has initiated the spring melt and the nesting cycle can then begin without delay. Table II shows that in 1963 and 1964 the average temperatures for the first week in June were 34 F and 38 F respectively.

After conversing with the Eskimos of Perry River I learned that the 1963 arrival of the Ross's Geese was late and that it is usual to see the first migrants during the last week of May. This may be true in an early spring or when suitable weather conditions prevail farther south. However, the spring of 1963 was late thus the birds were held back approximately one and a half weeks. Reports from the Canadian Weather Review for May 1963 state that most stations on the Prairie Provinces experienced mean temperatures 2 to 4 degrees below normal and new record minimum temperatures for the month were set in Alberta. In the Northwest Territories temperatures were 4 to 7 degrees below the monthly normal for May.

Breeding Condition on Arrival

Ross's Geese are presumed to be mated by the time they reach the nesting islands. There was no evidence of copulation or even courtship flights which have been noted in the Lesser Snow Goose and the Atlantic Brant at this stage (Cooch 1953, Barry 1956). The only "courtship" displays seen were the very common territorial triumph displays.

I have two records of observed copulation in the Ross's Goose. These observations came from Mr. L. Sugden who recorded them from geese that were migrating through Alberta on April 27, 1963. Sugden (pers. comm.) describes the procedure as follows:

"No preliminary display noted- male mo nted female in about one foot of water, grasped her nape with his bill. During act, which lasted approximately fifteen seconds, the female was completely submerged for about four seconds. At the termination of the copulation the mole slid off the females side ond appeared to swim against her side. Both birds then ruffed their feathers, stretched out of the water and flapped their wings".

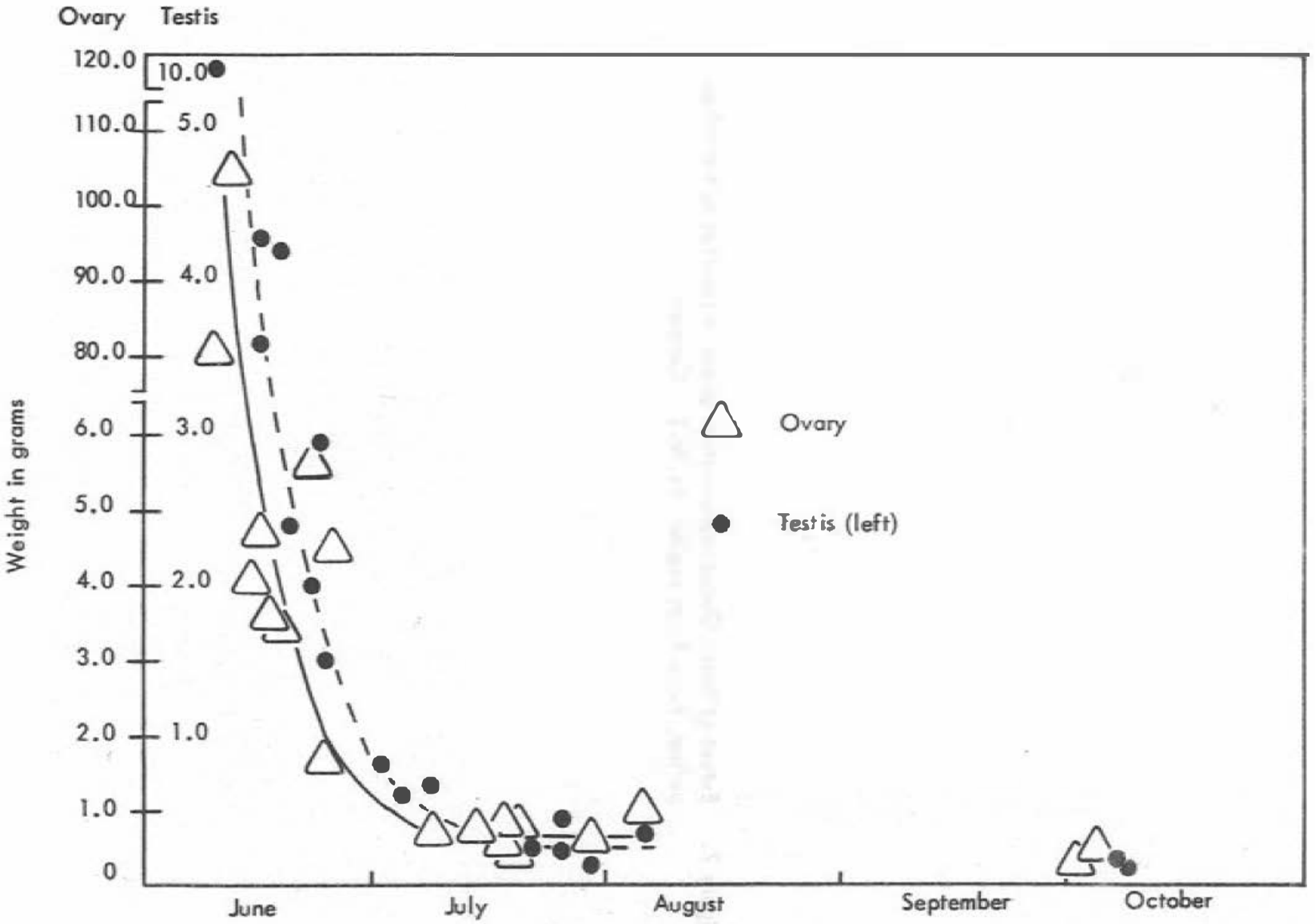
The second observation by Sugden reads as follows:

"This pair copulated within a few seconds of the first pair and complete oct was witnessed. Their behaviour wos similar to the first pair, except that the female did not completely submerge, the duration of the oct was about twelve seconds and after the male slid off the females back he moved owoy from her to about two feet, at which time both fluffed their feathers and flopped wings".

These observations are consistent with the "usual" copulatory procedure described by Delacour and Mayr (1945), for the Sub-family Anserinae.

Gonads collected from 26 Ross's Geese following their arrival showed a continuous weight decrease. This scheme (Figure 6) suggests that copulation probably occurs prior to the arrival on the nesting grounds and that the birds ore in fact physiologically copable of nesting and egg laying when they arrive. Barry (1962) found that the testes of the American Brant Branta bernicla hrota showed a continual decrease in weight and o low sperm count at the time of arrival and thereafter. He concluded that copulation had occurred further south in that species. In the Ross's Goose, as in other arctic nesting species, the courtship procedure is a lengthy and strenuous process, one which wou ld most certainly be selected against where the season is so short (Barry 1962). It seems almost inevitable that copulation should occur during the spring migration so that successful completion of egg-laying, incubation, hatching ond brood raising con be achieved during the summer season. This latter point con readily be seen by analysing Figure 7. The temperatures plotted here ore long term averages from Cambridge Bay, N.W.T., the closest meteorological station to the st dy area. The Ross's Geese arrive just prior to the mean 32°F. and depart just before the temperature drops again. Each of the breeding phases is so timed that the final phase is completed prior to o drop in temperature below the freezing point. By the time the mean temperoture falls again to 32°F the population hos moved south

Figure 6. Gonad weight changes of Ross's Geese during the breeding season 1963 and 1964.


Ovary
Testis
120.0
110.0
100.0
90.0
80.0
6.0
5.0
4.0
3.0
2.0
1.0
0
10.0
5.0
4.0
3.0
2.0
1.0
Weight in grams
Ovary
Testis (left)
June
July
August
September
October

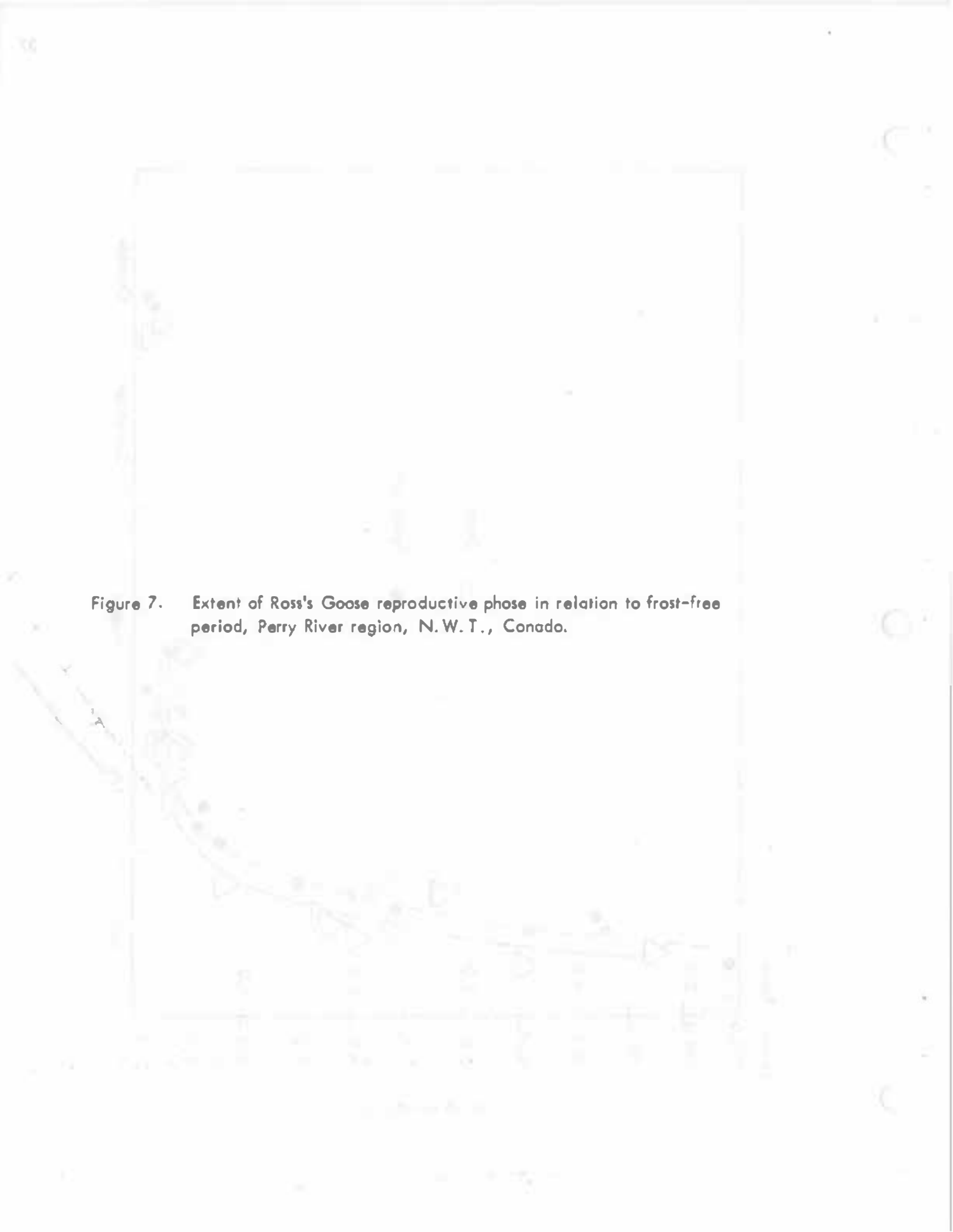
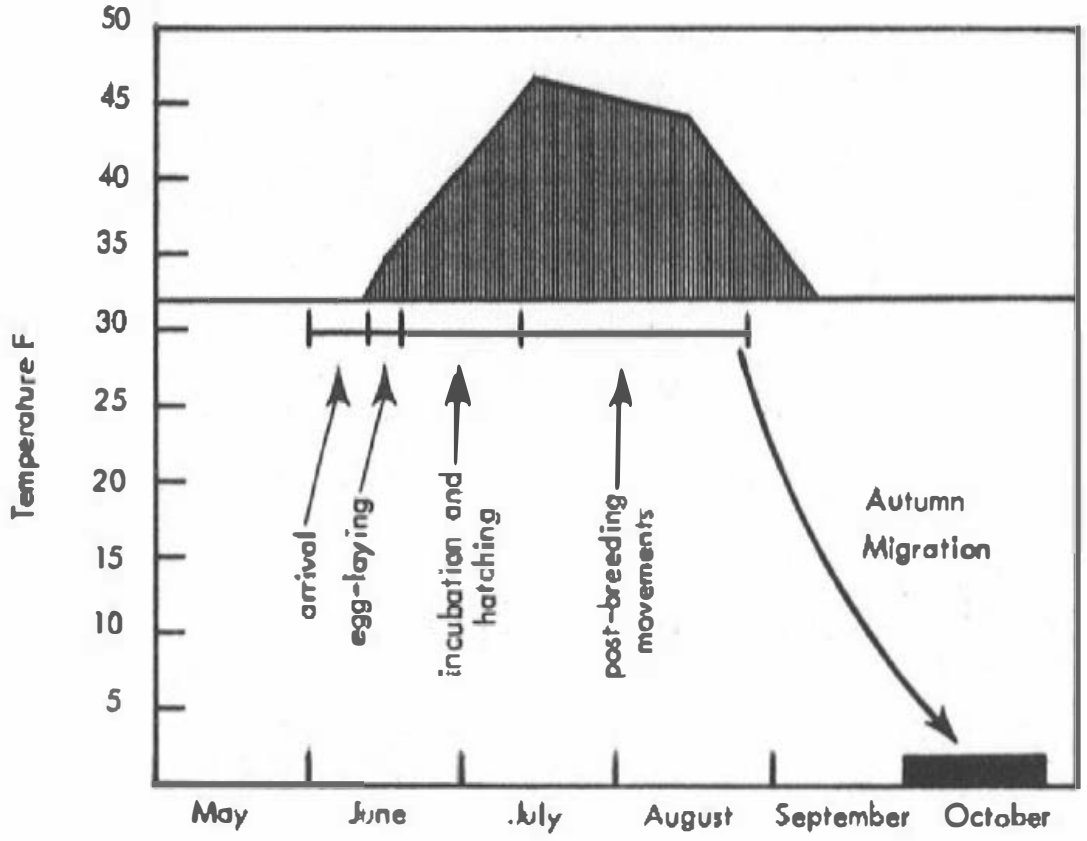


Figure 7. Extent of Ross's Goose reproductive phase in relation to frost-free period, Perry River region, N.W.T., Canada.


50
45
40
35
30
25
20
15
10
5
Temperature F
arrival
egg-laying
incubation and hatching
post-breeding movements
Autumn Migration
May
June
July
August
September
October

towards the first major staging areas of Saskatchewan, Canada.

Nesting

Nest site availability Although the Ross's Geese are physiologically capable of nesting almost immediately after their arrival on the nesting grounds, weather and snow conditions may delay such activities.

In 1963 the nesting was delayed for 5 days, presumably as the result of strong southerly winds from 5th - 9th June. The effect of the wind on the geese was marked. Dense concentrations of Ross's and Lesser Snow Geese were congregated on the leeward side of the islands. On 9th June, after the winds had subsided, the geese dispersed over the entire area to commence nesting activity.

In 1964 nest construction started just 3 days after the geese were first observed (1st June). Although strong winds prevailed and small amounts of snow fell during the 1st week the geese were not deterred from initiating nesting activities.

The effect of snow, as a factor which can limit nesting attempts, was seen on island B_1 in early June 1964. An estimated 20% of the optimum habitat was covered with snow or was submerged under snow-melt water which prevented geese from using this terrain. The drainage on the islands is poor and the presence of permafrost (Hanson et al 1956) prevents absorption into the soil causing water to remain in pools until much of it has evaporated. Minimum daily temperatures during early June invariably dropped below 32 F, causing the pools to freeze which further retarded the removal of surface waters. Not until an area was drained did the geese build their nests in that region.

The nesting grounds at the time of geese arrival in 1963 and 1964 provided space for immediate nesting, but because of wind and snow conditions in 1963 such was not accomplished.

Nest construction: As soon as the weather and snow conditions are favourable, nest construction begins. The nest materials are those available at the nest site. The nests on the open moss regions are composed primarily of plucked moss and old scats. Those that are in the thick birch stands are made of dead leaves, twigs and scats, while those in the mixed regions are composed of the materials close at hand, moss, twigs from birch and willow or masses of grass. There is considerable variation in the care taken in the construction of the nest. Many are poorly constructed in that they are extremely shallow and offer absolutely no protection for the eggs. Other nests are elaborately built with thick walls and deep cups. These latter nests may be built by older birds who are experienced whereas the poorly constructed nests may be the work of young birds or first nesters.

