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Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1977

Volume V. Receptors — Birds

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF INTERIOR
Bureau of Land Management

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Outer Continental Shelf Environmental Assessment Program

Boulder, Colorado

March 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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VOLUME V

RECEPTORS -- BIRDS

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Avian Community Ecology at Two Sites on Espenberg Peninsula in Kotzebue Sound, Alaska. A Composite Study of: 1) Habitat Utilization and Breeding Ecology of Waterbirds, 2) Habitat Utilization and Breeding Ecology of Shorebirds and Non-Waterbird Species, and 3) Habitat Utilization, Breeding Ecology, and Feeding Ecology of Predators of Birds.

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30 March 1977

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

Cape Espenberg is a 1.5 km wide peninsula, jutting 13 km into the western edge of Kotzebue Sound in western Alaska. It is comprised of a series of sand dune ridges, interspersed with numerous ponds and marshes. Prevailing winds are westerly during summer and currents, which sweep nearshore at Espenberg, come from the west. Thus, large oil spills on Chukchi Sea waters north of the Bering Strait to Kotzebue Sound are likely to be deposited on the beaches of Cape Espenberg.

The main objectives of this study are to: 1) determine the seasonality of habitat use by birds, 2) determine the productivity of nesting birds and factors affecting productivity, 3) determine use of the area by sea mammals, and 4) establish guidelines for future biological monitoring.

Although limited in total area (20.5 km^2), Cape Espenberg supports large concentrations of breeding loons, ducks, and shorebirds. Perhaps even more important are the mudflats in Espenberg Bay. Thousands of postbreeding and juvenile Pintails and shorebirds feed here from July through September during their southbound migration. Concentrations of molting sea ducks and migrating juvenile phalaropes were notably absent from Espenberg nearshore waters in 1976.

During the 1976 field season, 68 species of birds were observed. Thirty species nested on the cape, nine of which were recorded in high concentrations compared to nearby coastal areas. Birds nested most densely in marsh habitat, particularly where land and water formed a mosaic. Many species (shorebirds, passerines, some ducks) fed primarily in the marsh during the breeding season; others (loons, gulls, terns, some ducks) fed primarily in nearshore waters.

Although 1976 was a phenologically late year, there was no apparent affect on most nesting birds. The late season may have adversely affected the clutch sizes and breeding densities of some waterfowl and Western Sandpipers. Avian productivity was affectecd by the presence of one mammalian and two avian predators, which were common (and raised young) on the cape. Red foxes were the most important predators. They took numerous eggs and young, especially of waterfowl. Although arctic ground squirrel populations were high enough to serve as a partial buffer to fox predation on birds, microtine populations were too low to serve as a major food source for either of the avian predator species. Glaucous Gulls fed largely on marine organisms, although birds and eggs comprised a small part of their diet.

The majority of young birds were raised in the marsh. However, some waterfowl broods were moved to Espenberg Bay almost immediately after hatching. Post-breeding and post-fledging shorebirds congregated primarily on the mudflats in the bay. There they apparently fed on isopods (Arthropoda: Crustacea) and Ephyridae (Arthropoda : Insecta: Diptera). Thousands of Pintails and shorebirds were found here in August and September. Other habitats were used to a lesser extent by migrant birds.

Although some subsistence activities by Natives currently take place on the cape, their affects on the local breeding population of birds are minimal. Limited access to the marsh and restraint of pets is recommended to minimize the effects of future visitors on breeding birds in this area. Other recommendations to lessen human disturbance are provided.

Oil contamination of nearshore waters poses a threat to bird populations throughout the summer. Oil in leads in the ice may affect spring migrants which often concentrate in the limited open water of leads. Numerous birds rely upon marine organisms throughout the summer and would be subjected to oil contamination while foraging at sea. Beginning in July, post-breeding shorebirds concentrate on mudflats prior to or during migration. They are susceptible to oiling from July through September. Birds may also be indirectly affected by oil contamination through the loss of food resources.

The beach of Cape Espenberg is a likely site of sand extraction for petroleum development-related activities. Such an activity during summer may produce sufficient turbidity to lower the feeding efficiency of birds around the site, as well as downcurrent. Concomitant noise may lower the productivity of nesting birds, although this subject is poorly understood. More importantly, sand extraction may endanger the integrity of the cape, through subsequent erosion of the dunes, and jeopardize marsh habitat.

We have begun baseline monitoring of the breeding and migrating bird populations, the occurrence of beached birds and mammals, and the intertidal invertebrates.

II. INTRODUCTION

Justification

Cape Espenberg was chosen as our study area primarily for two reasons. First, it is highly susceptible to oil spills. Currents sweep easterly along the outside coast and especially at the cape. Prevailing winds are coming onshore from across open waters of the Chukchi Sea during July through September. Thus large oil spills on Chukchi Sea waters north of Bering Strait to Kotzebue Sound most likely will be deposited along the beach of Cape Espenberg. Second, Cape Espenberg hosts a large variety of breeding and staging birds. Especially high nesting densities of Red-throated Loons, Common Eiders, Glaucous Gulls, Semipalmated Sandpipers, Dunlins, Northern Phalaropes, and Lapland Longspurs were identified by Kessel and Gibson (1974). Of even greater importance are the intertidal mudflats along the inner beach south of the cape. These serve as the feeding grounds for 1000s of Pintails, Dunlins, Semipalmated Sandpipers, Western Sandpipers and lesser numbers of other shorebird species. Furthermore, these beaches, tideflats, and adjacent waters are the rearing grounds for many locally nesting Common Eiders and Emperor Geese.

For these reasons, we chose to determine: 1) distribution, abundance and habitat utilization of nesting, molting, rearing and migrating birds; and 2) factors affecting the distribution and abundance of birds--especially phenology, predators, and food availability in the intertidal mudflats. Furthermore, through an extensive banding program and intensive observation of several nesting species, we hope to gather information on the breeding ecology of several key species. Recaptures of banded juvenile birds also have permitted determination of growth rate, and in the future may reveal fidelity to Cape Espenberg.

Objectives

1. To determine phenology of events from spring arrival through departure of birds,
2. to determine the distribution and abundance of birds and their predators,
3. to describe habitat utilization of birds and their predators during migration, the nesting season, and the brood rearing season;
4. to estimate production of all avian species nesting on Cape Espenberg;
5. to determine the abundance of small mammals which are utilized by avian and mammalian predators,
6. to describe availability of food and utilization by shorebirds,
7. to determine distribution and abundance of sea mammals,

8. to provide recommendations to lesson the impact of developments on the avian community and avian habitat at Cape Espenberg, and
9. to establish baseline study plots to evaluate the impact of developments on the avian community and avian habitat at Cape Espenberg.

The last two objectives are relevant to petroleum development. We have established baseline plots to monitor nesting densities, nesting success, habitat utilization, abundance of beached birds and mammals, and availability of invertebrate foods. Based on data collected in 1976 and again in 1977, we can identify critical habitats and critical times when oil spills would be most harmful to birds and their habitats on Cape Espenberg. Also, we can suggest restrictions for air traffic over Cape Espenberg which would support exploratory drilling efforts. Other recommendations will emerge with the completion of the 1977 field work and during the process of planning for petroleum exploration and production (i.e. Environmental Impact Statements).

III. CURRENT STATE OF KNOWLEDGE

The current state of knowledge is based upon brief visits in 1973 by D. Gibson and H. Melchior and on our observations during an abbreviated field season in 1976 (4 June to 15 September). Observations of birds (Kessel and Gibson 1974) and of mammals (Melchior 1974) provide little more than lists and relative densities of species. We have phenology data for the nesting, brood rearing, and migration periods in 1976, but little or no data on spring migration. Based on weather records at Kotzebue and dates of flowering for plant species compared with other studies (see below), 1976 phenology was about one week later than average. This lateness of spring undoubtedly had an effect on avian distribution, abundance, production, and habitat utilization. Our data on mammals indicate a very low density of microtines, but an abundance of ground squirrels. Few sea mammals were observed, and red foxes were at a moderate population level. Populations of mammals may change in 1977, especially the microtine population which was also low in 1973 (Melchior 1974).

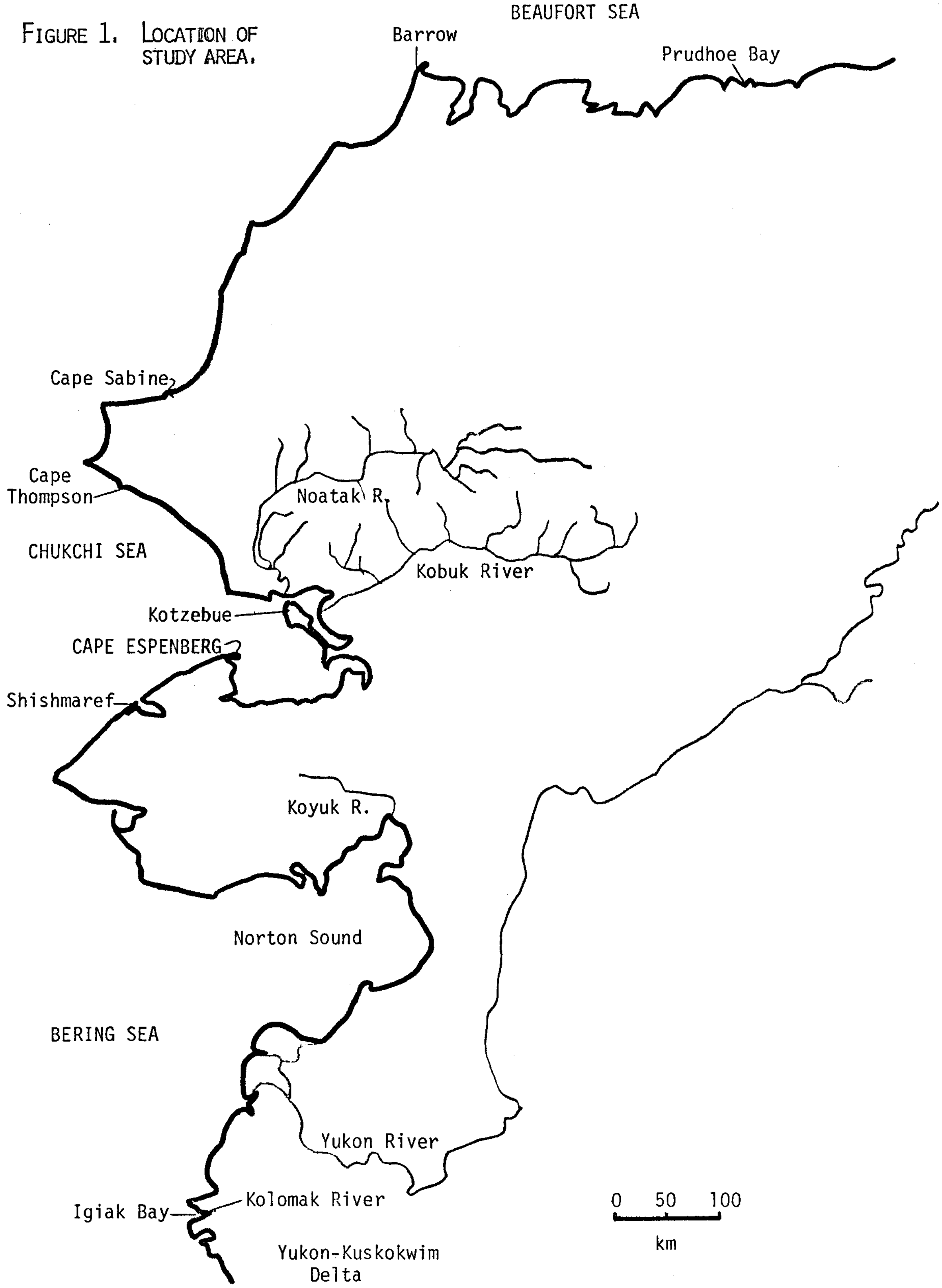
We have data on occurrence and relative abundance of foods used by shorebirds, but little data on actual shorebird food habits.

The 1977 field season will provide the opportunity for gathering comparative data on phenology, avian distribution, abundance, production, and habitat utilization; abundance of mammals, and abundance of invertebrates and their utilization by shorebirds.

IV. STUDY AREA

The Espenberg Peninsula lies 60 km southwest of Kotzebue, Alaska (Fig. 1). Our study area was confined mainly to Cape Espenberg which

FIGURE 1. LOCATION OF STUDY AREA.



is a 1.5 km wide peninsula jutting 13 km into the western edge of Kotzebue Sound. Cape Espenberg is a series of sand dune beach ridges interspersed with numerous ponds and marsh habitat (Fig. 2).

The vegetation of the cape has been characterized as "coastal meadows-dwarf shrub tundra mosaic" by Anderson et al. (1974). The sand dunes are colonized first by Elymus arenarius (plant names according to Hultén 1968) and Honckenya peploides. Mid-successional species on dune ridges include: Potentilla villosa, Lathyrus maritimus, Calamagrostis canadensis, Stellaria sp., Chrysanthemum arcticum, Artemesia Tilesii, Pedicularis spp., and several other grasses and forbs which have not yet been identified. Depressions between sand dunes often have small stands of dwarf Salix spp. and shallow ponds are typically surrounded by Juncus spp. and Carex spp. These dunes rise to a maximum of 10 m.

Tundra ridges are dominated by lichens, Potentilla villosa, Silene acaulis, Empetrum nigrum, Vaccinium vitis-idaea, Betula nana, and Salix glauca. Ledum palustre, Arctostaphylos alpina, Andromeda polifolia, Oxytropis spp., Cassiope tetragona, Pedicularis spp., Carex spp., Rubus chamaemorus, and other species also occur on these tundra ridges.

Approximately 1 to 2 m below these tundra ridges are marshes. There is a mosaic of vegetation in these marshes. Characteristic types include: tussock-shrub, cotton grass-sedge, sedge meadow, sedge-saltgrass meadow. The tussock-shrub type includes the following dominant species: Eriophorum angustifolium, Ledum palustre, Carex bigelowii, Vaccinium uliginosum, and Betula nana. Other species included: Rubus chamaemorus, Cassiope tetragona, Empetrum nigrum, and several grass and forb species.

Cottongrass-sedge was dominated by Eriophorum angustifolium, E. russeolum, and Carex aquatilis. Other species included: Betula nana, Andromeda polifolia, Arctostaphylos alpina, Vaccinium vitis-idaea, V. uliginosum, Ledum palustre and Cassiope tetragona.

Sedge meadow consisted of Carex aquatilis as the dominant species, and the following species: Eriophorum angustifolium, E. russeolum, Pedicularis sudetica, Betula nana, and Salix sp. Sedge meadow occurred over much of the flat marshy areas containing few or no hummocks.

Sedge-saltgrass meadow dominated a few sites along the inner (south) coast. Puccinellia phryganodes, Carex subspathacea, and Carex spp. dominate these sites. Other species include: Stellaria humifusa, Potentilla Egedii, Saussurea sp., and Chrysanthemum arcticum.

Emergent and submersed aquatic vegetation varied with pond depth and location. Some ponds amongst the outer sand dunes lacked submersed

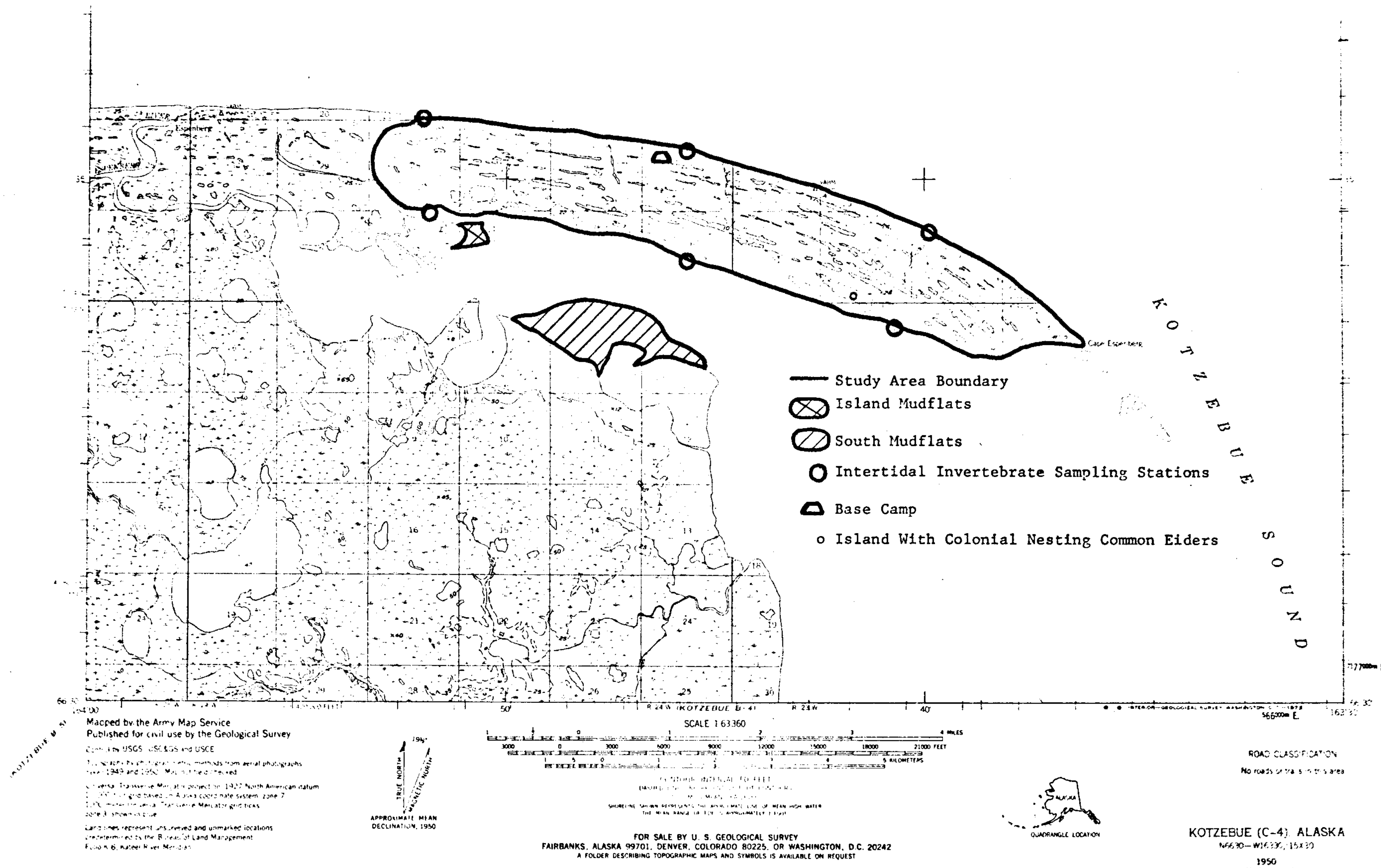


FIGURE 2. LOCATIONS OF STUDY AREA, ISLAND MUDFLATS, SOUTH MUDFLATS, INTERTIDAL SAMPLING STATIONS, CAMP, AND, ISLAND WITH COLONIAL NESTING COMMON EIDERS.

species, but did contain Juncus and Carex species. Ponds in marshy areas contained: Arctophila fulva, Potentilla palustris, Menyanthes trifoliata, Hippuris vulgaris and Ranunculus sp.

During the nesting season our efforts were directed mainly to four nesting plots and four census transects (Fig. 2). In addition, the outer and inner beaches along the coast were checked for dead birds and mammals. Although most of our work was confined to the nesting plots and census transects, we covered nearly all of the Cape on foot at least once during the field season. In addition, a few hiking trips were taken to Espenberg and along Espenberg River and a connecting slough to its mouth in Kotzebue Sound. Fred Goodhope, Jr., a part-time resident of Espenberg, kindly took us by boat along the outside beach of Cape Espenberg past several sandbars to an island about 6 km south of the tip of Cape Espenberg and to another island at least 6 km south of the base of the cape on 23 July. These two islands will be discussed under Results and Discussion.

V. METHODS

A detailed description of our methods for 1) locating nests, 2) data recorded at nests, 3) banding, tagging, and marking birds, 4) determining species abundance and distribution, and 5) sampling to determine food habits is given in our Quarterly Report for 1 July to 30 September 1976. Locations of nest sampling plots, census transects, and intertidal sampling stations are given in Figs. 2 and 3.

Intertidal invertebrate samples and bird stomachs were processed by D. Schamel at the Marine Sorting Center, Institute of Marine Science, University of Alaska. Mud samples were screened through 1.0 mm mesh to remove smaller sediments. The remaining material was transferred to a sorting tray, from which invertebrates were located with the aid of an illuminated magnifying lens, and removed. Personnel from the Sorting Center assisted with identifications. Wet weights were determined to the nearest 0.001 g., using a top-loading Mettler balance. Fully processed material has been retained in glass vials.

Glaucous Gull pellets, droppings, and food items collected around nests were processed by D. Tracy and D. Schamel. Each pellet or dropping was broken apart, then examined with a dissecting microscope. Most items in the pellets and droppings were identified easily to class, while many were identified to species by comparison with invertebrates collected at Espenberg. Diagnostic parts such as microtine jaws and fish otoliths were saved for later identification to species. Percent composition of each pellet or dropping, by food item, was estimated. After processing, each pellet or dropping was preserved in a small envelope. Many pellets and droppings remain to be analyzed.

VI & VII. RESULTS AND DISCUSSION

A. Avian Occurrence, Abundance, and Habitat Utilization

Occurrence:

During the 1976 field season from 4 June to 15 September, 68 species of birds were recorded on Cape Espenberg (Table 1). This is an increase of 23 species over the checklist reported by Kessel and Gibson (1974) for 3-5 July and 4-6 September 1973. Of these 68 species, 30 were nesting on Cape Espenberg. Of the remaining 38 species, 5 were spring migrants, 11 occurred during summer as non-breeders, 17 were fall migrants and 5 were migrants in both spring and fall.

As noted by Kessel and Gibson (1974), Cape Espenberg on the Seward Peninsula lies in the nearctic region. However, at Cape Espenberg there were several bird species not of nearctic origin and affinities. Species can be holarctic--regularly occurring in the arctic and north temperature zone of North America and Eurasia; palearctic--with Eurasian affinities; nearactic--with North American affinities, and beringian--differentiated in the Bering Sea during previous interglacial (land bridge connections between Siberia and Alaska) and glacial periods (Fay and Cade 1959:73). Birds are categorized as such in Table 2. It is important to note that palearctic species for instance, may use Cape Espenberg as a staging area. Even though these species breed elsewhere, Cape Espenberg or adjacent habitat may be a critical staging area during their migrations. For example, birds killed as a result of oil pollution at Cape Espenberg might not be observed on their wintering grounds in New Zealand (Bar-tailed Godwit), or on their breeding grounds in Siberia (Sharp-tailed Sandpiper for example).

Compared with adjacent areas along the western coast of Alaska, Cape Espenberg has a lower avian diversity (Table 3). This can be explained by a lack of two key habitats: nesting cliffs for seabirds, and willow thickets for passerines. Although more species will be added to the checklist during the more extended 1977 field season on Cape Espenberg, we do not expect to add more than a few breeding species.

Abundance:

Estimates of avian abundance on Cape Espenberg were derived by several methods. Our most reliable data were collected from four nesting plots. Two of 25 ha each were surveyed for all species, but most intensively shorebirds. Two plots of 1 km^2 each were surveyed for waterbirds primarily, but other species were recorded. Other estimates were obtained from census transects through four habitat types (Fig. 3). Also, rough estimates were made based on daily bird observations

Table 1. Nesting density, occurrence, and habitat use of birds at Cape Espenberg, 1976.

Species	Nesting Density (km^2)	OCCURRENCE[1] Spring	Summer	Fall	Nearshore Coastal Waters	Bay Waters	Outer Beach Tideflats	Inner Beach Mudflats	Sandy Outer Beach	Driftwood Along Coast	Driftwood Along Bay	TOTAL NEARSHORE	Outer Sand Dune	Tundra Ridge	Marsh	TOTAL ONSHORE
Yellow-billed Loon	?	10s	10s	<10s		10s						10s			10s	10s
Arctic Loon	0.2	10s	10s	10s	10s	10s						10s			10s	10s
Red-throated Loon	5.	100s	100s	~100	10s	100s						100s			100s	100s
Whistling Swan		10s	<10												10s	10s
Canada Goose	0.1	2	8	100s	100s							100s		10s	10s	~100
Black Brant	0.1	2	2	10s	10s							10s		2	2	2
Emperor Goose	0.5	10s	10s	100s	100s	10s		10s				100s		10s	10s	10s
Snow Goose		10s													10s	10s
Mallard				<10											<10	<10
Pintail	0.1	<10	<10	1000s				1000s				1000s			100s	100s
Green-winged Teal	0.2	<10	<10	<10											<10	<10
American Wigeon		<10		<10											<10	<10
Greater Scaup	0.5	10s	10s	10s											10s	10s
Oldsquaw	6.	100s	100s	100s	10s	10s						100s			100s	100s
Common Eider	45.	1000s	1000s	1000s	100s	100s		100s				1000s			1000s	1000s
King Eider	0.1	10s	10s	10s	10s	10s	<10	10s				10s			10s	10s
Spectacled Eider	0.1	10s	10s	10s		10s		10s				10s			10s	10s
Surf Scoter			100s		100s							100s				
Red-breasted Merganser		10s	10s	<10	10s							10s			10s	10s
Goshawk				<10									<10			<10
Rough-legged Hawk				1											1	1
Marsh Hawk		1		<10											<10	<10
Willow Ptarmigan	0.5	10s	10s	10s									10s	10s	10s	10s
Sandhill Crane	0.5	10s	10s	10s					<10	<10	<10	10s	10s	10s	10s	10s
American Golden Plover		10s		10s				10s				10s		10s	10s	10s
Black-bellied Plover		<10		<10										<10		<10
Ruddy Turnstone	0.4	10s	10s	10s			<10		<10	<10		<10		10s		10s
Black Turnstone	0.1	<10	<10	<10				<10				<10			<10	<10
Common Snipe			1												1	1
Whimbrel			10s	10s			10s	10s				10s		10s	10s	10s
Bristle-thighed Curlew			<10	<10			<10	<10				<10		<10	<10	<10
Red Knot				<10				<10				<10				
Sharp-tailed Sandpiper				10s											10s	10s
Pectoral Sandpiper			10s	100s											100s	100s
Baird's Sandpiper			<10	<10				<10				<10				
Curlew Sandpiper			1					1				1				
Dunlin	16.	100s	100s	1000s				1000s		100s	100s	1000s			100s	1000s
Semipalmated Sandpiper	20.	100s	100s	1000s				1000s				1000s		100s	100s	100s
Western Sandpiper	20.	100s	100s	1000s				1000s				1000s		100s	100s	100s
Sanderling				10s			10s					10s				
Long-billed Dowitcher	1.2	10s	10s	10s				10s				10s			10s	10s
Bar-tailed Godwit				<10			<10	<10				<10			<10	<10
Hudsonian Godwit				<10											<10	<10
Red Phalarope	20.	100s	100s	100s	10s	100s		100s				100s			100s	100s
Northern Phalarope	40.	1000+	1000+	1000+	10s	100s	10s	100s				100s	10s		1000+	1000+
Pomarine Jaeger		<10	<10		<10							<10				
Parasitic Jaeger	0.7	10s	10s	10s										10s	10s	10s
Long-tailed Jaeger		10s	10s	10s										10s		10s
Glaucous Gull	11.	100s	100s	100s	100s	100s	100s	100s	10s	10s		100s		10s	100s	100s
Mew Gull				2	2							2				
Black-legged Kittiwake		10s	10s	10s	10s	10s						10s				
Sabine's Gull	1.2	10s	10s	<10	10s	10s		<10				10s			10s	10s
Arctic Tern	5.	100s	100s	10s	100s	100s	100s	100s		10s		100s		10s	100s	100s
Aleutian Tern				2	2							2				
Common Murre		10s	10s	10s	10s							10s				
Thick-billed Murre		10s	10s	10s	10s							10s				
Horned Puffin		<10	<10		<10							<10				
Tufted Puffin		10s	10s		10s							10s				
Snowy Owl				<10										<10	<10	<10
Short-eared Owl		<10	<10	<10									<10	<10	<10	<10
Common Raven		<10	<10	<10					<10			<10		<10		<10
Wheatear		<10		<10										<10		<10
Arctic Warbler		<10												<10		<10
Yellow Wagtail		<10												<10		<10
Redpoll spp.	0.1	10s	10s	10s										10s		10s
Savannah Sparrow	1.	10s	10s	10s										10s	10s	10s
White-crowned Sparrow				<10										<10		<10
Lapland Longspur	6.	100s	100s	100s			10s	10s		100s		100s	10s	100s	10s	100s

[1]Estimated maximum number of birds present at any one time (not cumulative).

Table 2. Cape Espenberg avian species with Palearctic or Beringian affinities, or breeding grounds.[1]

Palearctic	Beringian
Goshawk	Yellow-billed Loon
Red Knot	Black Brant
Sharp-tailed Sandpiper	Emperor Goose
Curlew Sandpiper	Common Eider
Bar-tailed Godwit	Spectacled Eider
Arctic Warbler	King Eider
	Black Turnstone
	Bristle-thighed Curlew
	Pectoral Sandpiper
	Dunlin
	Western Sandpiper
	Long-billed Dowitcher
	Glaucous Gull
	Black-legged Kittiwake
	Aleutian Tern
	Common Murre
	Thick-billed Murre
	Horned Puffin
	Yellow Wagtail
	Lapland Longspur

[1]Modified from Kessel and Gibson 1974.

Table 3. Comparison of avian species recorded at Cape Espenberg in 1976 with adjacent areas.

Species	Location						
	Cape Espenberg	Barrow[2]	Cape Sabine[3]	Cape Thompson[4]	Shishmaref Inlet[5] Seward Peninsula	Inglutalik River, Norton Bay[6]	Igiak Bay[7]
Breeding[1]	30	35	55	65	39	20	59
Non-breeding	37	116	35	55	39	62	31
Total	68	151	90	120	78	82	90

[1]Includes those species nesting or suspected of nesting.

[2]Pitelka 1974.

[3]Childs 1969.

[4]Williamson et al 1966.

[5]Noble and Wright 1977.

[6]J. Shields (pers. comm.)

[7]Eisenhower 1976.

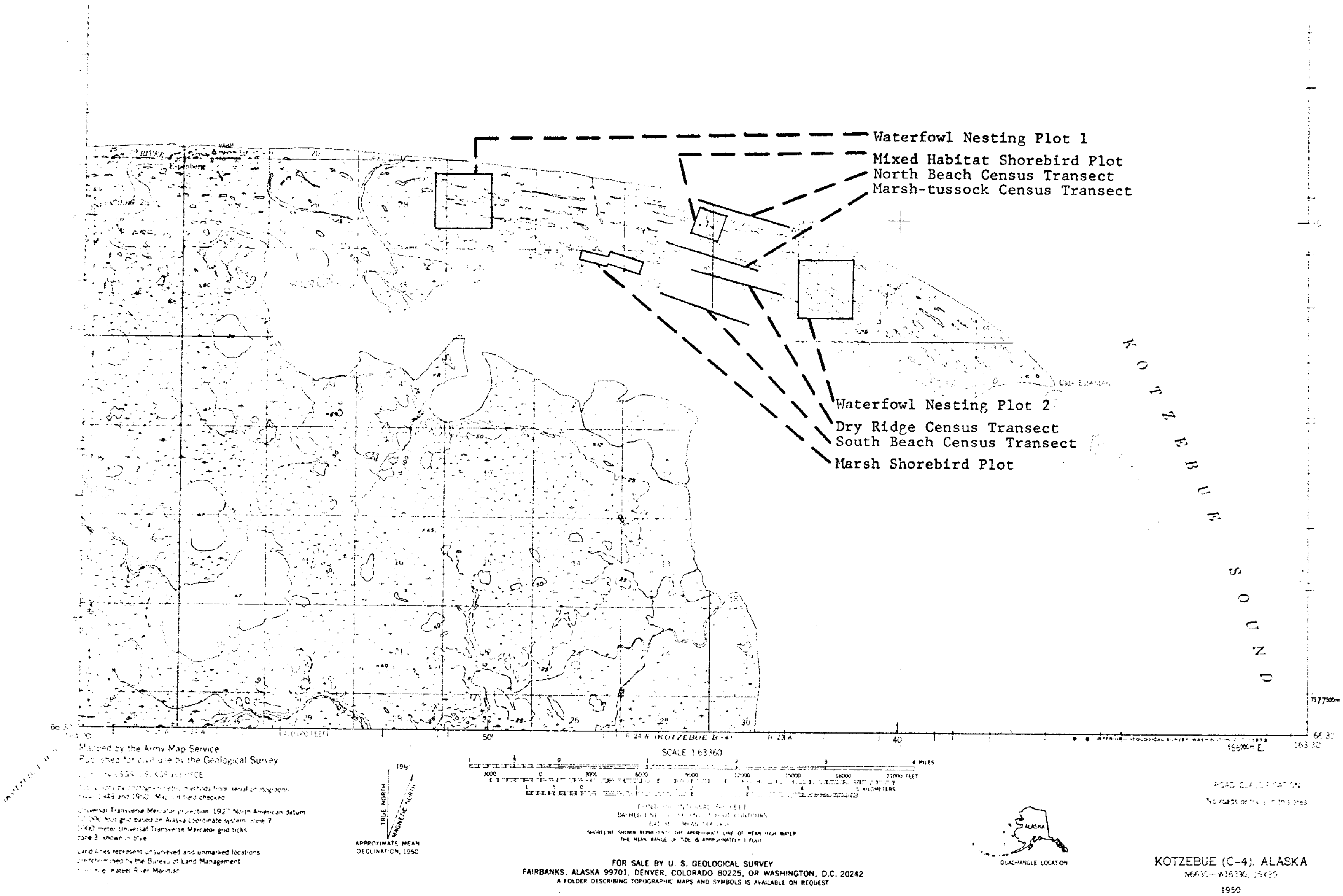


FIGURE 3. LOCATIONS OF NESTING PLOTS AND CENSUS TRANSECTS.

as reported in Table 5 of the 1 October-31 December 1976 Quarterly Report. Because of the lack of total coverage of Cape Espenberg, and the mosaic of habitat types, we are unable to provide estimates more accurate than orders of magnitude (Table 1). Only when a few individuals were present, can we give the exact number of birds observed.