Measurements of the outer, and inner diameter, and depth of nests are presented in Table IV. There is no significant difference between habitat types in the dimensions of inner diameter and of the depth of the nests. The only difference that was found was in the actual thickness of the nest wall between the nests in the open areas and the nests in the other three locations. The other dimensions are not significantly different ($P > .05$).

TABLE IV

DIMENSIONS OF NESTS IN RELATION TO HABITAT
(measurements in inches)

Habitat	Open	Rock	Birch	Mixed
outer diameter	19.3 (15-28)	16.6 (12-22)	15.4 (10-24)	16.3 (12-19)
inner diameter	6.2 (4-7)	6.4 (5-7)	6.3 (4-9)	6.9 (6-8)
thickness of nest wall	13.1	10.2	9.1	9.4
depth	3.2 (2.25-4.5)	2.7 (2-3.5)	2.3 (1.5-3.5)	2.5 (2-2.75)
n =	40	25	43	14

Nest Site Requirements

In order to obtain information on the preference of the Ross's Goose to a particular habitat, vegetational cover on the islands of Arlone Lake were investigated. This information was contrasted against that obtained by observing specific vegetational cover at the nest sites. Only from these two sources can one make accurate and meaningful conclusions in regards to the nest-site preference of the species and the density of nests in a particular area.

The results of such studies enable one to determine whether the dispersal of the geese on the islands is the end product of a random process or whether there is active selection on the part of the geese. Table V presents data on the available nesting cover (potential coverage) on each of the islands and nest rating percentage of Ross's Geese nests within these regions. Table VI presents the density of nests within each habitat on the islands.

TABLE V

COMPARISON OF NEST COVER AND POTENTIAL COVERAGE OF THE 4 MAJOR HABITATS ON ARIONE LAKE ISLANDS

nest rating % (potential coverage %)

Habitat	A	B_1B_2	C	D	E
mixed	58 (37)	50 (50)	39 (22)	56 (9)	24 (7)
rock	2 (5)	16 (9)	6 (7)	8 (7)	26 (5)
birch	33 (30)	20 (18)	18 (9)	28 (29)	39 (40)
open	7 (64)	14 (52)	37 (66)	8 (53)	11 (40)

TABLE VI

DENSITY OF NESTS IN EACH MAJOR HABITAT ON ISLANDS
(per 1000 sq. ft.)

Habitat	Mixed	Rock	Birch	Open
Island				
A	2.17	0.40	1.50	0.15
B_1	4.10 (5.90)	4.10	3.40	0.83
B_2	3.70	-	3.80	-
C	19.60	2.80	6.50	1.80
D	20.60	4.50	3.10	0.60
E	6.70	4.00	2.60	0.80
Mean =	9.50	3.27	3.42	0.84

Average for colony = 4.26 nests/1000 sq. ft.

It will be noted that the greatest density is in the mixed habitat whereas the lowest density of nests occurs in the open area. It appears as though the rocky and birch areas are intermediate between the two extremes. The data from island A and island C show preferences for the birch areas instead of the rocky areas. This is the opposite of the densities of the other islands. I consider that both island A and C are unique in respect to the rocky areas. On island A this area is localized and composed of small rocks situated on the highest portion of the island. This results in it being far inferior as a protective site than any of the other regions, excluding the open area. On island C, the majority of the rocks are located at the east end of the island in low clusters which offer no grazing area for the geese. The rocky regions on the other islands are so situated as to present large enough rocks for protection and they are dispersed sufficiently to afford ample grazing area on the territory.

The thick birch stands provide adequate protection but no grazing area on the territory and the open areas provide for no protection. The mixed region, being composed of small birch stands and rocks provide for both protection and grazing. It seems that the above two conditions are required for maximum density.

On island B_1 the data show equality of preference between the mixed and rocky areas. This apparent discrepancy is accounted for by the lack of available mixed habitat at the nesting period. When the vegetation census was taken the overall area of the mixed region was greater in proportion to the area available at the start of the season. An estimated 20% of the total mixed cover of this island was not available due to snow cover. If this factor is taken into consideration the density in themixed area was 5.9 nests per 1000 square feet. This agrees with the results from the other islands.

It is felt that two limiting factors determine the density of nests in a given region. These are, sufficient protection from the elements and ample space for grazing. The latter dictates the presence of moss or grass on the area. Plates 8, 9, 10 and 11 show the four main habitat types on the islands.

Plate 8. Mixed habitat

Plate 9. Rock habitat

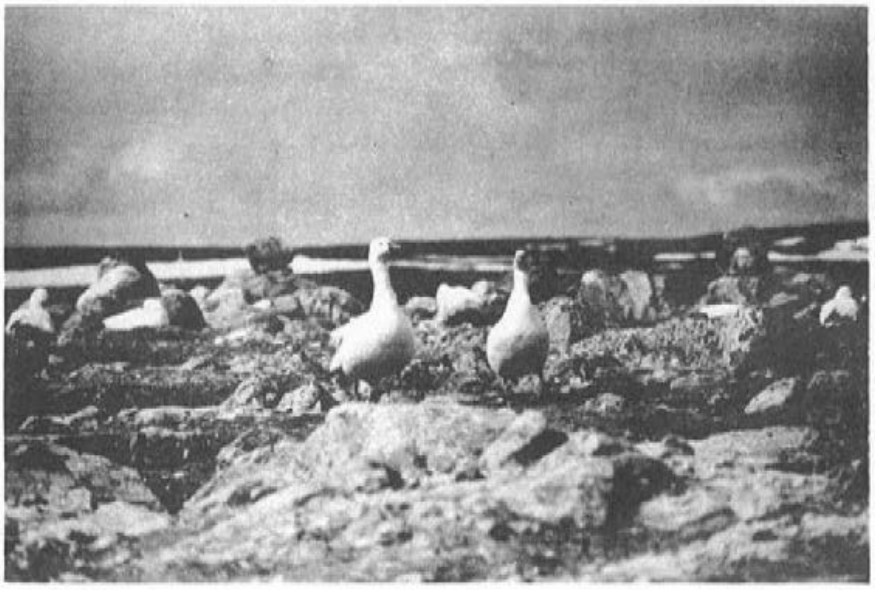


Plate 10. Birch habitat

Plate 11. Open habitat

The Egg-Laying Period

Dates: In June 1963 and 1964 there was no delay between the nest construction phase and the egg-laying phase. In 1963 the first eggs (22) were seen on 9 June. On this day we saw the first Ross's Goose nests (29). On 8 June no nests were observed on any of the islands so that initial nest construction in 1963 took place on the morning of 9 June.

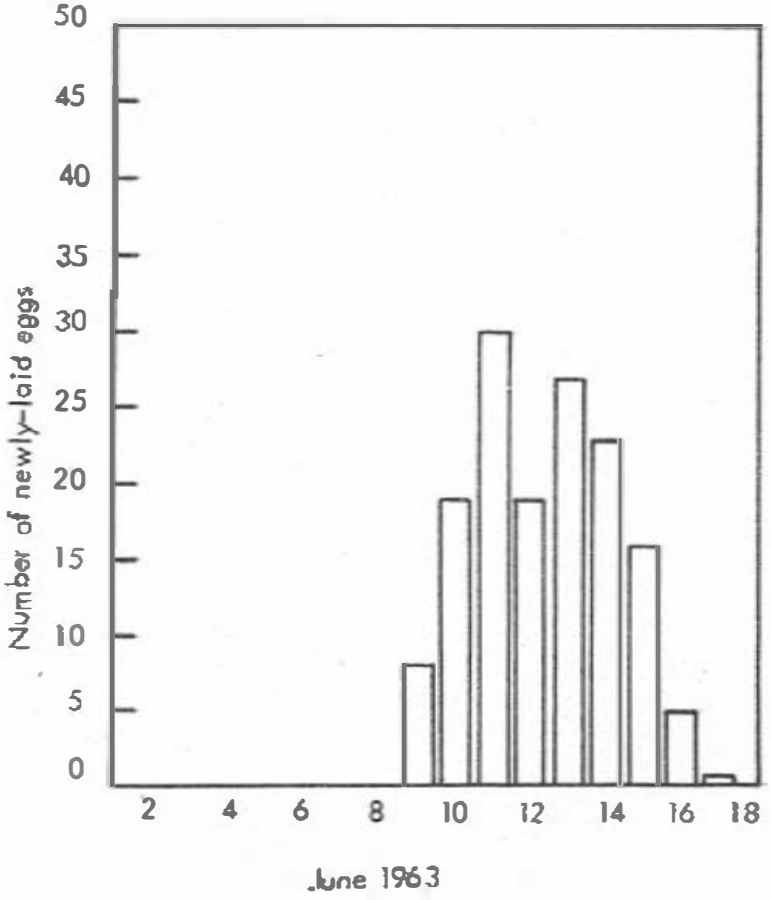
In 1964 the first Ross's Goose nest was seen on 4 June. No nests were observed on 3 June. In both years the Lesser Snow Goose started laying prior to the Ross's Goose, in 1963 by two days (7 June) and in 1964, six Snow Goose nests were found on 4 June in comparison to only one Ross's. Figure 8 shows the frequency of egg-laying in terms of newly laid eggs.

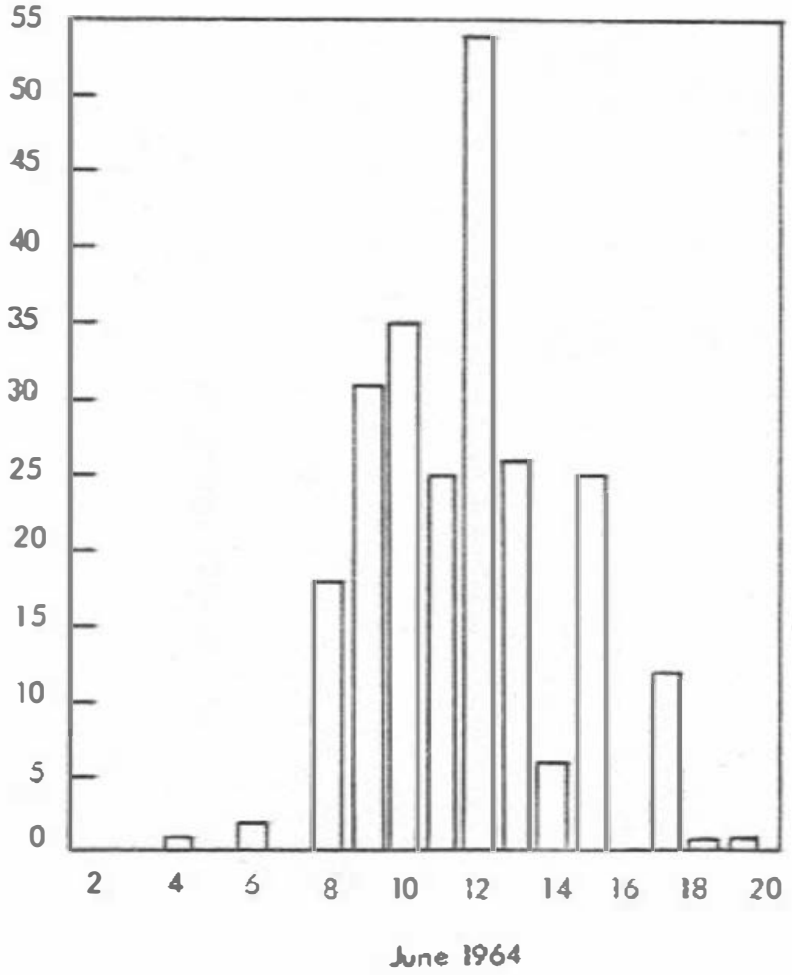
The 1963 egg-laying period lasted from 9th-17th June, a period of 9 days. This period started on 4 June, 1964 but the bulk of the population did not begin until 8 June.

The modal date of nest initiation was virtually the same in both years despite the earlier arrival of the Ross's Geese in 1964. Initial attempts to nest in 1964 were harassed by the presence of Arctic foxes in the area. Ten foxes were seen between 11 and 26 June in comparison to only one in 1963.

Behaviour: The Ross's Goose lays one egg every 1.5 days on the average (56 clutches). During the egg-laying period the geese remain on the islands for much of the time although pair flights to the mainland were very common. The geese spend short periods at the nest site at this time. When on the territory, one member of the pair appeared to watch for intruders while the other grazed. Territorial defence appeared to be taken in rotation. Sometimes however both birds acted together in the expulsion of another goose from the territory. Territorial interactions were not observed to be sex specific as it is common to see females successfully evict males of Ross's and Lesser Snow Geese from the territory. When a pair of intruders enter the territory it is the

Figure 8. Frequency of egg-laying in Ross's Goose 1963 and 1964.


Number of newly-laid eggs
50
45
40
35
30
25
20
15
10
5
0
2
4
6
8
10
12
14
16
18
June 1963


55
50
45
40
35
30
25
20
15
10
5
0
2
4
6
8
10
12
14
16
18
20
June 1964

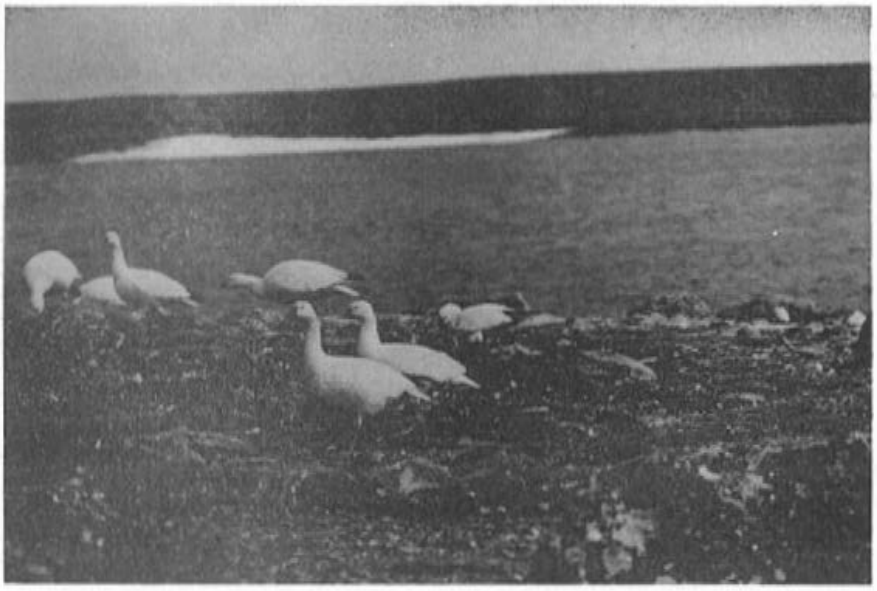
male defender who heads the charge with the female right behind.

The defence posture of the Ross's Goose is typical of members of the genus Anser but differs markedly from Branta. Typically the Ross's defence procedure takes the form of a charge with the neck held horizontally and mouth agape (Plate 12). In Branta the neck is in the form of a sigmoid curve and not stretched straight out. I was able to distinguish two types of vocalizations which accompany the charges depending upon the intensity of the interaction with the intruder. The first was a high-pitched squawk given by both members of the pair, if both are involved, and the second a low moaning grunt given prior to and following the charge. The former vocalization is heard only during the more intensive or "near contact" scuffles or when actual physical contact is achieved. The latter call is most commonly heard during the more subdued interactions, but occasionally during the serious conflicts. When the male has successfully driven an intruder out of the territory, he returns to the female and, with neck stretched upwards at 60° he utters the low moaning sound. This behaviour on return of the mate is considered to be a form of post nuptial display, (any display or ceremony that takes place between the sexes after copulation has ceased and incubation begins) (Van Tyne and Berger 1961). Delacour and Mayr (1945) state that this "triumph ceremony" is characteristic of the geese and that it plays an important part of the pair-bond display. Armstrong (in Van Tyne and Berger 1961) says birds which exhibit this post-nuptial display recapitulate briefly the features of the pairing ceremony.