Six species occurred in the 1000s at any one time: Pintail, Common Eider, Dunlin, Semipalmated Sandpiper, Western Sandpiper, and Northern Phalarope. All of these species nested on Cape Espenberg, but numbers of Pintails and sandpipers were enhanced substantially by arrival of fall migrants which staged primarily in the bay south of Cape Espenberg.

Besides these very abundant species, 100 or more pairs nesting on Cape Espenberg were recorded for: Red-throated Loons, Oldsquaws, Red Phalaropes, Glaucous Gulls, Arctic Terns and Lapland Longspurs. A more detailed summary, analysis, and comparison with other areas will be presented under the section on Avian Production.

Habitat Utilization:

At least 10 habitat types can be described for Cape Espenberg. These are listed in Table 1 along with the estimated order of magnitude of use by each species. First, a description of these habitat types is appropriate.

Nearshore coastal waters refer to the Chukchi Sea up to 2 km north of Cape Espenberg. This habitat was ice-bound until 18 July 1976. Leads were present by mid-June. Bay waters include those to the south of Cape Espenberg, in Kotzebue Sound, and will be designated as Espenberg Bay. Those waters are shallow, generally less than 70 cm, but are deeper during periods of high tides and winds from the east and south. Generally, both the nearshore coastal waters of the Chukchi Sea and waters of Espenberg Bay are calm while the ice pack is present, and during calm weather. Once ice disintegrates, wind action is common. Relatively calm waters occur on the lee side of Cape Espenberg unless winds exceed 25-30 knots.

The outer beach tideflat is a narrow zone between high and low tides, which are generally no more than a 30 cm fluctuation (USGS map). Since the sandy beach is on a moderate gradient, this intertidal zone is only a few meters wide. Where small streams enter the coast, a tideflat of up to 4 m may be exposed at low tide. The outer beach tideflat is sandy and subject to much wave action during storms, after ice has disintegrated. Hence it harbors a lower diversity and generally less food for birds compared with the inner beach tideflats.

In contrast, the inner beach tideflats of Espenberg Bay are richer in invertebrates because they have a muddy bottom and are influenced less by storms. Mudflats are on a low gradient and may extend for 20 m or more, depending on tides and winds in Espenberg Bay.

One large slough serves as the west boundary of our Cape Espenberg study area (Fig. 3). This slough is tidal to only a minor extent. In 1976 its north mouth was plugged by sand, most likely deposited by storms during the previous summer. According to Fred Goodhope, Jr., this slough is open most years.

The sandy outer beach is that zone from high tide to the vegetated dunes on the north side of Cape Espenberg. It consists of almost pure sand, however debris does wash ashore. Based on accumulation of drift wood, prevailing winds, and plant succession, the outer beach is building northward. Hence there is an unstable intertidal area which is being buried constantly. Data on sediment transport and deposition is being collected by OCSEAP investigator Jan Cannon (pers. comm.).

Driftwood accumulates along the storm zone of the outer sandy beach and to a much lesser extent on the beach along Espenberg Bay. These accumulations of logs, limbs, and litter provide shelter for such pioneering plants as Honckenya peploides and Elymus arenarius.

The outer sand dunes, tundra ridges, and marsh habitats have been described under Description of the Study Area.

Of the nearshore habitats, coastal waters, bay waters, and inner beach mudflats receive the most use by birds (Table 1). This is to be expected since 16 species are considered to be marine and many other species feed at sea or on intertidal mudflats. In spring many of these birds are initially dependent upon open leads which are the only feeding and/or resting sites available until ice melts in ponds and marshes. Coastal and bay waters continue to serve as feeding and resting sites (Figs. 10-14, 21-26 in 1 Oct.-31 Dec. 1976 Quarterly Report) until continuous ice forms in the fall.

Once ice disintegrates and/or is carried off by currents and wind (by late June in 1976), the mudflats of Espenberg Bay have even greater use. Geese, dabbling ducks, and occasional shorebirds feed and rest on the mudflats during the breeding and brood-rearing season (Table 4). After young hatch in July, some move to the tideflats for feeding. This is a critical time period. Young are growing rapidly and have tremendous demands for protein. Likewise some waterfowl are molting in the bay and also feed on invertebrates which constitute a rich protein source. Migrant dabbling ducks and shorebirds occur in high densities on Espenberg Bay mudflats during August and early September (Tables 1 and 2, 1 Oct.-31 Dec. 1976 Quarterly Report). Thus, the

Table 4. Avian habitat utilization for Cape Espenberg during 4 June-15 September 1976.

Species N = Nest Site B = Feeding Site during Breeding Season R = Brood-rearing Nesting Site F = Brood-rearing Feeding Site M = Migration Resting Site S = Migration Feeding Site	Nearshore Coastal Waters	Bay Waters	Outer Beach Tideflats	Inner Beach Mudflats	Sandy Outer Beach	Driftwood Along Shore	Outer Sand Dune	Tundra Ridge	Marsh	Sedge-Saltgrass Meadow
Yellow-billed Loon	-	BMS	-	-	-	-	-	-	NRM	-
Arctic Loon	BRFMS	BRFMS	-	-	-	-	-	-	NBRFMS	-
Red-throated Loon	BRFMS	BRFMS	-	-	-	-	-	-	NRFM	-
Whistling Swan	-	-	-	-	-	-	-	M	MS	-
Canada Goose	-	-	-	MS	-	-	-	RM	NBRFM	BRFMS
Black Brant	-	RFMS	-	BRFMS	-	-	-	BRFMS	NBRFMS	BRFMS
Emperor Goose	-	RFMS	-	BRFMS	-	-	-	-		-
Snow Goose	-	-	-	-	-	-	-	-	MS	-
Mallard	-	-	-	-	-	-	-	-	MS	-
Pintail	-	-	-	MS	-	-	-	-	NBRFMS	-
Green-winged Teal	-	-	-	-	-	-	-	-	NBRFMS	-
American Wigeon	-	-	-	-	-	-	-	-	MS	-
Greater Scaup	-	-	-	-	-	-	-	-	NBRFMS	-
Oldsquaw	BMS	BMS	-	-	-	N	-	-	NBRFMS	-
Common Eider	BRFMS	BRFMS	-	RFMS	-	-	-	N	NBRFMS	-
King Eider	BMS	BMS	-	RFMS	-	-	-	-	NBMS	-
Spectacled Eider	BMS	BMS	M	RFMS	-	-	-	-	NBRFMS	-
Surf Scoter	MS	-	-	-	-	-	-	-		-
Red-breasted Merganser	MS	-	-	-	-	-	-	-	MS	-
Goshawk	-	-	-	-	-	-	M	-	M	-
Rough-legged Hawk	-	-	-	-	-	-	-	-	M	-
Marsh Hawk	-	-	-	-	-	-	-	-	MS	-
Willow Ptarmigan	-	-	-	-	-	FS	BRFMS	NBRFMS	NBRFMS	-
Sandhill Crane	-	-	BFS	BFS	-	BFS	BRFMS	BRFMS	NBRFMS	BFS

Table 4. Continued

Species N = Nest Site B = Feeding Site during Breeding Season R = Brood-rearing Resting Site F = Brood-rearing Feeding Site M = Migration Resting Site S = Migration Feeding Site	Nearshore Coastal Waters	Bay Waters	Outer Beach Tideflats	Inner Beach Mudflats	Sandy Outer Beach	Driftwood Along Shore	Outer Sand Dune	Tundra Ridge	Marsh	Sedge-saltgrass Meadow
American Golden Plover	-	-	-	S	MS	-	-	MS	MS	MS
Black-bellied Plover	-	-	-	FS	-	-	-	MS	F	-
Ruddy Turnstone	-	-	BRFMS	-	BRFMS	BRFMS	-	NBRF	-	-
Black Turnstone	-	-	-	MS	-	-	-	-	NBRFMS	BRFMS
Common Snipe	-	-	-	-	-	-	MS	MS	MS	-
Whimbrel	-	-	MS	MS	-	-	-	MS	MS	-
Bristle-thighed Curlew	-	-	MS	MS	-	-	-	MS	MS	-
Red Knot	-	-	-	MS	-	-	-	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	MS	-
Pectoral Sandpiper	-	-	-	-	-	-	-	-	BMS	-
Baird's Sandpiper	-	-	-	MS	-	-	-	-	-	-
Curlew Sandpiper	-	-	-	MS	-	-	-	-	-	-
Dunlin	-	-	MS	MS	MS	MS	-	M	NBRFMS	RFMS
Semipalmated Sandpiper	-	-	BMS	BMS	-	-	NB	NBRFMS	NBRFMS	RFMS
Western Sandpiper	-	-	-	BMS	-	-	-	NBRFMS	NBRFMS	RFMS
Sanderling	-	-	MS	-	MS	MS	-	-	-	-
Long-billed Dowitcher	-	-	-	MS	-	-	-	-	NBRFMS	RFMS
Bar-tailed Godwit	-	-	MS	MS	-	-	-	-	MS	-
Hudsonian Godwit	-	-	-	-	-	-	-	-	MS	-
Red Phalarope	MS	MS	-	MS	-	-	-	-	NBRFMS	MS
Northern Phalarope	MS	MS	MS	MS	-	-	NB	-	NBRFMS	MS
Pomarine Jaeger	S	-	-	-	-	-	-	-	-	-
Parasitic Jaeger	S	-	MS	-	-	-	-	BMS	NBRFMS	NBRFMS
Long-tailed Jaeger	S	-	-	-	-	-	-	MS	MS	-

Table 4. Continued

Species N = Nest Site B = Feeding Site during Breeding Season R = Brood-rearing Resting Site F = Brood-rearing Feeding Site M = Migration Resting Site S = Migration Feeding Site	Nearshore Coastal Waters	Bay Waters	Outer Beach Tideflats	Inner Beach Mudflats	Sandy Outer Beach	Driftwood Along Shore	Outer Sand Dune	Tundra Ridge	Marsh	Sedge-saltgrass Meadow
Glaucous Gull	BS	BRFMS	BFMS	BRFMS	BRFMS	BRFMS	RM	RM	NBRFMS	-
Mew Gull	-	S	-	-	-	-	-	-	-	-
Black-legged Kittiwake	BS	S	M	-	-	-	-	-	-	-
Sabine's Gull	B	BS	BS	BS	-	-	-	-	NBRF	-
Arctic Tern	BS	BS	BFS	BRFMS	RFMS	NM	NR	NRF	NBRFMS	-
Aleutian Tern	S	S	-	-	-	-	-	-	-	-
Common Murre	MS	-	-	-	-	-	-	-	-	-
Thick-billed Murre	MS	-	-	-	-	-	-	-	-	-
Horned Puffin	MS	-	-	-	-	-	-	-	-	-
Tufted Puffin	MS	-	-	-	-	-	-	-	-	-
Snowy Owl	-	-	-	-	-	-	MS	MS	MS	-
Short-eared Owl	-	-	-	-	-	-	MS	MS	MS	-
Common Raven	-	-	-	-	-	-	MS	MS	-	-
Wheatear	-	-	-	-	-	-	-	MS	-	-
Arctic Warbler	-	-	-	-	-	-	MS	MS	-	-
Yellow Wagtail	-	-	-	-	-	-	-	MS	-	-
Redpoll spp.	-	-	-	-	-	NBRF	MS	-	-	-
Savannah Sparrow	-	-	-	-	-	-	-	BRFMS	NBRFMS	-
White-crowned Sparrow	-	-	-	-	-	-	-	MS	-	-
Lapland Longspur	-	-	MS	BMS	MS	BRFMS	NBRFMS	NBRFMS	NBRFMS	MS

mudflats of Espenberg Bay are extremely important as a feeding area during July, August, and September. The adjacent bay waters are used by molting ducks and duck broods which feed and rest there during July and August. Aerial surveys conducted in 1976 by C. Harrison (pers. comm.) indicate that concentrations (+30 birds/km^2) of eiders and other seabirds occur off the Noatak and Kobuk River mouths. However, the south side of Kotzebue Sound, and near Espenberg Peninsula have not been surveyed intensively during summer, thus use of areas adjacent to Cape Espenberg is largely unknown.

The sandy outer beach and the driftwood zone around Cape Espenberg were used predominately by resting shorebirds, gulls, terns, and Lapland Longspurs (Tables 1 and 4). Sandhill Cranes, some shorebirds and Lapland Longspurs foraged on these areas. Ruddy Turnstones set up territories around beached walrus carcasses where they fed on fly pupae. Glaucous Gulls fed on the remains of walrus and other mammal and bird carcasses washed ashore (Table 5). Only Arctic Terns, at least one Oldsquaw and one Redpoll were known to nest in the driftwood zone.

Outer sand dunes were the least used by birds (Table 1 and 4). Of the few species using sand dunes, most roosted on them. Willow Ptarmigan, Whimbrels, Bristle-thighed Curlews, Sandhill Cranes and Glaucous Gulls fed on insects and berries on the dunes. Lapland Longspurs and Semiplamated Sandpipers nested amongst beachgrass of the outer sand dunes.

In contrast, greater use was made of tundra ridges for nest sites. At least 9 species nested on tundra ridges (Table 4). Geese, some shorebirds, Long-tailed Jaegers, and passerines fed on berries and/or insects available on the tundra. Tundra ridges and associated sand dunes and blowouts also were used as den sites for red foxes and arctic ground squirrels.

Marsh habitat was utilized by 25 out of 30 nesting species (Tables 1 and 4). Marshes provided a variety of nesting habitats including: hummocks, peninsulas, islands, and a mosaic of water and land. Hummocks, and islands often were selected by eiders, gulls, and terns as nesting sites. These were usually not accessible to red foxes, thus were more secure from predation and more likely to be successful.

One island in the large lake in southwest section 32 (Fig. 2) was the site of a colony of nesting Common Eiders and Arctic Terns. This island was 10 x 100 m and vegetated with various forbs, grasses, sedges, and dwarf willows. A maximum of 234 active Common Eider nests were counted on 8 July 1976. Also nesting were 17 pairs of Arctic Terns, 2 pairs of Glaucous Gulls, one Oldsquaw, and one pair of Arctic Loons.

Other aggregations in marshes were recorded for nesting Common Eiders, Glaucous Gulls, Sabine's Gulls, and Arctic Terns. These

Table 5. Summary of bird and mammal carcasses found beached on Cape Espenberg, 1976.

Species	Number	Species	Number
Shearwater spp.	2	Arctic Tern	3
Fulmar	4	Kittiwake spp.	39
Dabbler	1	Murre spp.	20
Oldsquaw	6	Puffin spp.[1]	4
Eider spp.	3	Crested Auklet	1
Black Scoter	1	Unidentified Alcid	3
White-winged Scoter	1	Unidentified Seabird	5
Shorebird	1	Common Raven	2
Parasitic Jaeger	2	Unidentified Bird	2
Long-tailed Jaeger	1	Bearded Seal	3
Glaucous Gull	4	Walrus[2]	1

[1] Only one Horned Puffin was found with a moderate amount of oil; no other carcasses were oiled.

[2] Carcass washed ashore during 1976; approximately 25 remained from previous years.

species preferred to nest on islands or peninsulas at ponds and lakes. High densities of nesting Red and Northern Phalaropes also were found in marshes (Table 1).

Marshes served as feeding sites for most non-pelagic species. Nesting shorebirds, and later their young, fed extensively in marsh habitat. Migrant Pectoral and Sharp-tailed Sandpipers were found almost exclusively in marshes. Migrant Golden Plovers frequently fed in marsh areas. During high tide, 1000s of Dunlins were sometimes found in this habitat, both roosting and feeding. Insects were frequently captured by Arctic Terns in marsh areas and fed to the young, which passed the pre-fledging period in the relative safety of the wet marsh.

Sedge-saltgrass meadows served as feeding and resting sites for geese and some insectivorous shorebirds (Table 4). The total area of these meadows was very limited and use was minimal. We did see goose dung, and cropped sedges, which indicate previous use of this habitat. Judging from observations on the Yukon-Kuskokwim Delta (Mickelson 1975) we expected greater use by geese and brant. However, most of these birds left the study area after nest termination.

B. Avian Production

Production of birds on Cape Espenberg was assessed by several methods. A 25 ha shorebird nesting plot in marsh habitat and another 25 ha plot in mixed habitat (Fig. 2) were searched intensively for all nesting birds. Probably 90 percent of the bird nests in these plots were found. Two waterfowl plots, each 1 km^2 (Fig. 2) were intensively searched for loon, waterfowl, and gull nests, but other nests were recorded if found. Perhaps 80 percent of the loon, gull, and waterfowl nests, but less than 50 percent of shorebird and passerine nests were found. Nests outside of these 4 plots were recorded when found, but often we were unable to relocate them after hatching, and therefore could not determine production.

Production data recorded at nests included: 1) number of eggs present, 2) condition of eggs present, including stage of incubation as determined by the flotation method (Westerskov 1950), or whether destroyed or deserted, and 3) number of egg shells with inner membranes separated (indicating a successfully hatched egg, Mickelson 1975). Some nests which were deserted were probably destroyed by predators before we rechecked them.

Determining the exact cause of destruction was difficult at times. Tooth marks indicated that the egg was taken by a fox. However foxes often carried eggs away from the nest and cached them. For waterfowl, gull and loon eggs, Parasitic Jaegers often pecked the egg and ate its contents at the nest. Glaucous Gulls generally broke a larger hole in the egg and ate the contents, unless a human approached, and then the gull would fly off the with the egg pierced on its bill, or swallow the whole egg. Eggs of birds smaller than loons, gulls, and waterfowl were eaten whole. Thus, exact fate of eggs was sometimes unknown. A discussion of predation follows in the section on Factors Affecting Production.

Number of eggs hatched in a nest was dependent upon: 1) counting young in the nest and/or 2) counting intact egg shell inner membranes in the nest. In some cases inner membranes and egg shells were tossed out of nests (usually eider or goose) by Glaucous Gulls and Parasitic Jaegers which picked up and shook nest materials. Thus, membranes from successfully hatched eggs might not be found and recorded. Therefore, our estimates of hatched eggs is a minimum.

Broods were counted whenever seen. However, only one goose brood remained on Cape Espenberg, most eider broods left the cape soon after hatching, and young of cranes, ptarmigan, shorebirds, and passerines quickly moved away from their nest sites. Therefore, assessment of fledged young was not possible based on our observations.

We have presented production data in Tables 6 through 11. The following results and discussions on production are organized by species or species group.

Loons:

Yellow-billed, Arctic, and Red-throated loons nested on Cape Espenberg. Unfortunately no Yellow-billed Loon nests with eggs were found. Three pairs occupied three different portions of the cape and 2 nest scrapes were found. Because no eggs or young were seen, we believe all nesting attempts were failures.

We lack adequate data for Arctic Loons. We know that at least 4 pairs nested and that at least 2 nests failed as a result of predation. However, several broods were sighted in August. This leads us to believe that more than 4 pairs nested and that some were successful.

Red-throated Loons were very abundant on Cape Espenberg compared with all other study sites listed in Table 9. Their high nesting densities might be explained by: 1) abundance of small, shallow, fishless ponds which are unsuitable for nesting by the larger loons, and 2) proximity to marine waters for feeding. Nesting success for Red-throated Loons was difficult to assess because our visitation to nesting ponds often resulted in predation by Parasitic Jaegers and Glaucous Gulls. Similar difficulties were reported by Petersen 1976 on the Yukon-Kuskokwim Delta. We frequently found empty nest platforms during our initial nest checks in the waterfowl nesting plots. For 7 nests with known fates, only 1 hatched (Table 7). Nest success was probably higher outside the plots, where our visits were less frequent.

Table 6. Preliminary average clutch size for birds on Cape Espenberg, 1976.

	Average Clutch Size					
Species	Initiated	No. (nests)	Incubated	No. (nests)	Hatched	No. (nests)
Arctic Loon	1.5	2	2.0	1	0	-
Red-throated Loon	2.0	4	2.0	4	2.0	1
Canada Goose			6.0	1	6.0	1
Black Brant	5.0	1	0	-	0	-
Emperor Goose	-	-	4.30	10	3.33	6
Green-winged Teal	6.0	1	0	-	0	-
Greater Scaup	-	-	7.10	7	5.00	2
Oldsquaw	-	-	6.05	20	4.86	7
Common Eider	-	-	5.26	381	3.46	298
King Eider	1.0	1	0	-	0	-
Spectacled Eider	-	-	3.66	3	4.50	2
Willow Ptarmigan	10.67	3	10.67	3	9.75	4[1]
Sandhill Crane	2.00	2	-	-	2.00	2
Ruddy Turnstone	3.50	4	3.50	4	3.00	1
Black Turnstone	3.00	1	-	-	0	0
Dunlin	4.00	16	4.00	16	4.00	14
Semipalmated Sandpiper	3.91	22	3.91	22	3.86	14
Western Sandpiper	3.17	24	3.26	23	3.00	9
Long-billed Dowitcher	3.67	3	3.67	3	3.67	3
Red Phalarope	3.41	26	3.67	24	3.26	19
Northern Phalarope	3.61	43	3.61	43	3.76	25
Parasitic Jaeger	1.77	13	1.77	13	1.33	3
Glaucous Gull	2.68	100	2.68	100	2.47	48
Sabine's Gull	2.00	11	2.00	11	2.00	11
Arctic Tern	1.94	32	1.94	32	1.94	27
Savannah Sparrow	-	-	4.00	2	3.50	2
Lapland Longspur	4.62	8	4.62	8	3.67	12[2]

[1] One ptarmigan was not discovered until after hatching.

[2] Four longspur nests were not found until near fledging.

Table 7. Nest fate for birds on Cape Espenberg, 1976 (waterfowl data preliminary).

Species	Total Nests	Nest Fate: % successful[1]	% lost to predators	% abandoned	% fate unknown
Arctic Loon	2	-	100.0	-	-
Red-throated Loon	7	14.3	71.4	-	14.3
Canada Goose	1	100.0	-	-	-
Black Brant	1	-	100.0	-	-
Emperor Goose	7	100.0	-	-	-
Greater Scaup	8	25.0	62.5	12.5	-
Oldsquaw	26	30.8	69.2	-	-
Common Eider	499	59.9	29.5	2.6	8.0
King Eider	1	-	-	100.0	-
Spectacled Eider	2	100.0	-	-	-
Willow Ptarmigan	4	75.0	-	-	25.0
Sandhill Crane	4	50.0	25.0	25.0	-
Ruddy Turnstone	4	25.0	-	-	75.0
Dunlin	16	87.5(100.0)[2]	-(-)[2]	-(-)[2]	12.5
Semipalmated Sdp.	22	63.5(79.9)	9.1(13.7)	4.5(6.4)	22.7
Western Sdp.	26	34.6(49.1)	15.4(33.2)	15.4(17.7)	34.6
Long-billed Dowitcher	3	100.0	-	-	-
Red Phalarope	29	65.5(65.7)	13.8(28.5)	10.3(5.8)	10.3
Northern Phalarope	42	59.5(66.1)	14.3(26.6)	4.8(7.3)	22.8
Parasitic Jaeger	4	100.0	-	-	-
Glaucous Gull	115	41.7	13.0	-	45.0
Sabine's Gull	11	90.9 (87.4)	9.1(12.6)	-	-
Arctic Tern	32	84.4(82.9)	9.4(10.6)	6.2(6.5)	-
Savannah Sparrow	2	100.0	-	-	-
Lapland Longspur	13	53.8[3]	23.1[3]	-	23.1[3]

[1]Success defined as a nest hatching at least one young.

[2]Calculations based upon Mayfield's (1975) method of estimating nesting success.

[3]Fate determined through departure of chicks from nest. Success determined by at least one chick surviving this period.

Table 8. Estimated nesting success for selected bird species at Cape Espenberg in 1976 compared with adjacent areas.

Species	Cape Espenberg (66°N)[1]	Prudhoe Bay (70°N)[2]	Barrow (71°N)[3]	Norton Bay (64°N)[4]	Yukon-Kusk. delta (61°N)[5]	Cape Sabine (67°N)[6]
	Estimated Nesting Success (%) at:					
Red-throated Loon	14.3	-	-	25.0	33.3-75.0	-
Emperor Goose	100.0	-	-	-	65.6-100.0	-
Spectacled Eider	100.0	-	-	-	50.0-90.0	-
Dunlin	87.5	50	77-94;72	46.7	-	-
Semipalmated Sdp.	63.5	52-84	73	87.7	-	-
Western Sdp.	34.6	-	-	46.7	72-92	-
Red Phalarope	65.5	31-83	47-73;50	-	-	-
Parasitic Jaeger	100.0	-	0	-	-	50-75
Glaucous Gull	33-76	-	-	100.0	73-88	-
Lapland Longspur	53.8	60	63	70.5	-	-

[1]This study; [2]Norton et al. 1975; [3]Maher 1974, Norton et al 1975, Schamel (unpubl.); [4]Shields and Peyton 1977;

[5]Holmes 1972, Dau 1974, Mickelson 1975, Eisenhauer 1976, Petersen 1976; [6]Maher 1974.

Table 9. Nesting densities of selected bird species at Cape Espenberg in 1976 in comparison with adjacent areas.

Species	Estimated Nesting Density (Nests/km^2) at:					
	Cape Espenberg (66°N)[1]	Prudhoe Bay (70°N)[2]	Barrow (71°N)[3]	Shishmaref (66°N)[4]	Norton Bay (64°N)[5]	Yukon-Kusk. delta (61°N)[6]
Arctic Loon	0.2				4	4.9
Red-throated Loon	5.				2	.3
Black Brant	0.1					2.8-1650.
Emperor Goose	0.5					1.3-27.
Pintail	0.1			10		
Green-winged Teal	0.2			10		
Oldsquaw	6.		2		.05	
Common Eider	45.				.1	
Spectacled Eider	0.1					2.8-6.8
Willow Ptarmigan	0.5			10		
Sandhill Crane	0.5				2	0.36-0.74
Dunlin	16-20	5	15;21	30	20	75
Semipalmated Sandpiper	4-60	37	12	30	85	-
Western Sandpiper	4-60	-	-	20	20	240-350
Long-billed Dowitcher	4	-	-	10	-	-
Red Phalarope	0-72	22-37	44;9-24		-	-
Northern Phalarope	32-104	4-6	-	39	35	-
Parasitic Jaeger	0.7		0.03-0.04		.05	.29
Glaucous Gull	12				1	5.9
Sabine's Gull	0-44				.05	
Arctic Tern	0-108				10	
Redpoll sp.	0.1			30		
Savannah Sparrow	0-4				30	
Lapland Longspur	12-24	7-8	30	20	20	

[1]This Study; [2]Norton et al. 1975; [3]Maher 1974, Myers (unpubl.), Schamel (unpubl.); [4]Noble and Wright 1977; [5]Shields and Peyton 1977; [6]Eisenhauer 1976, Petersen 1976, Dau 1974, Mickelson 1975, C. Boise, pers. comm., Strang 1976, Mickelson (unpubl. data).

Table 10. Clutch size of Common Eiders on Cape Espenberg, 1976.

Location	Incubated Clutch Size	Hatched Clutch Size
Shorebird Marsh Plot	3.62(29[1]/8[2])	5.00(15[1]/5[2])
Shorebird Mixed Plot	5.00(15/3)	5.00(5/1)
Other	4.16(25/6)	2.80(14/5)
Waterfowl Plot 1	4.33(377/87)	3.21(122/38)
Waterfowl Plot 2	4.12(177/43)	3.44(93/27)
Eider Colony (Island)	5.90(1382/234)	3.53(783/222)
Totals	5.26(2005/381)	3.46(1032/298)

[1]Total eggs, [2]Total nests.

Table 11. Fate of Common Eider nests on Cape Espenberg, 1976.

	Total Nests	% Successful	% lost to predators	% abandoned	% Fate unknown
Shorebird Marsh Plot	34	14.7	82.4	2.9	0
Shorebird Mixed Plot	13	7.7	92.3	0	0
Other	31	19.3	74.2	0	6.5
Waterfowl Plot 1	90	41.1	30.0	0	28.9
Waterfowl Plot 2	59	45.7	38.9	3.4	11.9
Eider Colony (Island)	272	82.4	12.1	3.7	1.8

Geese:

Goose production on Cape Espenberg is given in Tables 6 and 7. Nesting density was quite low for both Canada Geese (Branta canadensis parvipes?) and Black Brant. Only one pair of each nested, but only the eggs of the Canada Geese hatched. The brant nest was apparently taken by predators. In contrast, 12 Emperor Goose pairs were known to nest. Most nests (10) were located outside of our 4 nesting plots. Average clutch size was 4.3 for 10 nests being incubated, and 3.3 for 6 nests known to have hatched (Table 6). The fate of only one other nest was known. It was destroyed by a predator during or after human visitation in the vicinity of the nest. Young from hatched eggs were led by parents away from Cape Espenberg as no family groups were observed after mid-July. Two broods moved westward across the west boundary slough (Fig. 2). Another (2+ young) was observed on Espenberg Bay south of the tip of the cape on 8 July.

Only the Canada Goose family remained on Cape Espenberg. Both adults and 6 young were observed on 22 July near Espenberg Bay approximately 2 km west of their nest site.

In comparison with the Yukon-Kuskokwim Delta which is the best goose nesting habitat in Alaska (Spencer et al. 1951, King and Lensink 1971), goose production on Cape Espenberg was very low (Tables 8 and 9). Based on habitat comparisons with the Yukon-Kuskokwim Delta, Cape Espenberg appears to be good nesting habitat for brant (and Common Eiders), but poor for Emperor and Canada Geese. Because of the late spring in 1976, perhaps fewer than normal geese and brant nested (see discussion on Phenology below). Nesting densities probably will be greater in 1977, if phenology is earlier than in 1976.

Ducks:

Production of Green-winged Teal, Pintail, Greater Scaup, Oldsquaw, King Eider, and Spectacled Eider was low on Cape Espenberg (Tables 6 and 7). Common Eiders nested in high densities and will be discussed separately. Oldsquaw nesting densities varied considerably on Cape Espenberg. The majority were found in a mosaic of hummocks, marsh, and water. Many nests were detected in the shorebird marsh plot, but this was not the case in either of the waterfowl nesting plots which contained similar habitat. Furthermore, Oldsquaw broods were not common in either waterfowl plot. This is partly due to poor success (30.8%) for Oldsquaw nests (Table 7).

Other duck species nested in very low densities on Cape Espenberg (Table 9). Only a few nests of each species were found on the cape. Greater Scaup, Pintail and Green-winged Teal had poor nesting success (Table 7). The majority of unsuccessful nests were destroyed by predators. This will be discussed under Factors Affecting Production.

In contrast, Common Eiders nested in high densities and were moderately successful compared with other duck species on Cape Espenberg (Tables 7 and 9). Incubated clutch size was highest for eiders nesting on the island in the lake in southwest section 32 (Fig. 2). For 234 nests, average clutch incubated was 5.9 eggs (Table 10). This can be explained by the occurrence of compound nests in which 2 or more Common Eiders were laying eggs. Of these 234 nests, 33 (14.1 percent) contained 9 or more eggs (Table 7 in the Quarterly Report for 1 October to 31 December 1976) which represented 23.5 percent of total incubated eggs. Also, some nests contained eggs of 2 or more different colors and sizes, suggesting they were laid by 2 or more females. In addition, one nest had 2 eggs which may have been King Eider, and 3 nests had eggs of Oldsquaws.

Of course, all eggs in parasitized nests would not hatch, nor would eggs in nests containing two layers of eggs. If all could be covered and each frequently turned, then all viable eggs would hatch. However, clutches of 9 or more eggs often were arranged in 2 layers or had eggs along the edge of the nest rim.

Nests in the eider colony had the greatest success (82.4 percent, Table 11). Their success was most probably correlated with lack of fox predation, and to reduced avian predation which will be discussed under Factors Affecting Production.

Cranes:

At least 9 Sandhill Crane pairs nested on Cape Espenberg. This density is surpassed only by cranes nesting near the Koyuk River, north of Norton Bay (Table 9). Of these 9 nests, we know that 2 nests were deserted or destroyed, primarily as a result of our activities (Table 7). However, 9 different young cranes in 8 broods were counted in July and August.

Ptarmigan:

An estimated 20 pairs of ptarmigan nested on Cape Espenberg. Based on fate of 4 nests, nesting success was 75% (Table 7). Thus production for Cape Espenberg was good, although higher production was recorded for birds near Shishmaref (Table 8, Noble and Wright 1977).

Shorebirds:

In general, shorebird nesting densities at Cape Espenberg were similar to or greater than other areas in arctic Alaska and the Seward Peninsula (Table 9). However, densities were considerably lower than R. T. Holmes found along the Kolomak River on the Yukon-Kuskokwim delta (Table 9). The large variations in nesting density on the cape correspond to habitat preferences. Densities were highest in the "fine-grained mosaic" (MacLean 1973) of shallow water and narrow ridges in the marsh plot (see Table 3 of the September Quarterly Report) and lowest in the mixed habitat plot, where the marsh was much less extensive and more homogeneous in composition.

Comparative information on shorebird nesting success in coastal Alaska is scant (Table 8). Based upon success rates elsewhere in Alaska, only two species at Espenberg varied noticeably from expected success: Dunlins and Western Sandpipers. Dunlins had slightly higher nesting success (at least 87.5%) than expected. Holmes (1966) suggested that a 25% nesting failure may be normal for Barrow Dunlins. Western Sandpipers, however, showed a greatly reduced success rate (no greater than 49.1%) from that reported by Holmes (1972) for Kolomak River birds (72-92%). In addition, our Western Sandpipers produced much smaller clutches ($\bar{x}$ = 3.26, Table 6) than those at the Kolomak River ($\bar{x}$ = 3.84) (Holmes 1972). Westerns at Cape Espenberg also had the greatest nest abandonment rate of the sandpipers (Table 7). These three factors all indicate that Westerns suffered a reproductive set-back in 1976. Northern and Red Phalaropes had the next lowest clutch size and nesting success figures (Tables 6 and 7). However, clutch sizes closely resembled those found at Barrow for Red Phalaropes ($\bar{x}$ = 3.61 and 3.67) (Schamel, unpublished data) and the nesting success was comparable with other areas (Table 8).