The period of the territorial fight is short, usually lasting only a few seconds. Very little resistance is shown by intruders, who usually run away or take flight immediately. Even the larger Lesser Snow Goose does not show resistance to the small Ross's Goose.

During egg-laying the geese were timid and tended to retreat from the territory for no apparent reason. When disturbed, large groups took flight, soon splitting into smaller sub-flocks which settled on the lake 10-40 yards from the island.

Plate 12. Defense posture of Ross's Goose.



Within 10-15 minutes the small groups and pairs returned to the islands and settled down on the territories. At this time territorial disputes were at a maximum. It seemed as though the birds inevitably landed in the wrong territory causing great disturbance among the other geese. An uproar continued until the birds had arranged themselves on the appropriate territories.

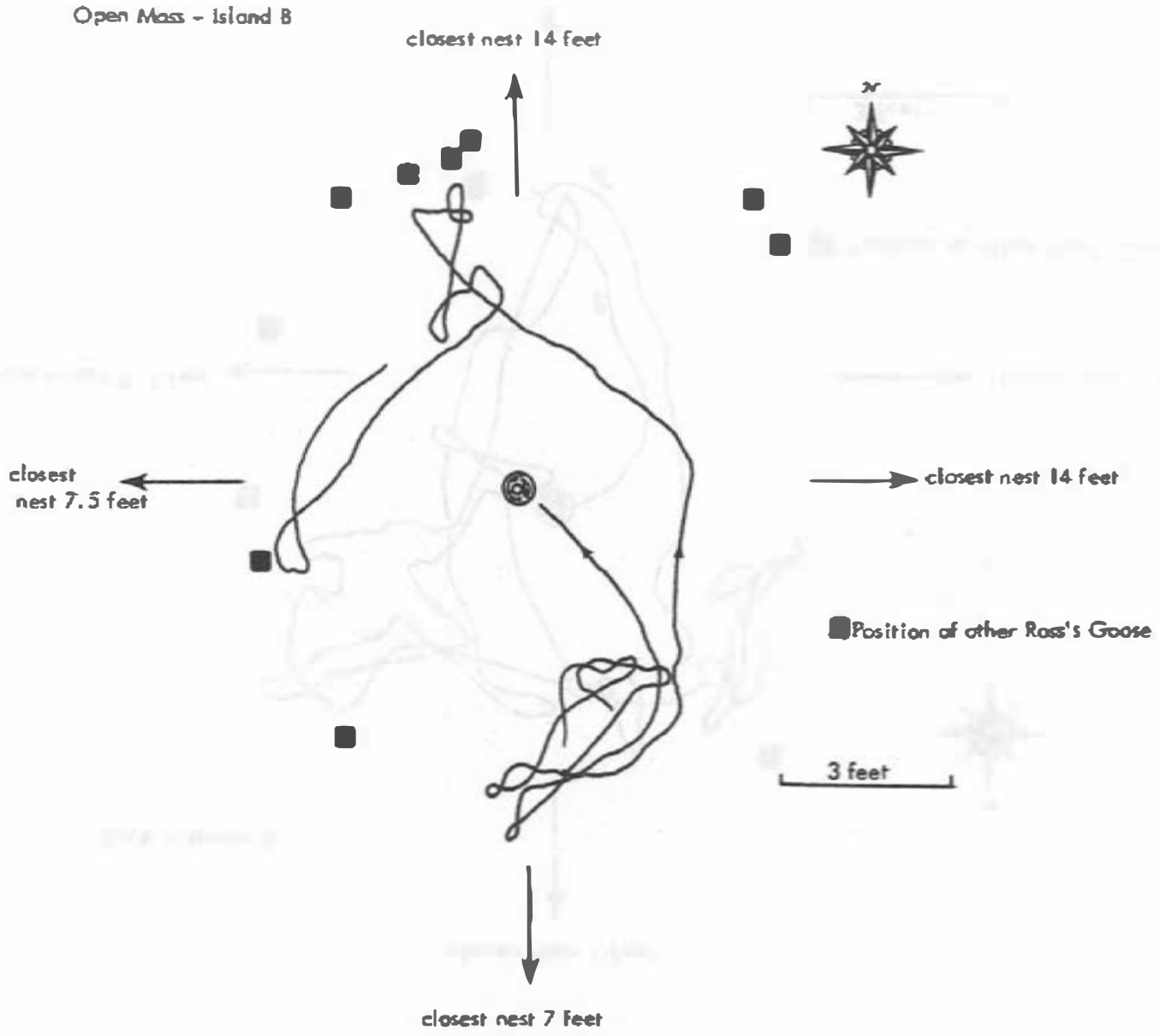
Territories: Two territories were mapped from observations of two pairs of Ross's Geese on island B_1 (Figure 9 and 10). The greatest diameter of the two territories in the open and rock habitat was 8 and 12 feet respectively.

The islands not only supply territory space but also communal areas. Generally, the communal areas are located on the open moss regions and not in the thick birch stands. Thus the actual density of nests per unit area of the island is not a valid reflection of the territory size, because of the incorporation of space in which there were no nests (Table V). Barry (1960a) noted that within Atlantic Brant nesting colonies there existed communal areas in which the males, during the incubation period, often stayed close to their own territories. This was not observed in the Ross's Goose. The males appeared to stay in the confines of their own territories.

Clutch Sizes

The modal clutch size for Ross's Geese at Arlone Lake was 4 although the averages for each island was approximately 3, in both seasons (Table VII). In most cases a numerical decrease in clutch size occurs during the incubation period. The resulting difference is however not significant ($P > 0.05$). In cases of a retarded season, as in 1963, or in the event of heavy predation at the beginning of the season, the average clutch size tends to decrease. Clutches started later in the season are smaller than those started early (Table VIII). Under optimum conditions Anser rossii has 93 days in which to complete the nesting and moulting cycle (see below).

Figures 9 and 10. Ross's Goose nesting territories.


Open Mass - Island B
closest nest 14 feet
closest nest 7.5 feet
closest nest 14 feet
Position of other Ross's Goose
3 feet
closest nest 7 feet

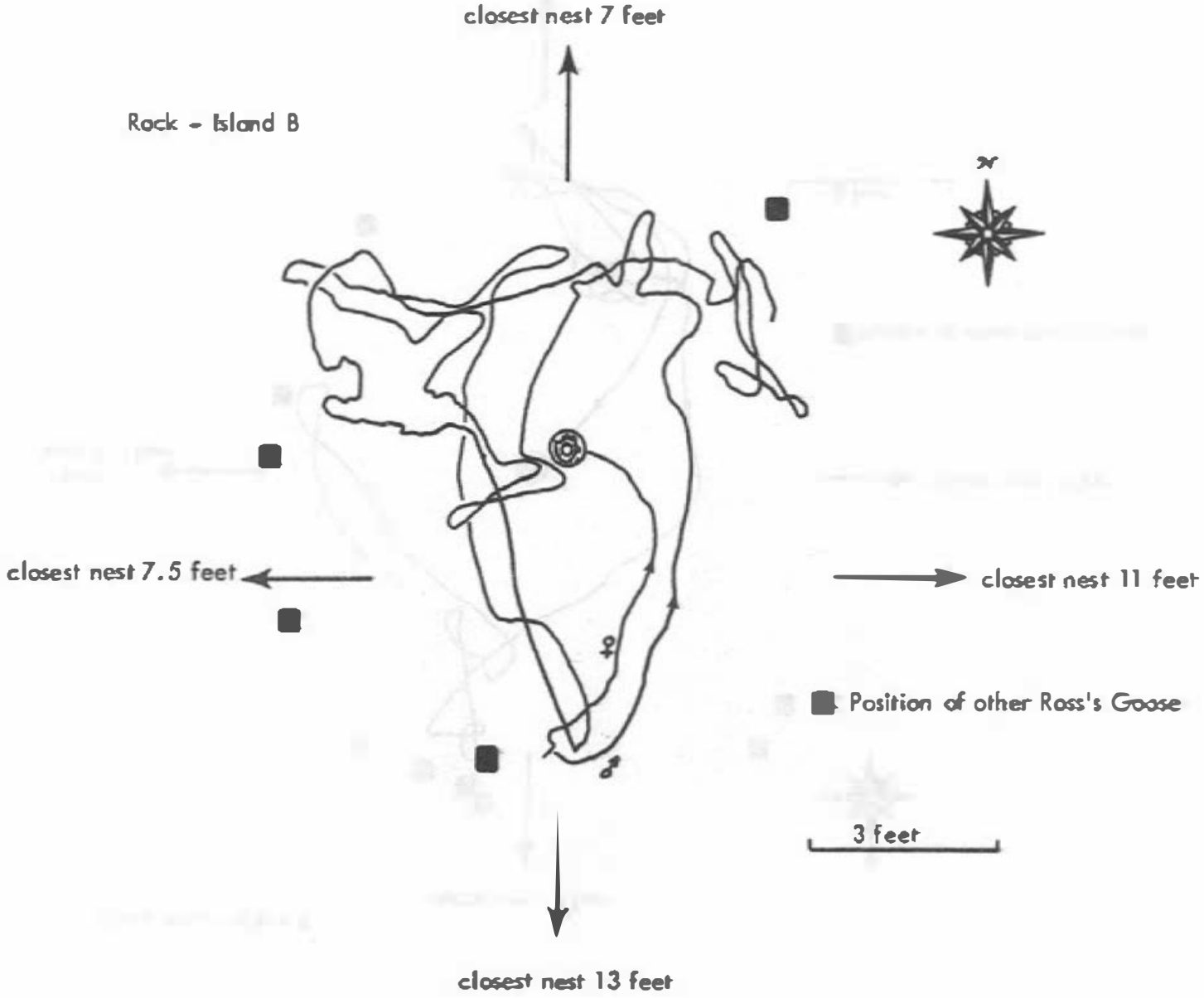

closest nest 7 feet
Rock - Island B
closest nest 7.5 feet
closest nest 11 feet
Position of other Ross's Goose
3 feet
closest nest 13 feet

TABLE VII

CLUTCH SIZES OF ROSS'S GOOSE FROM ARLONE LAKE, 1963 and 1964

Island	no. of active nests	mean clutch before incubation	mean clutch after incubation
A	124	3.73	3.69
	69	2.77	2.95
B_1	189	3.80	3.59
	255	3.64	4.06
B_2	65	3.78	3.48
	75	3.53	3.40
C	16	3.44	2.93
	199	3.40	3.36
D	133	3.62	3.54
	308	3.84	3.50
E	242	3.65	3.59
1963 Total	769	3.67	3.47
1964 Total	906	3.58	3.47

If a season was retarded or initial predation destroyed first-laying attempts, the phases of the nesting cycle con be shortened as much as a week by laying a smaller clutch. In 1963 and 1964 Ross's Geese utilized 86% of the frost-free period to complete the reproductive cycle (Figure 7). Clutches were generally smaller in 1964 than those of 1963 (Figure 11). There was no difference in clutch size for nests in four major habitats on the islands. Data are presented (Table IX) from 1964 which suggest thot the habitat in which the nest is located has no influence on clutch size.

TABLE VIII

CLUTCH SIZE OF ROSS'S GEESE IN RELATION TO DATE OF FIRST EGG

date of first egg	mean clutch	
June 9, 1963	4.06	
June 10, 1963	3.61	n = 40
June 11, 1963	3.08	
June 8, 1964	5.00	
June 9, 1964	4.28	n = 58
June 12, 1964	2.85	

On 17 and 18 June, 1964 eggs were removed from 50 nests on Island D. The number of eggs removed varied from one to the complete clutch (Table X). On 18 June, 1964, eggs were odded to ten nests on island C. The number of eggs added varied from two to ten (Table XI). The purpose of the depletion experiment was to determine whether o bird would loy more eggs in the nest, that is, make up a loss, remain with the remnant of the clutch or desert the depleted clutch. The addition experiment was primarily to determine how many eggs the species could

Figure 11. Clutch size frequency of Ross's Geese nesting at Arlone Lake, N.W.T. 1963 and 1964.

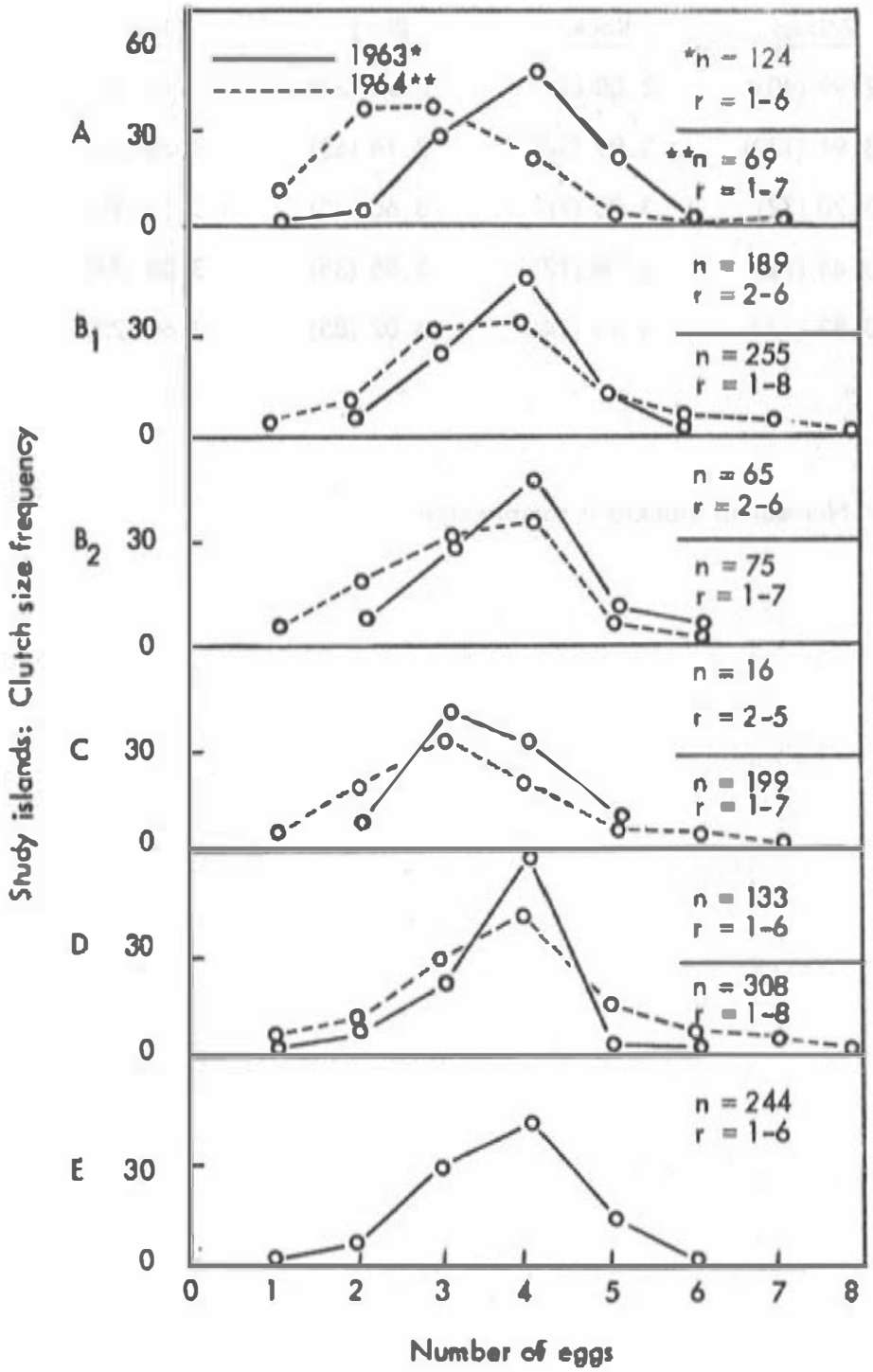
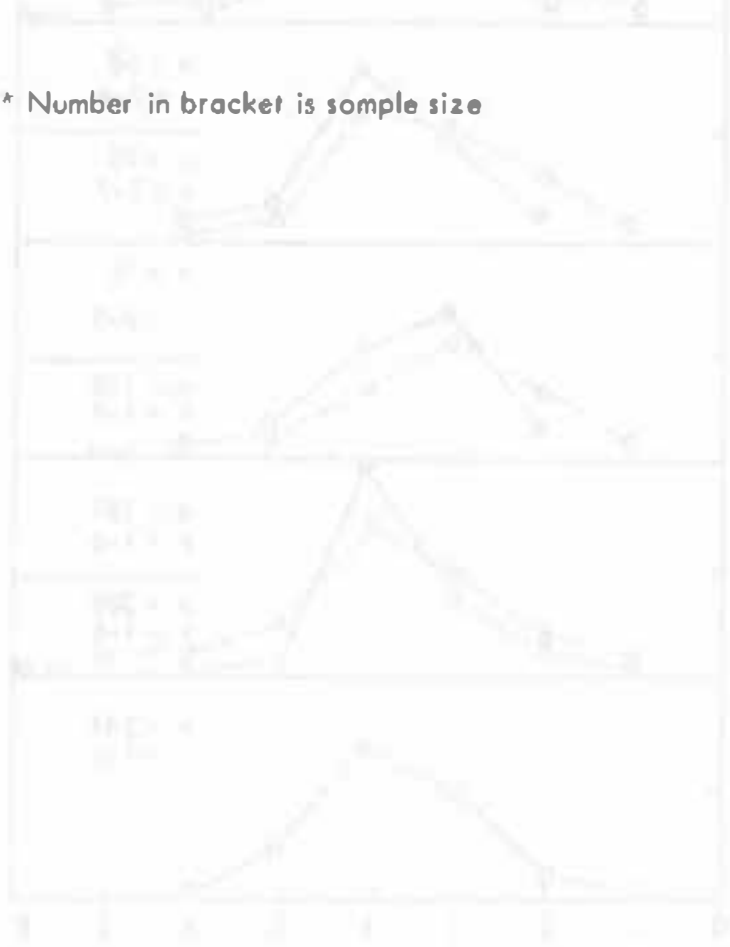

1963*
1964**
*n = 124
r = 1-6
**n = 69
r = 1-7
A
n = 189
r = 2-6
B1
n = 255
r = 1-8
n = 65
r = 2-6
B2
n = 75
r = 1-7
n = 16
r = 2-5
C
n = 199
r = 1-7
n = 133
r = 1-6
D
n = 308
r = 1-8
n = 244
r = 1-6
E
60
30
0
0 1 2 3 4 5 6 7 8
Study islands: Clutch size frequency
Number of eggs

TABLE IX

CLUTCH SIZE IN RELATION TO HABITAT 1964

Island	Mixed	Rock	Birch	Open
A	2.99 (40)*	2.00 (1)	2.60 (23)	2.40 (5)
B_1	3.91 (122)	3.89 (37)	3.16 (62)	3.26 (34)
B_2	3.70 (37)	3.00 (7)	3.60 (20)	3.18 (11)
C	3.45 (78)	3.76 (12)	3.85 (35)	3.08 (74)
D	3.82 (174)	3.54 (24)	4.02 (85)	3.60 (25)
E	-	-	-	-

* Number in bracket is sample size



successfully hatch above the normal clutch laid by the individual.

A high percentage of hatching and nesting success was observed in those nests in which at least one egg was left in the nest. In the nests with completely depleted clutches, the geese abandoned the site. The nests in which eggs were added showed very poor success. Non had 100% hatching success. The eggs were inevitably scattered around the nest site (Plate 13) and later were destrayed by predators.

TABLE X

EGG DEPLETIONS FROM COMPLETE CLUTCHES. ISLAND D. ARLONE LAKE
June 17 and 18, 1964

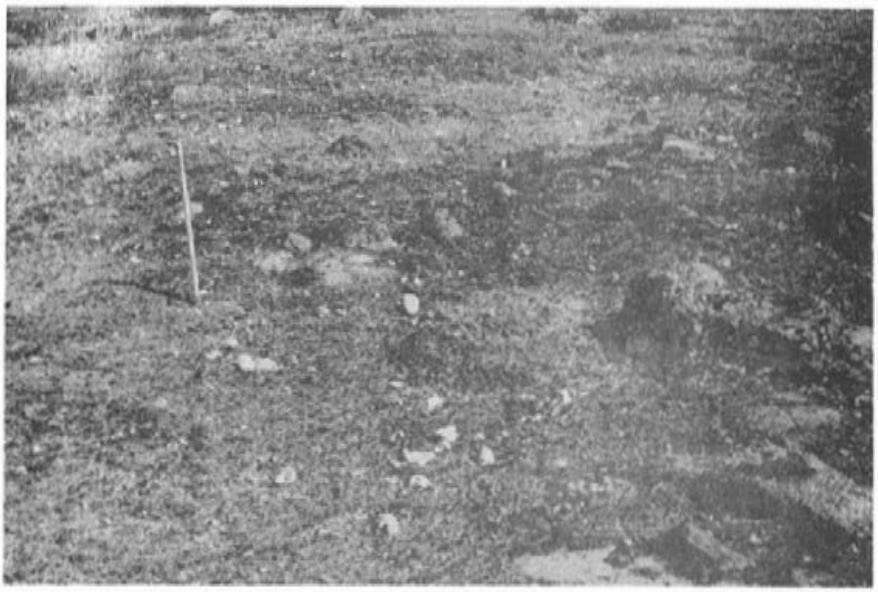
nest number	initial clutch	depletion clutch	total eggs	no. eggs hatched	% success nesting	% success hatching
1 - 5	4	1	15	14	100	93
6 - 10	4	2	10	10	100	100
11 - 15	4	3	5	5	100	100
16 - 20	4	4	0	0	0	0
21 - 25	3	1	10	8	100	80
26 - 30	3	2	5	4	100	80
31 - 35	3	3	0	0	0	0
36 - 40	2	1	5	2	100	40
41 - 45	5	2	15	14	100	93
45 - 50	5	5	0	0	0	0
Total 50	185	120	65	57	70	88%

TABLE XI

EGG ADDITIONS TO COMPLETED CLUTCHES, ISLAND C, ARLONE LAKE
June 18, 1964

nest number	initial clutch	added clutch	no. hatched	% success nesting	% success hatching
1	4	10	9	100	90
2	3	12	0	0	0
3	5	7	0	0	0
4	3	11	0	0	0
5	4	9	0	0	0
6	4	8	1	100	12
7	3	7	0	0	0
8	3	13	0	0	0
9	4	14	0	0	0
10	5	15	0	0	0
10	38	106	10	20	10.6

Plate 13. Destroyed eggs around a hyperclutch nest of Ross's Goose.



THE INCUBATION PERIOD

The incubation period for the Ross's Goose has been calculated to be 22 ± 1.3 days (r = 19–25; n = 45 last eggs). The incubation period is taken as the average time interval between the laying of the last egg and the emergence of the young bird from the shell of that egg. The last egg was used in the above calculation because no incubation was noted prior to its deposition. By June 18 of 1963 and 1964, incubation had commenced.

The initiation of this period was marked primarily by a noticeable silence over the colony, by the deposition of plucked down in the nests which initially disperses like snow over the islands, and by a unique flocking behaviour of the geese.

Data were compiled on the relation between down deposition and the egg number in the clutch. It was found that 82% of the nests had down in them following the laying of the last egg, 16% after the penultimate, 2% prior to the penultimate egg. Sample size was 55 clutches.

Percent attentiveness or the amount of time the female spends on the nest during the egg laying period, was calculated from the following formula:

$$\% \text{ attentiveness} = \frac{\text{number of days/hatched egg}}{\text{number of days/laid egg.}} \times 100\%$$

Using this formula the percent attentiveness for the Ross's Goose during egg laying is

$$\frac{0.067 \text{ days/hatched egg}}{1.50 \text{ days/laid egg.}} \times 100\% = 4.4\%$$

Behaviour

In the 1963 study season three marked females which were nest trapped, were used to determine the roles of the sexes in incubation and territory protection. After several hours of observation on these marked geese and other unmarked individuals I came to the conclusion that only the female incubates. This finding was further substantiated in the 1964 season when ten neck-banded females nested on the

islands. These females were never seen to exchange incubation responsibilities with the males.

The Ross's Geese are not close sitters. The longest observed period of incubation was 46 minutes. When the bird was off the nest the pair did not leave the territory. Generally the incubating female sat on the nest for a short time then left it and it accompanied the male on the territory to feed but not to defend. During the time the female is on the nest the male remains near, within the territory, ready to defend it (Plate 14).

The incubation posture of the Ross's Goose is similar to other members of the genus Anser (Plate 14). The head and neck are held vertical not horizontal as occurs in Branta. While incubating the female frequently pulls nest material towards her body with the bill. She often moves in circles while on the nest, presumably rotating the eggs, in this way distributing heat over the complete clutch as well as rotating the developing embryo.

As mentioned above one of the characteristics of the incubation period is the unique flocking behaviour of the birds. Previously it was mentioned that during the egg-laying period when the birds were disturbed they would alight in large groups subsequently splitting into smaller flocks. During the incubation period the birds would similarly take to the air when disturbed, but instead of splitting up, the flock tended to revolve in a huge circle directly over the island. Within 5-10 minutes the geese were back on their respective territories after the usual territorial disputes. It was obvious that attentiveness had increased.

Under undisturbed conditions the female, before leaving the nest, always covered the clutch by pulling down over the eggs with her bill. This behaviour also occurred during the relief period when she accompanied the male on the territory. The probable survival value of such activity was made clear on the evening of 11 July, 1963, during a check of island E. I came across an unhatched nest containing

Plate 14. Incubating posture of Ross's Geese.

four eggs. These eggs had been pipping, but there was no sign of the parents. I therefore assumed the nest to be abandoned. I broke open all four eggs and found that three of the goslings were alive and one was dead. Leaving three of the goslings including the dead one outside the nest, I put the remaining live gosling without its egg shell inside the nest and covered it with down. I left the nest momentarily then come back to find four Parasitic jaegers at the nest. These birds had devoured all the goslings that were left outside of the nest, but the one which was covered with down had been untouched, even though it was making a considerable amount of noise with its high pitched squeak.

It was stated earlier that the geese arrive on the nesting grounds in family groups. These family groups are intact until the incubation period. The yearlings leave the nesting territories and distribute themselves on the communal areas and the mainland feeding regions. Following the initiation of the incubation period never more than two geese were seen to occupy a single territory. Previously three or four geese in one territory were not uncommon. I have observed the yearlings participate in territorial defence but this is the only apparent function they serve on the islands. This presumably is the first time the young geese are separated from their parents and they do not leave in a matter of 1 day. Flocks of obvious non-breeders are seen flying around the nesting lake and with time the radius of their flights get wider and wider until by the time the hatching phase starts, most of these birds have left the lake and are on the moult migration.

THE HATCHING PERIOD

The first pipping was seen on 5 July, 1963 and 3 July, 1964. Peak hatch dates for the two seasons were 7-8th July and 5-6th July respectively. Figure 12 shows the hatching frequency for 1964.

The goslings are precocious. They are helpless until dry but by the time they leave the nest a few hours after hatching they have developed protective instincts of concealment. When approached on land they crouch with head and neck flat on the ground. This makes them extremely difficult to see, as they blend in well with the surrounding terrain. On water they sometimes dive to elude predators.

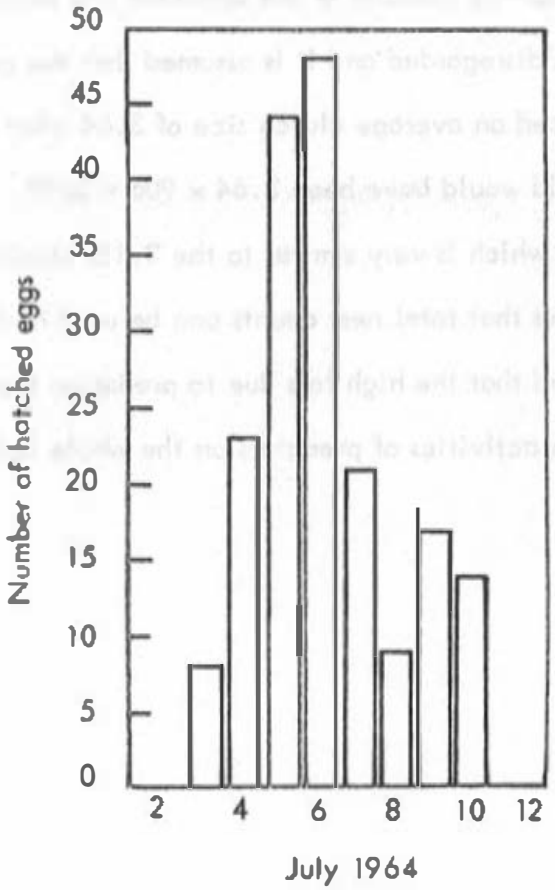
The parents guard the young fiercely. When a newly hatched brood is approached, the female walks away from the disturbance calling the goslings. The male stands his ground facing the intruder with wings outspread and mouth agape. As soon as the female and the brood are far enough away the male then flies to her side.

Nesting and Hatching Success

The factors which tend to decreose the initial clutch size and potential productivity of a species are: predation, desertion, and egg sterility. In 1963 a sample of 93 nests from island E which initially contained a total of 351 eggs ($X = 3.77$), was followed from 24 June to the end of the incubation period 8 July. Three of the nests representing o total of 12 unproductive eggs did not hatch at all. If a successful nest is defined as one in which at least one egg hatches, then 1963 the nesting success was 96.7%. The fate of individual eggs which were unproductive are given in Table XIIa.

In 1964 the same study was done with 59 marked nest on island B_1B_2. A total of 230 eggs were laid in the 59 nests ($X = 3.89$). The nesting success was 83%. The fate of individual unproductive eggs is given in Table XIIb. Nine dump nests were located in the colony having from 10 to 29 eggs in them.

Figure 12. Hatching frequency of Ross's Goose 1964.


Number of hatched eggs
50
45
40
35
30
25
20
15
10
5
0
2
4
6
8
10
12
July 1964

The initial colony clutch count done on 19 June, 1964, showed that a total of 3244 eggs were present on that date (906 nests). The estimated number of eggs in the colony on 4 July was 3143. This was calculated by multiplying the total number of nests (906) in the colony as determined on 19 June, by the average clutch size of 300 nests ($\bar{x} = 3.47$) counted on 4 July. This indicates that 101 eggs (3.1%) were lost during the period between 19 June and 4 July.

To find out the validity of the apparent low percentage loss of eggs (3.1%), the loss of 101 eggs is disregarded and it is assumed that the geese, under suitable conditions, could have produced on average clutch size of 3.64 (that of island B_1). Then the total number of eggs laid would have been $3.64 \times 906 = 3298$. The percent loss would then be equal to 4.7% which is very similar to the 3.1% obtained from the original date.

This shows that total nest counts can be used to determine losses throughout the nesting season, and that the high loss due to predation found on island B_1 in 1964 is not a reflection of the activities of predators on the whole colony.

TABLE XIIa

FATE OF 351 EGGS IN 93 NESTS, 1964

Fate	Number		Percent	
hatched		329		93.7
unhatched				
no embryo	4		1.1	
destroyed	8		2.2	
head embryo	7		2.1	
addled	3	22	0.9	6.3
total		351		100.0

TABLE XIIb

FATE OF 230 EGGS IN 59 NESTS, 1964

Fate	Number		Percent	
hatched		182		79.2
unhatched				
no embryo	4		1.7	
destroyed	33		14.4	
dead embryo	7		3.0	
addled	4	48	1.7	20.8
total		230		100.0

POST-BREEDING BIOLOGY OF ROSS'S GOOSE

Movements: Following the hatching period the geese leave the nesting islands and begin their post-nuptial moult. This movement is slow but continuous, involving small flock units or family groups which move to inland lakes and river courses. The common unit is made up of two to 15 families. By 9 July, 1963 and 10 July, 1964 over 80% of the Ross's Geese had left the nesting islands. These periods are less than a week after the peak hatching dates for the colony.