The summer of 1976 presented an unusual opportunity for comparisons of breeding waterbirds on the Seward Pensinsula. In addition to our group, Noble and Wright (1977) worked in the Shishmaref Inlet area and Shields and Peyton (1977) concentrated their efforts in the Inglutalik River delta in northern Norton Bay. A comparison of nesting densities is complicated by habitat differences. However, clutch size data should be comparative. Two shorebird species showed regional trends in 1976: Semipalmated and Western sandpipers. Semipalmated mean clutch sizes decreased north-south, while Western Sandpiper clutch size showed the opposite trend (Fig. 4).

These differences may relate to the breeding distribution of the two species. Although Kozolva (1962) shows a sympatric breeding range for these sandpipers in Alaska, we feel that major differences are evident. Semipalmated Sandpipers seem to dominate the north coastal marshes of Alaska, while Westerns dominate those south of the Arctic Circle. Semipalmated Sandpipers are regular and abundant breeding birds at Barrow and eastward, along the Beaufort coast; Western Sandpipers are only occasional breeders in this area. At the Kolomak River, on the Yukon-Kuskokwim delta, Western Sandpipers were the most abundant breeding shorebird found by Holmes and Black (1973); no Semipalmated Sandpipers were even observed there by these biologists.

All three field parties will return to the Seward Peninsula again in 1977. We hope that additional data from the upcoming field season will help clarify the Western/Semipalmated picture.

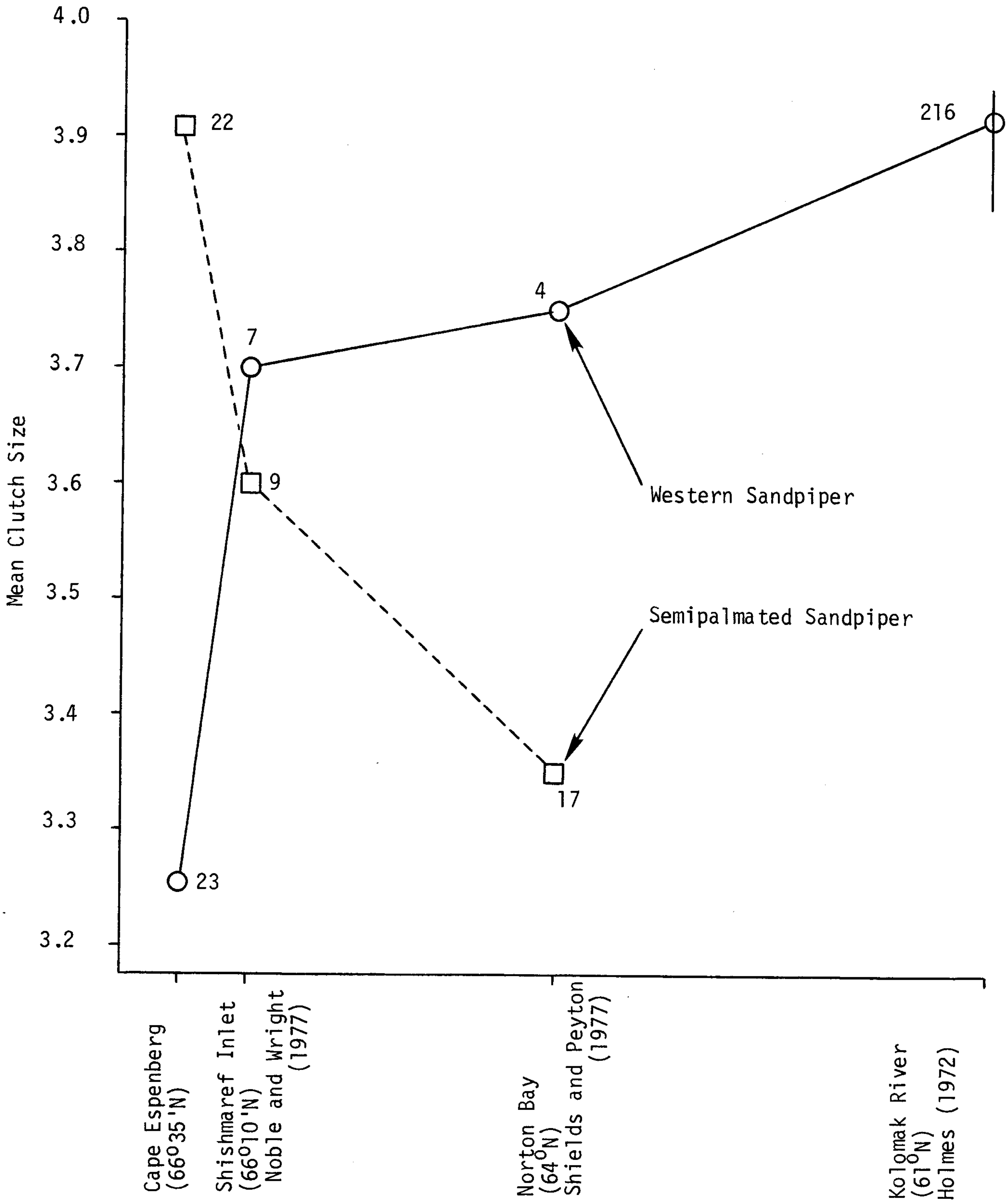


Figure 4. Comparison of Semipalmated and Western sandpiper clutch sizes in western Alaska, with accompanying sample sizes.

Arctic Terns and Sabine's Gulls:

Nesting success of Arctic Terns on the cape (84.4%) was considerably higher than success figures reported by Lemmetyinen (1973) for southern Finland (55-77%) and by Bengtson (1971) for Spitsbergen (49-70%). No comparative data are available for Sabine's Gull nesting success.

Passerines:

Lapland Longspur nesting density on the cape (12-24 nests/km^2) was higher than that reported from Prudhoe Bay, but roughly comparable to Barrow and Norton Bay (Table 9). Nesting success was quite comparable with that reported in the literature (Table 8).

C. Factors Affecting Production and Habitat Utilization

Phenology:

Weather conditions, especially in spring, influence the beginning of nesting season, nesting density, and clutch size of arctic nesting birds (Cooch 1958 and 1965, Lemieux 1959, Barry 1962 and 1967, Ryder 1967, and Mickelson 1975). Based on observations made by H. Melchior in 1973 (pers. comm.), J. King (pers. comm.) over many years, and F. Goodhope, Jr. (pers. comm.) throughout his lifetime as a resident of the Chukchi Coast, the spring of 1976 was later than usual. We estimate that there was about a week delay in nest initiation for most species. Ice still covered all of the larger ponds until mid-June. All ponds under 10 ha in size were free of ice by 29 June, but most ponds under 2 ha were ice-free by 10 June. Espenberg Bay first became totally ice-free on 26 June, but ice had not disintegrated or blown away from the north shore of Cape Espenberg until 18 July. However, leads opened one to two weeks earlier than these dates of total ice disappearance.

Weather conditions as reported by the National Weather Service Station in Kotzebue are given in Table 12. Generally, weather was only slightly better at Cape Espenberg compared with Kotzebue. We observed that the cape had less cloud cover and slightly less wind than Kotzebue. An analysis of the weather data from Kotzebue indicates that the departure from average daily temperatures was -0.8 °F. during May, but -4.1 °F. during June. This cooler weather during spring, combined with late ice cover because of prevailing winds from the Chukchi Sea, accounts for the late breeding season.

Since we arrived on the study area after much of the spring migration activity had terminated, we know little about ice conditions and avian habitat utilization during early spring. Upon arrival on 4 June, snow cover was confined to the north slopes of the sand dunes.

Table 12. Daily weather data collected at Kotzebue during May through September, 1976, based on National Weather Service observations.

Date	Temperature °F. Max.	Min.	Ave.	Departure from Ave.	Weather Type	Precipitation (in.)	Wind Speed (MPH) Ave.	Max.	Direction (Degrees)	Sky Cover (Tenths)
May										
1	46	33	40	18		0	9.8	20	90	2
2	46	28	37	14		0	6.2	12	70	3
3	49	35	42	18		0	11.4	17	100	8
4	46	28	37	13		0	6.9	9	240	3
5	41	26	34	9	Heavy Fog	0	6.0	9	250	3
6	37	24	31	5		0	15.0	25	290	4
7	30	24	27	1	Fog	Trace	15.0	21	290	9
8	27	23	25	-2	Fog, Glaze	Trace	8.8	14	310	10
9	28	21	25	-2	Glaze	Trace	8.9	14	270	8
10	42	20	31	3		0	5.6	10	90	4
11	32	23	28	0		0	7.6	12	70	7
12	31	21	26	-3		Trace	7.3	12	230	8
13	28	20	24	-6		0	10.5	15	250	8
14	28	13	21	-9		Trace	10.8	21	280	8
15	40	16	28	-3		Trace	13.7	23	130	10
16	45	35	40	9		Trace	13.1	21	120	10
17	46	35	41	9		.01	7.6	12	100	9
18	46	31	39	7		0	8.1	15	300	8
19	38	24	31	-2		0	16.3	22	280	5
20	35	20	28	-5		0	19.1	25	290	0
21	31	17	24	-10		0	10.4	15	260	0
22	33	21	27	-7	Heavy Fog	0	11.5	23	290	5
23	30	23	27	-8	Fog	Trace	20.7	30	290	10
24	29	24	27	-8	Fog, Snow	Trace	31.6	39	290	9
25	29	23	26	-9	Fog, Glaze	.10	24.3	28	270	10
26	27	21	24	-12	Fog, Glaze	.01	11.9	20	270	10
27	27	19	23	-13		0	21.6	35	300	4
28	33	18	26	-11		Trace	24.3	35	300	7
29	31	26	29	-8		Trace	13.7	20	280	10
30	33	28	31	-6	Fog, Glaze	Trace	16.4	29	290	10
31	46	30	38	0		Trace	14.0	21	140	10

Table 12. Continued

Date	Temperature °F Max.	Min.	Ave.	Departure from Ave.	Weather Type	Precipitation (in.)	Wind Speed (MPH) Ave.	Max.	Direction (Degrees)	Sky Cover (Tenths)
June										
1	56	37	47	9		.04	12.7	20	120	10
2	48	36	42	4	Heavy Fog	.09	6.9	14	190	10
3	40	30	35	-4	Fog	Trace	8.5	12	290	8
4	54	30	42	3		0	8.3	14	90	7
5	58	34	46	6	Fog	0.4	14.1	20	140	10
6	39	33	36	-4		Trace	5.6	13	200	7
7	43	30	37	-3		0	7.2	15	290	5
8	40	30	35	-6	Fog	0	8.5	21	300	5
9	34	30	32	-9	Fog	0	24.9	30	290	6
10	38	31	35	-6		0	19.4	24	300	1
11	40	34	37	-5		0	12.5	17	290	3
12	47	33	40	-2		0	7.3	14	300	4
13	50	33	42	0		0	8.8	15	300	3
14	42	34	38	-5		0	11.7	21	270	2
15	42	33	38	-5	Fog	0	11.9	17	280	5
16	41	33	37	-7		Trace	9.4	12	260	5
17	40	34	37	-7		Trace	10.4	16	260	10
18	39	33	36	-8	Fog	Trace	11.2	15	250	10
19	46	33	40	-5		Trace	4.9	12	10	10
20	50	35	43	-2	Fog	.01	8.6	13	180	10
21	39	34	37	-9	Fog	.20	5.5	12	200	10
22	47	37	42	-4		.06	7.3	16	120	10
23	53	41	47	1		0	16.4	22	120	8
24	47	33	40	-7	Heavy Fog	.11	13.4	21	280	8
25	65	32	49	2	Heavy Fog	Trace	10.9	16	190	7
26	59	39	49	1		0	9.2	14	200	5
27	41	33	37	-11	Fog	0	14.1	20	280	8
28	40	33	37	-11		0	16.7	25	280	7
29	42	34	38	-11		.10	15.8	26	290	9
30	40	33	37	-12	Fog	.03	20.4	28	290	9

Table 12 . Continued

Date	Temperature °F Max.	Min.	Ave.	Departure from Ave.	Weather Type	Precipitation (in.)	Wind Speed (MPH) Ave.	Max.	Direction (Degrees)	Sky Cover (Tenths)
July										
1	37	32	35	-15	Fog	Trace	21.0	24	280	9
2	45	30	38	-12	Fog	.02	13.8	18	120	9
3	44	36	40	-10		.73	20.3	35	150	10
4	39	34	37	-14	Fog	.07	18.7	25	280	9
5	47	34	41	-10		0	7.2	12	300	10
6	54	42	48	-3		Trace	10.6	17	300	10
7	44	35	40	-12	Fog	0	15.0	18	290	7
8	48	36	42	-10	Heavy Fog	0	8.8	14	280	5
9	55	44	50	-2		0	9.4	14	300	3
10	60	48	54	2		0	8.1	15	300	0
11	61	50	56	3		0	8.3	12	360	1
12	69	55	62	9		0	9.9	16	300	1
13	59	39	49	-4	Heavy Fog	0	22.4	30	290	9
14	50	39	45	-8	Fog	0	9.9	17	280	6
15	67	48	58	5		0	7.8	14	210	0
16	58	50	54	0		0	10.4	15	300	2
17	61	47	54	0	Fog	0	13.5	20	190	7
18	56	45	51	-3	Fog	.12	12.1	23	180	8
19	67	46	57	3		0	10.4	16	160	6
20	66	51	59	5		.05	12.8	18	70	10
21	68	53	61	7		0	10.2	17	300	6
22	63	51	57	3	Fog	0	15.8	25	290	4
23	67	47	57	3	Fog	0	9.2	18	290	2
24	70	57	64	10		0	12.8	23	310	5
25	62	53	58	4		0	17.5	26	300	7
26	57	50	54	0		0	20.6	28	300	7
27	55	39	47	-7	Heavy Fog	0	15.8	25	290	8
28	62	52	57	3		.10	16.5	24	160	10
29	56	48	52	-2		.07	18.1	26	160	10
30	58	48	53	-1		0	17.1	21	170	8
31	63	47	55	1		0	11.8	18	120	5

Table 12. Continued

Date	Temperature °F Max.	Min.	Ave.	Departure from Ave.	Weather Type	Precipitation (in.)	Wind Speed (MPH) Ave.	Max.	Direction (Degrees)	Sky Cover (Tenths)
August										
1	60	50	55	1	Fog	0	6.6	13	230	2
2	65	50	58	5		0	11.5	18	290	6
3	54	50	52	-1		0	6.5	15	200	10
4	59	51	55	2		0	7.3	13	300	10
5	64	55	60	7		0	9.1	16	290	5
6	66	54	60	7		0	13.1	20	350	1
7	63	51	57	4		0	10.1	15	350	8
8	61	46	54	2		0	8.6	12	240	2
9	61	52	57	5		0	8.5	16	310	4
10	56	51	54	2		.03	8.6	16	310	10
11	62	52	57	5		0	9.8	17	300	5
12	64	53	59	7		.02	9.1	16	280	8
13	58	53	56	5		.09	8.5	18	260	10
14	61	53	57	6		.27	11.7	16	130	10
15	56	46	51	0	Fog	.07	18.0	25	180	10
16	58	47	53	2		0	14.7	21	170	7
17	59	47	53	2		0	8.5	12	210	4
18	60	43	52	2		0	9.6	25	300	1
19	56	47	52	2		0	12.8	24	300	3
20	56	50	53	3		0	13.2	16	270	3
21	56	50	53	3		0	11.5	18	290	7
22	64	48	56	6	Fog	Trace	8.1	13	150	7
23	65	50	58	9		0	10.2	21	260	8
24	62	49	56	7		0	10.4	18	160	9
25	65	52	59	10		Trace	12.8	23	160	4
26	62	52	57	8		0	9.6	20	310	3
27	60	50	55	7		0	9.4	14	280	2
28	57	52	55	7	Heavy Fog	0	14.5	21	280	4
29	58	53	56	8		0	11.8	15	290	1
30	58	48	53	5		0	5.5	9	270	2
31	66	46	56	9		0	8.5	14	100	3

Table 12 Continued

Date	Temperature °F Max.	Min.	Ave.	Departure from Ave.	Weather Type	Precipitation (in.)	Wind Speed (MPH) Ave.	Max.	Direction (Degrees)	Sky Cover (Tenths)
Sept.										
1	59	48	54	7		0	9.9	20	300	0
2	53	39	46	-1		0	23.7	31	310	7
3	43	33	38	-8		.01	21.1	28	300	2
4	41	34	38	-8	Fog	.23	12.9	20	280	10
5	41	34	38	-8		.46	12.1	18	350	10
6	44	37	41	-5		0	8.9	14	300	3
7	49	37	43	-2		0	8.3	17	350	9
8	46	37	42	-3		0	23.0	32	310	8
9	43	37	40	-4		Trace	15.5	30	300	9
10	48	39	44	0	Fog	.10	16.4	23	100	9
11	49	42	46	2	Fog	.05	17.0	22	110	9
12	56	40	48	5		Trace	16.3	21	90	8
13	57	43	50	7		0	15.8	23	90	6
14	54	43	49	7		Trace	9.2	15	80	10
15	49	42	46	4		Trace	5.2	8	310	9
16	51	41	46	5		Trace	3.9	7	300	10
17	50	42	46	5		Trace	5.9	12	40	8
18	56	41	49	9		0	10.4	21	90	5
19	54	39	47	7	Fog	0	7.9	16	280	4
20	49	39	44	5	Heavy Fog	.23	7.5	14	90	10
21	51	38	45	6		.16	11.9	22	230	6
22	51	38	45	7		Trace	10.2	21	360	8
23	49	40	45	7		.08	11.8	17	100	10
24	52	42	47	10		0	8.1	12	70	4
25	52	41	47	10		0	11.9	17	90	9
26	54	39	47	11		0	10.2	16	90	4
27	50	42	46	11	Heavy Fog	.01	9.1	14	100	7
28	53	39	46	11		0	13.7	20	360	8
29	43	37	40	6		.01	13.1	21	90	9
30	47	35	41	8		0	16.4	22	100	5

Those tundra-nesting species which normally begin egg-laying early, were not affected by the late spring. Sandhill Cranes nested earlier than any other species. Based on dates of hatching, clutch size, egg-laying time, and incubation time, we estimate the some cranes began egg-laying as early as 23 May. Presumably ptarmigan and Lapland Longspurs nested on time since tundra was snow-free during early June.

Most loons, shorebirds, and larids have fixed clutch sizes. We recorded the usual clutch sizes for these species (except Western Sandpipers) and therefore believe that they were not affected much by the late spring. In western Alaska, Emperor Geese are the latest to nest among goose species (Mickelson 1975 and Eisenhauer 1976). Thus, they are not affected by late springs as much as other geese. However, Eisenhauer (1976) reported a significant difference between clutch sizes for two late and one early nesting seasons at Igiak Bay on the Yukon-Kuskokwim Delta. The weighted average clutch for 155 nests in 1971 and 1972 was 4.75 eggs, but was 5.42 eggs for 107 nests for 1973, the year with an early spring. The Cape Espenberg Emperor Goose average clutch size was 4.3 for 10 nests (Table 6). This is below the average for emperors nesting during the early spring of 1973 at Igiak Bay. During late springs, geese resorb ovarian follicles and have more atretic follicles. Thus, they produce fewer eggs (Barry 1967). This may have been the reaction of Emperor Geese at Cape Espenberg in 1976.

Only one pair of Black Brant nested on Cape Espenberg in 1976. They produced a clutch of 5 eggs, but later deserted. Harvey (1971) found that Blue Geese that did nest in a late year lost considerable weight, in fact some starved, but others deserted. Whether the brant deserted because of exhausted fat reserves, disturbance from our nest surveys, or other reasons, is not known. We did expect to find more nesting brant on Cape Espenberg. Perhaps the late spring accounted for their very low nesting density.

Ducks on Cape Espenberg probably were affected little by the late spring. Because we have no comparative phenology data from previous years, it is difficult to know the total effect of the 1976 late breakup. Important events are listed in Table 13. Comparative data will be gathered in 1977 and hopefully a clearer picture will emerge.

Predation:

Glaucous Gulls

In the nesting plots and along the gull pellet collection route, 107 Glaucous Gull nests were located. On 10-11 July an effort was made to locate all other Glaucous Gull colonies on the peninsula east of the large slough in Section 28, T14N, R24W, Kateel River Meridian (Fig. 2). From this survey it was estimated that about 250 pairs of Glaucous Gulls were nesting on the entire cape. The overall density was about 12 nests/km^2, considerably higher than the 5.9 nests/km^2

Table 13. Chronology of avian events at Cape Espenberg, 1976.

Date	Nearshore	Tundra
4 June	Few Sabine's Gulls and Arctic Terns flying along coast and bay; Semipalmated Sandpipers and Ruddy Turnstones feeding along coast and bay; numerous Glaucous Gulls along coast and bay; no open leads near shore	All nesting species except Emperor Geese present; Sandhill Cranes are only nesting species; no snow on tundra; ice on larger ponds
10 June	No open leads near coast; a little open water in bay;	All bird species nesting, except Arctic Terns and Emperor Geese which were present
20 June	Glaucous Gulls, kittiwakes present along coast and bay; Arctic Terns, Semipalmated Sandpipers, Ruddy Turnstones feeding along shoreline of cape; Sabine's Gulls, Semipalmated and Western Sandpipers, and phalaropes feeding along bay; phalaropes flying along coast and bay	Nest initiation continues for most species; Arctic Terns and Emperor Geese begin nesting
30 June	Small numbers of loons, eiders, Oldsquaws in sea and bay; few Semipalmated Sandpipers feeding along coast	End of nest initiation and start of hatch for most species; peak eider numbers on ponds
10 July	Loons, eiders, Arctic Terns, Glaucous Gulls, few Semipalmated Sandpipers, Northern Phalaropes found along sea and bay; kittiwakes along coast; ice moving offshore	Peak of hatch for many species; Arctic Terns begin hatch
20 July	Loons, eiders, Northern Phalaropes, Glaucous Gulls, Arctic Terns along coast and bay; kittiwakes along coast; ice gone	End of hatch; some young sandpipers flying
24 July		First young flying Sabine's Gull

30 July	Pintails on mudflats; loons, eiders, Western Sandpipers, Glaucous Gulls, Arctic Terns along coast and bay; Northern Phalaropes along bay; kittiwakes along coast; Red-throated Loons and Dunlins begin flocking; peak flocking of Western Sandpipers	Nearly end of fledging period for most shorebirds; most Semipalmated Sandpipers and Red Phalaropes departed; influx of Pintails to ponds, flocking longspurs on dunes
2 Aug.		First flying young Arctic Tern
10 Aug.	Red-throated Loons flocking in bay; Pintails on bay mudflats eider broods in bay; Sanderlings first seen on coast; end peak of Western Sandpiper migration, continued flocking of Dunlins, Sabine's Gulls departed	Pintails on ponds, most Ruddy Turnstones gone; influx of large numbers of Pectoral Sandpipers in marshes
20 Aug.	Red-throated Loons flocking in bay; eider broods in bay; Dunlin flocking	Canada Goose migration begins westward; influx of migrating juvenile Golden Plovers; most Northern Phalaropes gone; large numbers of Pectoral Sandpipers on marshes
30 Aug.	Red-throated Loons flocking in bay, Black Brant migrating west in small numbers along coast and bay; Black Turnstones departed; flocking of Dunlin; increase in Glaucous Gull numbers along coast, Arctic Terns departed	Increase of Arctic Loons on ponds; start of fall migration of Emperor Geese, Canada Goose migration; some flocking Dunlin on marshes

reported by Strang (1976) for 1973 in his coastal study area on the Yukon-Kuskokwim delta. The fate of too many of the Espenberg Glaucous Gull nests was unknown to say anything conclusive about hatching success. The success is believed to be lower than Strang's (1976) 72.9-87.5% success rate over several years at the Yukon-Kuskokwim delta.

Most of the gulls at Espenberg nested on hummocks in the marsh or along pond shorelines, while most of Strang's birds nested on islands in ponds. The Espenberg gulls were more susceptible to fox predation. The average clutch size of 2.68 at Espenberg was similar to Strang's 2.70. Only preliminary results are available on the Glaucous Gull diet. There are still many pellets and droppings to analyze. However, 50-70 pellets and dropping have been analyzed for each of the seven collection periods and the results are presented in Fig. 5. Food remains, such as partially eaten eggs, were treated the same as one pellet.

Between the time of arrival of the gulls and mid-June, microtines and berries remaining from the previous summer were the most important food items. Later, as ice moved out of the bay and away from the north coast of the cape, marine invertebrates became increasingly important as food. Marine invertebrates were the most frequently occurring food item in the pellets and droppings from mid-June through mid-September. From 5 July to 18 August marine invertebrates occurred in 88% of the pellets and droppings examined. Saduria sp. (all that could be identified to species were Saduria entomon) was the most important marine food, occuring in 74% of the pellets and droppings from 5 July to 18 August, and remaining important into September. Ephyridae pupae (shore flies) and starfish were also frequently utilized marine invertebrate food sources. The starfish were probably scavenged from the north beach. As new berry crops became available in late July and August, berries became increasingly important as a food source for the gulls. Berries occurred in 43% of the pellets from 18 August to 11 September. Bird eggs, young, and scavenged adults occurred in only 3-25% of the pellets during each of the seven collection periods. The greatest use of avian food items occurred from the time of arrival to 5 July (22% of the pellets) and involved adult birds (which were probably scavenged) and eggs. Glaucous Gulls do not appear to be highly predacious on eggs or young birds at Espenberg. Strang (1976) found that Glaucous Gulls near the coast on the Yukon-Kuskokwim delta utilized chiefly marine food sources, while gulls nesting inland were much more dependant on eggs and young birds as a food source. The Glaucous Gulls at Espenberg could easily be affected by a local oil spill because of their dependence on marine food sources.

Parasitic Jaegers

Parasitic Jaegers occurred as breeding pairs (14) and non-breeders (several) on Cape Espenberg. Thirteen nests were located prior to

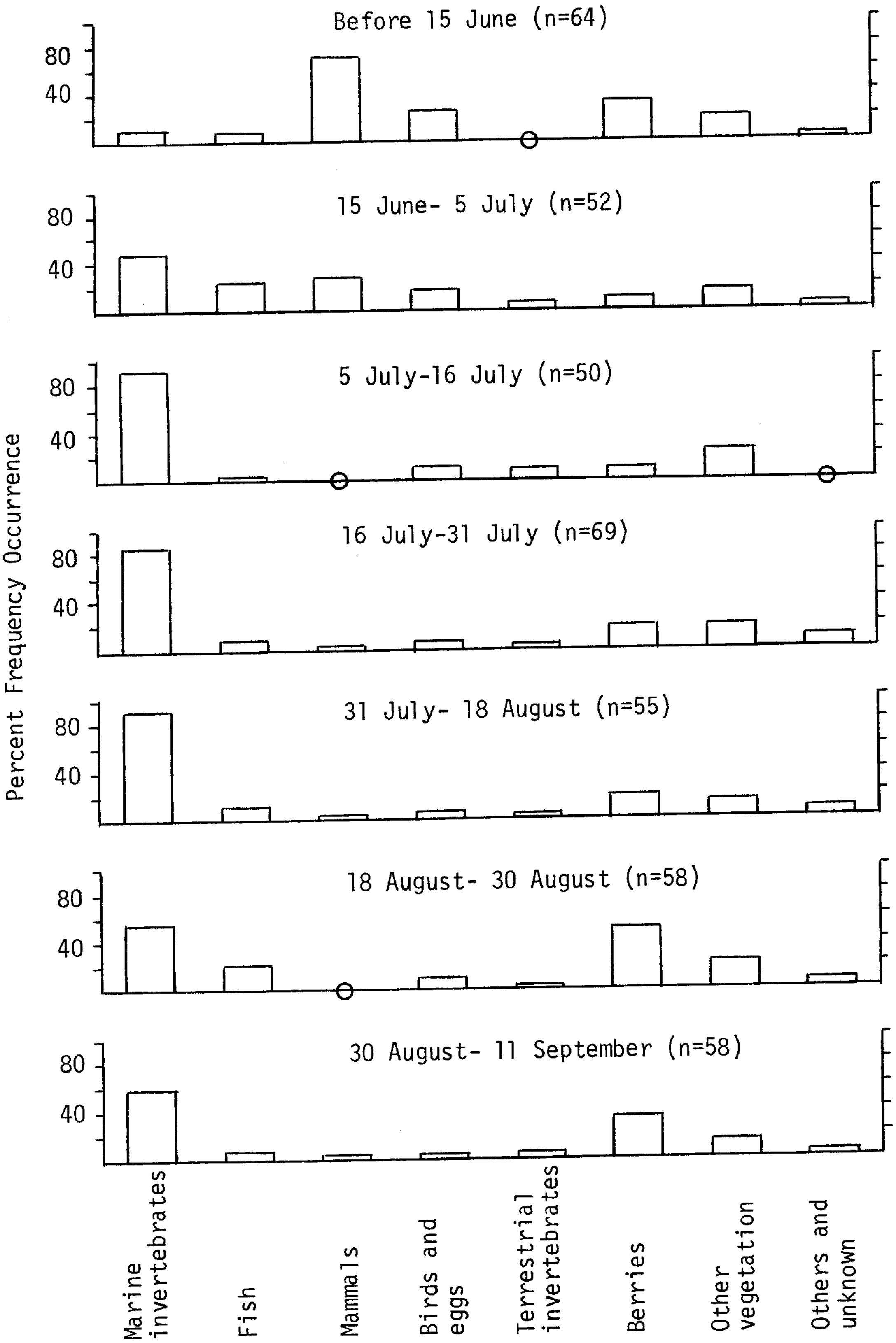


Figure 5. Summer diet of Glaucous Gulls on Cape Espenberg, Alaska, 1976. (Preliminary results of pellet analysis).

their hatch. Clutch size averaged 1.8 for 13 nests under incubation, and 1.25 for 4 nests with young hatched. Generally only one young survives to fledging (Maher 1974).

Data assembled in Maher (1974) indicate that the breeding density of Parasitic Jaegers was higher at Cape Espenberg that at Cape Sabine, Lakes Peter and Schrader, Kaolak River, and Barrow. Clutch size of jaegers at Espenberg averaged slightly less than for Parasitic Jaeger populations summarized in Maher (1974).

In future years, there is no reason to suspect a decline in breeding density of Parasitic Jaegers on Cape Espenberg, since this species feeds predominantly on birds, although microtines, insects, and fish are taken opportunistically (Maher 1974). On Cape Espenberg Parasitic Jaegers were observed taking eggs of Common Eiders, Glaucous Gulls, Red-throated Loons, and even eggs of their own species (one case where a pair was disturbed during a nest trapping operation). Both breeding pairs and non-breeders took eggs. One non-breeder seemed to specialize in taking eggs of birds not incubating when investigators were checking nests nearby. Parasitic Jaegers were observed chasing kittiwakes along the coast, presumbly trying to induce kittiwakes to regurgitate freshly caught fish. After mid July, the majority of the jaeger diet was probably made up of young shorebirds and passerines.

Long-tailed Jaeger

Long-tailed Jaegers were not breeding on Cape Espenberg in 1976. Flocks of up to 10 non-breeders were observed walking across tundra ridges. Presumably they fed on terrestrial insects, probably crane-flies. We have no direct observations of predation by Long-tailed Jaegers on eggs or young. We suspect that their impact on bird populations was very minor in 1976. Perhaps the lack of microtines prevented breeding by Long-tailed Jaegers.

Red Foxes

A systematic search was made of the entire cape in an attempt to locate all fox dens. Seven den sites were located, three in the dunes on the south side. The number of entrances to these dens was as follows: 5, 7, 12, 18, 26, 36, and 43. Foxes tend to add new entrances each year a den is used (Allison 1971). Dens with over 25 entrances have been considered old (Skrobov 1959, cited in Macpherson 1959). At least three of the dens on Espenberg apparently have been used many times in the past. Four of the dens were used in 1976. Apparently, two red fox (Vulpes vulpes) families each used two dens during the course of the summer. During the end of July and in August we observed the active dens to determine the number of pups present. One family included two pups and one family included four pups. Our best estimate of the number of red foxes using the cape during the summer of 1976 is four adults and six pups. It is possible that one or more non-breeding individuals were also present. No arctic foxes (Alopex lagopus) were observed, but two relatively fresh skulls, with some white winter fur and muscle still attached, were found. Arctic foxes were probably present on the cape during the previous winter.

Red fox scats and food remains were collected at the active dens. However, these have not yet been analyzed in detail. Cursory examination during collection indicated that the foxes were feeding heavily on bird eggs, young, and adults. Several carcasses of Common Eider females and a few Oldsquaw carcasses were found at the dens. Foxes were observed taking eggs from eider nests on several occasions. They were also observed capturing Arctic Tern chicks. Microtine and ground squirrel remains were noted in scats. The diet of foxes will be presented in detail after scat analysis is complete.

Small Mammals as a Food Source for Predators

Small mammals were systematically trapped in five different habitat types (see "Methods" in September Quarterly Report). During 480 trap-days (one trap-day equals one trap set for 24 hours) 13 different Microtus oeconomus (tundra vole) were captured a total of 23 times. No other species were captured. Seven of the M. oeconomus were captured during 80 trap-days of effort in a well vegetated area of dunes just north of the shorebird mixed habitat plot (Fig. 3). The vegetation included dense Elymus arenarius and Lathyrus maritimus. This type of habitat contained the most extensive and dense microtine colonies observed. Some small colonies occurred on hummocks in the marsh and around ponds. In general, the microtine density was very low. In 1973, Melchior (1974) captured one Microtus oeconomus and one Sorex arcticus in ca. 410 trap-days of effort at Cape Espenberg. His trapping techniques were not directly comparable to ours, and he did not trap in the habitat where we found the largest colonies. Overall microtine densities appeared low in 1973, also. In 1976, microtines were utilized as a food source by Glaucous Gulls (Fig. 5), Snowy Owls, red foxes, and probably jaegers.