A few Ross's Geese and Lesser Snow Geese move down the Perry River as far as its estuary. The maximum number of Ross's Geese on the Perry River from 1-10 August was 500-800, based on the number caught during banding operations in 1963. After 420 Ross's Geese had been banded, retrapping occurred. This number represents approximately 33% of the nesting population at Arlone Lake.

Three weeks after the hatching period the post-nuptial flocks are large, sometimes numbering as many as 200 geese. Seldom does one see a single family group. The geese remain in these large flocks around the lakes and rivers until the moult is completed. In the last week of August the geese are capable of flight and prepare to migrate south.

Moult: The moulting sequence of the Ross's Goose is similar to that of the Blue Goose (Anser caerulescens), as described by Cooch (1958). The Ross's Goose goes through one moult per year, immediately following the breeding season. The timing and synchronization of moult stages in adult breeders and goslings is one of the most important phases of the life-cycle. If after raising a successful brood, a bird cannot complete the moulting period before the onset of cold weather, complete mortality of the individual and brood occurs.

Although more quantitative data is required on the moulting sequence in Ross's Geese, sufficient information has been collected to make general comments.

The first moulting geese seen on the Perry River following the nesting season are the non-breeders and sub-adults. These birds retire from the nesting area at the beginning of the incubation period. By the middle of July this group have lost the flight feathers. This is approximately one week ahead of the same stage in the breeding birds, who by 20-25 July, 15 to 20 days following the peak hatch date, have completed ecdysis. Feather spikes appear on the breeding birds at the end of July. Generally, it is the central tail feather and 10th primary which appear first in all age groups.

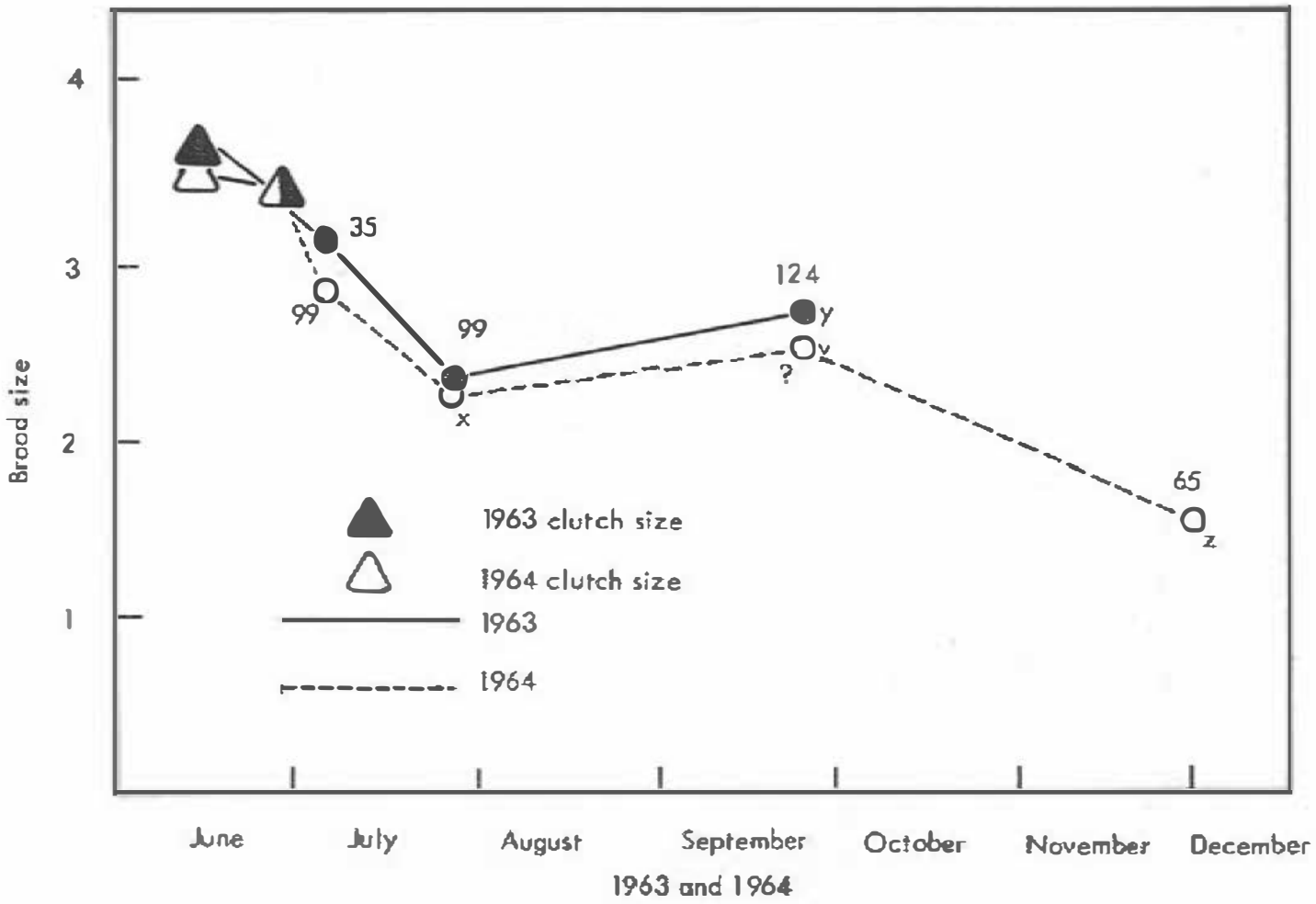
The gosling moult is well synchronized with the breeding bird category. The birds of the year attain sheathed spikes of tail, primaries, secondaries, and scapulars 21 days after the modal hatch date.

BROOD COUNT ANALYSIS OF PRODUCTIVITY

Figure 13 summarizes the actual productivity of Ross's Geese for 1963 and 1964. Complete migration brood size data is available for 1964 only. As has been pointed out earlier, an insignificant loss is realized during the incubation period. Following the hatch, an immediate drop in brood size results from abandonment, trapped goslings, predation. Subsequent to the initial elimination of the "weak" members of the population it appears as though a drop occurs in brood size from 1 week and less old goslings and 3 week old birds. This is then followed by an apparent increase in brood size from counts made on the Saskatchewan staging area. The brood size counts made when the goslings are 3 weeks old are not valid as a result of "flock clumping" between the brooding and non-brooding flocks. Brood data collected during banding procedures or from aerial photographs tend to decrease the proportion of young to adults. It is difficult to obtain reliable data of this kind at this time unless a brood flock is singled out and kept segregated from the flocks possessing no broods. This integration of flocks is readily apparent from banding experience. When the canoe approached any given number of separate flocks, the disturbance immediately resulted in flock integration. Presumably the same situation would occur with a low flying aircraft. Thus, it is useless to try and evaluate yearly production of this species from brood counts made at the age of 3 weeks.

The data from Saskatchewan were made from direct observations of family groups in Kindersley. The family unit is discrete and can be easily separated from the birds which have no familial responsibility. However, one discrepancy is possible with this method of counting. Apparently in late nesting seasons such as occurred in 1962 large rafts of predominantly young geese are seen in Saskatchewan. High hunting pressure may break up family groups with the resultant wandering of unattached young. These orphans may then be adopted by other family groups. It may also be a case of the late hatching geese not being physiologically capable of

Figure 13. Productivity of Ross's Geese from clutch and brood counts, 1963 and 1964.



x - Lumsden (1964)

y - Dzub (pers. comm.)

z - Lynch (pers. comm.)

migration from Saskatchewan at the time their parents depart, thus leaving the young of t' year for adoption by later leaving families (Dzubin 1964). Whatever the cause of this disproportionate number of young geese appearing on the staging area, it is inevitable that for accurate brood information, such has been obtained by Dzubin, counts be taken prior to the hunting season and of discrete family groups. Simple ratios of young to adults taken from flocks following the beginning of the hunting season or from banded samples are extremely biased and offer no accurate information on the production of young for a given year.

One of the advantages of taking counts in Saskatchewan is that they possibly give a more reliable estimate of realized or actual productivity in that the birds of the year which have progressed to the stage at which the count takes place have the potential to continue to the wintering grounds. Lynch's figure of 1.65 young per family of Ross's Geese is taken from the 1964 season following natural mortality and hunting pressure. Table XIII shows the numerical and percent decrease in brood size from one week old and younger broods at Ferry River to those counted in California.

TABLE XIII

BROOD SIZE DATA FROM THE 1964 MIGRATION OF ROSS'S GEESE

(a) Perry River	(b) Saskatchewan	(c) California
2.88 (99)*	2.59 (348)**	1.65 (65)*

Percent decrease in brood size:

a to b = 10% b to c = 36%

Overall decrease:

a to c = 42%

* no. of broods. (California figure from Lynch, J. (pers. comm.)

** no. of individual birds of the year (Dzubin 1964).

Although the data are taken from one years tabulation, they do suggest that the mortality is greatest from Canada south to California. This is the period in the life of the species which has to receive attention in terms of management so that population numbers can be maintained.

PHYSICAL ATTRIBUTES

Growth, Weight and Morphometrics

The body weights of the adult geese ore at a maximum at the time of arrival on the nesting grounds (Figure 14). A steady decline follows, especially in the females, until the termination of the incubation period. The abdominal fat is exceptionally abundant at arrival time, particularly in the females. A rapid decrease in fat thickness occurs into the incubation period. The moles were observed to lose this fat more rapidly than the females.

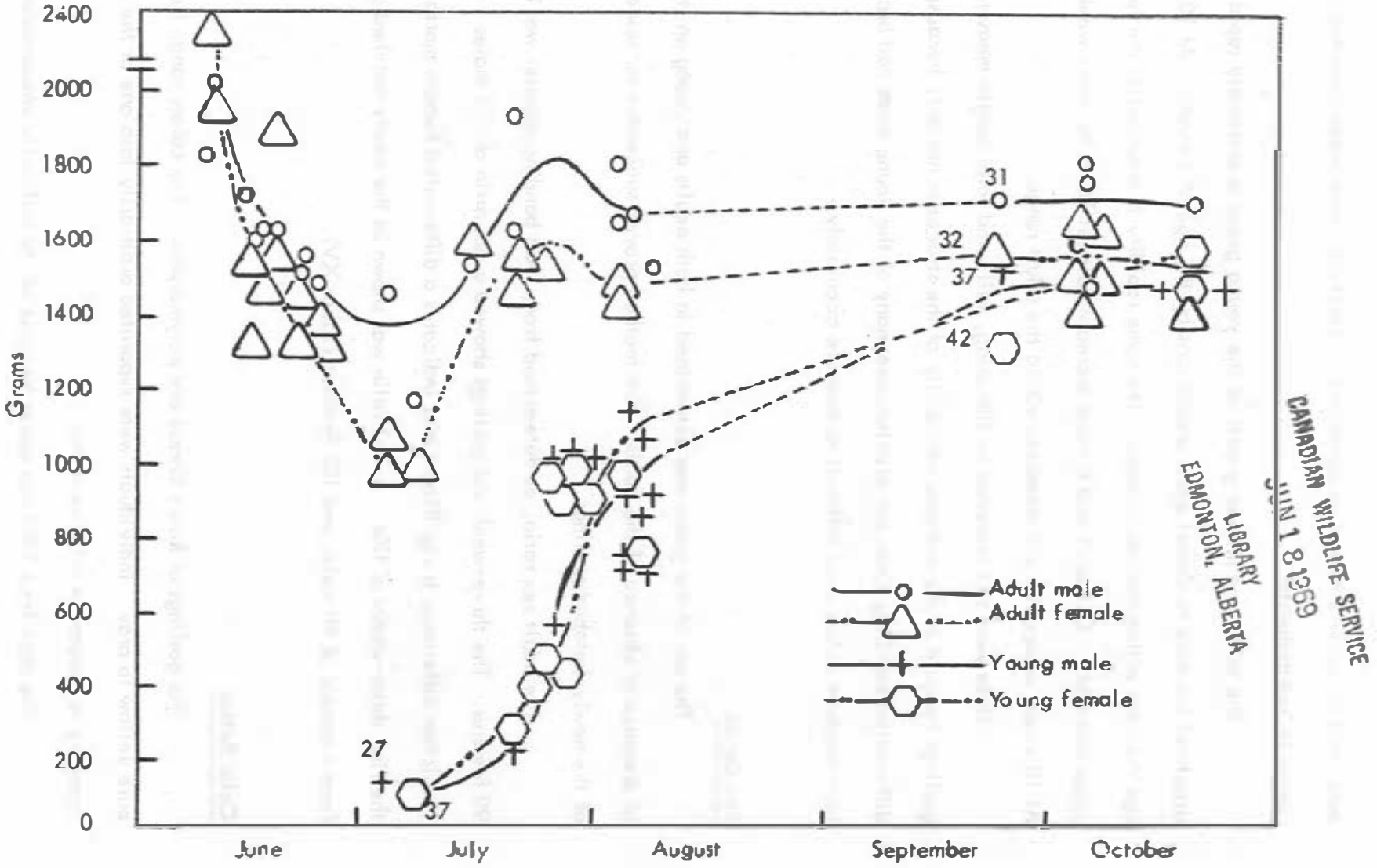
Barry (1962) found that a weight loss occurred during the hatching and moulting period In the male American Brant. The female nesting Brant showed a continual decrease in weight from the time of arrival until hatching at which time a gradual increase occurred. Coach (1958) found that during the egg-laying period the female Blue Goose showed marked decrease in weight followed by o steady decline into the incubation period. The mole Blue Goose showed a weight maximum at arrival than a sharp decline into the egg-laying period. This was followed by a levelling off and increase approximately coinciding with the hatching period. Following the hatching period the moles again lost weight. This was recorded both in mole ond female nesting Ross's Geese.

Following the post-nuptial moult, the Ross;s Geese maintain a fairly constant weight, at least until they reach the first staging area in Saskatchewan.

The growth curve of the goslings is sigmoid (Figure 14) and the weight gain is exceptionally rapid. At hatching the average gosling weight is 65 grams. This increases to on overage of 900 grams by the fourth week of age. All 10 primories, all secondaries, and some tertiaries are growing in by the end of the 3rd week. Toil feathers and body pin feathers ore also coming in by this time (see Moult).

Table XIV presents body measurements of both sexes of adults, and 3 age-groups of goslings, 1-day-old, 3-week-old, and 10-12-week-old. The 10-12-week

Figure 14. Weight changes of Ross's Geese during 1963 and 1964 seasons.



data, and all other information contained in brackets, were taken from migrating Ross's Geese in Saskatchewan.

The tarsus and midtoe growth of the young geese is extremely rapid. These structures increase to almost adult proportions by the age of 3 weeks. At 10 weeks of age they are within the adult range. The same rapidity is observed in the length of upper mandible. Culmen I and II have increased almost 100% by three weeks of age. At 10 weeks of age the bill measures within the adult range.

Data were not recorded on flat wing, tail, and total length measurements of goslings because of the extreme variability of the structures not only because of differential hatching times but also because many of the young birds had broken or bent feathers which were difficult to measure accurately.

Sex Ratios

The sex of the geese was determined in both adults and young on the basis of presence or absence of the penis. This method proved successful for sex determination of the newly-hatched goslings.

The adult sex ratio, as determined from 1963 banding samples was 84 males : 99 females. The three-week old goslings showed a sex ratio of 137 males : 100 females. The latter difference is significant and indicates a differential female mortality during the first three-weeks of life. A 1 : 1 ratio was shown in the newly hatched goslings from a sample of 90 males and 102 females (Table XV).

Color Ratios

The goslings of Ross's Geese are polymorphic. The colors range from almost pure yellow to gray. Individuals were separated arbitrarily into one or the other color category to determine relative ratios.

The data from 1963 are sparse because of the difficulty encountered in

TABLE XIV

PHYSICAL MEASUREMENTS OF ROSS'S GEESE

		Culmen I	Culmen II	Tarsus (total)	Midtoe	Flat Wing
Sample	1	23 (31)*	23 (31)	24 (31)	24 (31)	19 (31)
	2	27 (32)	27 (32)	27 (32)	27 (32)	24 (32)
	3	8 (37)**	8 (37)**	11 (37)**	11 (37)**	- (37)**
	4	7 (42)**	7 (42)**	8 (42)**	8 (42)**	- (42)**
	5	3 -	3 -	3 -	3 -	-
	6	5 -	5 -	5 -	5 -	-
Range	1	4.10-4.57 (3.6-4.6)	4.21-5.41	8.03-9.12 (8.1-8.9)	5.06-5.88 (4.8-5.7)	22.9-39.5 (36.0-40.3)
	2	3.81-5.00 (3.5-4.3)	4.34-5.14	7.62-9.50 (7.5-8.6)	4.64-5.64 (4.5-5.4)	24.0-39.1 (35.5-38.2)
	3	2.68-3.77 (3.5-4.2)	2.86-3.88	4.80-8.93 (7.4-8.9)	2.78-5.66 (4.6-5.6)	- -
	4	2.05-3.10 (3.4-4.7)	2.50-3.74	5.09-8.07 (7.4-8.5)	2.79-5.34 (4.4-5.3)	- -
	5	1.46-1.67 -	1.75-2.10	3.65-4.09 -	2.46-2.70 -	- -
	6	1.50-1.55 -	1.73-1.93	3.58-3.87 -	2.32-2.60 -	- -
Mean	1	4.27 (4.12)	4.93	8.56 (8.48)	5.40 (5.18)	37.10 (38.64)
	2	4.08 (3.90)	4.69	8.29 (8.05)	5.39 (4.84)	35.75 (36.85)
	3	2.97 (3.94)	3.57	7.37 (8.27)	4.57 (5.04)	- (36.49)
	4	2.65 (3.79)	3.13	6.81 (7.88)	3.92 (4.83)	- (35.38)
	5	1.54 -	1.88	3.80 -	2.61 -	-
	6	1.51 -	1.81	3.76 -	2.46 -	-
S.D.	1	0.154 (2.28)	0.233	0.100 (2.29)	0.223 -	0.350 (8.65)
	2	0.236 (2.08)	0.070	0.361 (3.17)	0.223 -	2.710 (8.39)
	3	0.310 (2.54)	0.368	4.170 (3.37)	0.980 -	- (8.53)
	4	0.380 (2.76)	0.463	1.15 (2.87)	0.858	- (9.49)
	5	0.12 -	0.190	0.25 -	0.120	
	6	0.05 -	0.070	0.12 -		

1. Adult Male
2. Adult Female
3. Young males (3 wks old)
4. Young females (3 wks old)
5. Young males 1 day old
6. Young females 1 day old

Data in brackets, courtesy,
* Dzubin, A., Canadian Wildlife Service, Saskatoon, Saskatchewan.

** Young Ross's geese 10-12 weeks old (Dzubin).

defining a color group for each individual. The data includes only those observations in which color was obviously one phase. The ratios are presented in Table XVI.

In 1964 it was decided that the gradations of each of the basic color phases could be placed into one or the other on the basis of apparent preponderonce of one color. Therefore, pearly-gray, white, and dark gray were placed in the gray class and yellow-green, dark yellow, black-yellow and light yellow were placed in the yellow class.

The results of the 1964 brood counts are outlined in Table XVII in the same style as Hanson et al (1956). From 99 broods a preponderance of monomorphic broods were seen. Within this group there were twice as many individuals placed into the gray-phase class as placed into the yellow-phase group. This ratio did not hold true for the mixed broods in which there is a 1 : 1 ratio of yellow: gray individuals.

TABLE XV

SEX RATIO OF NEWLY HATCHED ROSS'S GEESE

Color	Sex			Color Ratio			Sex Ratio		
	Male	Female		Yellow		Gray	Male		Female
Yellow	30	33	63	1	:	2	1	:	1
Gray	60	69	129				1	:	1
Total	90	102					1	:	1

TABLE XVI

COLOR COMBINATIONS OF 1 DAY-OLD ROSS'S GEESE BROODS OBSERVED AT ARLONE LAKE, N.W.T., 1963.

Color	no. of broods		percent		
unrecorded	5		15		
recorded	29		85		
monomorphic		23		79	
yellow		10			43.5
groy		13			56.5
dimorphic		6		21	
yellow		4			60
gray		2			40
TOTAL	34	29	100	100	

TABLE XVII

COLOR COMBINATIONS OF 1 DAY-OLD ROSS'S GEESE BROODS OBSERVED AT ARLONE LAKE, N.W.T., 1964.

	Broods number	%	Individuals number	%	Ratio of broods yellow : gray	Ratio of individuals yellow : gray
Broods of one color	53	53.5				
yellow individuals	21	21.2	47	16.5	1 : 2	1 : 2
gray individuals	32	32.3	85	29.9		
Mixed broods	46	46.5				
yellow individuals			66	23.3		
gray individuals			86	30.3		1 : 1
TOTAL	99	100	284	100		

INTERSPECIFIC RELATIONSHIPS

Parasitism

A total of 57 Ross's Geese, 40 adults and 17 young were autopsied to determine helminth types present during the reproductive phase of the geese. The geese were collected from 3 areas; Arlone Lake, the Perry River and Kindersley, Saskatchewan.

Identifications were made with the aid of Dr. J. C. Holmes, Messrs. M. Colbo, J. R. Gallimore, and L. Graham of the Department of Zoology, University of Alberta, Edmonton, Alberta.

Table XVIII presents data on percent infection found during the study.

The most commonly occurring helminths were the nematodes. These were found primarily in the ventriculus where mixed infections of Amidostomum sp. and Epomidiostomum sp. occurred, the latter being more common. Three specimens of Tetrameres sp. appeared in the proventriculus of 2 adult Ross's Geese collected at Kindersley, Saskatchewan.

Two types of cestodes occurred in the small intestine. One was identified as Microsomacanthus sp. The other was not identified because of a lack of sufficiently good specimens.

Trematodes occurred only in the caecum. Three types were identified; Notocotylus attenuatis, 2 specimens of Echinostomum revolutum and 1 specimen of Zygocotyle lunatum.

Evidence of mortality or emaciation resulting from parasite infections was lacking during the nesting and postnuptial moult periods. Cestodes were observed protruding from the vent of both adults and young during the banding operations in 1963.

Predation

The mortality of the adults on the nesting grounds is almost non-existent. A few old rifle shells were found in the area but these were probably used by the Eskimos

TABLE XVIII

EXTENSITY OF HELMINTH INFECTIONS OF ROSS'S GEESE COLLECTED DURING 1963 and 1964.

	Arlone Lake		Perry River		Kindersley	
	Adults	Young	Adults	Young	Adults	Young
no. autopsied	26	1	3	12	8	3
no. negative	3 (11%)	0	0	2 (17%)	0	0
cestodes	2 (8%)	0	2 (67%)	9 (75%)	3 (38%)	2 (67%)
trematodes	13 (50%)	0	1 (33%)	0	0	0
nematodes	20 (80%)	1 (100%)	2 (67%)	0	6 (75%)	2 (67%)

for spring caribou hunts rather than for killing geese. The Eskimos I did interview showed little interest in geese as a food resource and said they do not bother the waterfowl unless the caribou or seal hunting is poor. Hanson et al. (1956) states that the Eskimos appeared to have been the primary detrimental factor in the eradication of the Ross's Goose colonies near the coast. This could possibly have resulted in the abandonment of such colonies as Discovery Lake, which was originally described by Gavin (1940).

In 1963, three dead adult Ross's Geese were found on the shore of south Arlone Lake. The condition of these specimens indicated that death had occurred a year earlier so the cause could not be determined. However, the feathers of one of the specimens was scattered around a large birch patch suggesting that it may have been killed by an Arctic Fox or other mammalian predator.

In early June 1964, two Ross's and two Lesser Snow Geese were found dead on the islands of Arlone Lake. All these geese except one of the Snow Geese were in the egg-laying posture. The Snow Goose had obviously been attacked and killed by

Arctic Fox. The cause of death of the other geese is not known. All had one egg in the uterine portion of the oviduct. Although non of the birds were at o nest site, the activity of Arctic Foxes at this time may have flushed them from their nests, thus introducing o stress factor in addition to the already present stress of laying. This could possibly result in death.

With the abundance of Arctic Foxes in June of 1964 compared to 1963, the protective value of the islands as a refuge from predators is almost completely eradicated. The foxes visited the islands as long as an ice bridge exists between the islands and the mainland. Subsequently they ceased to harass the geese. The protective value of the insular nesting habitat is readily realized at this stage when a definite water barrier prevents mammalian predation and insures a potentially productive season.

Although the three species of jaeger, Glaucous Gull and Snowy Owl nested in the area their numbers and predatory importance were low (Table XX). At the beginning of the hatching period a marked increase in avian predators occurred, primarily Glaucous Gulls. On 7 July, 1963, 13 of these gulls were seen encircling island B_1 at the same time. This is a high concentration for the area as prior to this one or two gulls per hour was normal. Numerous observations were made of young Ross's Geese being snatched off the water and devoured whole by this large predator. Lemieux (1959) found that jaegers were in large numbers on the Bylot Island (73° 13'N, 78° 34'W) Greater Snow Goose colony but he notes the relative insignificance of these as important predators. Barry (1956) stressed the importance of gulls and jaegers on Atlantic Brant at Boos River (63° 40'N, 85° 50'W), N.W.T., in that these predators take a heavy toll of brant eggs and young.

TABLE XIX

NUMBER OF AVIAN PREDATOR NESTS RECORDED AT ARLONE LAKE, N. W. T. 1963 and 1964 SEASONS

Species	Number of nests 1963	1964
Stercorarius pomarinus	0	0
Stercorarius parasiticus	0	0
Stercorarius longicaudus	1	0
Larus hyperboreus	1	1
Larus argentatus	0	0
Nyctea scandiaca	5	0
TOTAL	7	1

Five Snowy Owls nested at Arlone Lake in 1963. None were seen in 1964 presumably because of the lack of microtine rodents. No predatory activities of Snowy Owls were seen during either study seasons suggesting that this species did not act as an important predator on the young geese. Lemieux (1959) found the same conditions to exist re owls in the Bylot Island Greater Snow Goose colony.

A number of factors on the islands cause some loss of young Ross's Geese. The large birch stands act as traps from which the newly hatched goslings find it impossible to escape once entangled. Twenty-one goslings in 1963 and 17 in 1964 were rescued from these areas. It is likely that many more goslings were not found because it is hard to see them under the thick cover. Apparently the trapped goslings are abandoned by their parents who make no extra effort to recover their progeny other than calling them. Old Eskimo caches and rock piles acted as traps in the same way, but to a lesser extent. Nests in these regions often lost young before they had moved far. It seems almost ironical that the most favoured nesting habitat (birch and rock) should be somewhat detrimental to the young.

Egg predation was generally low at Arlone Lake. In 1963 the hatching success was exceptionally high (93.5%). The presence of Arctic Foxes at the start of the season in 1964 decreased the potential production and success of the colony but the end result of this was insignificantly different from the late 1963 season. A recorded 144 Ross's and 122 Lesser Snow Goose nests were destroyed by foxes in the first week in June 1964. In 1964, island E was deserted because of the destruction of nests by Arctic Foxes. Once the foxes had left the colony the goose nests are preyed upon only by a small number of avian predators, from which they suffer little. The geese stay close to their nests and are adept in warding off the predators.

Egg fertility is high in Ross's Geese. Not more than 1% of the total eggs on the colony were sterile. Cooch (1958) found that infertility, crumpled and rolled out eggs seldom exceeded 1% of the total loss in Blue Geese. Hanson (1950) found that fertility in the Canada Goose (Branta canadensis) was 93% and 94% in California and Utah respectively.

Competition with the Lesser Snow Goose

The Ross's Geese nesting at Arlone Lake share the islands with the larger and often more aggressive Lesser Snow Goose. In 1963 and 1964, 726 and 356 Snow Geese were recorded nesting at Arlone Lake. It was of interest to find out whether direct competition existed between the two species for nesting sites and food, and to discover if the presence of the larger species had any detrimental effect on the productivity of the Ross's Goose population.

Calculations of Snow Goose nest desnity were made for each habitat on all the islands and in addition daily observations were conducted on the feeding grounds for detecting any evidence of behaviorol competition for food.

Table XX presents the density of Snow Goose nests at Arlone Lake for 1964. With such a small population of a potentially competitive species, in a comparatively large colony of Ross's Geese, it is difficult to arrive at any definite conclusions

TABLE XX

NESTING DENSITIES OF THE LESSER SNOW GEESE AT ARLONE LAKE nests per 1000 sq. ft.

	habitat			
island	open	rock	birch	mixed
A	0.06	0.81	1.01	0.44
B_1B_2	0.08	0.74	1.63	0.44
C	0.07	1.66	0.63	1.66
D	0	0	1.02	4.61

regarding nest site preference for the Snow Goose in this area. The data do suggest that, as in the Ross's Geese, the open regions are shunned in preference for the cover and edge areas of birch and mixed habitats. Although this apparent similarity of nest site could easily give rise to a serious competitive situation, there was no evidence of this occurring at Arlone Lake. One just has to look at the density and clutch sizes of Ross's geese in the regions of highest density on Snow Geese (i.e. mixed areas of islands C and D), to see that the clutches in these regions were the some as the other areas where Snow Goose density was low (island A and B_1B_2 mixed areas). If the Snow Goose was noticeably competing with the Ross's Goose in this area, one would expect a low density of the latter species in regions where a high concentration of Snow geese nested as a result of displacement. This is especially true in that the nest site requirements are so similar in the two species. However, such a situation did not occur at Arlone Lake, and the Snow Goose did not noticeably displace the smaller species from its preferred nesting locations.

Food is abundant in the area. Numerous feeding stations exist around the pools on the tundra mainland. These pools attract small groups of integrated flocks of Snow and Ross's Geese at all times of the day. Interspecific interactions were far

less common in these areas than were the intraspecific type between Ross's Geese. Only when an individual become situated too close to another did a dispute occur.

The threshold of competition between the Lesser Snow Goose and the Ross's Goose is not known, but at present it does not appear to have been reached in the Arlone Lake colony, at least to have any noticeable effect on the Ross's Goose population. If a large immigration of the larger species were to migrate into the Perry River region sometime in the future, effective displacement of the Ross's Geese might occur. In view of the relict type distribution of the Ross's Goose, which may have resulted, as MacInnes and Cooch (1963) say, from competition with the larger and more aggressive A. coerulescens, it is somewhat disconcerting to envisage the reality of the report (Cooch 1963) that if the present increase of blue-phase Anser coerulescens in the Hudson Bay drainage continues a population will be established within 15 to 20 years which will be capable of supplying large donor population to the western regions. If the blue-phase and white phase Snow Geese invade, in ever increasing numbers, the specialized nesting habitat of the Ross's Goose, then MacInnes and Cooch (1963) may prove to be correct and the Ross's Goose populations of the central Arctic may be displaced into an environment to which they are not readily adopted.

The foregoing is speculative and has not yet been observed in any existing colony of Ross's Geese. The obvious limiting factor at Arlone Lake is nesting space, which could be seriously depleted in the presence of a substantial increase in the population of Lesser Snow and Blue Geese.

BANDING OPERATIONS

Banding operations were a major part of the post-breeding study of the Ross's Geese. Information from such activities is essential for future determination of mortality, life-table construction and migration routes. Very few Ross's Geese have been banded in the immediate vicinity of the nesting grounds in the Perry River region (see Hanson et al. 1956, MacInnes and Weske 1962).

The banding techniques used were those outlined by Coach (1953). A temporary camp was constructed (Figure 3 - cabin) from which the operations were based. The procedure entailed canoeing up the Perry River 15 miles each day intercepting as many flocks of moulting geese as possible.

In 10 days 493 geese were banded in 1963, 409 Ross's and 84 Lesser Snow Geese. Sexes were distinguished in both age classes by banding the left foot of males and the right foot of females. Age-sex classes were further differentiated by using colored neck bands (Craighead and Stockstad 1956).