Arctic ground squirrels (Citellus parryi) were observed very frequently, especially in the north dunes, at Cape Espenberg. They were utilized at least by the foxes as a food source.

Impact of Predators on the Avian Community

Predation rates appeared to be high, 50 to over 90%, for several species of waterfowl at Cape Espenberg (Tables 7 and 11). Loons, Common Eiders, Oldsquaws, and Greater Scaup suffered heavy predation. Red foxes are probably the most significant and efficient predator of waterfowl nests and adults on the cape, as indicated by observations of: 1) the hunting technique of foxes, 2) foxes taking waterfowl eggs,

3) many nests with the eggs missing but with the nest materials intact (not torn apart, with scattered down, as avian predators often do) and no egg shells or fragments by the nest, and 4) large quantities of egg shells and avian remains at fox dens and in fox scats. Parasitic Jaegers were observed taking waterfowl eggs and shorebird young. Their densities, coupled with our observations and Maher's (1974) report that a high percentage of diet of Parasitic Jaegers consists of eggs and birds, probably make them significant predator on the avian community at Espenberg. Glaucous Gulls were probably also of significance because of their large numbers, even though the pellet and dropping analysis indicates that only a small part of the gull's diet consists of eggs and young birds (Fig. 5).

The estimated predation rates on shorebird, Arctic Tern and Sabine's Gull nests (10-30%) were much lower than for waterfowl (Table 7). Which predators are most important to these birds is not known. Foxes, Parasitic Jaegers, and Glaucous Gulls were all known to have taken shorebird and/or tern chicks.

Table 11 presents the estimated predation rates for Common Eider nests in each of the nesting plots and on the eider island. The estimates vary greatly, from 12.4% to 92.3% predation of nests. The eider nests in the island colony suffered the least predation (12.4%). The island provided protection from predation by foxes. It will be checked in 1977 to determine if a barrier of open water exists around the island at the time when nest initiation begins. The island had only two Glaucous Gull nests on it. These gulls were observed taking eggs from one nest and taking four of a group of nine newly-hatched eiders while an investigator was on the island. Parasitic Jaegers were observed taking eggs from two or three unattended nests while an investigator was present. Cape Espenberg has only a few islands where nesting birds are almost completely safe from fox predation and only a small percentage of the total waterfowl nesting population use islands. However, there are extensive areas of hummocks surrounded by shallow marsh water which are utilized by waterfowl and probably provide some protection from foxes.

The estimated predation rates on the Common Eider nests in the shorebird nesting plots (82-92%) are considerably higher than the estimated predation rates in the waterfowl nesting plots (42-44%) (Table 11). It is impossible to say with certainty what caused these differences. One or more of the following factors may be involved: 1) The shorebird plots were checked during the laying period as well as throughout incubation, while, in order to minimize the effects of human disturbance, the waterfowl plots were checked only after most laying was complete. Most predation that occurred during the laying stage would not have been detected in the waterfowl plots. 2) Much more human activity occurred in the shorebird plots, especially in the marsh plot, than in the waterfowl plots. Care was taken not to flush eiders, but when they did flush, the eggs were covered and potential predators were observed. Nor predation of eider nests was observed while investigators were present in the shorebird plot. However, human scent may have attracted foxes to some nests. Also, the nest markers (a tongue depressor pushed half way into the ground) may have attracted both avian and mammalian predators. A different method of marking nests will be used in 1977. In the waterfowl plots the tongue depressors used to mark nests were pushed into the ground until nearly out of sight. This made relocating nests difficult and sometimes impossible, but this method probably rarely visually attracted predators to nests. 3) The shorebird marsh plot had by far the highest waterfowl nesting density of all the plots. This fact could have increased predation by increasing searching and success rate of predators. 4) The eider nests in the shorebird mixed habitat plot were all in very dry, exposed locations compared to the nesting habitats used in the other plots.

Use of Birds by Natives:

Judging from the number of old house pits on Cape Espenberg, Natives had ample opportunity to make intensive use of birds near the north central portion of the cape. Most pits were located near or to the east of our 1976 camp. This previous use probably influenced the density and distribution of birds, especially eiders, geese, loons, and gulls. Other species probably were reduced by free-ranging dogs owned by the Natives. Compared with other areas (Table 9) Cape Espenberg does have a low nesting density of geese, despite apparently good nesting habitat. This may have been the result of egging and killing of adults and young. There is no reason not to believe that local Natives did not influence nesting distribution and densities, as even in the last 20 years, they have influenced nesting waterfowl near their villages and camps (Klein 1966, King and Lensink 1971).

In recent years, Fred Goodhope, Sr. (pers. comm.) of Espenberg mentioned that he did take eggs on Cape Espenberg. He preferred eggs of Glaucous Gulls and Common Eiders. Despite the activities of Fred Goodhope Sr. and his family, Common Eider and Glaucous Gull nesting densites are quite high compared with other areas (Table 7).

Stell Newman (pers. comm.) of the National Park Service, on a hike to Cape Espenberg from Shishmaref in late July and early August 1976, said that the Natives of Shishmaref did not want to come to Cape Espenberg because researchers were going to be there all summer, thus they did not egg or shoot birds. We believe that use by Shishmaref people is very minor or nil. Cape Espenberg is 2 1/2 hours by boat from Shishmaref. It is along the route to Kotzebue, so it might be convenient to stop at the cape to take eggs and shoot adult birds.

However, because of the late break up, the first boat did not travel the outside beach until 17 July. Most eggs were hatched or were in the latter stage of incubation at this time. Thus, eggs would not likely be taken in a late year such as 1976. Also, people from Shishmaref were very busy hunting for bearded seals during June and early July in 1976, and most did not have time to go egging (G. Seaman, pers. comm.). However in normal years, egging and bird hunting might be practiced more often. Based on 1976 observations, present use of birds is minor or nil.

Other Human Activity:

Besides visits by the Goodhope Family of Espenberg, three parties from the University of Alaska, one from the National Park Service, and one from Western Washington University camped overnight on Cape Espenberg in the summer of 1976. All groups were conducting research on birds, vegetation or recreational opportunities.

Cape Espenberg is part of the U.S. Dept. of Interior proposed Chukchi-Imuruk National Reserve to be jointly managed by the National Park Service and U.S. Fish and Wildlife Service. Furthermore, Natives from the Kotzebue Sound area have selected 160 ac. claims on Cape Espenberg under the Alaska Native Claims Settlement Act of 1972. At present, the Bureau of Land Management still administers Cape Espenberg, although Native claims have been surveyed.

Because of impending changes in ownership of the cape, it is likely that human use will increase. Increased human activity may be detrimental to migrating, breeding, brood-rearing, and molting birds. Reaction of birds to human activities varies with the species of bird and the stage in their annual cycle. Based on our observations and those of Drury (1976), non-nesting waterfowl usually move away upon close approach of humans or if shooting or other loud noises occur. On the other hand, shorebirds exhibit a higher tolerance for birdwatchers and even hunters. Some nesting waterfowl, particularly those in the latter stages of incubation, will permit very close approach of humans. Of course this is convenient for photographers, but means death to the bird if the person is a subsistence hunter.

Birds which are migrating overhead or using leads in the sea ice are disturbed little by human activity unless this involves shooting or other harassment. People hiking in or inhabiting the breeding grounds during the nest selection and egg-laying periods can cause birds to desert their territories and/or nest sites (Mickelson 1975). Once birds begin incubation, they are less likely to desert their eggs. Adults and young are influenced little by low levels of human activities, such as hiking and camping. However, unrestricted pets may harrass or kill birds, their eggs, and their young.

Broods of geese and eiders moved to the tideflats and waters of Espenberg Bay and other parts of Kotzebue Sound. Here they are safe from most human activities. Other species use marshes and mudflats which are more accessible to humans. Pre-fledged young and molting adults cannot easily escape or move to less disturbed sites, even if these are available.

Thus, the most susceptible habitats are the marshes where birds are nesting and rearing, and the mudflats where birds are staging. Human activities, especially hunting or loud noises such as produced during construction projects, would affect birds most during the early nesting period in June, and again during late July, August, and September when birds are staging. Habitation by humans and their pets affects both distribution and production of birds through the breeding season.

We suggest to future landowners and administrators that consideration be given to regulating amounts, locations, and types of human activities especially at these times. Cape Espenberg can be visited with minimal disturbance to birds simply by hiking the outer beach, or the sand dunes. This would have little impact on most birds, yet would provide hikers with the opportunity of viewing all of Cape Espenberg and much of its fauna. However, extensive hiking in the dunes may increase erosion and lead to blowouts. It might be necessary to restrict foot travel to beaches which can withstand greater use. Thus, consideration should be given to disturbance of birds and habitat, plus frequency of human use.

Intensive nesting studies, such as ours at Cape Espenberg, are bound to result in some nest abandonment and human-induced predation. Our presence near two Sandhill Crane nests resulted in their desertion and subsequent predation. After egg-laying, cranes incubate nearly continuously (C. Boise pers. comm., and Walkinshaw 1965). It is unlikely that crane eggs would be taken by such predators as Glaucous Gulls and Parasitic Jaegers, unless the incubating bird leaves the nest when a human approaches.

Glaucous Gulls and especially Parasitic Jaegers learn to follow biologists as they locate and check nests. These predators take advantage of any eggs exposed in nests as close as 30 m to a human. This becomes a serious problem in colonial nesting species, such as Glaucous Gulls and Common Eiders (Choate 1967). Mickelson (1975) estimated a loss of 10-12 percent of Cackling Goose eggs on his study area on the Yukon-Kuskokwim Delta due to human-induced predation by Parasitic Jaegers and Glaucous Gulls. We know losses of eggs to gulls, jaegers, and foxes occurred on Cape Espenberg as a result of our activities. However, we were unable to quantify these losses in 1976. Efforts will be made to document human-induced predation during 1977.

Availability and Importance of Invertebrates as Foods

Invertebrates were important alternate foods for some predators and were important as the primary food for many shorebirds. Migrant Dunlins and Western Sandpipers collected in late August and early September were feeding primarily upon the isopod Saduria entomon and pupae of the shore fly, Ephyridae (Table 14). As discussed in the December Quarterly Report, these shorebirds were most numerous on the bay mudflats, primarily in areas of reduced (H_2S present) muds. Saduria entomon and chironomid midge larvae were the largest and most numerous organisms found in mud samples from these areas. Although Saduria was taken by these birds, chironomids were apparently not taken (Table 14). Surprisingly, very few ephyrid larvae or pupae have been found in the intertidal mud samples.

Saduria entomon and shore fly pupae appear to be the most important invertebrate prey for Glaucous Gulls (Fig. 5) and migrant shorebirds. Saduria isopods are important in gull diets for the entire ice-free period. Shore fly pupae were most prevalent in gull pellets in mid July, but were taken by gulls through September in limited numbers.

Knowledge of the seasonal distribution and abundance of these two prey items is poor. The biology of Alaskan shore flies is unknown. We noted numerous adults along the bay beach and driftwood zone throughout the summer. Very few larvae or pupae were found in the intertidal zone. Stan Senner, working on migrant shorebirds in the Copper River delta of south-central Alaska, also found few pupae in the intertidal area, although these organisms were very numerous in migrant Dunlin and Western Sandpiper stomachs (S. Senner, pers. comm.).

Only two studies have examined Saduria isopods in arctic Alaska (Crane 1974, Feder et al 1976). Both studies found juveniles to concentrate in shallow water in summer. Crane (1974) made estimates of the standing crop of Saduria entomon in the Colville River delta (Beaufort Sea). He guessed that three size classes existed and, therefore, that these isopods lived less than three years. There is currently little information on the seasonal distribution and reproduction of Saduria entomon. There is no information on the growth rate of these animals or on their tenacity to a given area. We feel that these questions need to be addressed, particularly since Saduria isopods are: 1) frequently found in nearshore waters that may be affected by oil contamination and 2) an important food resource for resident and migrant birds. We would like to study Saduria entomon intensively throughout the upcoming field season. We would also like to study the distribution of Ephyridae pupae.

Table 14. Preliminary results of shorebird stomach analysis, Cape Espenberg, 1976.

		Percent of Bird Stomachs Containing:						
		Annelida		Arthropoda				
Bird Species	Number of stomachs	oligochaete	polychaete	mysid	isopod	ephyrid	chironomid	unknown dipteran adult
Dunlin	4	25[1]	25	25	75	75	25	25
Western Sandpiper	2	0	0	0	100	100	0	50[1]

[1]Trace amount.

D. Assessment of the Probable Impacts on Birds of Oil and Gas Development

Oil Pollution:

Based on currents, prevailing winds, and driftwood deposits, oil spilled in the Chukchi Sea in the area north of Bering Strait to Kotzebue Sound will likely be deposited on Cape Espenberg beaches. First, we will consider the direct effects of oil on birds. Oil on plumage reduces the insulative value of feathers and often results in hypothermia and consequent death (Erickson 1963, Bourne 1968). Oiled birds attempt to preen their plumage to remove such deposits. In the process, oil is ingested and this may cause death (Hartung and Hunt 1966, Hartung 1967).

At Cape Espenberg, species most susceptible to spilled oil include those which derive most of their food in marine waters, especially by diving (loons, seaducks, alcids) and surface-seizing (phalaropes and larids). Table 15 lists the degree and timing of susceptibility to direct effects of oil pollution. Of the Cape Espenberg avifauna, loons, seaducks, larids, and alcids spend nearly all of their feeding time at sea. Phalaropes feed at sea prior to nesting. Females return to sea after egg-laying, males after brood rearing, and young after fledging. These are also the arctic species most often found dead as a result of oil pollution in the marine environment (Vermeer and Anweiler 1975:475).

Concentrations of these species, as well as gulls, terns, and kittiwakes occur in leads during spring. Oil contamination in these leads may result in catastrophic die-offs. Other feeding aggregations were noted at Cape Espenberg after ice disintegrated or was blown offshore. In late July concentrations of several 100s of gulls and kittiwakes and 10s of terns were feeding near the tip of the Cape, where currents mix and food organisms congregate. An even larger aggregation of gulls and kittiwakes was noted in mid July at the head of Espenberg Bay in a slough leading to Espenberg River. These birds would become contaminated if they plunged into or rested on oil-coated water while feeding.

Gulls, alcids, seaducks, loons, and phalaropes also tend to land on and feed in calmer water after flying to new feeding and resting sites. Since oil calms choppy waters, these are the very locations where birds would land and hence become contaminated (Curry-Lindahl 1960).

Molting sea ducks and flightless young are especially susceptible to oil spills because their only locomotion is by swimming or walking. At present we do not know where most adult male Oldsquaws and eiders from Cape Espenberg molt during July, nor where adult female eiders molt in August and September. We do know that eider broods are

Table 15. Estimated degree and time[1] of susceptibility of Cape Espenberg birds to oiling of plumage and ingestion of oil based on percent of time birds spend on the water, their feeding behavior and their reaction to oil patches.

Species	Unlikely to Be Susceptible[2]	Location of Oil: Nearshore Coastal Waters and Intertidal Flats	Bay waters and Intertidal Flats	Beaches to Driftwood Zone	Sedge-Saltgrass Meadows
Yellow-billed Loon			High: June-Sept.		
Arctic Loon		High: June-Sept.	High: June-Sept.		
Red-throated Loon		High: June-Sept.	High: June-Sept.		
Whistling Swan	X				
Canada Goose			Low: July-Sept.		Low: June-Sept.
Black Brant			Mod: July-Sept.		Low: June-Sept.
Emperor Goose			Mod: July-Sept.		Low: June-Sept.
Snow Goose	X				
Mallard	X				
Pintail			Mod: August		
Green-winged Teal	X				
American Wigeon	X				
Greater Scaup	X				
Oldsquaw		Mod: June-Sept.	Mod: June-Sept.		
Common Eider		High: June-Sept.	High: June-Sept.		
King Eider		Mod: June-Sept.	Mod: June-Sept.		
Spectacled Eider			Mod: June-Sept.		
Surf Scoter		Mod: July			
Red-breasted Merganser		Mod: June-Sept.			
Goshawk	X				
Rough-legged Hawk	X				
Marsh Hawk	X				
Willow Ptarmigan				Low: June-Sept.	
Sandhill Crane			Low: July-Sept.	Low: June-Sept.	
American Golden Plover			Low: June, Aug., Sept.		
Black-bellied Plover			Low: June, Aug.		Low: June-Aug.

[1] Only for months of June through September, based on 1976 observation.

[2] Based on data for 1976; birds could use oiled waters in the future.

Table 15. Continued

Species	Unlikely to Be Susceptible[2]	Location of Oil: Nearshore Coastal Waters and Intertidal Flats	Bay waters and Intertidal Flats	Beaches to Driftwood Zone	Sedge-Saltgrass Meadows
Ruddy Turnstone		Low: July, Aug.	Low: June, Aug, Sept.	Low: July, Aug.	
Black Turnstone			Low: August		Low: June-Aug.
Common Snipe	X				
Whimbrel		Low: July, Aug.	Low: July, Aug.		
Bristle-thighed Curlew		Low: July, Aug.			
Red Knot			Low: July, Aug.		
Sharp-tailed Sandpiper			Low: Aug., Sept.		
Pectoral Sandpiper			Low: July, Aug.		
Baird's Sandpiper			Mod: June, Aug.		
Curlew Sandpiper			Mod: June		
Dunlin		Low: July-Sept.	Mod: July-Sept.		Low: Aug.-Sept.
Semipalmated Sandpiper		Low: July-Sept.	Mod: July-Sept.		Low: Aug.-Sept.
Western Sandpiper		Low: July-Sept.	Mod: July-Sept.		Low: Aug.-Sept.
Sanderling		Mod: Aug.-Sept.		Low: Aug.-Sept.	
Long-billed Dowitcher			Mod: July-Sept.		
Bar-tailed Godwit			Low: July-Aug.		
Hudsonian Godwit	X				
Red Phalarope		Mod: June-Aug.	Mod: June-Aug.		Low: June-Aug.
Northern Phalarope		Mod: June-Aug.	Mod: June-Aug.		Low: June-Aug.
Pomarine Jaeger		Low: June-July			
Parasitic Jaeger		Low: June-July		Low: July-Aug.	
Long-tailed Jaeger		Low: June-July			
Glaucous Gull		Mod: June-Sept.	Mod: June-Sept.	Low: June-Sept.	
Mew Gull			Mod: August		

Table 15. Continued

	Location of Oil				
Species	Unlikely to Be Susceptible[2]	Nearshore Coastal Waters and Intertidal Flats	Bay waters and Intertidal Flats	Beaches to Driftwood Zone	Sedge-Saltgrass Meadows
Black-legged Kittiwake		Mod: June-Sept.	Mod: June-Sept.	Low: June-Sept.	
Sabine's Gull		Low: June-Aug.	Mod: June-Aug.		
Arctic Tern		Mod: June-Aug.	Mod: June-Aug.		
Aleutian Tern		Mod: September			
Common Murre		High: June-Aug.			
Thick-billed Murre		High: June-Aug.			
Horned Puffin		High: July			
Tufted Puffin		High: July-Aug.			
Snowy Owl	X				
Short-eared Owl	X				
Common Raven	X				
Wheatear	X				
Arctic Warbler	X				
Yellow Wagtail	X				
Redpoll sp.				Low: June-Aug.	
Savannah Sparrow	X				
White-crowned Sparrow	X				
Lapland Longspur		Low: Aug.-Sept.	Low: Aug.-Sept.	Low: Aug.-Sept.	

present on Espenberg Bay and on coastal waters (few broods). An oil spill in these areas would result in death of downy young, and possibly of adults. Likewise downy young of brant and Emperor Geese would be susceptible if led by their parents into contaminated waters or onto oiled mudflats.

Staging Pintails and shorebirds would be subject to oil spilled on the mudflats of Espenberg Bay during July, August, and September. Pintails, curlews, godwits, dowitchers, Dunlins, peeps, and phalaropes would be susceptible since these species often wade into the water and at least their belly plumage is wetted.

Oil spills also affect bird populations by killing or contaminating their food source (Evans and Rice 1974). Zooplankton and some invertebrates retain and/or concentrate hydrocarbons when exposed to low levels of oil pollution (Lee 1975, Neff and Anderson 1975, Stainken 1975). Effects of oil pollution on intertidal organisms may persist through successive seasons (Carter 1976). The contamination of these foods would affect most shorebirds and some alcids and seaducks. Contamination of intertidal invertebrates would be a serious loss to staging shorebirds and dabbling ducks during late July, August, and September. Since fishes often are mobile enough to avoid oil spills (Rice 1973), piscivorous birds such as loons, gulls, terns, and murres probably would have a food source available.

Beached carcasses of oiled birds and mammals might be unsuitable for such scavengers as gulls, ravens and foxes. Other contaminated foods include vegetation near the high tide and storm tide lines. The sedge-saltgrass meadows would be affected by oil contamination. These would be unusable by grazing geese and brant, and by resting shorebirds.

The net result of contamination of these foods and feeding areas would be movement of birds to other feeding areas which likely would be of lower quality and/or already occupied by other staging birds which are also competitors for a limited food supply.

Oil may cause indirect effects which lower survival of birds (Evans and Rice 1974). For instance, oil taken into the eyes or ingested could affect feeding behavior. Likewise, oil may obscure food items of plunge divers like terns and kittiwakes, and of surface-seizers like phalaropes and gulls. This, in turn, could force them away from contaminated areas, but may result in competition with other birds.

In summary, oil spills can produce a variety of direct and indirect effects which reduce the survival of birds. All possible caution should be used to minimize the probability of a large oil spill. Chronic low level oil pollution especially should be minmized. It is potentially more dangerous to the ecosystem than catastrophic spills since food organisms may concentrate hydrocarbons and remain contaminated for several years (Evans and Rice 1974).

In view of the danger from oil spills, the most rigid safety standards must be strictly enforced. To give a few examples, transportation of oil should be by tankers equipped with double hulls and separate ballast tanks; pipelines should have an extra set of automatic shut-off valves if pressure should drop below normal; and drilling platforms must be capable of withstanding both wind and wave action, in addition to wind and current-driven thick ice sheets. Should an oil spill occur, booms and other clean up devices must be stationed nearby for immediate deployment.

As Carter (1976) pointed out for the Beaufort Sea, a blowout in an exploratory well could lead to massive losses of fish, birds, and mammals. Since a blowout may occur, an auxillary drilling platform should be stationed nearby to quickly drill a relief well. These precautions will be expensive but, in the long run, will prove their worth.

Material Sites:

Sand and gravel extraction will be necessary for a variety of oil development related activities. Likely material sites are those areas where an abundance of sand and gravel is easily obtained with a minimum disturbance to flora and fauna. Mining of sand dunes, with resultant removal of vegetation, would promote instability of the dunes and result in loss of habitat. In addition, protection of marshes from storm tides and winds would be lost if dunes were removed. More likely sites include the outer beaches of capes and points where sand and/or gravel is continuously deposited by ocean currents. Point Hope, Cape Krusenstern, and Cape Espenberg are such sites (J. Cannon, pers. comm.).

However, sand extraction along the outer beach of Cape Espenberg may have harmful effects. The outer beach is a loafing and feeding area for several bird species (discussed under Habitat Utilization). Sand extraction during July through September would result in turbid waters which would obscure food items for divers like loons, seaducks and alcids, for plunge divers like kittiwakes and terns, and for surface seizing feeders such as phalaropes and gulls. Furthermore, turbid waters and sand extraction during summer would lower the carrying capacity for the food items eaten by birds.

Also, sand is important for maintenance of Cape Espenberg and associated sand bar islands to the south (J. Cannon, pers. comm.). These sand bars are loafing sites for Glaucous Gulls, Black-legged Kittiwakes, Common Eiders, and Oldsquaws during June through September. In September and October they are used by bearded and largha spotted seals (F. Goodhope Jr., pers. comm.).

Therefore, extraction of sand when the coast is ice-free would not only disrupt feeding and loafing birds, and loafing seals, it might prevent maintenance of the cape and sand bars. However, it may be possible to extract sand during winter when biological effects would be reduced by heavy ice cover along the coast and in Kotzebue Sound.

Noise:

Oil and gas developments have associated construction and transportation needs which produce noise. Airplanes and helicopters ferrying supplies and personnel to and from drilling and production platforms; earthmoving equipment, compressors, and tugs in coastal waters all produce noise which can affect the distribution of birds, and, possibly, their production and survival.

High noise levels near Cape Espenberg during spring may affect distribution of birds using leads in the sea ice. Noise from aircraft contributed to abandonment of nests and lowered fledging success of Lapland Longspurs, based on studies along the Frith River, Yukon Territory (Gallop et al. 1974). Aircraft also have been found to frighten non-breeding waterfowl from small lakes in arctic Canada; however, brood-rearing females were unwilling to relocate or abandon their broods (Schweinsburg et al. 1974).

Post-breeding waterfowl vary considerably in their reaction to aircraft. Snow Geese are perhaps the most sensitive. Salter and Davis (1974) reported that flocks of these birds flushed due to fixed-wing aircraft overflights at altitudes up to 10,000 ft. (ca. 3,000 m). Other species of geese react by flushing, milling about in the air, or departing for their staging or wintering areas (P. Mickelson, pers. observ.). In contrast, helicopter overflights were found to have little affect on molting Oldsquaws (Ward and Sharp 1974). On low overflights, birds dived. However, this was only a momentary disturbance and birds soon returned to pre-disturbance activities. Moreover, frequently-disturbed areas were not abandoned by these birds (Ward and Sharp 1974). Studies such as these are necessary to determine species-specific reactions to aircraft and seasonal changes in sensitivity. This information, when coupled with knowledge of avian distribution and density, can be used to provide realistic recommendations for minimizing harassment of birds. Other studies are necessary to set standards for noise levels from construction activities.

Baseline Monitoring Program:

Studies in other arctic areas have shown large annual variations in the numbers, distribution, and productivity of many bird species (Pitelka 1959, Barry 1960, Childs, 1969, Bergman 1974, Maher 1974, Pitelka et al. 1974, Norton et al. 1975). Factors influencing this variation include: weather (for waterfowl and some shorebirds), cyclic prey species (for jaegers), and features not yet determined (for species such as Buff-breasted Sandpipers). The nature and magnitude of normal annual fluctuations need to be understood before the effects of oil and gas development can be assessed meaningfully. For this reason, we have established census transects, nesting plots, and carcass surveys to monitor the avian community at Cape Espenberg. Intertidal invertebrate transects were also established. Although it would be best to continue our present intensity of study, monetary and time constraints will probably limit future efforts (after the 1977 field season) to monitoring only a few indicator species.

Criteria for choosing indicator species might include breeding birds that have: 1) a high position in the food chain, 2) a high degree of site tenacity, 3) a dispersed nesting distribution, 4) at least moderate abundance, and 5) little annual variation in density. Such birds would be most readily affected by the biological magnification of contaminants in the food chain. Strongly site tenacious birds are more likely to show the effects of disturbance to a small area than are free-ranging birds. If the birds normally show only a small amount of annual variation in breeding numbers, then the effects of disturbance should be readily noticeable.

Of the larger waterbirds, Red-throated Loons may best fit these criteria (Bundy 1976:249). They feed almost entirely at sea, where they are one of the top-level consumers. These birds nest solitarily on small ponds throughout the cape.

Of the shorebird species at Cape Espenberg, Dunlins and Western Sandpipers should be considered for indicator species. Both species have been found to have a high degree of site tenacity and low annual variations in breeding densities (Holmes 1970, 1971, 1972). Both species feed primarily in the marsh during the breeding season. They move to coastal mudflats in late July and August where they feed mainly on fly pupae and isopods. Oil contamination of these intertidal areas would likely affect these birds and result in a much lessened return rate of breeding adults the following year.

By following populations of indicator species, impacts on most habitats could be evaluated. Furthermore, beaches could be surveyed for carcasses of birds and mammals. Only one carcass, a Horned Puffin, was found to be oiled in 1976 (Table 5). Future surveys could be conducted to monitor losses due to oil pollution.

VIII. CONCLUSIONS

During the 1976 field season (4 June through 15 September), 68 bird species were recorded on Cape Espenberg. Of these, 30 species nested on the cape. Adjacent areas along the coast have more breeding species because they have cliff nesting habitat for seabirds and/or shrub thickets for nesting passerines.

Based on observations made late in the 1976 spring migration, important habitats for staging birds include: open water leads in sea ice along the coast (outer, northern beach) of Cape Espenberg, snow-free tundra, and ice-free ponds and marshes. Birds rest and feed at these sites before moving to more northerly breeding grounds or before nesting activities begin at Cape Espenberg. Other than a few Common Eiders, there were no concentrations of non-breeders which summered on Cape Espenberg. However, numerous Black-legged Kittiwakes, both murre species, and both puffins fed in adjacent coastal and bay waters.

The majority of breeding birds nested in marsh habitats. Some Common Eiders, most Sandhill Cranes, some Willow Ptarmigan, Ruddy Turnstones, Semipalmated Sandpipers, Western Sandpipers, most Parasitic Jaegers, some Arctic Terns, and most Lapland Longspurs nested in marsh habitat. Birds often fed in or near their nesting habitat, except those feeding on marine fish and invertebrates. Loons, gulls, and terns fed mostly at sea along the outer coast or in Espenberg Bay south of the cape.

Brood-rearing occurred primarily on Cape Espenberg marsh habitat. Notable exceptions include: movement of all Emperor Goose broods, and most Common Eider broods to Espenberg Bay. When shorebirds fledged, many moved to intertidal mudflats along Espenberg Bay where abundant invertebrates provided a rich protein source for build up of fat prior to migration.

The intertidal mudflats of Espenberg Bay were also important for numerous species of staging shorebirds which had bred or were reared elsewhere. In addition, concentrations of Pintails fed on mudflats during August. Other migrants staged on marshes, along the driftwood zone of the coastline, and in adjacent coastal waters.

In terms of avian production, Cape Espenberg had high nesting densities of Red-throated Loons, Oldsquaws, Common Eiders, Sandhill Cranes, Dunlins, Semiplamated Sandpipers, Western Sandpipers, Red Phalaropes, Northern Phalaropes, and Glaucous Gulls. A very high number of Common Eiders and Arctic Terns nested on an island in a large lake near the tip of Cape Espenberg. Compared with adjacent areas, Cape Espenberg had high densities for nearly all of the above-mentioned species. Even higher densities have been reported for Dunlins and Semipalmated Sandpipers nesting near Shishmaref Inlet and Koyuk.

Very low nesting densities were recorded for Arctic Loons, Canada Geese, Black Brant, Emperor Geese, all ducks except Common Eiders and Oldsquaws, and Savannah Sparrows. For some species, these low densities could be explained by poor habitat, but other factors such as phenology, predation, and human activity may have been involved.

Phenology, as manifested in timing of nest initiation, can be important. Late initiation of nests, as occurred in 1976 at Cape

Espenberg, probably resulted in lower nesting densities, smaller clutches, and less nesting success or non-breeding for some species, especially waterfowl.

Predation also affected production by reducing clutch size and nesting success. Parasitic Jaegers and red foxes were the two most important predators. Both relied on birds and their eggs as a food source. Glaucous Gulls did take eggs and young birds. However berries, microtines, and invertebrates apparently were more important in their diet, based on preliminary analysis of gull pellets.

In contrast to previous exploitation by Natives of eggs, young, and adult birds, current losses of birds as a result of human activity are thought to be minor. Although one family of Natives at Espenberg does take eggs of eiders and gulls, they apparently have had little effect on these populations. Previous inhabitants of Cape Espenberg very likely affected distribution and abundance of nesting birds.

Presently, human activity is not significantly affecting avian production or use of Cape Espenberg, based on 1976 observations. Although our research activities (such as checking nests) induced some predation of eggs, these losses were minor. Because of a change in ownership and administration of Cape Espenberg, greater human use is expected in the future. Based on our experiences in 1976, we have suggested regulations (type of activity, time and location) to avoid or reduce conflicts with staging, nesting, and brood-rearing birds.

Based on our 1976 field season we will present some preliminary conclusions about the importance to birds of Cape Espenberg in relation to other areas, and discuss the susceptibility of birds to oil pollution and other OCS impacts. Tentatively, Cape Espenberg is an important nesting area for certain waterbird species, as listed above. But it, and Espenberg Bay are equally, if not more, important as staging areas for local and migrant sandpipers and Pintails during August and early September. The waters and intertidal mudflats of Espenberg Bay host thousands of Pintails, Dunlins, Semiplamated Sandpipers, Western Sandpipers, and Glaucous Gulls, where they apparently feed heavily on Saduria isopods and shore fly pupae. Few areas north of the Yukon Delta have been identified (King and Lensink 1971) to be as important as Cape Espenberg was in 1976. Perhaps other OCSEAP investigators will discover such sites.

Based on currents, prevailing winds, and accumulations of driftwood, oil spills north of Bering Strait to Kotzebue Sound may be deposited on Cape Espenberg. Critical time periods are: 1) spring, when birds are feeding and resting on open water of leads in sea ice, 2) July through September, when sea ducks are molting, 3) July, when eider broods are in the bay, and 4) late July through September, when birds are staging prior to or during migration.

Birds are also susceptible to oil pollution causing a direct loss of food or contamination of foods or feeding areas. Migrant shorebirds, terns, gulls, and kittiwakes would be most susceptible. Likewise, these species may be affected by silted waters (hence obscuring food items) caused by sand extraction during May through September.

We suggest that monitoring of indicator species such as Red-throated Loons, Dunlins, and Western Sandpipers be continued to provide baseline figures on numbers, nesting density, and nest success. Also beached carcass surveys should be continued in order to evaluate the impact of marine pollution incidents.

Only by setting and enforcing strict pollution control standards and by taking precautions to prevent oil spills, can we hope to maintain the current populations of birds at Cape Espenberg.

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IX. NEEDS FOR FURTHER STUDY

Because our field season did not begin until 4 June 1976, we missed spring migration. We need to known when and how many birds are: overflying Cape Espenberg and feeding and resting at the cape and then moving on to more northerly areas. We also need cooperation from other investigators so that concentrations of loons, sea ducks, and alcids can be located in spring.

During the 1977 field season we need comparative information on species occurrence, abundance, and habitat utilization. We will have a detailed habitat map which can be used to plot locations of nests, feeding areas, resting sites, and other important uses by birds. A more accurate estimate of nesting density, average clutch hatched, and average brood size is necessary. This will require surveys of additional study sites on Cape Espenberg.

Both shorebird nesting plots will be resampled in 1977. However, the 2 waterfowl nesting plots will be reduced to 0.5 km^2 each and another waterfowl plot (0.5 km^2) will be added near the tip of the cape. This is necessary to more adequately sample the marsh habitat and to obtain better data for the outer fourth of the cape, which was unsampled by our nesting plots in 1976. For similar reasons we plan to establish a plot in the sand dunes which will be sampled primarily for passerines and Semipalmated Sandpipers.

A greater effort will be made to observe and record broods utilizing Cape Espenberg and Espenberg Bay. This will require additional air or boat support in order to sample Espenberg Bay. We want to determine where eider and Emperor Goose broods are reared, and also where and when concentrations, such as eider creches, occur.

We have identified two important intertidal invertebrate prey items for birds: Saduria entomon and Ephyridae pupae. Life history information on these animals is limited or non-existent. We propose to look at these invertebrates in much more detail in 1977.

For comparison with 1976, we need more detailed information on phenology. When do tundra, marshes, ponds, and lakes become free of snow and ice, and available for feeding and nesting? When do plants flower?

We should assess more closely the numbers and locations of birds killed and eggs taken by red foxes on Cape Espenberg. The active fox den was not located until late July in 1976. Use of alternate foods such as ground squirrels and beached carcasses needs to be documented in more detail.

In addition, our impact on avian production and habitat utilization deserves further study. We know that Parasitic Jaegers and Glaucous

Gulls will accompany investigators during nest checking. This human-induced predation needs to be assessed by an independent observer watching from a distance.

To obtain a clearer picture of the importance of Cape Espenberg, we need additional information on adjacent ares. We do not know the locations of molting areas for: 1) adult male eiders and Oldsquaws during July, 2) breeding adult female eiders in August and September, and 3) male scaup and Pintails in July. Location of these habitats is important since these molting birds are particularly susceptible to oil spills.

Location of nearby staging areas for shorebirds and dabblers needs to be determined. Where are birds prior to their arrival on Cape Espenberg? What other staging areas are utilized, to what degree are they utilized, and when? Also, the availability and relative abundance of foods at these areas should be evaluated. If an oil spill should reach Espenberg Bay, these adjacent sites might serve as staging areas if they are not already heavily used.

Therefore, we are proposing several aerial surveys in the Espenberg Bay and Kotzebue Sound area. One should be conducted in the last half of May in order to determine use of leads and identify concentrations of staging birds. Another flight in mid-July will be necessary to locate eider and goose broods, and concentrations of molting waterfowl. Additional flights in mid- and late August, and in mid- an late September will be required to assess importance of adjacent staging areas. The flights in September also may reveal the locations of loafing sites used by marine mammals.

Finally, the fall migration in 1976 was observed only until 15 September. It would be appropriate to continue observations into early October in 1977.

The original intent of our study was to compare populations of staging, breeding, molting, and brood-rearing birds at two sites on Espenberg Peninsula (which we have referred to as Cape Espenberg, the 13 km long peninsula). We have done this for shorebirds and waterfowl on Cape Espenberg. Furthermore, we have extrapolated these data for the entire cape. However, we have identified Espenberg Bay as a critical fall staging habitat for many birds. Therefore, we propose to compare Cape Espenberg with Espenberg Bay. As discussed above, this will require additional sampling on Cape Espenberg and more aerial surveys, brood counts, counts of staging birds, and invertebrate sampling in Espenberg Bay. Final plans will be formulated prior to leaving for Cape Espenberg on 15 May, 1977.

X. SUMMARY OF OPERATIONS FOR DECEMBER 31, 1976 to 31 MARCH 1977.

A. Laboratory Activities

1. Field trip schedule: none

2. Scientific party and responsibilities:

P. G. Mickelson, Principal Investigator: coordination of data summarization and analysis: coordinate planning and preparations for 1977 field season.

D. Schamel, Research Associate: shorebird and invertebrate sample summarization and analysis: planning for 1977 field season.

D. Tracy, Research Associate: predator data summarization and analysis: processing of predator scats and pellets: planning for 1977 field season.

A. Ionson, Graduate Assistant: waterbird data summarization: planning for 1977 field season.

3. Methods: See Annual Report of 31 March 1977.

4. Sampling localities: no samples collected during 4th quarter.

5. Data analyzed:

Weather records for Kotzebue during 1976 field season and comparable periods in 1973-1975.

Avian occurrence, distribution and habitat utilization.

Avian production during nesting season.

Phenology--correlations between weather, vegetation, and avian activities.

Effects of predators on avian distribution and abundance.

Intertidal invertebrate samples--analyses continuing.

Predator scats and pellets--analyses continuing.

6. Milestone chart and data submission schedule:

Milestone chart on schedule.

Data and information product submission schedule (for products not submitted before 31 March 1977):

bird censuses--coding in progress	15 May
nest site data--coding in progress	15 May
intertidal invertebrate samples--analysis continuing	15 May
predator pellet and scats analysis in progress	30 Sept.
floral species list--identification of species in progress	1 May
base map of study area	15 May
preliminary habitat map	15 May

B. Problems Encountered and Recommended Changes

See Annual Report of March 31, 1977, Part IX.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 27 R. U. #441

PRINCIPAL INVESTIGATOR: Dr. P. G. Mickelson

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
1976 Field Season	6/4/76	9/15/76	6/30/77	6/30/77	5/30/77	9/30/77
			Batch 5	6	7	8
1976 Field Season			5/30/77	5/30/77	4/30/77	4/30/77

1 Data management plan has been submitted and approved by F. Cava; we await contractual approval.

ANNUAL REPORT

NOAA OCSEAP
Contract No. 03-6-022-35208
Research Unit #447

STUDIES OF POPULATIONS, COMMUNITY STRUCTURE AND ECOLOGY OF MARINE BIRDS AT KING ISLAND, BERING STRAIT REGION, ALASKA

PRINCIPAL INVESTIGATOR

William H. Drury
College of the Atlantic
Bar Harbor, Maine 04609

Report prepared by:

William H. Drury
and
Benjamin B. Steele

March 1977

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III. CURRENT STATE OF KNOWLEDGE

Included with the annual report for Research Unit #237, omitted here for brevity.

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VIII. and IX. CONCLUSIONS and NEEDS FOR FURTHER STUDY

Include reference to all our work in the Norton Basin. These sections are included in the annual report for Research Unit #237 and are omitted here for brevity.

FIGURES -- KING ISLAND

1. Map of Norton Sound and Chirikov Basin.
2. Views of King Island from the North and from the South. The location of the study sites are marked by the numbered arrows.
3. Log plot of populations of seabirds on King Island.
4. Map of distribution and numbers by dates: Pelagic Cormorant.
5. " : Glaucous Gull.
6. " : Black-legged Kittiwake.
7. " : Murres.
8. Hourly variation in the numbers of murres counted from the village.
9. Map of distribution and numbers by dates: Pigeon Guillemot.
10. " : Horned Puffin.
11. " : Tufted Puffin.
12. Estimates of numbers of auklets on the island and percentage composition by species.
13. Map of distribution and numbers by dates: Least Auklet.
14. " : Crested Auklet.
15. " : Parakeet Auklet.
16. Air Transect: Waterfowl.
17. Air Transect: Glaucous Gull.
18. Air Transect: Black-legged Kittiwake.
19. Surface Transects: Black-legged Kittiwake.
20. Surface Transects: Black-legged Kittiwake.
21. Air Transect: Murres.
22. Surface Transects: Murres.
23. Surface Transects: Murres.
24. Air Transect: Auklets.
25. Surface Transects: Auklets.
26. Surface Transects: Horned Puffin.

TABLES -- KING ISLAND

1. Numbers of nests and of adults: Kittiwakes.
2. Events at Study Site #2: Kittiwakes.
3. Counts of Thick-billed and Common Murres at study sites.
4. Counts of puffins -- two observers counting the same sections of cliffs.
5. Estimates of numbers of auklets on the upland and percentage composition by species.
6. Counts of auklets in the amphitheater above the village Ukivok.

I. SUMMARY

Objectives, conclusions and implications with respect to OCS oil and gas development.

The objectives of this work include 1) learning what species occur where in what numbers, 2) identifying which areas are of great importance, why and what factors cause stresses on seabirds, 3) identifying what activities associated with mineral development may diminish these wildlife populations, and 4) recommending stipulations to mitigate the negative effects and maximize beneficial effects of development.

King Island is a major center of seabird reproduction of worldwide importance. It supports remarkable numbers of Thick-billed Murres, Common Murres, Horned Puffins, Least Auklets, Crested Auklets and Parakeet Auklets. It also supports important populations of Pelagic Cormorants, Tufted Puffins and Pigeon Guillemots. The population of murres is interesting because there are equal numbers of Thick-billed Murres and Common Murres. Parakeet Auklets are especially numerous and Crested Auklets are less numerous than we expected.

Observations indicate that the sea waters are constantly moving past King Island, at times from the north, but primarily from the south. The seabirds feed tens of nautical miles in all directions from the island, primarily to the west.

The natural stresses to which seabird nesting areas and their feeding grounds are exposed are already near the limit of tolerance. Furthermore the patchiness of resources means that those habitats which are suitable cannot be readily replaced by second choices.

A number of selecting forces have brought out specialized adaptations among seabirds. These include small clutches of eggs (usually 1), reproduction delayed until the birds are several years old and, associated with these, long life expectancy. Slow growth of young allows them to survive temporary food failures. Long adult life allows populations to be maintained during several years of reproductive failure. But because it requires several years for a young adult to make a place among those holding breeding territories, large numbers of non-breeding (excluded) or pre-breeding (young) birds are found at most colonies. Our studies indicate that a large percentage of the birds at King Island do not hold breeding territories. This surplus means that breeding numbers would probably not be immediately affected by a large die-off. The season of 1976 was one of reproductive failure, one of the major stresses to which northern seabirds are subject.

These observations suggest two pitfalls to simple interpretations of direct effects of mineral development. The first pitfall would be to accept automatically a cause-and-effect relation if reproductive failures occurred among seabirds in the first years of development. Reproductive failures are chronic in arctic regions. The second pitfall would be to conclude minor damage following a first oil spill which had only small impact on the numbers of birds breeding at major seabird cliffs. A first oil spill might eliminate most of the non-breeding birds already excluded from holding territory. A second spill of similar size could seriously affect the number of reproducing pairs. Because seabirds lay only 1 or 2 eggs and may delay breeding for 3 or 4 years, the impact of such an event could be felt for many years.

King Island is a core area for the population of seabirds in the Norton Basin. Seabird nesting areas should be as little disturbed as possible during the breeding season because their annual reproductive contribution is small and the natural stresses high. For reasons discussed in the text we conclude that close overflights by aircraft, and especially overflights by helicopters, should be categorically forbidden except when amply justified.

The continuous flow of water past the island suggests that contamination by oil or other industrial chemicals spilled almost anywhere in the Norton Basin will probably reach the island or the feeding grounds of local seabirds and sea mammals.

These observations and conclusions suggest that strict stipulations as to safety precautions will have to be mandatory over a wide area of the northern Bering Sea if the seabird populations of this area are to be maintained. Because the island is a seabird colony of major importance on a world scale, there is a direct conflict of interests between the private property interests of natives and the public property interests of the U.S. public in the wildlife. Thus special political institutions are necessary to guarantee the survival of and access to the breeding areas.

II. INTRODUCTION

A. General nature and scope of the research

This report is part of a study of seabirds in the biological structure of the northern Bering Sea. Its objectives are 1) to increase the knowledge of the ecology of this major world center of number and diversity of seabirds, and 2) to gather information relevant to the formulation of guidelines and stipulations for mineral development.

The Bering Sea is a complex water mass divisible into two major parts. The first occupies a deep basin north of the Aleutian Islands, and the second is spread over a shallow continental shelf extending north from the Pribilof and Saint Matthew Islands through the Bering Strait. The outflow of the Yukon River dominates the shelf waters in the eastern Bering Sea, including the waters of Norton Sound (Figure 1). North Pacific water flows through deep passes between the Aleutian Islands. Some of this water probably contributes to the highly saline water which flows out of the Gulf of Anadyr into the Chirikov Basin and joins with the northwest drift of Yukon River water to move through the Bering Strait. This saline water is characterized by impressively high primary productivity. The Chirikov Basin and western Bering Strait also benefit from unusually high productivity at the ice edges as drift ice retreats northward.

Reportedly, cold bottom water has prevented commercially valuable fishes from extending their ranges into the Chirikov Basin to crop the high diversity of benthic life. But other vertebrates have. Walruses, Bearded Seals, Ringed Seals and Spotted Seals are abundant at the ice edge. Bowhead and Beluga Whales are part of the under-ice and ice-edge fauna. There seabirds formed the food base of a sophisticated pre-colonial Eskimo culture in the Saint Lawrence Island waters and Bering Strait.

Although seabirds are numerous in Norton Sound, fewer species and smaller numbers occur there than in the Saint Lawrence Island waters and Bering Strait. Our research examines why there are similarities and differences.

B. Specific objectives

Specifically this study is a survey of the seabirds, waterfowl and shorebirds along the shores and islands of the Seward Peninsula. What marine birds occur in what numbers and at what places? What is the schedule of breeding events and how is that schedule related to the weather? What natural sources of stress affect them? Which areas are most important for wildlife?

The study is divided into three main parts. The first examines the coastal distribution of waterfowl. What is the seasonal distribution of waterfowl in coastal waters, lagoons and beaches? What fresh and brackish wetlands are most important gathering places before and during migration? What redundancy of resources is necessary to allow populations to survive periods of stress? Are there obvious effects of out-of-season hunting?

The second part of this study examines the distribution of sandpipers and plovers. What habitats are used by shorebirds for breeding or for gatherings before and on migration? Does the presence of people disturb them on their breeding or gathering areas?

The third study is the main focus. It is a study of the breeding biology of seabirds. This project is in two parts:

1) Continuing detailed studies are being made at the cliffs at Bluff between Nome and Golovin. At Bluff we have established 19 study sites at which individual nests of kittiwakes, murres and puffins are

mapped and visited every other day. Events at the nests were recorded between the end of May and the second week of October in 1976.

2) Surveys, censuses and short-term studies have been made at other colonies such as the major one on King Island and the minor ones on Sledge Island, Cape Denbigh, Egg Island, Cape Darby and Topkok. We have surveyed the shore and islands of the Seward Peninsula for all the seabird nesting areas between Teller and Stebbins. In the future we hope a) to survey the important colonies at Fairway Rock and on Little Diomede Island, and b) to work on the distribution, behavior and diet of birds offshore on their feeding grounds.

C. Relevance to problems of petroleum development

As we argued at a symposium on marine birds held at Seattle in May 1975, it appears that the sweeping generalizations of most current ecological theory will not be helpful in plans to assist seabird populations through the periods of stress promised by economic development in the Bering Sea.

It is our experience that the awkward details of seabirds' daily behavior, many of which seem to clash with general theory, are the "stuff" which really makes natural systems work. But there is not enough time to carry out the detailed studies needed to identify the critical population-habitat interactions before designing programs to help seabirds maintain their numbers. Because detailed studies take too much time and because much ecosystem theory is more of "heuristic" than practical value, we conclude that it is necessary to identify those biological characteristics of seabirds which are most relevant to their survival. A knowledge of these ecological characteristics and habitat needs will allow us to make predictions about the impacts which development of mineral resources may bring.

Further perspective is given in Section III "Current state of knowledge" in the annual report for Research Unit #237. For those being sent a copy of both reports, that section is omitted here for brevity.

IV. STUDY AREA -- KING ISLAND

The studies at King Island during 1976 are part of a larger study of the seabirds, waterfowl and shorebirds of the Norton Basin and south shore of Seward Peninsula, northwestern Alaska (Figure 1).

King Island lies at approximately 65° North Latitude and 168° West Longitude in the Chirikov Basin about 40 n.mi. (75 km) south of Cape Prince of Wales which is the westernmost point in continental North America. It is also about 40 n.mi. west of the beaches at Cape Woolley on the Seward Peninsula. The water to the east is mostly less than 20 fathoms (40 meters) and that to the west is mostly deeper than 20 fathoms.

The island (Figure 2) is 1200 feet (370 meters) high, largely granitic with bold outcrops forming arretes on the south and north sides, massive vertical slabs on the east side and "Stonehenge"-like monuments on the gently rolling uplands. Gullies extending down the sides of the island between bedrock outcrops are occupied by boulders and scree slopes at 40-45°. These are heavily vegetated with grass (*Calamagrostis*).

The village, Ukivok, abandoned for about ten years, lies on a shoulder of a fan of massive granite boulders. The fan has been undermined by wave action during recent storms.

King Island, like Saint Lawrence Island and Little Diomede Island, is a nesting site for large numbers of Thick-billed Murres and three species of auklet. These four species are virtually absent from Norton Sound. Studies of the breeding biology of these species and why they occur where they do is relevant to knowledge of the biological structure of the northern Bering Sea.

Our 1976 activities at King Island involved work in June and August: 1) surveying the island for the numbers and kinds of species

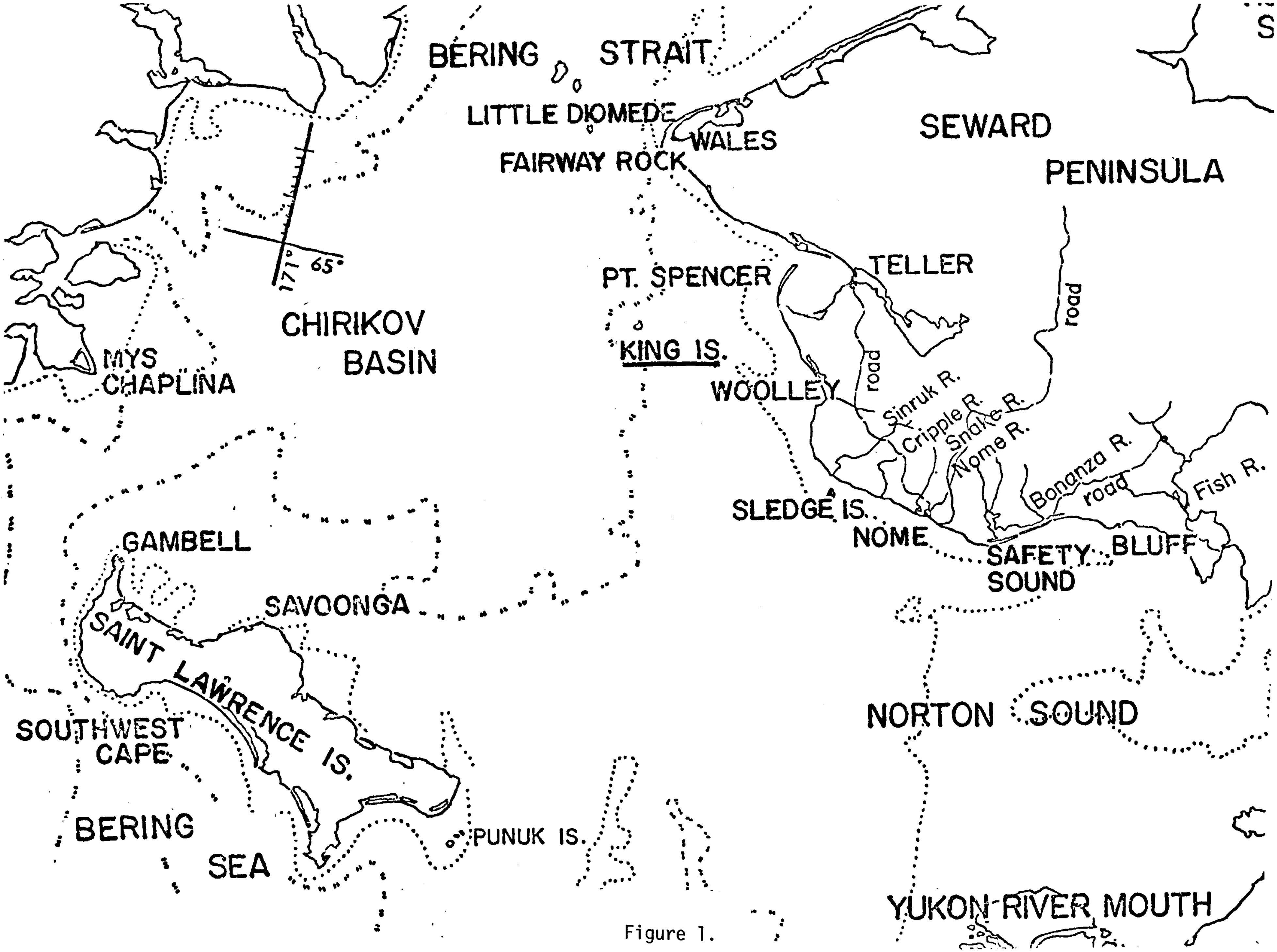

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
S
171°
65°
CHIRIKOV
BASIN
MYS
CHAPLINA
PT. SPENCER
KING IS.
TELLER
road
WOOLLEY
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
SLEDGE IS.
NOME
SAFETY
SOUND
BLUFF
GAMBELL
SAVOONGA
SAINT LAWRENCE IS.
SOUTHWEST
CAPE
BERING
SEA
PUNUK IS.
NORTON SOUND
YUKON RIVER MOUTH

Figure 1.

Figure 2

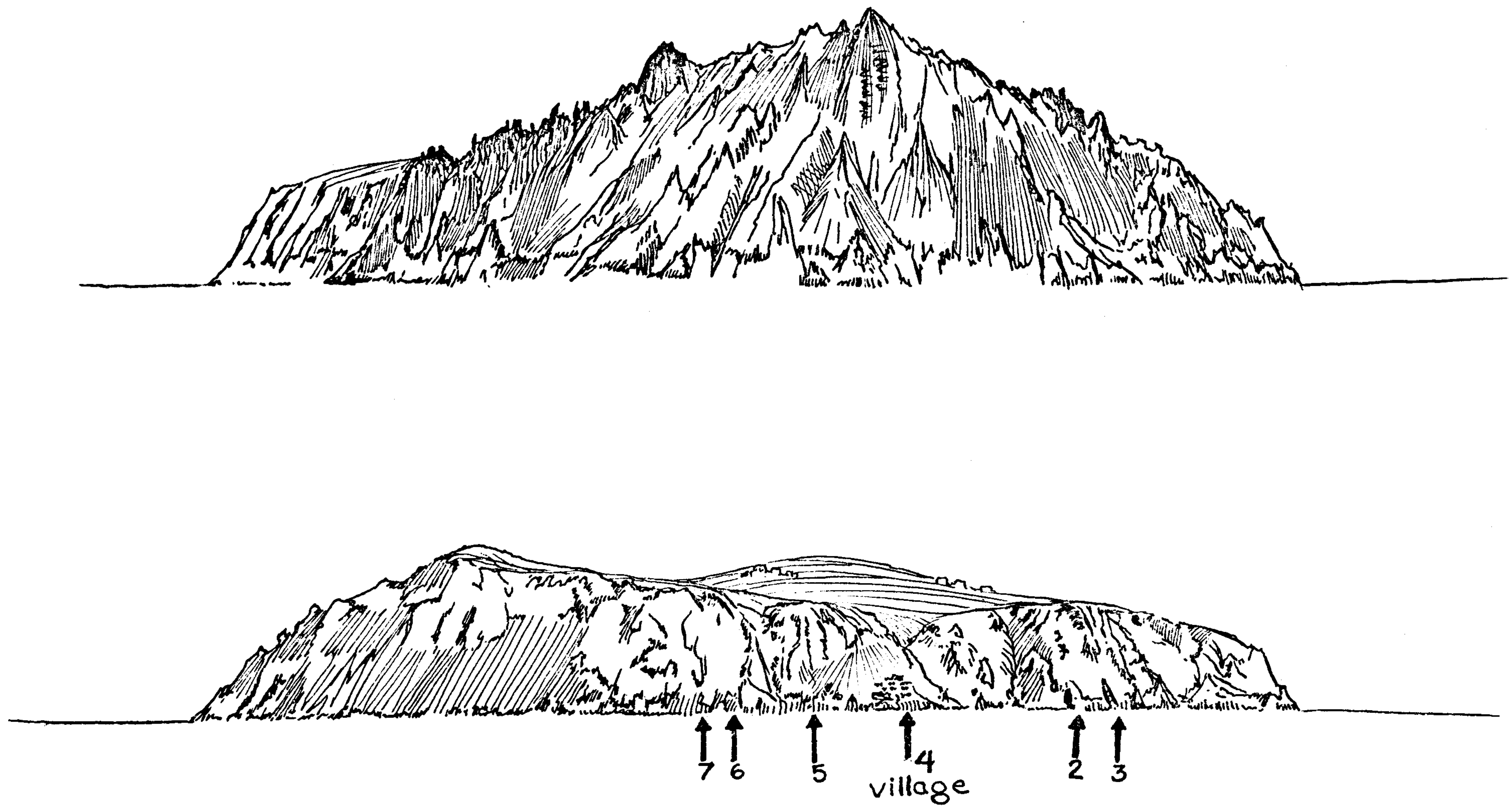


Figure 2 King Island from the north and south

nesting there; 2) observing the events during the breeding cycle; 3) learning where and in what habitats the birds nest; and 4) locating spots which would be suitable for study sites in case studies are carried out there in the future.

In addition to the activities on shore, we made air and surface transects over the waters of the Chirikov Basin to chart the distribution of birds at sea. These air and sea transect courses are shown on Figures 16-26.

The north point of King Island, showing the bold outcrops of slabs of granite, is illustrated in the top drawing of Figure 2. Tens of thousands of murres nest from near sea level to high on the cones near the sky line. Some kittiwakes nest within 50 feet of the water on the right side of the area shown and some others on the middle left.

The lower drawing in Figure 2 portrays King Island as seen from the southwest. The village is in the middle. Arrows and numbers represent the locations at which study sites were established. The area referred to as the "amphitheater behind the village" lies between the arrow numbered 5 and that numbered 2. There were a few murres nesting low on the wave-cut cliffs of this part of the island. Kittiwakes nested on wave-cut cliffs east of the village, at several places on the southwest shore and in an aggregation around the corner on the west side of the island. Horned Puffins nested in the grassy slopes between arrows 7 and 3 and in very large numbers on the grassy slopes on the southwest slopes. Auklets nested in boulder fields on the slopes behind the village, but their greatest concentration was among angular boulders on the highest left-hand side of the island.

V. SOURCES, METHODS AND RATIONALE OF COLLECTING DATA

Methods

1. Cliff census. Censuses of breeding colonies were made from a small boat moving slowly past the front of the cliff. Counts of each species were made by ones, tens, or hundreds. We repeatedly had two people count the same species in order to "calibrate observers" to check the variability of the counts.

Past experience has shown that when several observers make estimates, the highest estimate is closest to the real number. Usually estimates are within 20% of the highest estimate. Twenty percent is under the daily fluctuation of numbers of birds on the cliff.

With some species, such as murres, it was necessary to count the numbers of birds that were scared off the cliff by the approach of the boat or were just circling before landing. The flying birds often consisted of a large portion of the total. It is presumed that the murres that are easily scared off are less attached to the cliff and are probably non-breeding birds. Hence, a count that is made after many birds have flown is closer to the number of breeding birds than is a count of the total number of birds on the undisturbed cliff. During all counts from a boat the number of flying murres was counted separately from the number of birds on the cliff.

It was impossible to tell the difference between Thick-billed and Common Murres while counting. Samples of murres were counted from a closer position to determine the proportion of Thick-billed Murres to Common Murres.

2. Reproductive success

a) Kittiwakes

Counts were made at study sites in late June and early July to determine the proportion of incubating or brooding adults to the number of nests. Similar counts were made from a small boat during mid-August. Although some birds that appear to be incubating do not have eggs and some eggs are left unattended at times, this measure of reproductive success is comparable to what we found using other methods used at Bluff (see report on Research Unit #237).

b) Murres

It is often impossible to see if there is an egg or chick under a murre on a crowded ledge. Therefore it is hard to measure breeding performance through the season. In the course of studies at Bluff Cliffs we developed a method that is sufficient for comparison.

Where we had a close view of a ledge we counted the total number of murres and the number that appeared to be incubating. By "incubating murres" we refer to those birds that have a slightly different posture than birds without an egg or chick. They stand facing the back of the ledge, not the sea. They lower their wing on one or both sides or assume a lower posture with their body closer to the ledge. Often they crouch right against the angle of the back wall with their bill pointed up.

However, we watched several birds squatting or with lowered wings who later got up and revealed no eggs. Likewise, there would sometimes be an egg under a murre that was standing on a ledge looking no different than the birds without eggs.

With murres, there are a lot of non-breeders present on the cliff so it is difficult to get an idea of the precise number of breeding pairs. So there is not an unequivocal measure of reproductive success.

c) Glaucous Gulls

Reproductive success was measured by observing and counting the numbers of young in each family when the young were big enough to be seen standing near a nest and had not yet fledged.

3. Breeding Schedule

The schedule of the breeding cycle was determined according to the stages: dates of arrival, courtship and egg-laying. These were compared to the schedule at Bluff Cliffs.

4. Attendance at the cliff

The pattern of daily and hourly attendance of birds on the cliff was established by counts of birds on specific sections of cliffs visible from the village. Forty-three counts were made during several days from 0330 to 2300.

5. Distribution at sea

a) Shipboard

Transects were made on board the NOAA ship Surveyor to determine where the feeding grounds in Norton Basin were. Two airplane flights were made to see if similar information could be collected more cheaply and quickly from a plane.

The Surveyor cruise trackline was planned to cover as much of Norton Sound and the Chirikov Basin as practical and to provide radial transects from the major breeding colonies. During transects an observer on the flying bridge recorded species, number, activity, direction of flight and distance from the ship within a 300-meter zone on one side of the ship from dead ahead to abeam. Standard 10-minute watches were taken almost continually during daylight hours. Identification was made to species except for the murres. Personnel on board Surveyor calculated starting and ending position for each transect, as well as time, wind speed and direction, depth and surface temperature of the water, barometric pressure, distance run, and speed. One hundred and ten standardized 10-minute watches were made during 170 nautical miles on 15 tracklines.

b) Aircraft

We chartered two twin-engine aircraft from Nome. One was a 9-passenger DeHaviland Islander which flew at approximately 100 knots at about 100 feet altitude. This plane afforded good visibility for one observer in the front seat, but other observers' vision was partially blocked by the engines and landing gear. The second plane was a Cessna Skymaster with one engine in front and one behind. The landing gear is below the fuselage so there is good visibility to the sides for four observers in the back seats. This plane also few at about 100 mph at 100 feet altitude.

Aerial flights over the ocean covered 465 nautical miles.

6. Prey species

Assistants climbed to ledges and collected fish that had been dropped. These fish were preserved in dilute formaldehyde and were identified at the Museum of Comparative Zoology at Harvard. It is assumed that these do not represent food items that are rejected by chicks.

The best method for getting a sample of food items is to examine the contents of their stomachs, but the birds that we shot on the colony had empty stomachs and we did not have the facilities to capture birds on the feeding grounds.

Forty prey items were collected including *Mallotus villosus* - 3, *Boreogadus saida* - 2, unidentified Gadids - 3, *Lumpenus* cf. fabricii - 20, *Ammodytes hexapterus* - 6, unidentified Cottids - 6.

7. Weather

To determine how the behavior, movement, reproductive success, and feeding of the birds related to the prevailing weather, observations of the weather were made whenever data was being collected. Wind speed was estimated using the Beaufort scale. Wind direction, sea state, cloud cover, temperature and visibility were also recorded at several times during each day.

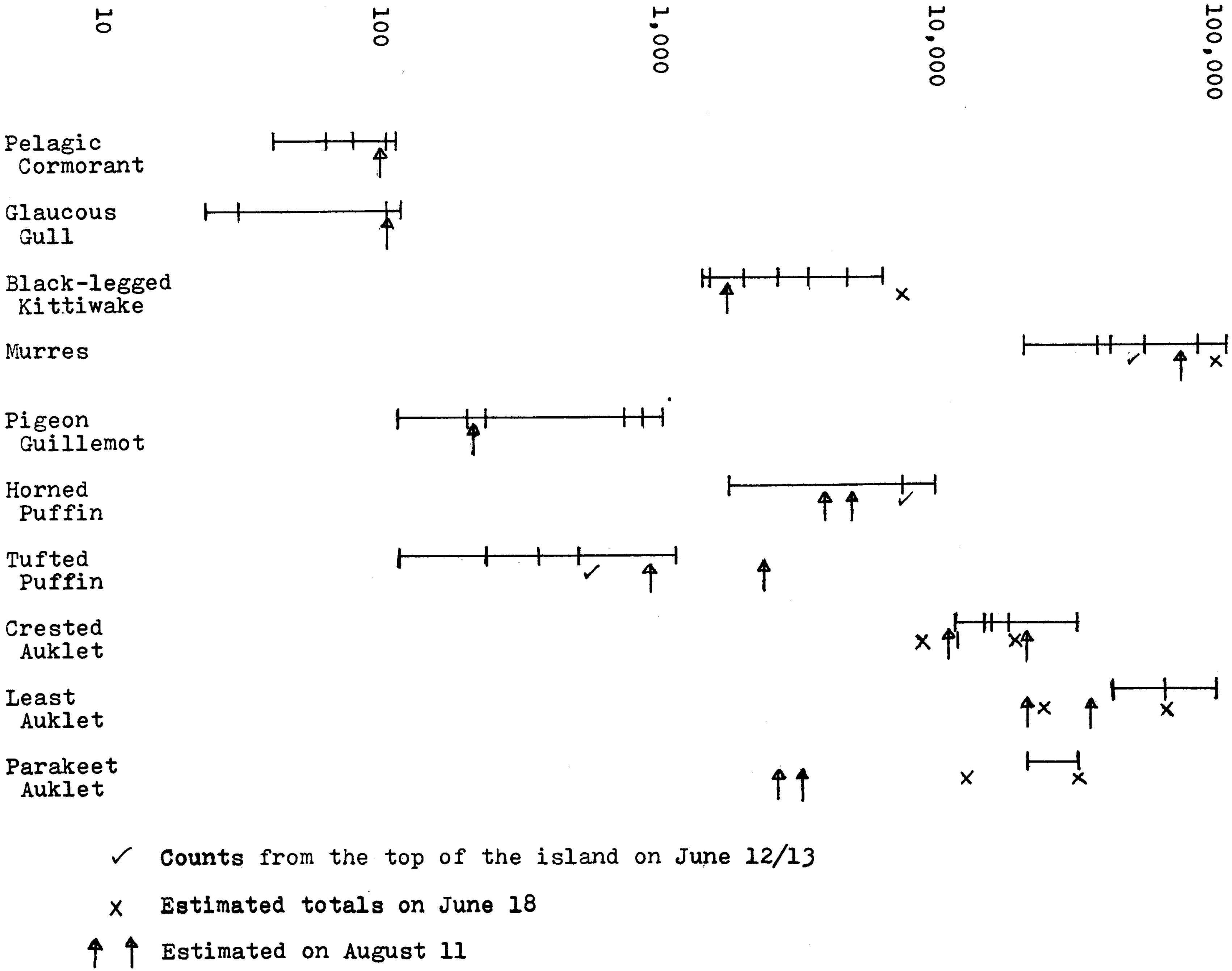

10
100
1,000
10,000
100,000
Pelagic Cormorant
Glaucous Gull
Black-legged Kittiwake
Murres
Pigeon Guillemot
Horned Puffin
Tufted Puffin
Crested Auklet
Least Auklet
Parakeet Auklet
Counts from the top of the island on June 12/13
Estimated totals on June 18
Estimated on August 11

Figure 3.