The procedure was highly successful in terms of percentage of flocks captured. As long as the geese were not permitted to reach the land they were exceptionally easy to drive into the banding corral. If the geese reached solid ground prior to capture they could easily out-run a man. Under such circumstances it was necessary to band the geese prior to the later stages of endyesis. It seemed to be instinctive that at this time the geese would rush for the banks of the river as soon as the canoe was observed. Prior to this they were tame and co-operative.

The Kogmiut are very efficient at driving the geese into the corral and must be given credit for their abilities.

DISCUSSION

The Ross's Goose, which nests only in the Arctic, faces the necessity each spring of leaving the California wintering grounds at a specific time. Movements must coincide with the appearance of food along the migration path and with the exposure of nesting habitat and food in the north. Such a correlation appears to exist in the spring migration of Ross's Geese. This is accomplished, in part, by following the 40 F isotherm. Other as yet uninvestigated environmental and/or physiological factors may be equally important in the control of migration (Forner 1955).

The physiological readiness for egg-laying, which is shown to exist in the Ross's Geese upon arrival on the nesting grounds, suggests that the lengthy pairing and courtship procedures are completed by this time. An obvious advantage to this situation is that it enables the geese to commence nesting activities immediately and thus complete reproduction during the short Arctic season. This lack of courtship activities has been reported in other Arctic nesting geese (Barry 1962, Hohn 1957 and Lemieux 1959). Although the extent of time required to complete the pairing and courtship procedures is not known, it is reasonable to assume that they have a negative selective value in the Arctic (Barry 1962). The observation of copulation in Ross's Geese in Alberta and the continual regression of gonad weights following arrival support these contentions and suggest that the Ross's Geese utilize the Arctic as strictly a nesting rather than a breeding area.

Following arrival on the nesting grounds, initiation of nesting activities is controlled by two conditions. The first of these is that potential nest sites must be exposed. Lack (1933) said that a marked difference in breeding time can clearly be correlated with the suitability of the ground for nesting and nothing else. This was found to be partially true on the islands at Arlone Lake. Habitat which was covered with snow even though, when exposed, provides optimum nest sites was ignored and the geese utilized sub-optimal regions. On island B1 where approximately 20% of the mixed

region was snow covered, a high density of nests occurred in the poorer region. The second factor which delays nest initiation is local inclement weather. The 1963 5 day delay was directly caused by gale force winds. Soper (1930), in his classic monograph on the Blue Goose reported that the summer of 1929 was "decidedly unpleasant". Conditions of cold penetrating wind and below-freezing temperatures caused the arriving flocks of Blue Geese to turn south. Barry (1962) found that the Atlantic Brant made long flights back and forth over the snow fields when nesting habitat was not available. After the thaw started, the flocks subdivided and nesting activities began.

The presence of Arctic Foxes in the study area did not serve to delay nesting attempts.

The dispersion of the geese on the nesting islands is not random. A definite nest site selection occurs. The nesting habits of the Ross's Geese show that edge habitat is most suitable. One would think that because of the lack of coverage provided by tall bushes and emergent vegetation as exists in the southern region, the geese would naturally utilize any region which furnishes the most protection against the elements. Such was found not to be the case. Optimum habitat not only must provide coverage but also a grazing area. This exists in the form of mixed regions of small birch stands, rock and open moss. The pure rocky areas offer a certain amount of protection from the elements but not to the some degree. Depending on the direction of wind and rain, the rock-type nest site could be as suitable as the mixed regions or as poor as the completely open areas. The apparent interior quality of the open areas is reflected in the increased thickness of the nest wall. For maximum insulation in an exposed area a thicker nest wall is required. The nests in the birch and rocky areas receive insulation from the immediate surroundings thus the extent of wall thickness need not be so great.

In so far as the female is not attentive during the egg-laying period, certain behavioural characteristics have developed which increase the survival rate of the eggs during the period when the female is off the nest. The formation of comparatively small,

closely guarded territories insure protection for the nest and eggs from the activities of other geese and insure the presence of the adults on the territory to drive off potential predators. When the adults do leave the territory the action of covering the eggs with nest material forms a protective devise in that predators apparently cannot see the eggs from the air. Soper (1942) concluded that the down which lines the nest not only helps to screen the eggs from the prying eges of gulls and jaegers but retains the warmth during the birds absence. This mechanism was shown to work efficiently for gosling protection also.

Relatively little variation in clutch size of the Ross's Goose occurs. The clutch size control factors are not known. It has been shown from this work that fidelity occurs in depleted clutches except where no eggs are left in the nest and almost complete abandonment results from additions to a completed clutch. Delacour (1964) states that eggs are occasionally pushed out of the nest during normal movements, especially in the case of large clutches. The very sight of a few eggs lying around a "hyperclutch" nest may cause the female to abandon the rest of the clutch. Predators may be attracted to these unprotected eggs, harassing the adults to the point of desertion. In this study all the eggs out of the nest were broken. This possibly induced the female to desert. The data show ultimately that the species will not tolerate an excessively large clutch. The laying and hatching of each egg in a clutch of Ross's Geese consumes approximately 2% of the frost-free period. It does not include the incubation period. Large clutches would tend to jeopardize the success of the whole brood because of the limited time available for the reproductive phase. The ultimate control of clutch size may be the time factor which prevents laying of excessively large clutches. Additional data are presented which suggest the feasability of time as the clutch size controlling factor. Those clutches which are started later are smaller than those started earlier, to compensate for the time lost in nest initiation. Cooch (1958), Lemieux (1959) and Barry (1962) found a negative correlation between date of the first egg and final clutch size

in Blue Geese, Greater Snow Geese and Atlantic Brant respectively.

It is unlikely that renesting occurs in the Ross's Geese. The continuous regression of gonads following arrival and the determinate laying character of the species would prevent successful secondary ovulation and fertilization. Complete ovary and testicular recrudescence would be required judging from the gonad size at the end of the laying period (Figure 6). Coupled with this time consuming physiological requirement, the short season would definitely limit such a mechanism. Cooch (1958) and Barry (1962) found no renesting in Blue Geese and Atlantic Brant.

The high degree of attentiveness shown during the incubation period is reflected in the sudden silence over the colony. The birds do not leave the territories often but obtain most of their requirements from the territory. The appearance of down strewn over the colony is the result of active plucking of the breast feathers by the incubating female, providing added insulation to the eggs. Hanson (1959) states that in waterfowl if the incubation patch was moulted promiscuously as in most passerines, as a result of increased prolactin level at the time of egg laying, the feathers would not be available for placement in the nest. The positive correlation observed in this study between later stages of egg-laying and increased down deposition agree with Hanson (1959) who says that a high dependence of the plucking behaviour on complete development of the sexual (hormonal) cycle is suggested by the fact that down is placed in the nest only in the later part of the egg-laying period. It is presumed that prolactin is the hormone chiefly responsible for the development of the feather plucking in geese near the end of the egg-laying cycle. According to Welty (1962) prolactin, which is secreted from the pituitary gland, depresses the production of both lutienizing and follicle stimulation hormone and initiates broodiness (nesting and incubation).

The tightly knit flocks observed during the incubation period are attributed to the attentiveness at this stage. The flocking is certainly not a general character of the Ross's Goose during previous phases. Von Tyne (1961) mentions the existence of these

post-breeding flocks but no causal explanation is given. Emlen (1952) is speculative in his account of avian flocking. He attributes gregariousness to a positive binding force, which according to Van Tyne (1961) is absent during the breeding season and active during the post breeding period. The basic cause of the clumping of flight groups reflects the high degree of attentiveness during incubation which maintains the least distance between the birds and their nests during disturbance. The rapid return of the birds to the nest is indicative of augmented attentiveness.

The synchronous hatching of the eggs of Ross's Geese and precocious characteristic of the goslings insure maximal survival and productivity. The amount of food available on the nesting islands is not sufficient to feed 3 or 4 thousand newly-hatched goslings. Departure of the parents to the feeding areas on the mainland to bring back food would allow the goslings to become easy prey for the abundance of avain predators at this time. Consequently the parents must provide food and protection for the young simultaneously. This is accomplished by a marked movement of the family groups from the nesting area immediately after the clutch has hatched, to regions where food is available. The movement of the family dictates that each of the young be approximately equal in size so that the potential of food acquisition and the ability to keep up with the rest of the family is equal throughout the brood. Such abilities result only from a synchronous hatch.

Delacour (1964) and Hochbaum (1960) report the post breeding movement of waterfowl following the breeding season, and state that it takes the birds to regions where they are protected from predators and have a large food supply while undergoing the annual wing moult. I cannot agree with Hochbaum (1960) when he states that the moulting shift rarely occurs in breeding geese or swans. The Whistling Swan moves from its place of breeding to large lakes or streams where moulting occurs, (Kortright 1960), and the results of this study and observations made during the study on Canada Geese, Snow Geese and Whitefronted Geese disagree with Hochbaum on this point.

Apparently no constant geographical direction is shown in the shift, and as Hochbaum (1960) points out, it is an ecological rearrangement of the population, with a bias toward large marshes and lakes.

The cause of the moult migration in Ross's Geese is not known. In view of the abundance of food in the immediate vicinity of Arlone Lake there is no apparent reason for the extent of the movement. Hanson and Smith (1950) state that post breeding movements of the Canada Goose are orientated toward extensive feeding areas. Hanson (1956) observed that a slow movement of Ross's Geese toward the coast following the nesting season occurred in 1949, and that this movement was partly overland thus avoiding rapids and enabling the young to feed on insects and plants. Observations made during this research agree somewhat with these findings, however the small percentage of the total breeding population at Arlone Lake which were seen on the Perry River does indicate that a mass movement to the coast via the most obvious water route, the Perry River, does not occur and that the movement from the breeding group is a random movement of flocks from place to place on the tundra, during which time moulting occurs.

It has been shown that loss of eggs during the nesting season is insignificant. Predation is the most important contribution to egg destruction. Following the hatching period, mortality is increased on the young birds but it is suggested that in the long run, this has a decided advantage to the species in that weak individuals and perhaps undesirable genotypes are eliminated from the population. Taverner (1940) summarizes this idea when he stated, "Under certain abnormal conditions there may be such a thing as over-predation that fails to stop with the weaklings and makes inroads upon the strong; but all successful races can safely withstand the normal attacks of their natural enemies under the conditions through which they were evolved and have persisted. Were it otherwise, ipso facto, they could not have originated and survived to date". The predators recorded during this study do not seem to exploit significantly the "strong" individuals in the population.

The differential female mortality during the first 3 weeks after hatching cannot be explained. If it had been found that a high percentage of females were of the yellow phase it may have been possible to correlate mortality with this phase in that yellow may be more obvious to predators than gray. This would in effect increase the mortality of females and in part justify the findings of this research. However, both males and females show the same color ratios at hatching (1:2, yellow:gray) which does not support this theory. The idea that gray coloring may be disadvantageous to the females does not hold since the 1:2 ratio was obtained for males which were not apparently subjected to the same amount of predation. If the same degree of mortality occurred in males as in females, the sex ratio at 3 weeks would have been equal. The apparent mortality of females appears to be purely sexual and does not, from evidence presented, correlate with the color phases.

The coloration of Ross's goslings cannot be said to be distinctly a case of pure dimorphism. As Hanson, et al. (1956) pointed out, and substantiated in this study, polymorphism is common. The yellow and gray phases are extremes of the color types, and the gradations or mixed coloration which do occur make it exceedingly difficult to categorize accurately all individuals. A subjective index of classification may be used, as in this study, to show that a preponderance of the gray phase exists. However, depending upon the researcher, a gosling possessing characters of both phases may be placed into either category, gray or yellow. Hanson (1956) obtained a Mendelian 3:1 ratio of yellow:gray whereas our findings differ. Williamson (1957) used Hanson's data to determine genetic dominance of the color phases. This author erroniously concludes "The goslings of Ross's Goose Anser rossii may have either yellow or gray plumage, and this seems to be a case of simply dimorphism". Conclusions based on subjectively placed categories of coloration do not solve the problem of if, and much less why an apparent predominance occurs. At this stage the cause of one color type seemingly being more common than another is not known. Certainly, as yet no selective value has been shown

to exist for one pure phose, and at present the problem appears to be not the action of a single pair of alleles but possibly an action of multiple alleoles. Such alleles do not result in distinct coloration, but rather form gradations from one extreme to the other. Jaap, cited in Snyder and David (1957) found three sets of alleles affecting the plumage and color variations in the mallard duck.

The weights of the adult geese at arrival on the nesting grounds are at a maximum compared to the other phases of the reproductive phase. Hanson (1962) found the same condition in Canada Geese Bronta canadensis upon arrival on the nesting grounds. The pattern of fattening in the Ross's Goose is still unknown but Hanson (1962) found that the Canada Goose followed much the same pattern as species which migrate leisurely. He states that the abundance of fat in arriving geese is necessary to supply energy from the time of arrival on the breeding grounds until the snow cover has left and new plant growth is again available. The subsequent weight loss observed in the Ross's Geese may well result from the utilization of the stored fat supply, the relatively sparse food available at this time and the physiological stresses of territory formation, nest initiation and egg-laying. The greater total weight loss exhibited by females results from ovary and oviduct regression, increasing attentiveness to the nest site and minimol food consumption. The males continues to graze on the territory ond do not show such a substantial weight loss. Irving (1960) thinks that fat reserves may be important to moles during the intense period of courtship and territory maintenance. Courtship is not a stressful activity in mole Ross's Geese as this phose is completed prior to arrival in the north. The more rapid decline of male fatness has been explained by Hanson (1962). He states that because of the relative passiveness of the female during courtship procedures, this sex arrives in the north fatter thon the moles, and maintains comparable amounts of fat longer.

Following the hatching period both adult and young Ross's Geese gain weight rapidly. The abundance of mature flowers, leaves and stems, the long photoperiod and

the prolonged treck over the tundra all allow for an increased food intake over the nesting period. Another noticeable weight loss occurs during the moulting period. This is the period of physical maturation in the birds of the year. Hanson (1962) states that this is perhaps the period of greatest stress in the life of the adult Canada Goose. Data presented from this research and reports from other workers, (Barry 1962 and Cooch 1958), indicate similar occurrences in the Ross's and other arctic nesting geese. Hanson (1962) discusses the possible physiological causes of stress in the moulting geese which may leod to a decrease in weight. He states that a marked increase in the metabolic rate occurs as o result of the utilization of muscle proteins in the formation of feathers. Marshal (1960) says that moulting imposes a severe strain on birds in that o large amount of blood is required for the new feather growth.

In summary, the reproductive phase of the Ross's Goose does not appear to be the limiting foctor of the populotion nesting at Arlone Lake. Nesting and hatching success ore high, and mortality of the adults and young is low. At present competition with the Lesser Snow Goose is not affecting the potential and actual productivity.

The two study seasons at Arlone Lake were good ones. Neither climate nor biotic factors decreased markedly the production of Ross's Geese. However, it is stressed that in such an unstable ecosystem, late seasons or excessive continued predation could cause drastic annual drops in the productivity of the geese. In 1964 the Whitefronted Geese (Anser albifrons) nesting in the extreme western Arctic suffered greatly because of the late season and subsequent flooding of the nesting habitat. The studies of Barry (1962), Cooch (1958), and Lemieux (1959) all point out the importance of climate during the reproductive phase as probably the most important limiting factor controlling annual reproduction in Arctic nesting geese. Such works should be considered as standards when extrapolating for other geese nesting under relatively similar conditions. Until we have further data on the frequency of late seasons and inclement weather during the reproductive phase of the Ross's Geese, we

will not know specifically how such occurrences affect the species.

Predation is a factor, the importance of which cannot be minimized. The 1964 season at Arlone Lake showed the extent of Arctic Fox damage to the Arlone Lake colony, which resulted in the complete evacuation of one of the major nesting islands. The insular habitat presumably saved the colony from complete destruction. Until we know if the remaining nesting colonies of Ross's Geese are insular, we cannot say that it is not the mammalian predators that control the annual productivity.

The need for future study on the Arlone Lake and other nesting colonies is clear. We have now a general overall picture of the effects of weather, predation and human beings on a specific area, but long term studies are essential to provide added information on a more comparative basis.

SUMMARY

1. This study of the breeding biology of Ross's Goose in the Perry River region was carried out during the summers of 1963 and 1964 at Arlone Lake, N. W. T. and the Perry River.
2. The spring migration of Ross's Geese in 1964 correlated with the northword movement of the 40F isotherm.
3. Pairing and courtship activities are completed prior to arrival on the nesting grounds.
4. Nest initiation depends upon the presence of exposed ond suitable nest sites and suitable weather conditions on the nesting islands.
5. Excessive mammalian predation at the start of the nesting season results in the abandonment of nesting islands.
6. The distribution of nests is not random. Highest densities occur in edge areas of mixed birch, rock, and open terrain.
7. Subsequent eggs in the clutch are laid every 1 1/2 days with a resultant egg-laying period of 8 to 9 days for the whole colony.
8. The average clutch size is 3, with the most common clutch of 4. No significant differences in clutch size occur among the 4 major habitats.
9. A negative correlation exists between date of first egg laid and final clutch size.
10. Little attentiveness to the nest is shown prior to the incubation period. The beginning of incubation is marked by silence over the colony, excessive plucked down in the nests, tight flocking of disturbed groups, and rapid return to nest.
11. The incubation period is 22 days.
12. The covering of eggs with nest material by the female prior to the parents leaving the territory hos a selective advontoge.

13. Nests in open habitat are larger than those in regions which provide coverage.

14. Renesting probably does not occur in the study area.

15. Ross's Geese do not abandon a partially depleted clutch, but will desert excessively large clutches.

16. Hatching of a clutch is synchronous and assures maximum survival of goslings. The hatching period lasts approximately 8 days.

17. Predator numbers increased during the hatching period.

18. Nesting and hatching success was extremely high.

19. The post-nuptial migration of the Arlone Lake colony is not directed along the Perry River, but occurs as a dispersal over the tundra from the nesting area to the coast. Very few Ross's Geese reach the coast.

20. Predation was low during the reproductive phases of 1963 and 1964. The greatest percent-loss for 1964 occurred in the United States.

21. A 1:1 sex ratio exists in the adults and newly hatched goslings.

22. A differential mortality occurs against females during the first 3 weeks of life (137 males : 100 females).

23. It is suggested that brood counts taken while the geese are moulting are invalid.

24. Body weights of adults are at a maximum at arrival on the nesting grounds. Body weight drops immediately following arrival and again during the post-nuptial molt.

25. The growth rate of the goslings is rapid, showing the typical sigmoid curve.

26. Parasite extensity throughout the reproductive season is low.

27. No noticeable competition existed between the Ross's Goose and the Lesser Snow Goose at the Arlone Lake colony in 1963 and 1964. It is suggested that excessive immigration of Lesser Snow and Blue Geese into Ross's Geese

nesting areas would have a detrimental effect on the Ross's Geese.

28. The insular nesting habitat at Arlone Lake is an efficient protective device against continuous mammalian predation.

29. The reproductive phases of 1963 and 1964 were not the limiting stages in the life of the Ross's Goose at Arlone Lake.

30. Food is not a limiting factor on the nesting grounds.

31. The frost-free period in the study area extends over a period of 93 days. In 1963 and 1964, 86% of this period was used to complete the reproductive phase.

32. Continued study of the reproductive phase of Ross's Geese is required to determine quantitatively the effects of late seasons, and heavy predation. Comparative ecological data is needed from other nesting colonies.

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APPENDIX 1

REPRESENTATIVE FLORA FROM ARLONE LAKE STUDY AREA

Islands	Tundra	Moraines
	Arctophila fulva	Dryopterus fragrans
	*Hierochloe alpina	H. alpina
	Gramineae	
	Carex bigelowii ?	
Carex supina	Carex supina	
	Eriophorum vaginatum	E. vaginatum
	Juncus spp.	
Salix spp.	Salix spp.	Salix spp.
Betula glandulosa	B. glandulosa	B. glanduloso
	Coltho palustris	
Ranunculus sabinei		
Papaver radicatum		P. radicatum
Cruciferae		
Saxifraga tricuspidata		S. tricuspidata
Potentilla hyperarctica		P. hyperarctica
	Potentilla sp.	
Rubus chamaemorus		
Leguminosae		
Empetrum nigrum	E. nigrum	
Epilobium sp		
	Epilobium latifolium	E. latifolium
Hippuris vulgaris		
Cassiope tetragona		C. tetragona
		Ledum decumbens
Rhododendrum lapponicum		
Vaccinium Vitis-idaea		V. Vitis-idaea
Pedicularis sudetica	P. sudetica	
Petasites frigidus		
Senecio congestus		
Compositae		

* Lines joining areas depictcommon species to these regions

APPENDIX 2

AVIAN PHENOLOGY CHART PERRY RIVER, N.W.T. 1963

Species	Common name	Kagmiut	Date	(no.)
Buteo lagopus	Rough-legged Hawk	Kaalooq*	May 22	(1)
Nyctea scandiaco	Snowy Owl	Ukpik	May 22	(1)
Plectophenax nivalis	Snow Bunting	Amouligoq	May 22	(30)
Lorus argentatus	Herring Gull	Quxriq	May 22	(5)
Grus canadensis	Sandhill Crane	Tatidgoq	May 25	(35)
Branta canadensis	Canada Goose	Udluuq	May 25	(25)
Olor columbionus	Whistling Swan	Qugyuk	May 31	(3)
Lagopus mutus	Rock Ptarmigan	Niksaaktuq	May 31	(100)
Anser albifrons	Whitefronted Goose	Nirlivik	June 1	(10)
Corvus corax	Northern Raven	Tudlugoq	June 1	(2)
Eremophila alpestris	Horned Lark	Qupanuaqpaaryuk	June 2	(4)
Anser caeurulescens	Lesser Snow Goose	Kanguq	June 3	(4)
Calcarius lapponicus	Lapland Longspur	Nasaudlik	June 4	(100)
Pluvialis dominico	Golden Plover	Tudlik	June 4	(10)
Anser rossii	Ross's Goose	Koaroq	June 5	(12)
Anas acuta	Pintail	Qiqqaaq	June 5	(15)
Larus hyperboreus	Glaucous Gull	Nauyaq	June 6	(5)
Erolia bairdii	Baird's Sandpiper	Sigyariaq	June 6	(10)
Arenaria interpres	Ruddy Turnstone	Taligvak	June 6	(6)
Stercorarius pomarinus	Pomerine Jaeger	Isungngastruq	June 7	(7)
Clangula hyemalis	Old Squaw Duck	Aasongngiq	June 7	(5)
Somateria mollissimo	Common Eider	Amaulik	June 7	(4)
Somateria spectabilis	King Eider	Qingalik	June 9	(4)
Phalaropus fulicarius	Red Phalarope	Saavraq	June 9	(50)
Charadrius hioticula	Ringed Plover	Qudliqudliq	June 9	(1)
Mergus serrotar	Red Breasted Merganser	Paiq	June 9	(3)
Squatarola squatarola	Black-bellied Plover	Qirliiyuuq	June 10	(5)
Xema sabina	Sabine's Gull	Iqidgagioq	June 10	(2)
Sterna paradisaea	Arctic Tern	Imitqutoilaq	June 10	(5)
Asio flammeus	Short-eared Owl	Nipainngoqtoq	June 11	(1)
Erolia melanotos	Pectoral Sandpiper	Tuutuuq	June 13	(5)

Contd.

Species	Common name	Kogmiut	Date (no.)
Passerculus sanwichensis	Savannah Sparrow	Kuyaumiqtaayuuq	June 13 (1)
Falco peregrinus	Peregrine Faclon	Kidgavik	June 13 (1)
Ereunetes pusillus	Semipolmated Sanpiper	?	June 13 (2)
Gavia arctica	Arctic Loon	Maliriq	June 14 (2)
Gavia stellata	Red-throated Loon	Qaqsuoq	June 14 (1)
Stercorarius parasiticus	Porositic Jaeger	?	June 14 (1)
Stercororius longicaudus	Long-tailed Jaeger	Isungngaq	June 14 (2)
Anas carolinensis	Green Winged Teal	?	June 24 (3)
Lobipes lobatus	Northern Phalarope	Mangitquq	June 24 (2)
Aquila chrysaetos	Golden Eagle	Qupanuaqpak	July 31 (1)
Toxostoma rufum	Brown Thrasher	?	Aug. 13 (1)

* Courtesy Mr. Duncan M. Pryde, Manager, Hudson's Bay Co., Post, Perry River and Mr. Samuel Emingak, Kogmiut Eskimo, Perry River
"q" is pronounced with a uvular K; "k" = velar K.

AVIAN PHENOLOGY CHART PERRY RIVER, N.W.T. 1964

Species	Common name	Date	No.
Branta canadensis	Canado Goose	June 1	10
Anser albifrons	Whitefronted Goose	June 1	4
Anser caerulescens	Lesser Snow Goose	June 1	4
Anser rossii	Ross's Goose	June 1	19
Lagopus mutus	Rock Ptarmigan	June 1	8
Clarcarius lapponicus	Lapland Longspur	June 1	200
Plectophenax nivalis	Snow Bunting	June 1	150
Pluvialis dominica	Golden Plover	June 1	3
Erolia bairdii	Baird's Sandpiper	June 1	50
Grus canadensis	Sandhill Crane	June 1	100
Larus argentatus	Herring Gull	June 1	4
Larus hyperboreus	Glaucous Gull	June 1	1
Eremophila alpestris	Horned Lark	June 1	3
Stercorarius pomarinus	Pomerine Jaeger	June 2	8
Anas acuta	Pintail Duck	June 2	7
Buteo lagopus	Rough-legged Hawk	June 2	1
Falco rusticolus	Gyrefalcon	June 3	1
Asio flammeus	Short-eared Owl	June 3	1
Hirundo rustica	Barn Swallow	June 4	1
Corvus corax	Northern Raven	June 8	2
Arenorio interpres	Ruddy Turnstone	June 8	1
Clangula hyemalis	Old Squaw Duck	June 8	5
Stercororius longicaudus	Long-tailed Jaeger	June 8	1
Sterna paradisaea	Arctic Tern	June 9	13
Olor columbianus	Whistling Swan	June 9	4
Gavia arctico	Arctic Loon	June 10	2
Calidris canutus	Knot	June 10	5
Stercororius parasiticus	Parasitic Jaeger	June 11	2
Somateria spectabilis	King Eider Duck	June 12	5
Charadrius hiaticula	Semipalmated Plover	June 13	1
Phalaropus fulicarius	Red Phalarope	June 14	1
Erolio melonotos	Pectoral Sandpiper	June 17	2

Contd.

Species	Common name	Date	No.
Ereunetes pusillus	Semipalmated Sandpiper	June 20	2
Xema sabina	Sabine's Gull	June 27	2
Acanthis flammea	Common Redpoll	June 27	1
Gavia stellata	Red-throated Loon	June 30	2
Mergus serrator	Red-breasted Merganser	July 5	2
Falco peregrinus	Peregrine Falcon	July 12	2
Erolia alpina	Dunlin	Aug. 2	2

APPENDIX 3

MAMMALS OBSERVED IN THE PERRY RIVER REGION, N.W.T. 1963 and 1964

Species	Common name	Kogmiut
Lepus arcticus	Arctic Hare	Ukoliq
Citellus parryii	Arctic Ground Squirrel	Siksik
Dicrostonyx groenlandicus	Collared Lemming	Qilangmiutaq
Lemmus trimucronatus	Brown Lemming	Avingnagoq
Clethrionomys rutilus	Red-backed Mouse	Ulimakkaq
Canis lupus	Gray Wolf	Amaruq
Alopex lagopus	Arctic Fox	Tiriganniaq
Mustela erminea	Short-tailed Weasel	Tirioq
Gulo luscus	Wolverine	Qodvik
Phoca hispida	Ringed Seal	Notsiq
Rangifer tarandus	Barren-ground Caribou	Tuktu

APPENDIX 4

COMMON AND KOGMIUT NAMES OF FISH OBSERVED AT PERRY RIVER, N.W.T. 1963 and 1964

Common name	Kogmiut
Sculpin	Kanayuq
Flounder	Nataarhok
Arctic char	Igalukpik
Trout	Isuuq
Whitefish	Kapisilik
Sucker	Milugiaq
Burbot	Tiktaaliq
Nine-spined stickleback	Kakilasak
Tomcod	Uugaq
Arctic Grayling	Sulukpaugaq
Miller's Thumb	Igalugaq
Smelt	Innangaoynq

Nest No.	Island	Dimensions	Habitat Type	Distance	Eggs									
					1	2	3	4	5	6	7	8	9	10
Egg fate														
Date hatch														
Remarks														

Nest No.	Island	Dimensions	Habitat Type	Distance	Eggs									
					1	2	3	4	5	6	7	8	9	10
Egg fate														
Date hatch														
Remarks														

APPENDIX 6

Ross's Goose Collection Data

No._____ Date _____ Collector _____ Sex ____

Location _____ Elevation _____

Habitat _____

Method of collection _____

Weather: Temp. _____ Wind _____ Snow cover (%)_____

Weight_____ Age _____ Culmen 1_____ Culmen 11 _____

Plumage _____

Wart length_____ Tarsus length _____ Midtoe _____

Wing spread (flat)_____ Tail length _____

Total length _____ pre-ovulatory follicles _____

post-ovulatory follicles _____

atretic follicles _____

Oviduct width _____ Adrenals _____ Fat _____

Keel depth _____ Pectoral muscle _____ E.I._____

Food _____

_____

Lens weight _____

Previous tag marks _____

_____

Remarks:

APPENDIX 7

FOOD HABITS

Data on Ross's Goose food habits were obtained from analysis of 26 ventriculi (TableXXI). Of these 8 were collected in 1963 field season and 18 in 1964.

The only available data on food habits of Ross's Geese on the nesting grounds are documented by Hanson et al. (1956). He states:

> "Contents of 5 gizzards were examined: 2 gizzards contained the stems and leaves of the sedge Eriophorum, though in one there were only trace quantities, the third contained mainly Eriophorum with some Carex, the fourth was largely Carex with some Poa, and the fifth gizzard was empty".

During the month of June and particularly in the early spring the geese fed largely on the roots of sedges. This is most likely due to the fact that the stems, leaves and flowers are not yet mature or that in the early spring condition these structures do not furnish sufficient nutrients. Later in the season the geese utilize primarily leaves and spikelets. This is especially true of the young geese when on the post-hatching migration across the tundra. Lemieux (1959) found a similar sequence in the feeding habits of the Greater Snow Goose (Anser hyperborea atlantica). He states that in the early spring, roots of the legume Oxytropis maydellions and Polygonum viviparum (Knotweed) were utilized. Later on, especially when broods were accompanied by parents on lond the common foods consisted of blades of gross and leafy plants. Although the goslings food consisted primarily of marsh vegetation blades of grass were common. Delacour (1964) in his review of food habits of onserinae makes no mention of animal matter being utilized by these birds ond states that a major part of the food consists of grasses, sedges and semi-aquatic vegetation. Non of the specimens of Ross's Geese collected during this study contained animal material in the digestive tract. Barry (1956) observed young captive American Brant feeding on mosquitoes and larvae as well as short grass and flowers of Ronunculus.

TABLE XXI

RESULTS OF FOOD ANALYSIS OF 26 ROSS'S GOOSE VENTRICULI COLLECTED IN THE PERRY RIVER REGION 1963 and 1964

Food item	June(Frequency*)	July(Frequency*)
roots - Gramineae	1	-
- Cyperaceae	2	-
- unidentified	3	2
leaves - Gramineae	-	1 + 1G
- Cyperaceae	-	-
- Carex spp.	-	3 + 3G
- Betula spp.	-	2
- unidentified	2	3 + 5G
stems - Gramineae	1	1G
- Cyperaceae	-	1
- Carex spp.	-	1G
- Eriophorum spp.	-	1G
- unidentified	-	1
spikelets - Gramineae	-	2
- Cyperaceae	-	1
- Carex spp.	-	3 + 3G
- Eriophorum spp.	1	3

* Frequency of occurrence.

** G = gosling