VI. RESULTS

We report here what we learned about numbers and the schedule of reproduction during 1976. The totals for each species of seabird is shown in Figure 3. Note that the scale is logarithmic.

In late September of 1975 we talked with Ed Muktoyuk who was brought up on King Island and who stayed until the last islanders left. He now works for the Alaska Department of Fish and Game. We asked him a number of questions and report his answers as we understood them. We were interested to notice that these people seemed to make little distinction between the two species of murre although they clearly recognized the differences. We found the same situation to be the case as regards Golden Plovers and Black-bellied Plovers among the Eskimos at Pond Inlet on northern Baffin Island.

A. Numbers and activities of birds on King Island

1) Explanation of maps.

The numbers shown around the map of the island are presented: Date followed by the number estimated on that date. Topographic points are indicated by letters. The estimates made between two topographic points are shown in the equivalent space. When an estimate included two usually separated units, that estimate is recorded outside, e.g., in Figure 4 those for 6/30, 7/1 and 7/2 refer to the area between B and D on the east side. The figure for 8/9 refers to the area between G and I. Figures in parentheses represent counts of nests. Totals of individuals for the entire island are shown on the left. On the maps for auklets, ovals have been drawn to designate the area concerned in the estimate indicated.

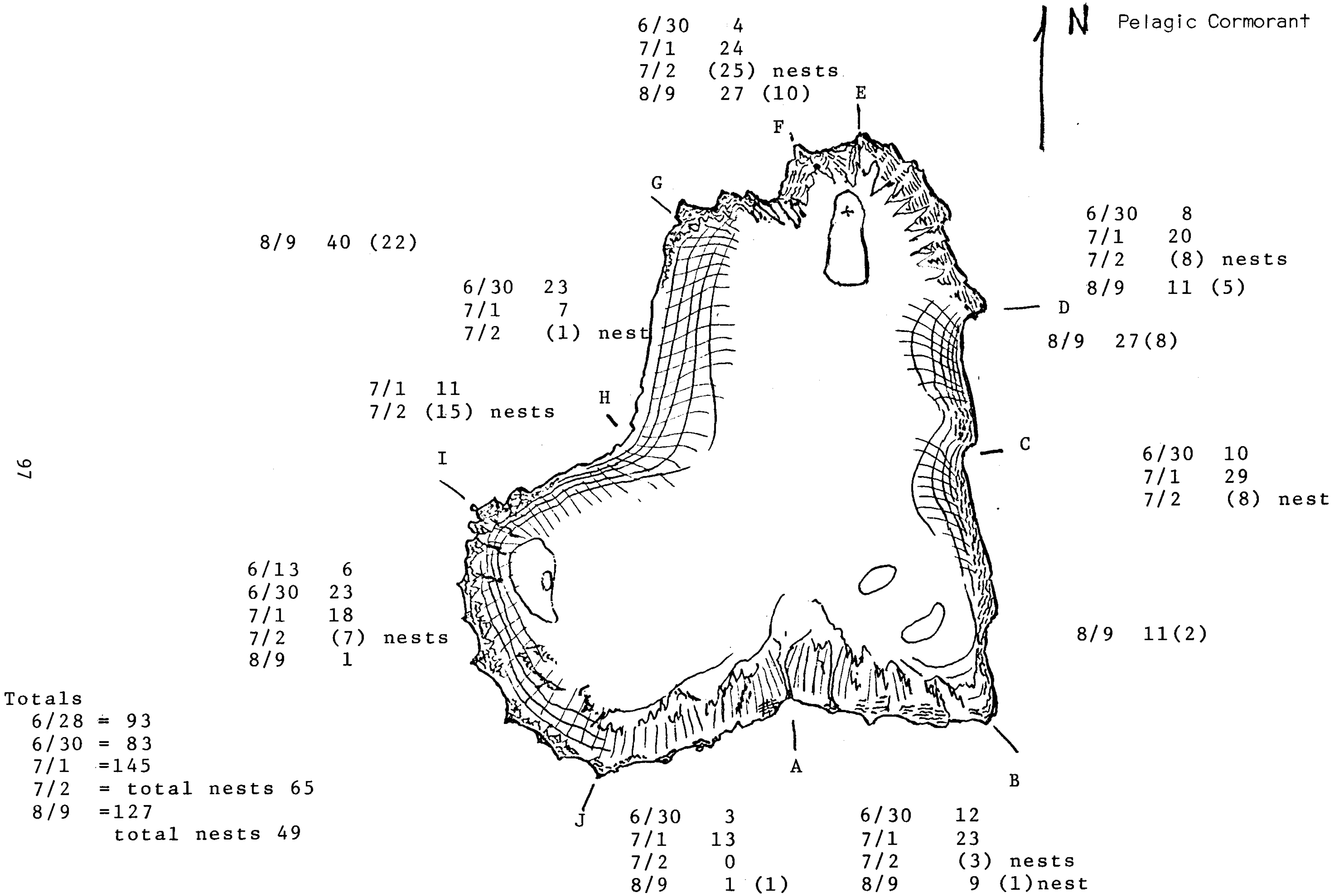

N
Pelagic Cormorant
6/30 4
7/1 24
7/2 (25) nests
8/9 27 (10)
E
F
G
8/9 40 (22)
6/30 23
7/1 7
7/2 (1) nest
7/1 11
7/2 (15) nests
H
I
6/13 6
6/30 23
7/1 18
7/2 (7) nests
8/9 1
6/30 8
7/1 20
7/2 (8) nests
8/9 11 (5)
D
8/9 27(8)
C
6/30 10
7/1 29
7/2 (8) nests
8/9 11(2)
B
A
J
6/30 3
7/1 13
7/2 0
8/9 1 (1)
6/30 12
7/1 23
7/2 (3) nests
8/9 9 (1)nest
Totals
6/28 = 93
6/30 = 83
7/1 =145
7/2 = total nests 65
8/9 =127
total nests 49

Figure 4.

2. Pelagic Cormorant (Pohltluk)

These birds (Figure 4) were already present on the cliffs when we flew over on June 4. Nests were scattered around the islands on large outcrops. Clusters of nests were found on the northwest and north points. Our counts varied from 65 nests counted in early June to 49 in mid-August.

Breeding Schedule. Cormorants were carrying nesting material on June 13 and 18. There were no nests that we could look into and we have no estimate of the number of chicks produced.

Feeding. Cormorants fed close to the island, especially when the ice there was breaking up and during storms. One bird regurgitated a wolf-fish 16 inches long.

Ed Muktoyuk told us that at the island cormorants lay eggs about the same time as murres, i.e., in the period June 20-July 5. The eggs, usually 4, hatch in late July. When the young, usually 2 or 3, fledge they leave the area of the nest and loaf somewhere else. These birds stay at the island later than most -- until freeze-up.

3. Glaucous Gull (Noyuk)

These gulls (Figure 5) were already on territories on the island when we flew over on June 4. Their territories were scattered along the perimeter of the island with a cluster of nests at the northwest and north tips. Nests were placed on rock outcrops just below vegetated slopes. Most were between 30-60 feet above the water.

Breeding Schedule. A clutch of 2 (which was later completed to 3) was seen on June 26. Two hatched chicks about a week old were seen on July 2 and two newly hatched chicks were seen on July 5. On August 9 we counted two broods of 1 chick, three broods of 2 chicks, and three broods

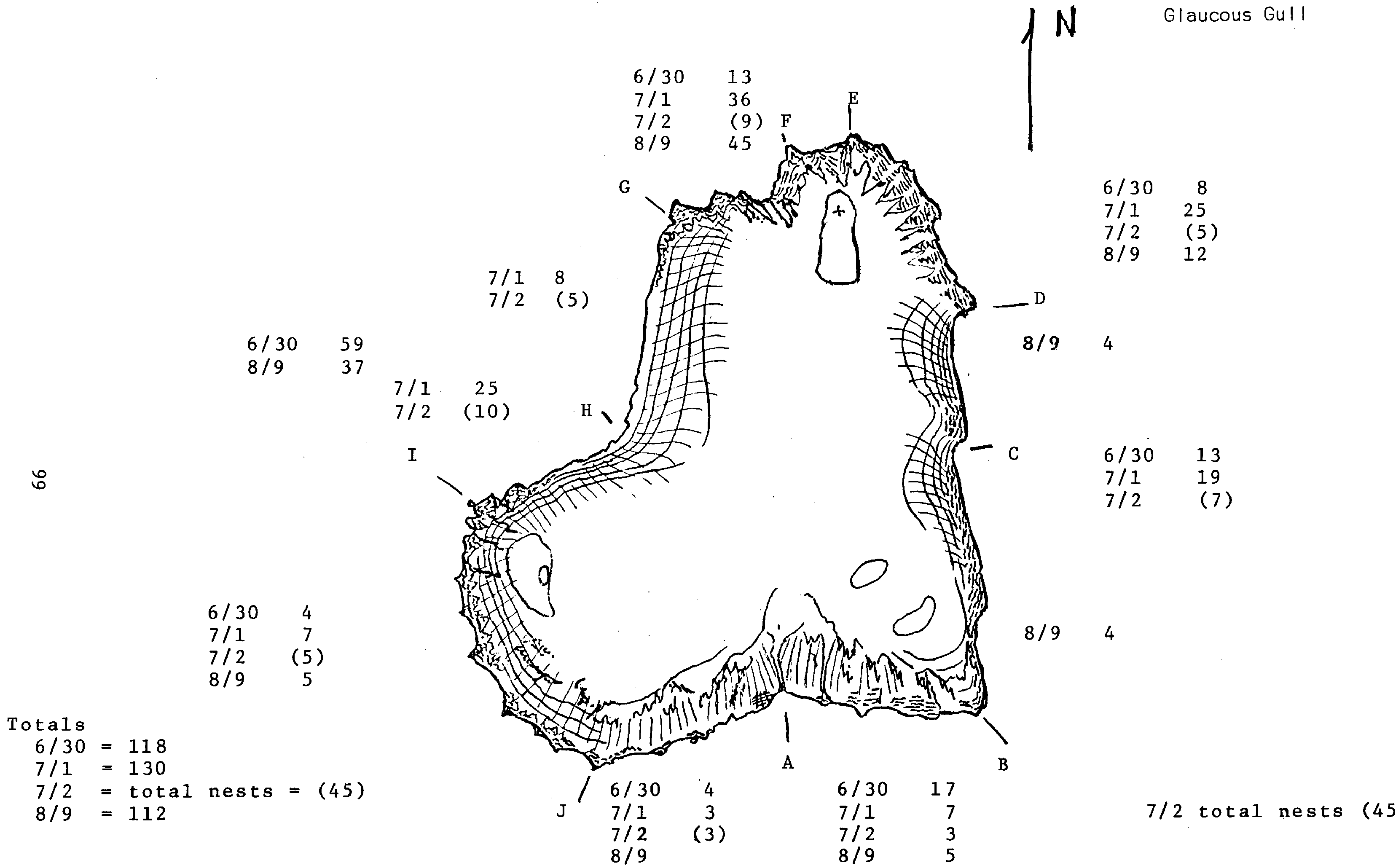

N
Glaucous Gull
6/30 13
7/1 36
7/2 (9)
8/9 45
F
E
G
6/30 8
7/1 25
7/2 (5)
8/9 12
7/1 8
7/2 (5)
D
8/9 4
6/30 59
8/9 37
7/1 25
7/2 (10)
H
I
C
6/30 13
7/1 19
7/2 (7)
6/30 4
7/1 7
7/2 (5)
8/9 5
8/9 4
Totals
6/30 = 118
7/1 = 130
7/2 = total nests = (45)
8/9 = 112
A
B
J
6/30 4
7/1 3
7/2 (3)
8/9
6/30 17
7/1 7
7/2 3
8/9 5
7/2 total nests (45)

Figure 5.

of 3 chicks in an area where we counted 15 nests on July 2. This gives a chick per nest production of 1.1, which is very high.

Ed Muktoyuk told us that these gulls come back to the island in the middle or last of April. Eggs, usually 2, are laid in the first week of June and hatch in late June or very early July. These gulls are increasing. They and white foxes eat lots of eggs and chicks of the other seabirds.

4. Black-legged Kittiwake (Eerok)

The numbers of kittiwakes (Figure 6) at the island varied less between censuses than did those of other species. Counts were made of nests and of total numbers of birds on cliffs a) east of the village and along the southwest shore from the sea ice, and b) at study sites. These indicate that the total birds on the cliff multiplied by .66 or .75 will give a good estimate of the numbers of nests.

Nest-building and egg-laying at King Island appeared to be disrupted in 1976 as it was at Sledge Island and the cliffs at Bluff. We are not sure, therefore, how our counts will compare to population estimates other years.

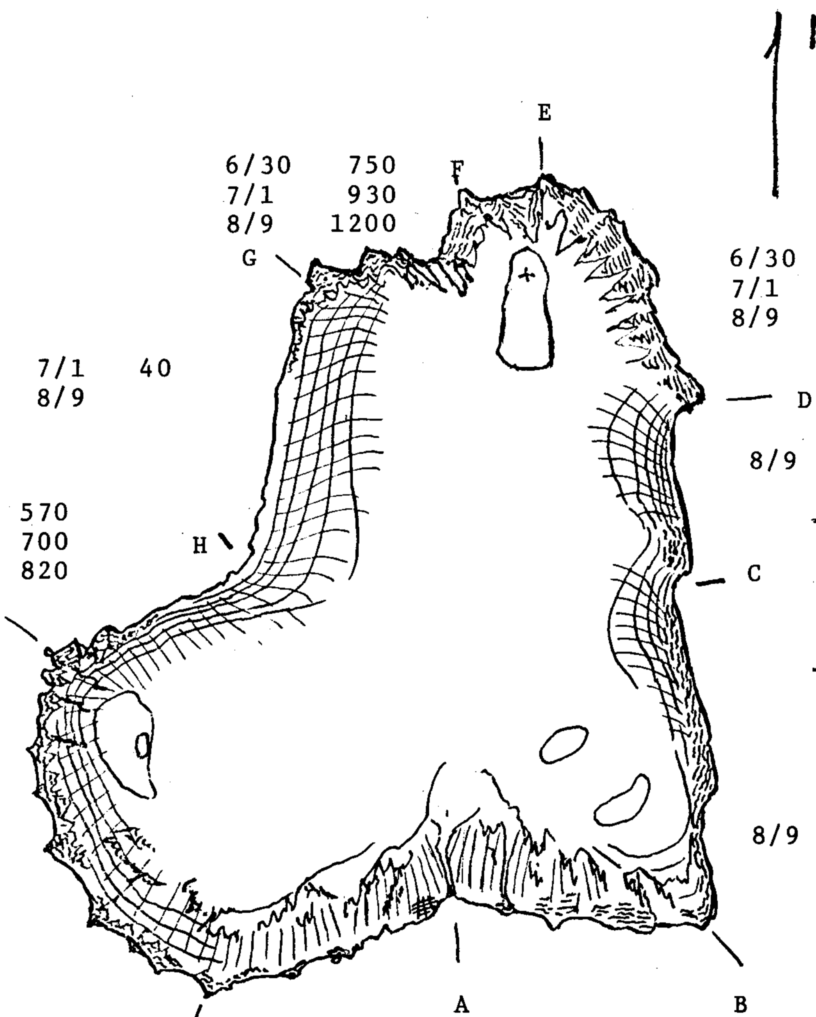

N
Black-legged Kittiwake
E
F
6/30 750
7/1 930
8/9 1200
G
6/30 270
7/1 210
8/9 230
7/1 40
8/9
D
8/9 60
6/30 570
7/1 700
8/9 820
H
I
C
6/30 80 D-B
7/1 100 D-B
6/13 298 nests
576
6/30 410
7/1 330
8/9 410
8/9 90
A
B
J
6/30 21
7/1 21
8/9 38
6/16 107 nests - 187 individuals
6/27 656 J-A-B-C-D
6/30 210
7/1 150
8/9 250
6/28 = 5200 total
6/30 = 2311
7/1 = 2481
8/9 = 3098
Estimate
1750-2000 nests

Figure 6.

TABLE 1

Numbers of nests and numbers of adult kittiwakes.

	Nests built or sites with clearly marked "flag"		Total of individuals		
Early counts, June 13 from sea ice along southwest shore	35		68		
	29		47		
	60		72		
June 16, from sea ice east of the village	67		140		
	48		47		
Counts while censusing		239		374	63%
June 26, stake 2	39		48		
July 6, stake 7	9		10		
		48		58	83%
Total		287		432	66%

Breeding Schedule. We saw many kittiwakes flying over the leads around the island in our flight on June 4. A few birds were on the cliff at the north tip and southwest corner.

On June 13 and June 16, 10-15% of the nests visible from the sea ice were not being defended by adults. Twenty to thirty percent of other nests were occupied and had been partly rebuilt.

On June 23 we saw kittiwakes copulating. We saw no eggs during our visit.

On July 5 we made a circuit of the island, with one observer looking specifically for incubating kittiwakes, and saw 10 in a population estimated at 1750-2000 nests.

TABLE 2

Events at Study Site #2 -- kittiwakes.

	Nests	Pairs	Single birds	
June 23	38	5	7	
June 26	39	16	15	
July 1	37	3	15	
July 4	39	7	14	
August 8	45	16	20	no eggs seen
August 12	31	1	20	no eggs or incubators

Feeding. When the shore-fast ice was still fixed to the island and Gray Whales were feeding along the edge of the ice, kittiwakes flocked to plunge dive and settle at the surface to feed around the whales when they came to the surface. As the ice was breaking up, kittiwakes fed in the finely broken, brash ice among the pans, especially between pans that were recently broken apart by the swells.

Kittiwakes were frequently seen sitting on the water next to the base of the cliff, pecking rapidly in the water as if feeding on tiny objects.

The "flag" under many kittiwake nests in late June and early July was tinted pink as if the birds were feeding on crustacea.

Ed Muktoyuk told us that these birds come back to the island very early, maybe in late April or the first of May, and fly around over open water. They land on the cliffs in mid-June and lay the first eggs (1 or 2) about June 20. More nests usually have two eggs than one. The birds usually fly around in flocks in mid-September and all go away together, except for a few young. The kittiwakes leave in late September in mild years. The King Islanders did not collect many kittiwake eggs because the eggs broke easily. At Little Diomede the people like to collect kittiwake eggs and small young.

5. Murre (Akpa)

Species present. The two species are present in approximately equal numbers on King Island (Figure 7). We tried two systems for estimating the proportions of the species and got conflicting results.

a) We made a circuit of the island estimating the proportion among the birds which flew low over our heads, having been frightened off the cliffs. The observations indicated a heavy preponderance of Common Murres.

During this circuit we also estimated the proportion of nesting ledges that were suitable for Common Murres (large and broad) as compared to those ledges that were suitable for Thick-billed Murres (small and narrow). The structure of the ledges is such that most of the lowest ledges were suitable for Common Murres and the lowest birds would be more readily frightened. Thick-billed Murres had begun to lay eggs, but there was no sign that Common Murres had done so. If a higher proportion of Thick-billed Murres than Common Murres had eggs, a smaller proportion of the Thick-billed Murres on the cliffs would have been willing to fly. Thus one should expect to find Common Murres disproportionately represented in the samples.

When we corrected for the distribution of large and small ledges on the cliffs, this technique gave a proportion of 40% Thick-billed Murres and 60% Common Murres.

b) We compared the proportion of Thick-billed to Common Murres at seven study sites on the south side of the island on three days in June/

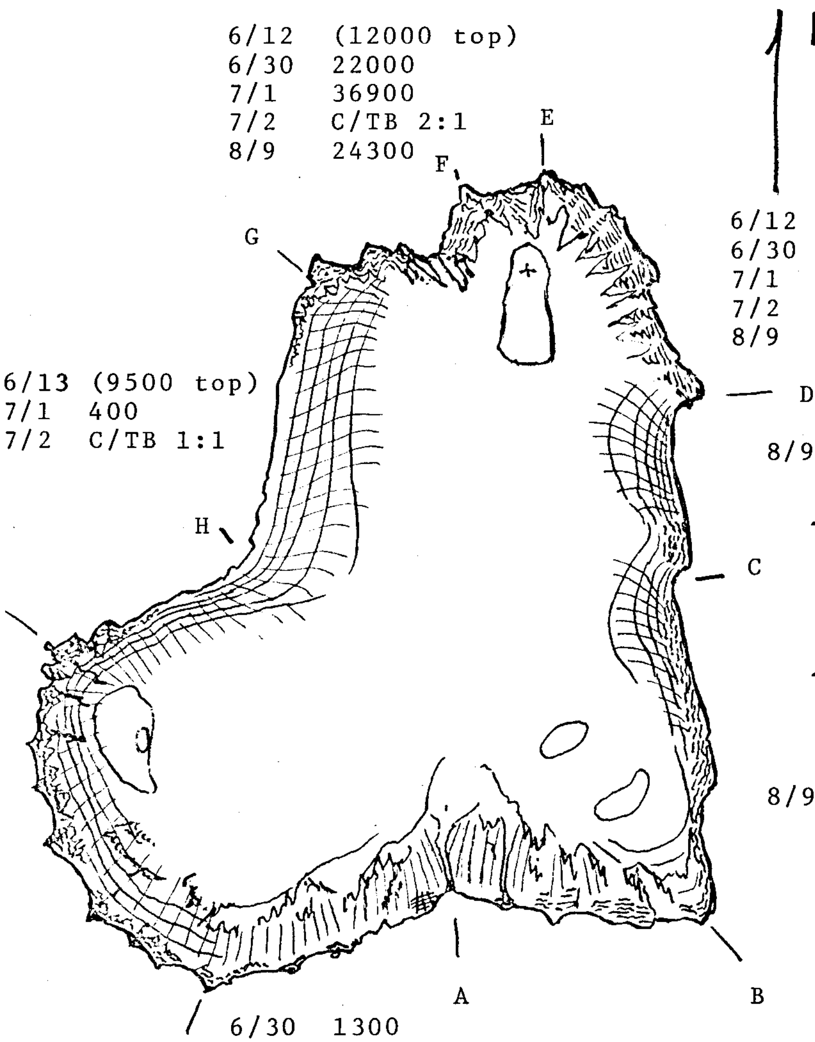

Murres
N
6/12 (12000 top)
6/30 22000
7/1 36900
7/2 C/TB 2:1
8/9 24300
E
F
G
6/12 (25000 top)
6/30 13400
7/1 31400
7/2 C/TB 2:1
8/9 12450
D
8/9 2000
6/13 (9500 top)
7/1 400
7/2 C/TB 1:1
6/30 12600
7/1 12000
7/2 C/TB 1:1
8/9 17300
H
I
C
6/12 (8000 top)
6/12 14000 from ice
6/30 13200
7/1 17200
7/2 C/TB 5:3
6/4 (5000 air)
6/30 3700
7/1 3200
Common/TB 7/2 2:1
8/9 1360
8/9 19500
A
B
6/12 (5500 top)
J
6/30 1300
7/1 800-1000
7/2 C/TB 1:1
8/9 600
6/12 (2000 top)
6/30 2700
7/1 900
7/2 C/TB 4:5
8/9 2850
Total
6/28 = 39200 total
6/30 = 68900
7/1 =102600
8/9 = 80360
Average 73000
6/4 6/12 6/13 on water 67000

Figure 7.

July and two days in August. The sum of these counts indicated 40% Common Murres, but the daily variation among Common Murres was very high. In one July day's sample at three stakes, Common Murres were 26% of the total; in another July day's sample at the same stakes (6, 7e and 7w) they were 74%. In one August day's sample at three stakes (1, 2 and 3), Common Murres averaged 30%. In another August day's sample at the same stakes, they averaged 42% (see Table 3).

The ledges where we counted murres have recently been reoccupied since release from egging. The structure of the bedrock outcrops on the south side of the island is not representative of the ledges on the rest of the perimeter, so these samples may not be representative of the population of the entire island.

This technique gave a proportion of 60% Thick-billed Murres and 40% Common Murres. We conclude that we cannot be more precise than to say that the species were present in approximately equal numbers.

Our observations on the two species revealed the familiar behavior patterns a) that Thick-billed Murres were found on narrow ledges while Common Murres were seen on wide ledges; b) the "flag" of excrement under the Thick-billed Murres was usually tinted orange-red, while the flag under and on Common Murre ledges was tinted white. The tint of excrement suggests that the Thick-billed Murres may have been eating more crustacea than the Common Murres.

Numbers. Our estimates of the numbers of murres are shown on the accompanying map of the island, divided into subsections for census purposes. Murres were most numerous at the northern tip (about 50,000 birds), at the southeastern corner (about 15,000 birds), and at the northwestern corner (about 15,000 birds).

TABLE 3

Counts of Thick-billed and Common Murres at study sites on King Island.

July	Stake 6	July 1	July 6
	Thick-billed	18	16
	Common	120	2
	Stake 7w		
	Thick-billed	32	31
	Common	61	15
	Stake 7e		
	Thick-billed	22	16
	Common	21	5
August	Stake 1	August 8	August 12
	Thick-billed	68	102
	Common	35	14
	Stake 2		
	Thick-billed	79	92
	Common	70	44
	Stake 3		
	Thick-billed	80	104
	Common	57	71

When we first arrived the weather was sunny, the sea calm and there were only a few patches of open water in the ice packed around the island. We estimated the murres on the leads from the top of the island, getting a total of 73,000 birds which is a close approximation of the average of our other estimates -- 76,000-80,000. If that count can be made another year, it is a lot less laborious way of getting a count than is our other technique which involves a slow trip around the island in a small boat. Both techniques depend on fair weather.

Schedule of breeding cycle. When we first flew over the island on June 4 many murres were gathered in the leads. When we walked around the island on the shore-fast ice on June 12 and 13 a minor proportion of the murres had occupied nesting ledges. When we made our first circuit by boat on June 28 after the ice left, the majority of birds were at their nest sites.

We saw the first Thick-billed Murre egg on June 25 and a sample of the eggs which we collected on July 5 for chemical analysis had "spots" or tiny embryos indicating that many murres laid June 28 to July 1. Thick-billed Murres were, according to our observations, a week or more ahead of Common Murres in their schedule.

Our counts at study sites suggested that Common Murres came in in large numbers in late June but that many left in early July. We can only speculate on whether their departure was related to the decrease in numbers of Common Murres which were recorded at the Bluff Cliffs or whether the birds were going to sea to feed and returned to lay eggs. Furthermore if there was a reproductive failure we don't know whether the failure was related to the same environmental factors which caused the decline of numbers and reproduction among Common Murres at Bluff. We made several counts during the period of late June when, according to our experience at Bluff Cliffs, the ledges should be occupied by breeding birds. The party had left the island and we do not have counts made during the period in mid-August when many non-breeders are present.

Daily pattern of activity. As soon as we arrived on the island we noticed a tide of birds returning to the island between 1600 and 2200, especially 1700-1900. This movement was much more evident on the east side of the island where there are many more nesting murres than on the west.

We made 43 counts of the numbers of murres on ledges visible from the porch of the house where we stayed. These data are plotted on Figure 8. These counts suggest a peak of attendance early in the morning, 0300-0600, and a subsidiary peak 1500-1700 with a conspicuous low 1800-2200. The pattern conforms to our impressions. The counts should be repeated many times before extraneous factors can be excluded such as previous bad weather (increasing the tendency to stay away feeding), present good weather (increasing attendance at the cliffs) and present strong offshore winds (decreasing attendance).

Reproduction. Counts by species at seven study sites on August 8 and August 12 indicated that 19% of 510 Thick-billed Murres appeared to be incubating eggs, and 16% of 242 Common Murres. At the Bluff Cliffs, for comparison, a count of 954 Common Murres at 17 study sites gave a spread of 18%-81%, average 44%, in incubating posture.

Ed Muktoyuk told us these birds come back the last of April to the open leads near the island. They first come to the cliffs a week or two after they arrive. Some years they lay eggs as early as June 20, but he

NUMBERS OF MURRES COUNTED FROM KING ISLAND VILLAGE

Ledges East of the Village

Late June and early July

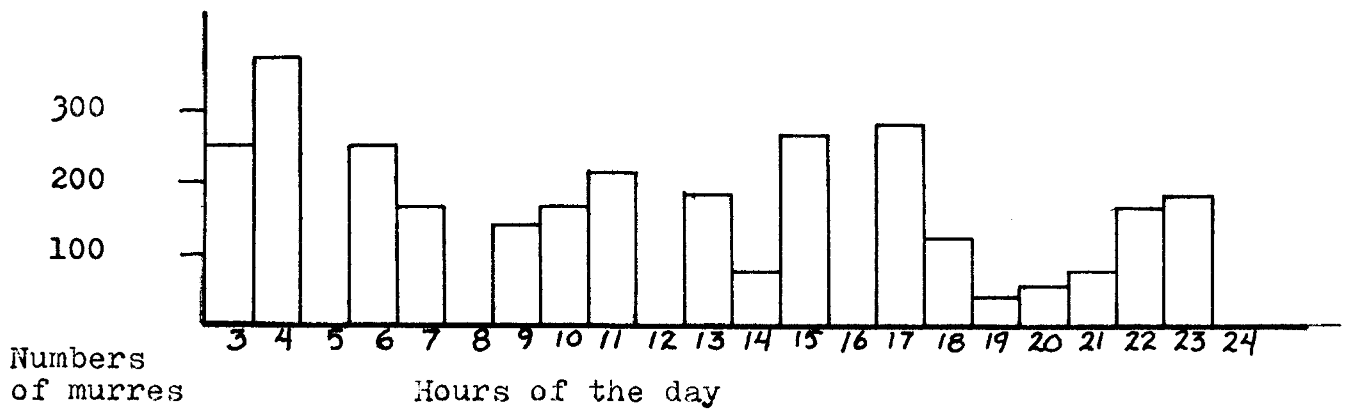


Figure 8.

was on the island in 1975 and the laying was late: there were still fresh eggs on July 5. It is hard to tell when the young hatch -- maybe the third week of July. Adults leave in early or mid-September. They feed on any kind of fish as do puffins. The people used murres more than the other species. They took adults when they first come back in spring. Children collect murre eggs.

6. Pigeon Guillemot (Serkwok)

Guillemots (Figure 9) became conspicuous as soon as the shelf ice broke away from the island. They were numerous on the west and northwest sides of the island.

At the village they gathered on some roofs at 0600-1000 as Parakeet Auklets were leaving and before the Horned Puffins arrived in full numbers.

As with their close relatives, Black Guillemots, they are very much more conspicuous early in the morning when the sea is flat than they are in the afternoon or when the sea is choppy.

Pigeon Guillemots occupied boulder piles and crevices 10-15 feet above the water level and below the area occupied by Tufted Puffins.

One individual was seen carrying a Prickleback (*Lumpenus*) in August.

Ed Muktoyuk said that these birds arrive in late May. They are present in numbers comparable to but fewer than Tufted Puffins. They nest in the rocks at the bottom of the slopes. They change plumage in late October and leave at about the same time. The young ones stay around until the weather is very cold. The people eat Pigeon Guillemot eggs.

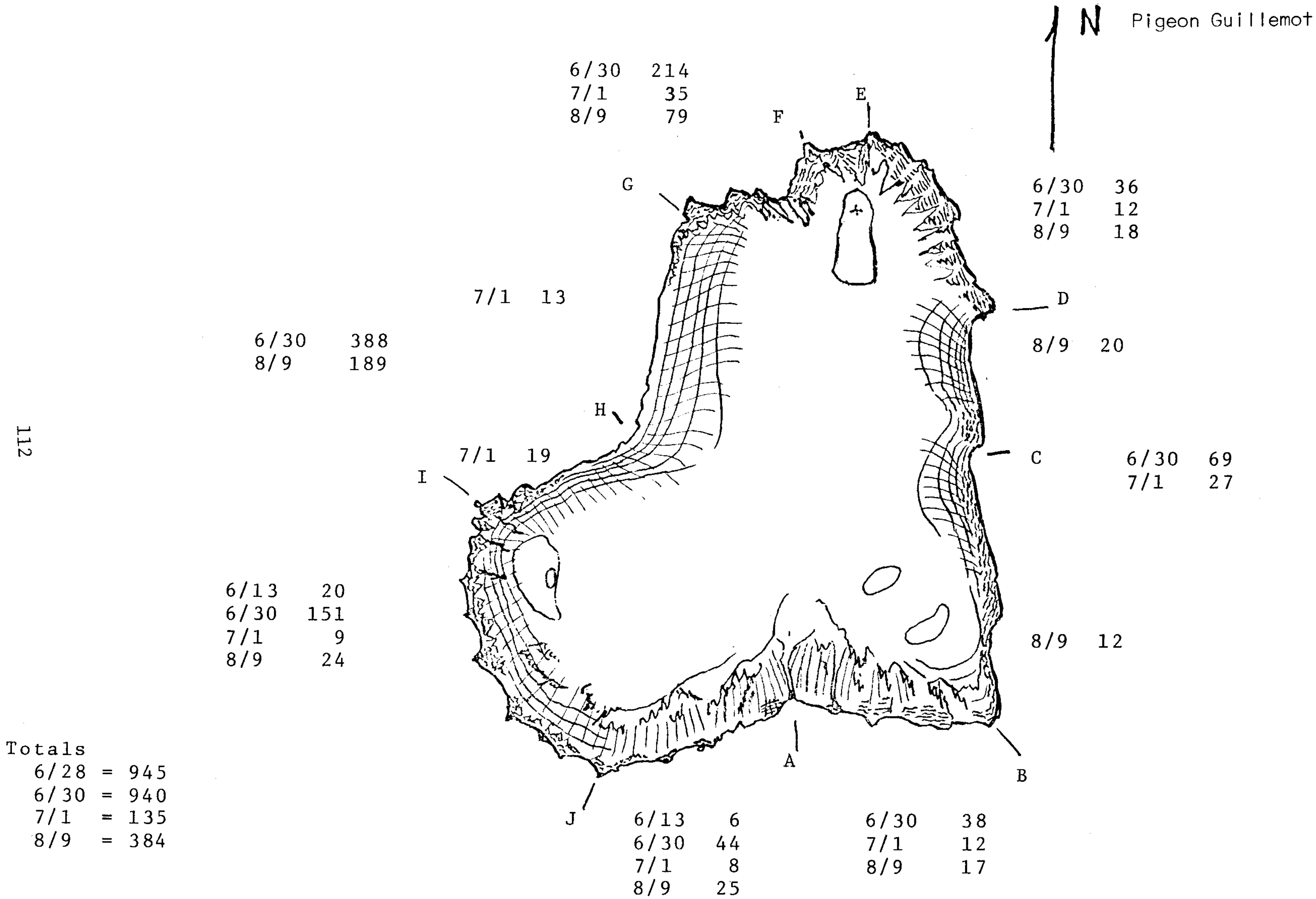

N
Pigeon Guillemot
6/30 214
7/1 35
8/9 79
E
F
G
6/30 36
7/1 12
8/9 18
7/1 13
D
6/30 388
8/9 189
8/9 20
H
7/1 19
C
6/30 69
7/1 27
I
6/13 20
6/30 151
7/1 9
8/9 24
8/9 12
Totals
6/28 = 945
6/30 = 940
7/1 = 135
8/9 = 384
A
B
J
6/13 6
6/30 44
7/1 8
8/9 25
6/30 38
7/1 12
8/9 17

Figure 9.

Puffins

Estimation of numbers. On June 12 and 13 we used binoculars from the top of the island to estimate the number of Horned Puffins among the birds gathered on the leads in the ice.

We also climbed from the ice to the top of the island up a gully on the northeast side where Horned Puffins and Parakeet Auklets gather. We counted 240 burrows along the route of the climb, 80% of which were in the lower two-thirds of the slope. At that time we estimated 10,000 Horned Puffins on the east side, 3,000 on the southwest, 2,500 in the northwest cove, and 1,500 on the south-facing slopes -- a total of 17,000 which we never approximated again. Only a few Tufted Puffins had arrived at the island on June 13.

The numbers of puffins of both species varied over wide limits from a minimum of 8 for the whole island on a cold, rainy day at the end of June to 6,500 in August. We made special circuits of the island on July 2 and August 11 to census puffins and to compare counts by different observers.

Table 4 shows the variation between two counts made at the same time. The part of the table for Tufted Puffins includes flying birds which increases the variation. This problem seems to result from an observer losing orientation. Counting birds on the cliffs requires careful separation of the areas counted from those not counted. Disorientation occurs when the observer must also count flying birds circling overhead. If one person counts only flying birds, they can readily separate those birds which fly directly away from those which keep circling the boat.

In the counts of flying puffins we did not separate species. This may have led to problems. On one hand Tufted Puffins perch lower on the

TABLE 4

Counts of puffins -- two observers counting the same sections of cliffs.

Tufted Puffins	5 July 76	C	B	
	A-B	67	59	
	B-D	189	198	
	D-E	38	23	
	E-G	118	50	
	H-I	257	167	
	I-J	297	242	
	J-A	146	125	
		1,042	864	950 ± 20% (includes fliers)
Horned Puffins	11 Aug. 1976	M	J	
	A-B	901	756	
	B-C	167	310	
	C-D	526	744	
	D-E	541	495	
	E-G	699	676	
	G-H	1,271	1,332	
	H-I	1,055	1,085	
	I-J	555	801	
	J-A	119	134	
		5,834	6,333	6,080 ± 4% (excludes fliers)

cliffs and fly more readily than do Horned Puffins so that they make a higher proportion of the low-flying birds than their proportion on the cliffs. On the other hand many flying puffins are several hundred feet off the water circling just below the brow of the island. Horned Puffins make up the great majority of high-flying birds and Tufted Puffins seldom joined the high-flying excursions.

The numbers of Tufted Puffins apparently increased through the season. Thus in early June the proportion observed was about 1 Tufted to 6 Horned Puffins, or 15%. In early July the percentage was 25%. During August the proportion was 30% to 40% Tufted Puffins.

7. Horned Puffins (Killyungyuk)

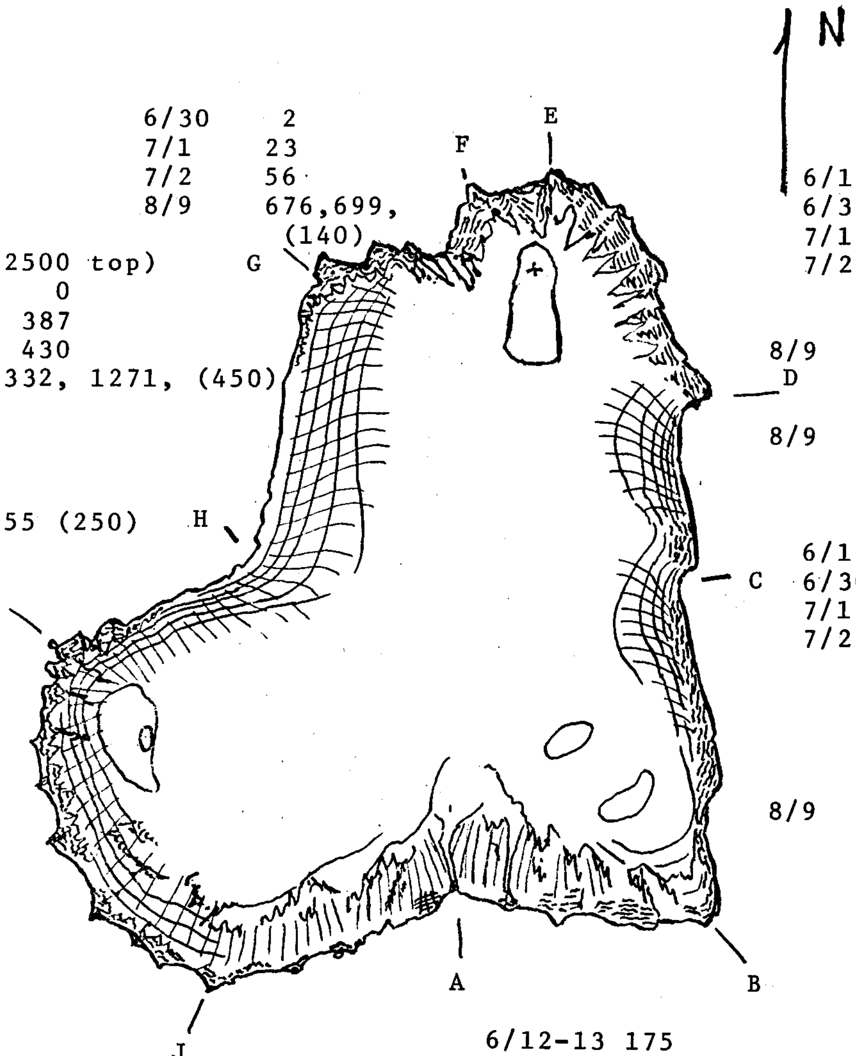
The full number of breeding pairs of this species (Figure 10) appeared to be present when we arrived on June 10. Their numbers were conspicuously higher in August than in June and July. We presume that these higher counts reflect the presence of non-breeding subadults.

As with puffins at Sledge Island and Bluff Cliffs, the numbers varied spectacularly with weather. Numbers were highest in sunny weather with moderate onshore winds. Counts were lowest in rainy weather.

Daily pattern. Horned Puffins began to arrive about 0730 in late June, reaching maxima by 1000-1200. Sometimes their numbers increased in the afternoon but often birds started to leave by 1400. Numbers clearly declined between 1900-2100 and few puffins were visible in the late evening or early morning.

Habitat. Horned Puffins were clustered on the lowest third of the island's slopes, sparsely distributed in the middle slopes. Few burrows were found on the top third of the slopes. However clubs of loafing birds

Horned Puffin



6/30 2
7/1 23
7/2 56
8/9 676,699, (140)

6/13 (2500 top)
6/30 0
7/1 387
7/2 430
8/9 1332, 1271, (450)

6/30 0
7/1 26
7/2 92
8/9 1085/1055 (250)

6/13 (665) 3000 est.
6/30 2
7/1 108
7/2 1163
8/6 2232 (2800)
8/9 801/555 (80)

6/12-13 (2500 top)
6/30 2
7/1 93
7/2 133

8/9 495, 541 (80)

8/9 744, 526 (80)

6/12-13 (1500 top)
6/30 2(including B-D)
7/1 150(including B-D)
7/2 414(including B-D)

8/9 310, 167 (50)

6/13 850
7/1 55
7/2 560
8/6 1074 (600)
8/9 134, 119

6/12-13 175
6/30 0
7/2 157
8/6 282 (150)
8/9 756,901

Totals
6/12-13 on the water 7650
6/28 = 1275
6/30 = 8
7/1 = 842
7/2 = 3005
8/9 = 6547 max.
5620 min.

Total of all Puffins, Tufted and Horned, sitting and flying = 11372.

August figures in parenthesis are flying birds.

Figure 10.

gathered at and below the brow of the island. Horned Puffins also gathered in clubs on the flat roofs of the village houses on sunny days but left as soon as we began to move around outdoors.

Ed Muktoyuk said that Horned Puffins come to the island in the first part of June. Their eggs are found (as are those of Least Auklets) in the first week of July. Chicks are found in the first week of August. They nest in the grass, usually in crevices but sometimes dig their own holes. Some birds occasionally lay their eggs outside of burrows. Young puffins, "new ones", gather in mid-September on the lower rocks. (I did not ask whether he meant chicks or returning pre-breeders.) Chicks begin to leave in the middle of September. Most birds leave in the last part of September, but a few stay into early October. He said that Horned Puffins on King Island feed on the same fish that they do at the Bluff Cliffs. The people considered chicks a favored food.

8. Tufted Puffins (Toon-oo-ok)

The numbers of Tufted Puffins (Figure 11) were very low in mid-June and rose steadily throughout the season as described in the section on relative proportions between the species.

Daily pattern. Tufted Puffins' daily activity followed the same pattern as the Horned Puffins. They seemed to come in earlier and to persist as late as 1800-1900, but left shortly after that.

Habitat. Tufted Puffins nested in the peaty turf and crevices at the top of the wave-washed rocks at the bottom of the slopes. Their clubs gathered on flat rocks at this low level. As we took censuses we noticed skeins of Tufted Puffins pouring off these low rocks ahead of the boat.

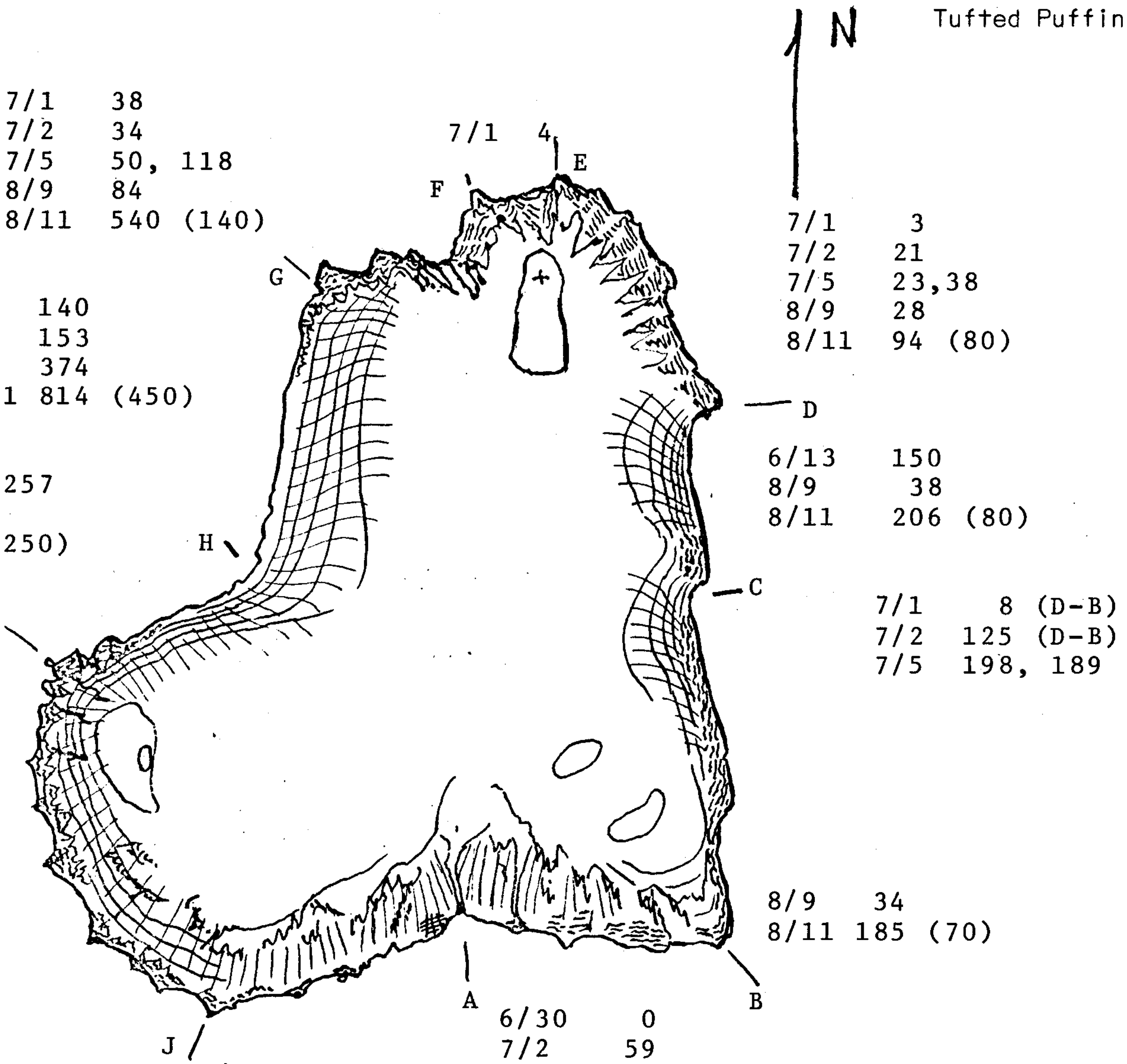

N
Tufted Puffin
7/1 38
7/2 34
7/5 50, 118
8/9 84
8/11 540 (140)
7/1 4
E
F
G
7/1 3
7/2 21
7/5 23,38
8/9 28
8/11 94 (80)
6/13 (390 top)
7/1 41
7/2 140
7/5 153
8/9 374
8/11 814 (450)
D
7/2 60
7/5 167, 257
8/9
8/11 831 (250)
6/13 150
8/9 38
8/11 206 (80)
H
C
I
7/1 8 (D-B)
7/2 125 (D-B)
7/5 198, 189 (B-D)
6/13 5 (250 est.)
6/30 2
7/1 38
7/2 174
7/5 242, 297
8/6 289
8/9 159
8/11 411 (80)
8/9 34
8/11 185 (70)
Totals
6/12-13 on the water 700
6/28 = 253
7/1 = 132
7/2 = 684
7/5 = 1017, 1265
8/9 = 869
8/11 = 3889 + fliers both species (1150)
A
B
J
6/30 0
7/2 59
7/5 59, 67
8/6 71
8/9 61
8/11 301
6/13 75
7/1 0
7/2 71
7/5 125,146
8/6 187
8/9 91
8/11 507

Figure 11.

Ed Muktoyuk said that Tufted Puffin numbers are somewhat more than a quarter of those of Horned Puffins. They come with and leave with the Horned Puffins. They feed like Horned Puffins. The people eat the young.

Auklets

Census methods. Parakeet Auklets nested in burrows and crevices on the lower third of the slopes and near the brows of the island; Least and Crested Auklets gathered primarily at the brows and in boulder fields on the top of the island.

a) We made two early morning surveys in mid-June (Figure 12) and one evening survey in early August (Table 5), estimating the numbers of birds and the percentage composition for each species milling over the boulder fields. In June we also surveyed most of the perimeter of the top of the island, estimating numbers and proportions. These figures are shown on the maps (Figures 13, 14 and 15) and Table 5.

b) We counted the numbers of auklets in the early morning and evening in the amphitheater above the village (Table 6). In this way we could get an accurate proportion of the species composition.

c) We counted the numbers of auklets, primarily Parakeet Auklets, visible on the large snowbank just east of the village at several times during the early morning.

Schedule of breeding. We found maximum numbers of auklets on the island as soon as we arrived. Courtship seemed to be most intense among Parakeet Auklets and Crested Auklets. Least Auklets appeared to be already mostly paired by June 13. Within a week courtship was completed in the other two species.

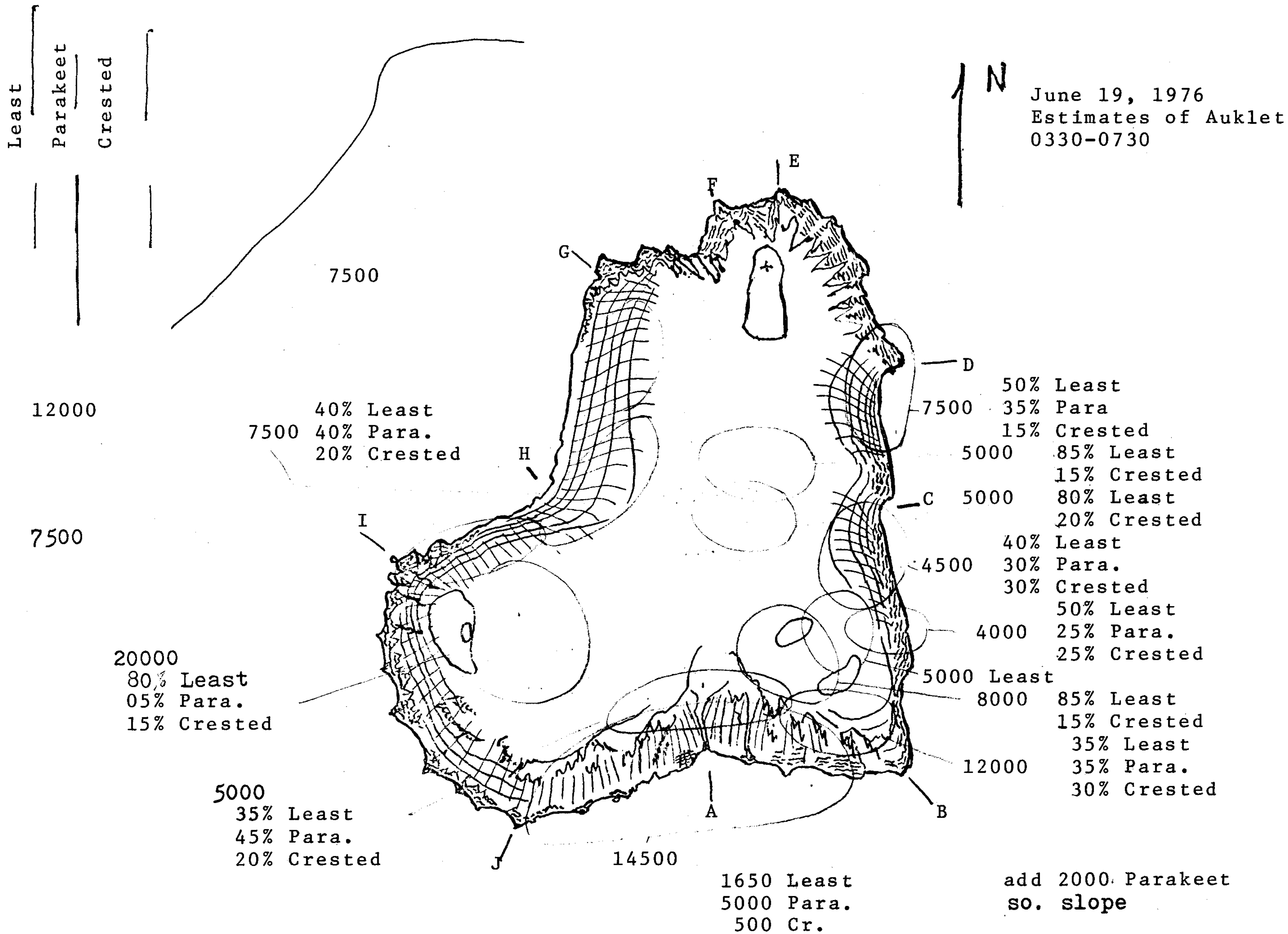

June 19, 1976
Estimates of Auklets
0330-0730
N
Least
Parakeet
Crested
7500
12000
7500
E
F
G
H
I
J
A
B
C
D
40% Least
7500 40% Para.
20% Crested
7500 50% Least
35% Para
15% Crested
5000 85% Least
15% Crested
5000 80% Least
20% Crested
4500 40% Least
30% Para.
30% Crested
4000 50% Least
25% Para.
25% Crested
5000 Least
8000 85% Least
15% Crested
12000 35% Least
35% Para.
30% Crested
20000
80% Least
05% Para.
15% Crested
5000
35% Least
45% Para.
20% Crested
14500
1650 Least
5000 Para.
500 Cr.
add 2000 Parakeet
so. slope

Figure 12.

TABLE 5

Estimates of numbers of auklets on the upland of King Island and percentage composition by species.

	Southwest corner		Northwest side		Center top of island	
	Estimate of numbers	Species %	Estimate of numbers	Species %	Estimate of numbers	Species %
June 19	(30,000) 17,000 13,000	Le. 80% Cr. 15% Pa. 5%	15,000	Le. 40% Cr. 20% Pa. 40%	5,000	Le. 80% Cr. 20%
August 11	(29,000) 21,000 20,000 15,000 13,000	Le. 70-80% Cr. 20-30%	11,500	Le. 75% Cr. 15% Pa. 10%	3,000	Le. 65% Cr. 20% Pa. 15%

During both surveys it seemed that there could be one-half to as many birds heard underground as were seen flying.

TABLE 6

Counts of auklets in the part of the amphitheater visible to the east from the village on King Island.

Date	Time	Parakeet	Crested	Least
June 18	0330	525		
June 19	0730	600		
June 26	0410	370		
June 28	0730	218		
	0830	243	40	15
July 1	0615	202	60	
July 4	0600	285	60	150
August 8	0935	260	36	28
August 9	0630	250	52	30
August 11	0810	293	47	26

For the whole amphitheater censused from the village and at sites half way up the slope and at the brow of the island.

June 18	0330	1500-2000	800-1000	3000-5000
June 19	0330	2200	500	1650
August 9	0630	600	150	100

By the end of June many auklets of all three species spent the day underground and we found Least Auklet eggs in early July and downy chicks in early August, but do not have further information on the breeding season.

Daily schedule. In June Parakeet and Least Auklets were virtually absent from King Island during the day after 0800. Some dense and active flocks of Crested Auklets stayed near the island on the water especially on dark days in June and early July, but these constituted only a small proportion of the total.

In June Least and Crested Auklets began to gather around the south end of the island about 1600 and by 2100 were conspicuous over the village and on top of the island. The numbers of Crested Auklets seemed to reach a peak about 2200 and hold their numbers until about 0500. The numbers of Least Auklets seemed to increase until midnight and hold until 0600. Parakeet Auklets did not become conspicuous until nearly midnight and reached their peak numbers between 0300 and 0700.

Our estimates and the corresponding percentages of species in those estimates are shown on the maps.

Estimate of validity of the figures. The June surveys (early morning - 0300-0700) covered most of the island, leaving out the gullies on the northernmost and northeastern parts of the island as well as the turf slopes on the southwest. The August surveys (0800-1100) covered the top of the island and as a consequence seem to have missed most of the Parakeet Auklets.

1) Table 5 shows the data for a) the boulder field on the southwestern top of the island, and b) for the rest of the top of the island. This table omits the turf slopes of the sides of the island.

2) Table 6 shows data collected during several counts of the birds visible above and to the east of the village as counted from the porch of the former store and warehouse. Decrease in numbers after 0600 and after June 25 are suggested. Otherwise the counts approximate each other.

3) In the evening of June 18 at 1945 we estimated (13,000, 17,000, 22,000, 30,000 birds) -- 15,000 Least, 1,000 Crested and 2,000 Parakeet Auklets flying over the boulder field on the southwest top of the island. On July 4 at 2100 we estimated 5,500 Least and 500 Crested Auklets. On July 5 at 2230 we estimated that in an area of 50 meters by 30 meters there were 50 pairs of Least Auklets and 5 pairs of Crested Auklets. Some areas are much more densely occupied, others less so. Using the U.S.C. & G.S. chart, we estimate the island to be 1.45 n.mi. (or 2.7 km) long and and 1.2 n.mi. across (2.2 km). We estimated the area of the boulder field on the southwest top to be 625 meters by 750 meters, or 468,750 sq mi ÷ 1500 sq mi = 312.5 units (of sample areas 50 m by 30 m). Now 312.5 x 50 makes 15,500 Least and 3,000 Crested Auklets. The closeness of the estimates of Least Auklets is suspicious because there are birds in the air as well as underground but these estimates suggest that our numbers are at least in approximate agreement.

9. Least Auklet (Akpalirak)

This was the most numerous species on King Island (Figure 13). We estimated 38,000 birds or 60% to be on the top of the island and 29,000 or 40% to be on the sides. We estimated 1500-2000 birds to be in the amphitheater over the village.

They appeared in large numbers in the evening of the first day we were there. In June they appeared in clouds in the evenings after the sun

Total birds % Leasts

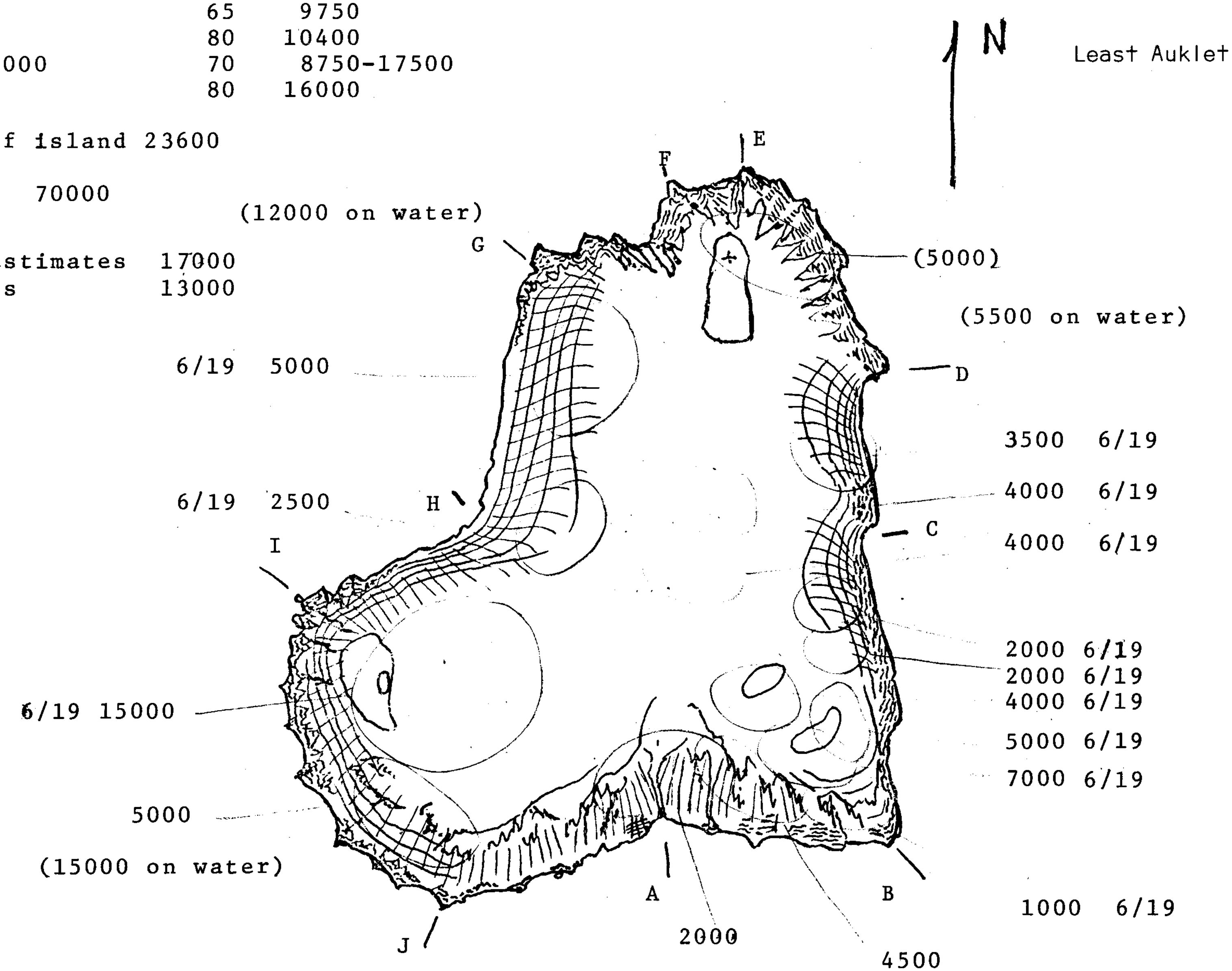
8/11 Southwest end

A	15000	65	9750
B	13000	80	10400
J	12500-25000	70	8750-17500
M	20000	80	16000

Total top of island 23600

6/19 Total 70000

Aver. all estimates 17000
Aver. Leasts 13000



6/18 3000-5000 in the amphitheater behind vil.
6/18 estimated 50000 to 75000 with upper limit 100000.

Figure 13.

had gone behind the island (2000-2130) before the main arrival of Crested Auklets. These clouds gathered over boulder fields on the southwest corner, on the southeast corner and on the south-facing, gentle slope of the middle of the island, increasing to maximum numbers between midnight and 0530. Smaller flocks, 50 or so, buzzed the slopes, gathering on large boulders, mostly high up on the slopes. In June Least Auklets began to leave the island as soon as the sun rose above the east side of the top and were virtually absent during the day. We did not observe Least Auklets in flocks on the water.

Schedule. It was hard to tell whether pairs had already formed or not during the first days we were there. The birds were in flocks of 15-50 birds but one darker-bellied bird seemed to associate with each light-bellied bird.

The first egg was found July 1. We did not undertake a search for nests, because the nests were mostly 4-6 feet down in boulders 3-10 feet across.

Least Auklets gathered primarily in three topographic areas indicated on Figure 12: 1) in the middle slopes on the sides of the island near the upper limit of Parakeet Auklets; 2) in boulder fields on the top of the island; 3) with the other auklets right at the brow of the island.

Ed Muktoyuk told us that these birds arrive at the island at the end of the first week of June. Eggs are found in the first part of July. Young crawl down through the village in the middle or toward the end of August. If the first egg is taken, it will be replaced and small young will be crawling down to the sea in September. The birds come in to the island in the evening and go in the morning.

10. Crested Auklet (Tayak)

These birds (Figure 14) formed dense and conspicuous flocks at the edge of the shelf ice in the evenings of the first days we were on the island. We did not make a circuit counting them, but we presume a good estimate of the total number of breeding birds could be made that way. It would be more complete than the estimates we have.

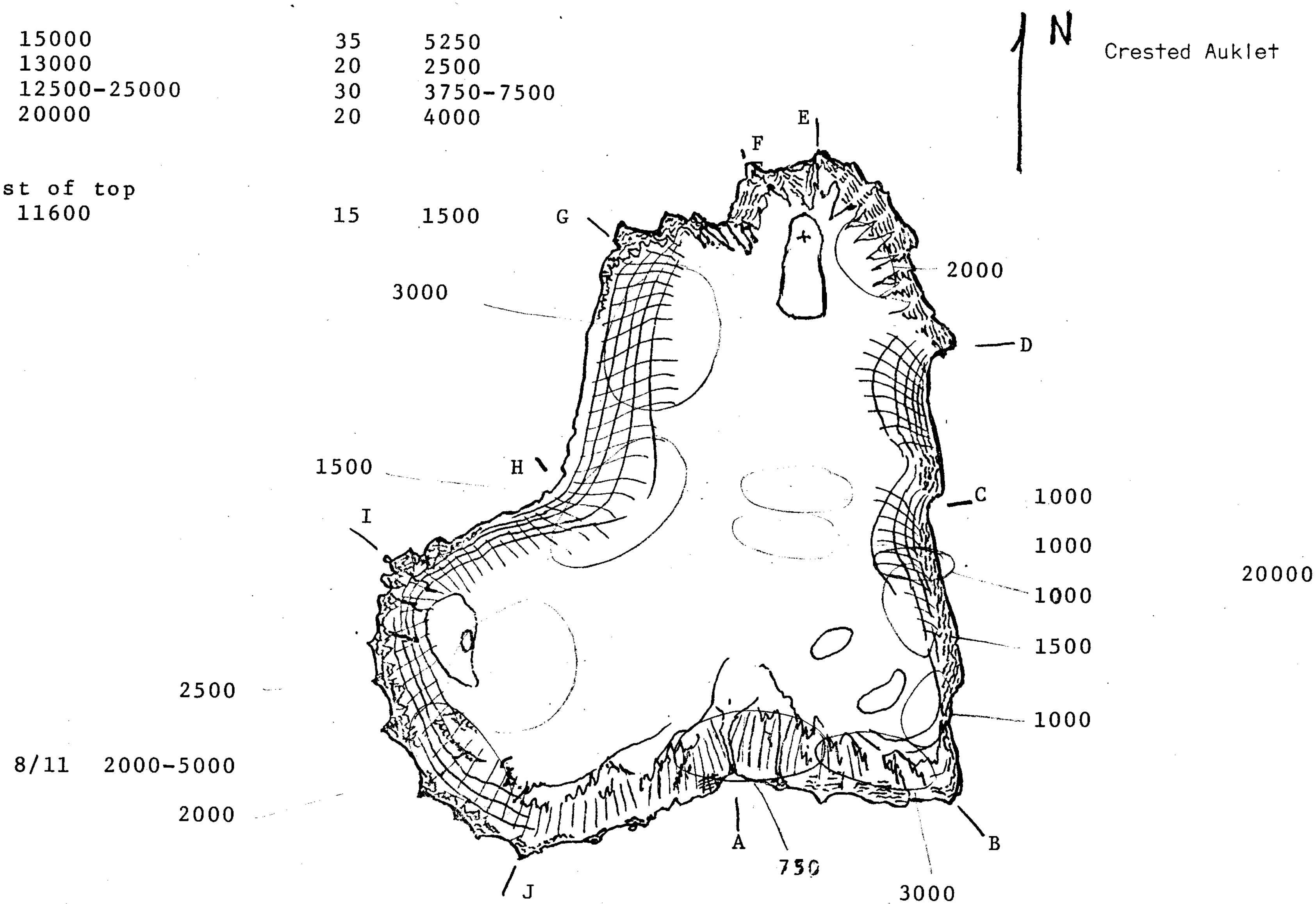
We estimated 8,000 birds (33%) to be on top of the island and 16,000 (67%) to be on the slopes. We estimated 800-1000 birds to be in the amphitheater over the village.

Breeding Schedule. There appeared to be intense courtship in progress on June 12-13 and after that courtship was much less evident. Each of these three mornings birds courted on a few boulder trains; then the next day and thereafter there was little courting activity at that site. Males apparently had much longer crests than females. The males called from their perches as birds flew over and occasionally spread their wings partially. When a new arrival landed the male present repeatedly bowed and raised his head. The female kept her head lowered and appeared to raise her tail. The barking calls characteristic of Crested Auklets accompanied the flying over but not the activities on the rocks.

Daily activities. In June Crested Auklets came in from the sea beginning at 1700-1800 and their numbers increased until about 2200. They started to leave when the sun rose over the eastern rim of the island. In June the flocks gathered on the sea between 0600 and 0900 but flocks were often present all day. On overcast days in late June and early July dense flocks showed nervous activity south of the village during most of the day, being especially active 1100-1300. Many hundreds of Crested

8/11 Southwest top

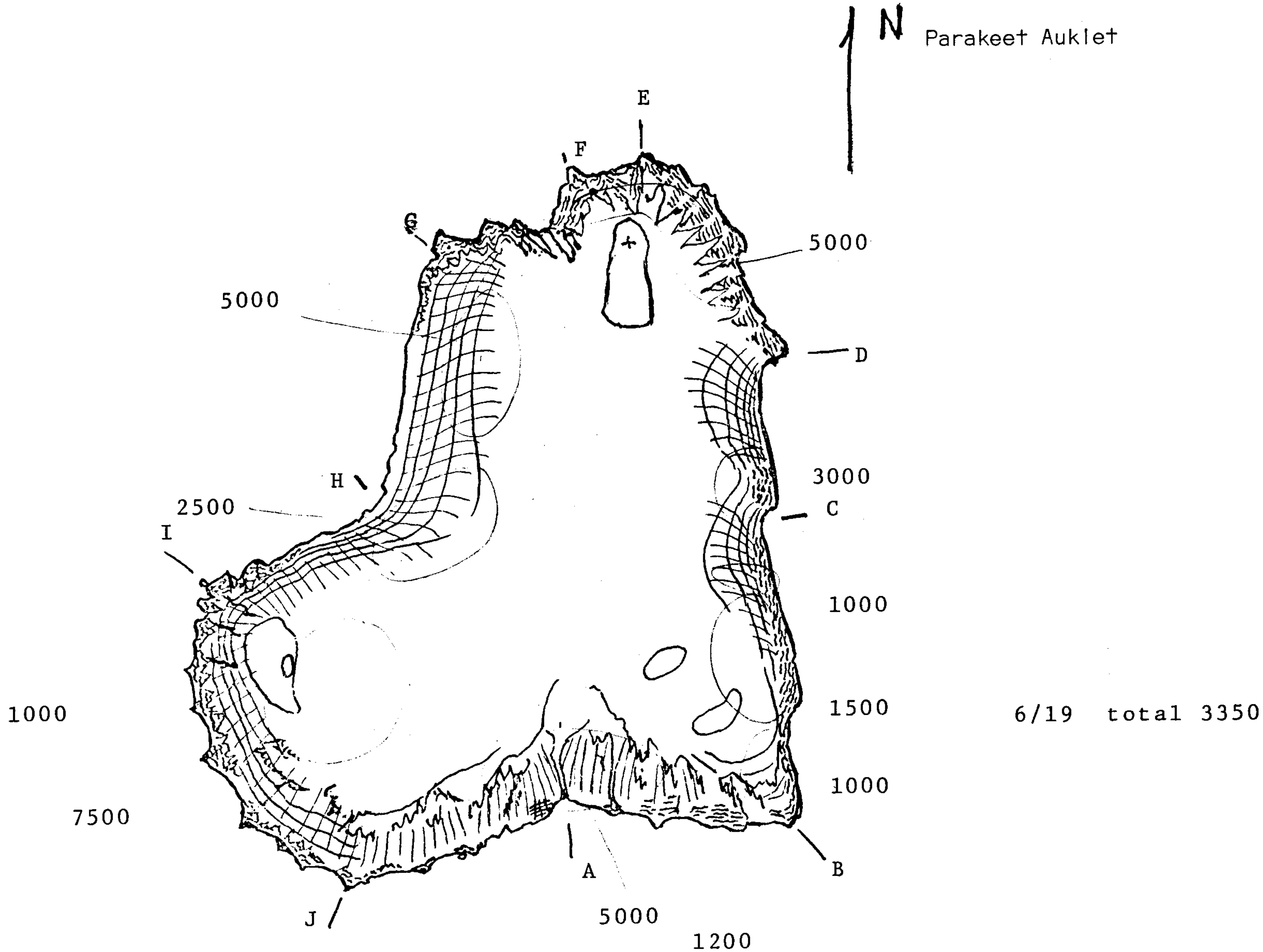
Total birds		% Crested	
A	15000	35	5250
B	13000	20	2500
J	12500-25000	30	3750-7500
M	20000	20	4000
Rest of top 11600		15	1500



8/11 Southwest top 2000-5000
Rest of top 1500

6/18 800-1000 in triangle over the village
6/18 estimated 10000-25000 with upper limit 50000.

Figure 14.



6/18 1500-2000 in triangle over village
6/18 estimated 25000 to 50000
6/19 counted 2200 estimated 5000 in village triangle

Figure 15.

Auklets were on the water on the northwest and northeast sides of the island during one census in the middle of the day.

Calling birds regularly flew headlong from the top of the island close over the village while their wings produced a high-pitched whine. Many pairs and small flocks did this. It was not apparent whether this was a display or simply a quick (if dangerous) way to get down to the water.

Ed Muktoyuk told us that Crested Auklets arrive at the island at the end of the first week, or really the second week, of June; that is, with the Least Auklets and after the Parakeet Auklets. Eggs are found early in July and young hatch about the first of August. After they hatch, the chicks stay in their holes until they are very fat. The adults begin to leave in the last week of August. Chicks leave less than a week after their parents. His report suggests that the nestling period of Crested Auklets is markedly different from that of Least and Parakeet Auklets.

B. Distribution of birds at sea

Data

1) Data gathered from a DeHaviland Islander on June 4, 1976 are shown on Figures 16, 17, 18, 21 and 24. The numbers and kinds of birds seen were recorded during five-minute periods.

2) Data gathered during 110 standardized ten-minute watches while the ship *Surveyor* was underway during the period between August 5 and August 13 are shown on Figures 19, 20, 22, 23, 25 and 26. Juan Guzman let us use the data he collected on this cruise. Dr. R. Gould sent us data he collected during ten-minute watches on September 7 on board the ship *Moana Wave*.

The tracks and the data are displayed in Figures 16 through 26. In some cases two maps are used for one species or species group. The number of individuals seen are shown on bar-graphs extending from the track. These bar-graphs are drawn on a logarithmic scale so that all data are displayed. Counts greater than 10 are shown by thicker bars. A short side-line has been added at "10" and two side-lines added at "100" to indicate the points of change in the logarithmic progression. The bar-graphs have been placed at the approximate location of the ship or plane at the time the birds were seen.

Results

Some waterfowl (Oldsquaw and eiders) were feeding along the edges and in large leads in the drift ice. Others (migrating flocks of Black Scoters) seemed to be following the edges of the windrows of drift ice as "leading lines".

As expected, the seabirds were concentrated near their breeding colonies. Otherwise the species were dispersed more widely at sea than we expected.

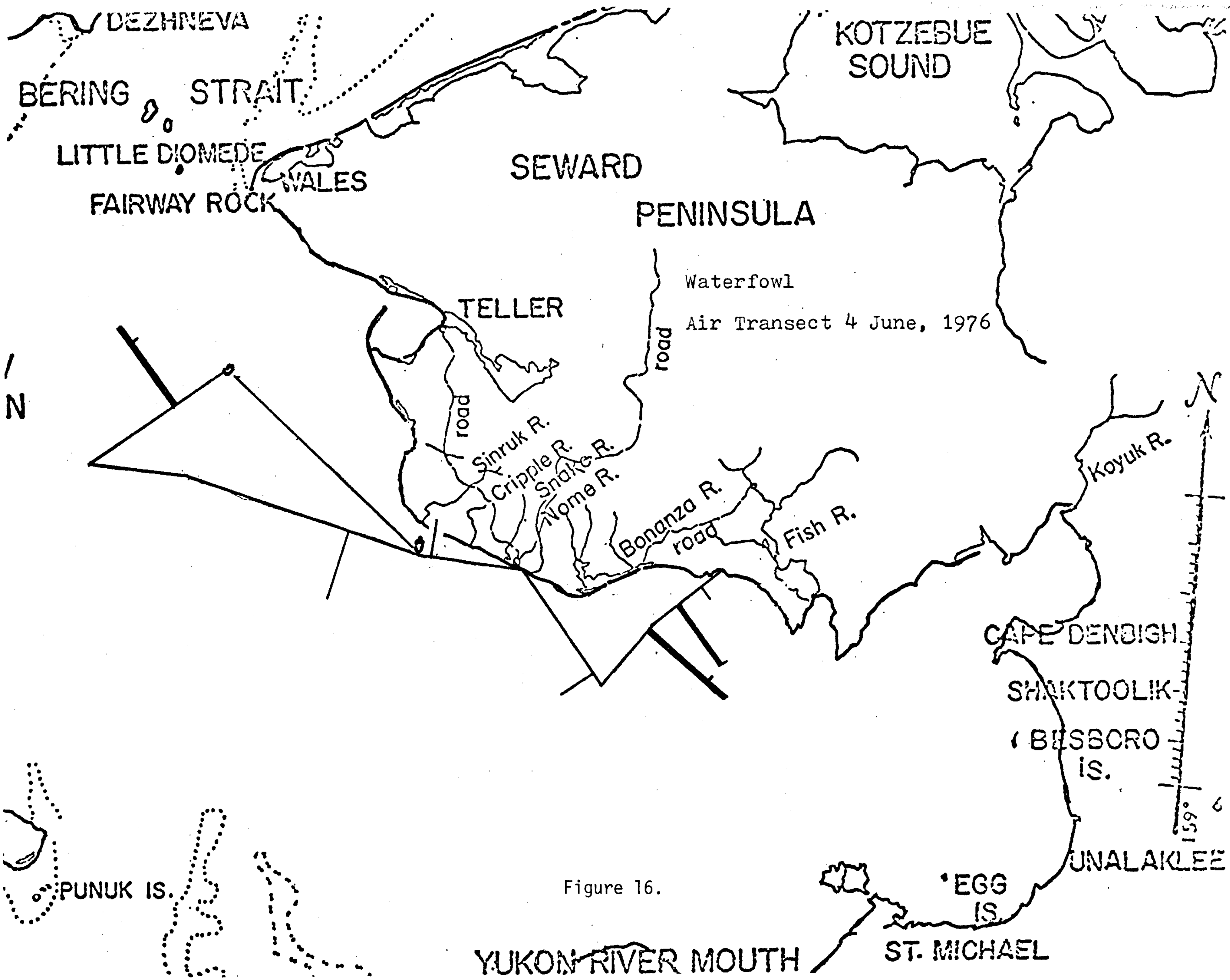
The best data are for murres. We did not distinguish between the species. Although numerous within 40 nautical miles of Bluff Cliffs, murres were especially numerous in the area west of Sledge Island and the area west and north of King Island.

We did not distinguish among the three species of auklets. Their sightings are more frequent and of larger numbers west and northwest of King Island, except for an aggregation of all three species along the edge of drift ice in Norton Sound on June 4.

Kittiwakes were widely distributed in small numbers. Our data suggest that many were feeding south and west of Sledge Island. Gould's data collected west and northwest of King Island may have been collected too late in the season. The kittiwakes may have started to migrate south.

Glaucous Gulls are so few and so widely scattered off shore that no pattern can be seen.

Horned Puffins appeared to stay closer to the colonies than did murres or kittiwakes. Our few sightings of Tufted Puffins were within the areas where we saw Horned Puffins.



Waterfowl

Air Transect 4 June, 1976

Figure 16.

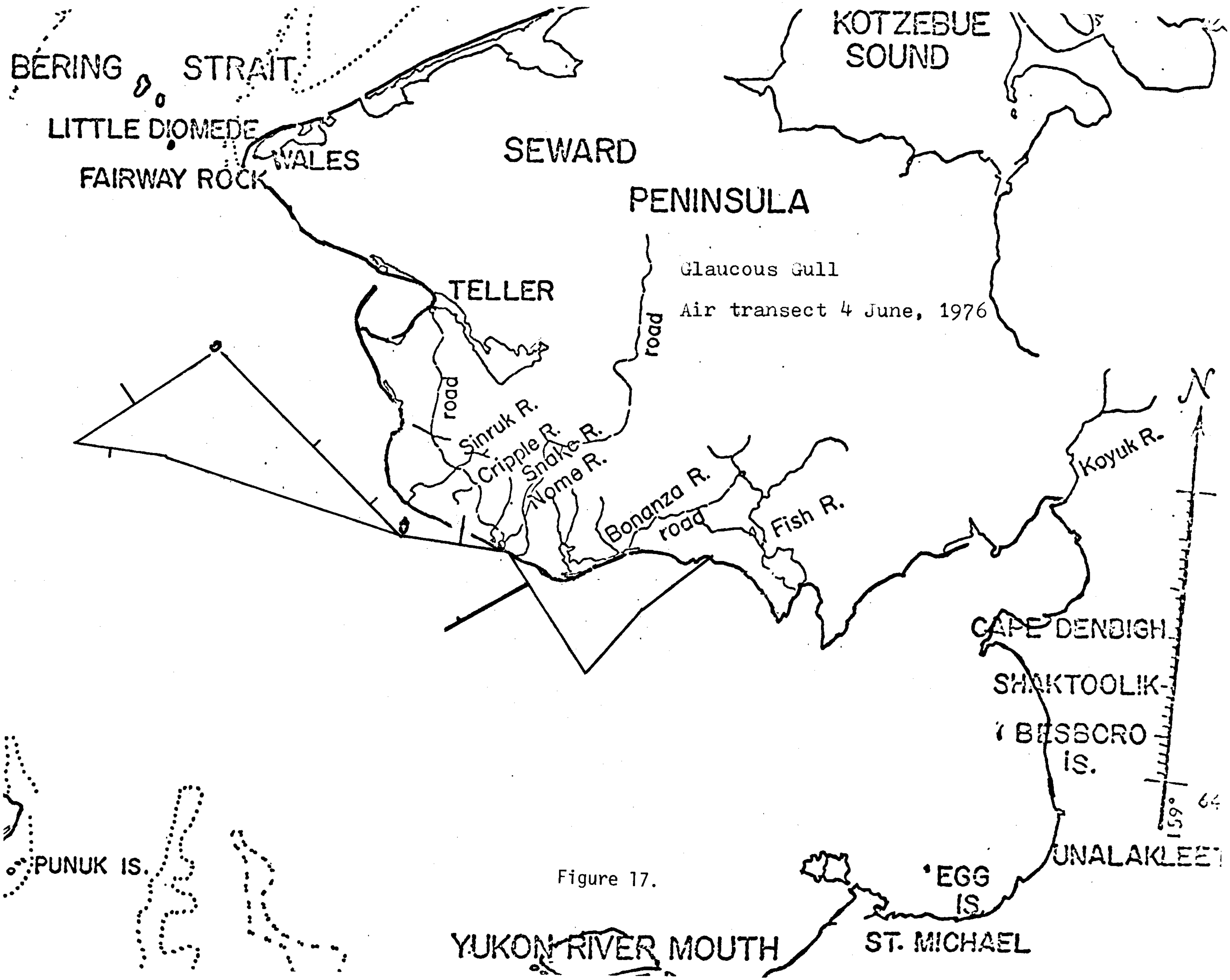

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE
SOUND
TELLER
Glaucous Gull
Air transect 4 June, 1976
road
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO
IS.
UNALAKLEET
EGG
IS.
ST. MICHAEL
YUKON RIVER MOUTH
PUNUK IS.
N
159°
64

Figure 17.

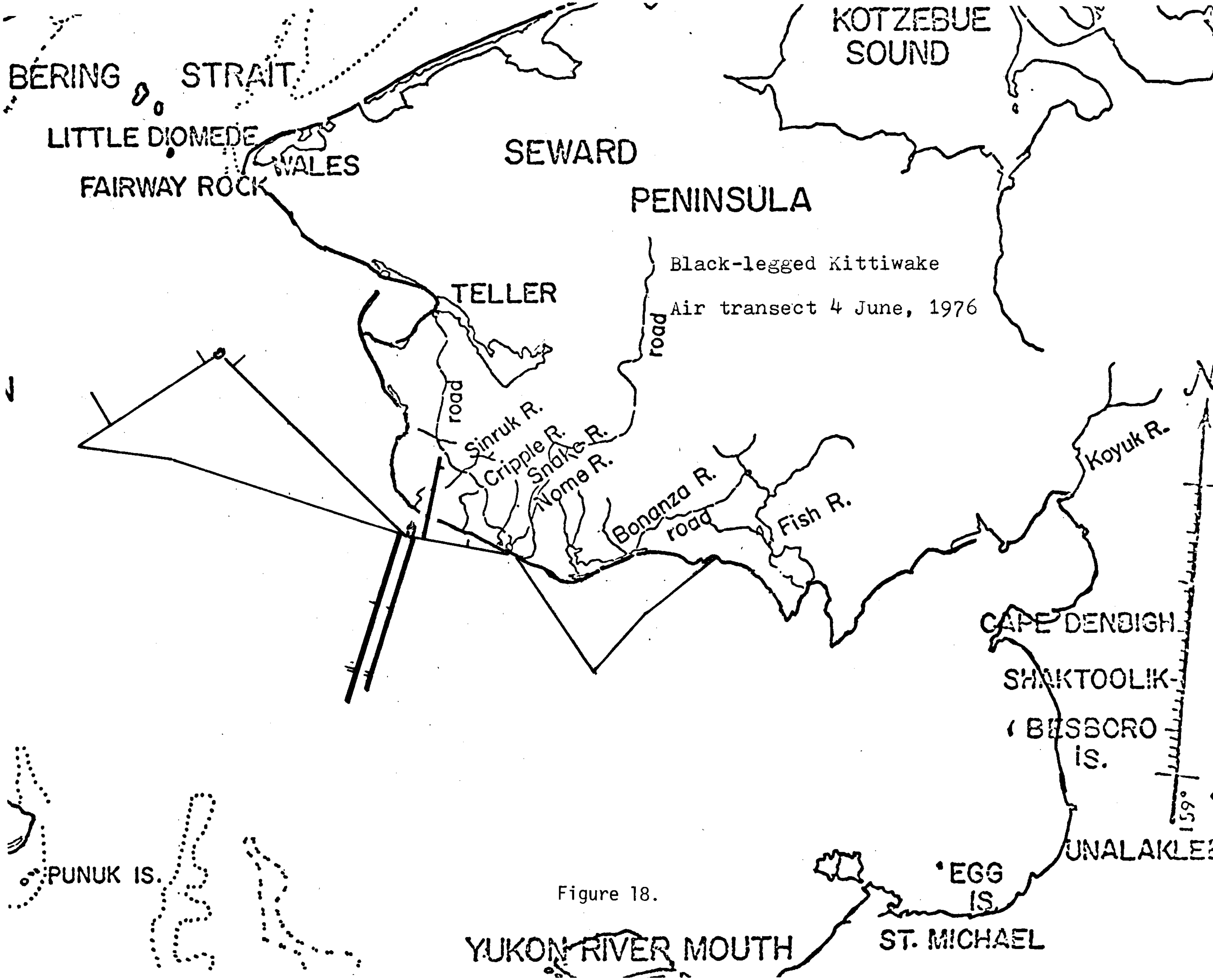

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE SOUND
TELLER
Black-legged Kittiwake
Air transect 4 June, 1976
road
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
Koyuk R.
N
CAPE DENBIGH
SHAKTOOLIK
BESBORO IS.
159°
UNALAKLEE
EGG IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 18.

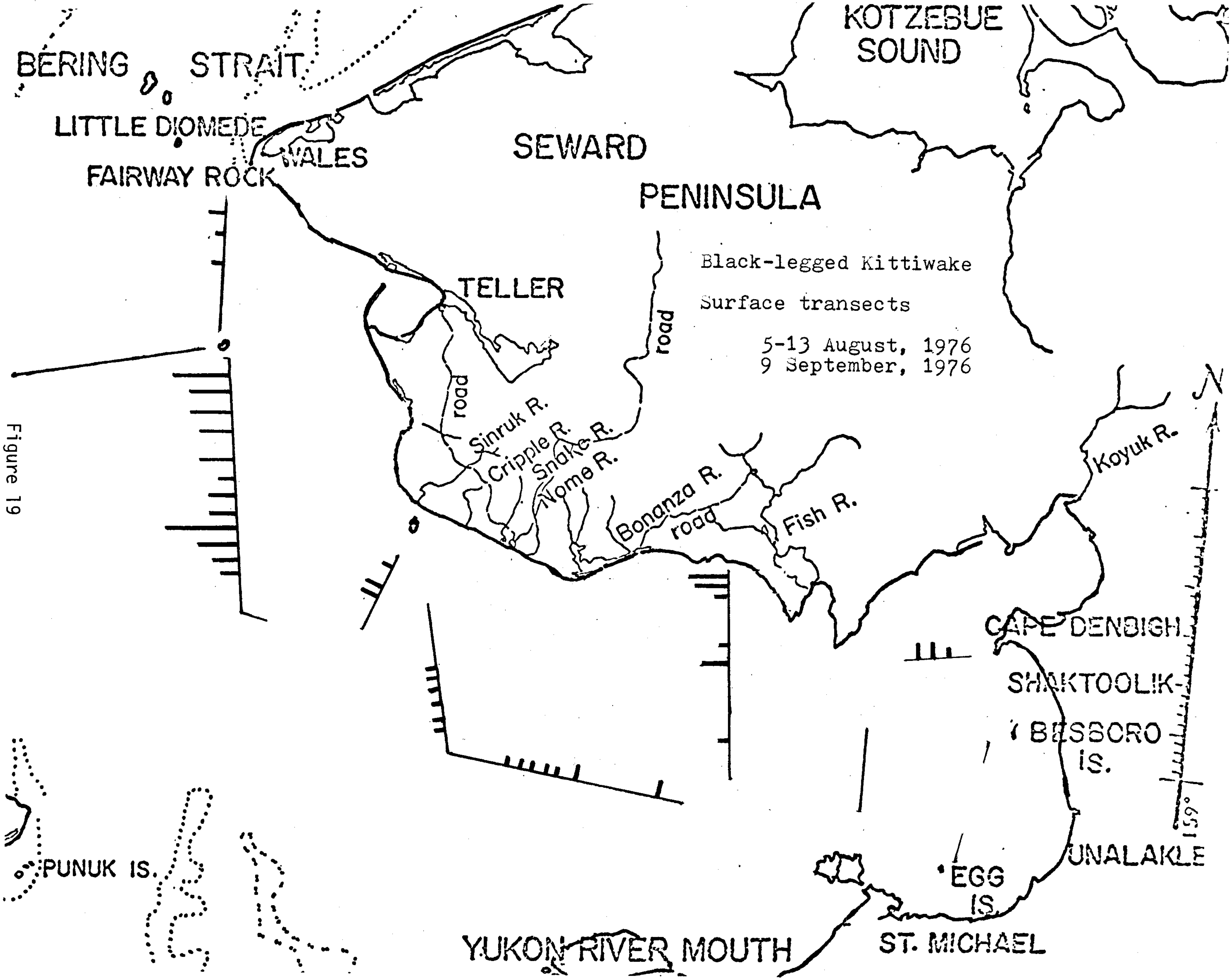

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE SOUND
TELLER
road
Black-legged Kittiwake
Surface transects
5-13 August, 1976
9 September, 1976
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO IS.
159°
UNALAKLE
EGG IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 19

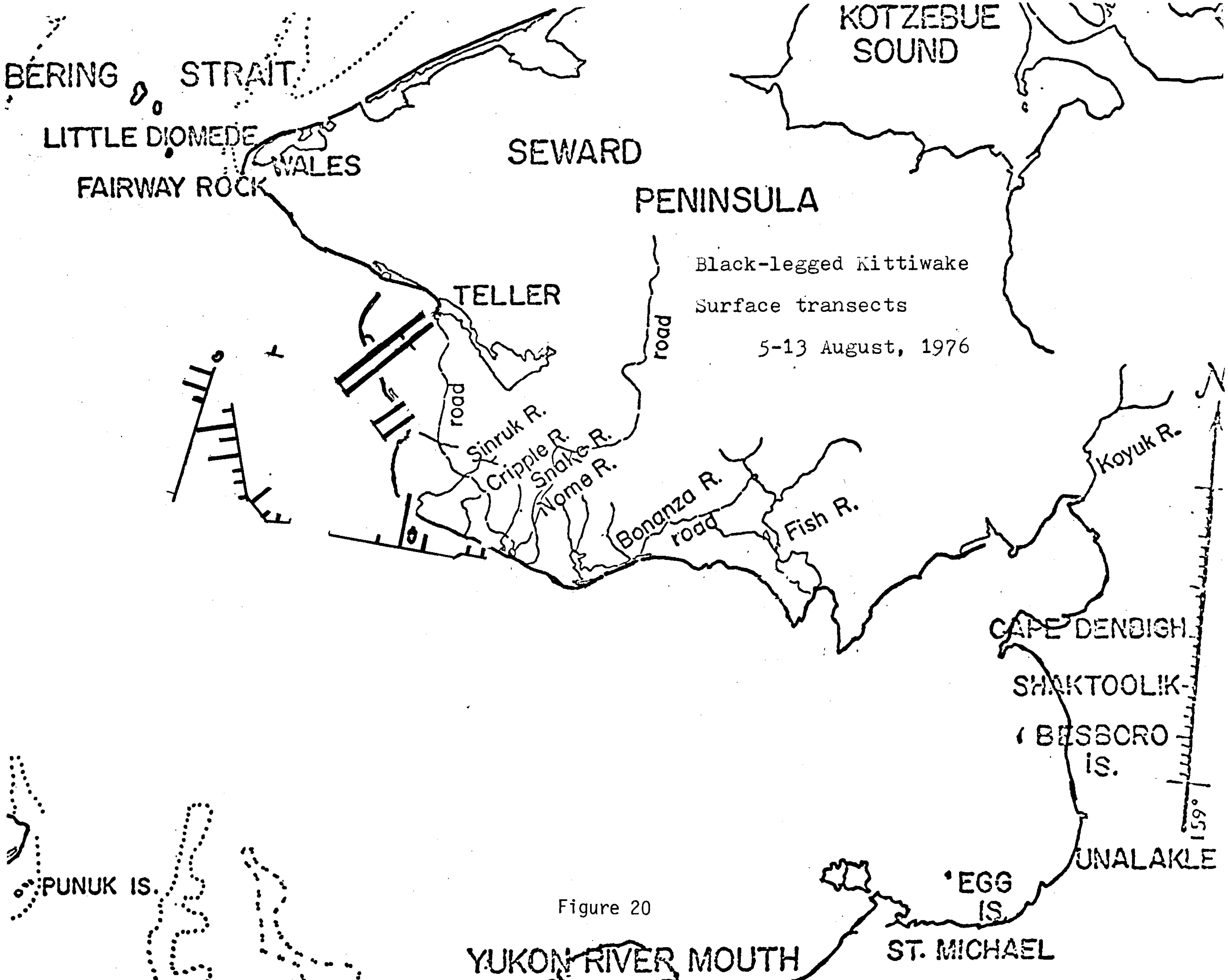

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE
SOUND
TELLER
Black-legged Kittiwake
Surface transects
5-13 August, 1976
road
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO
IS.
159°
UNALAKLE
EGG
IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 20

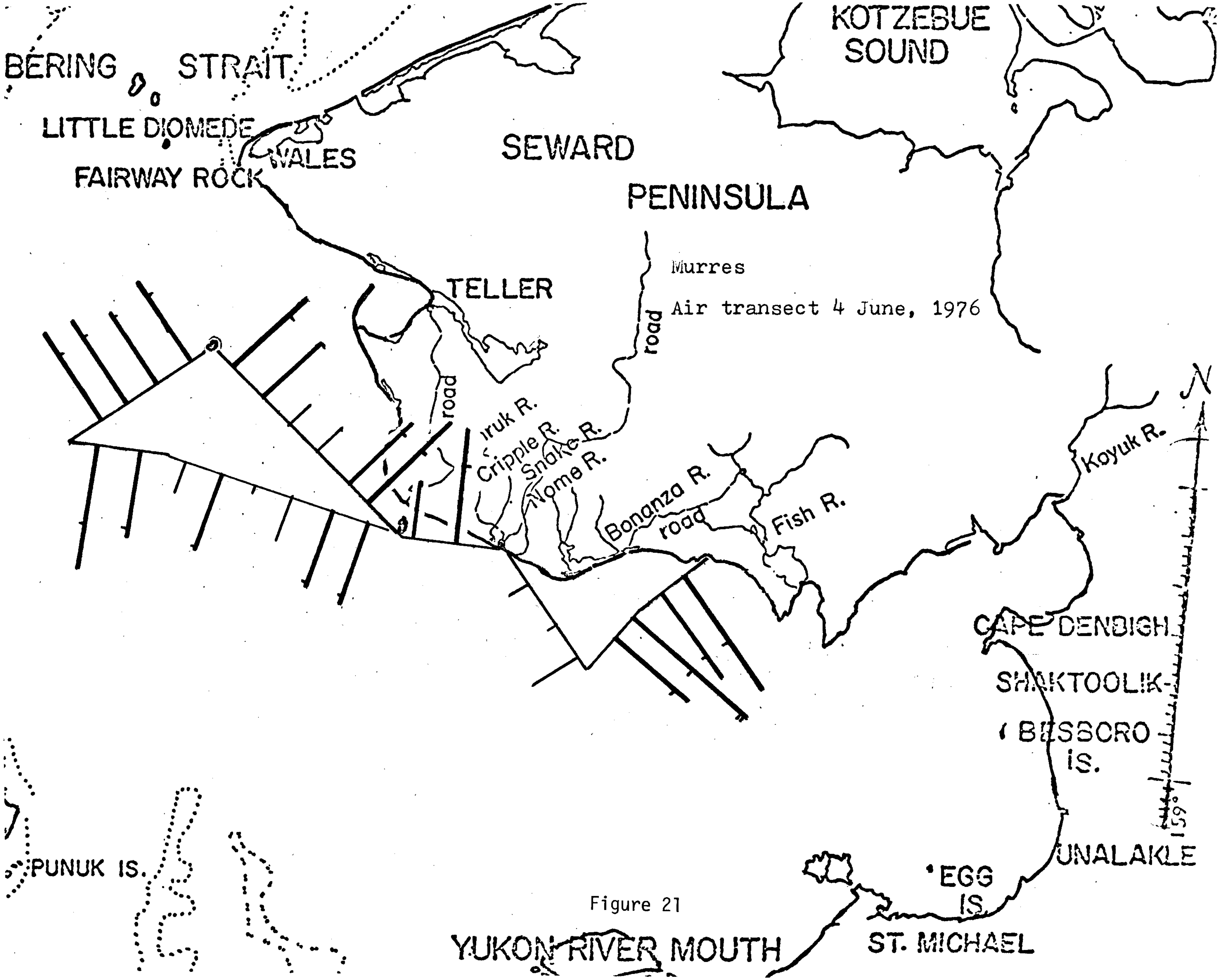
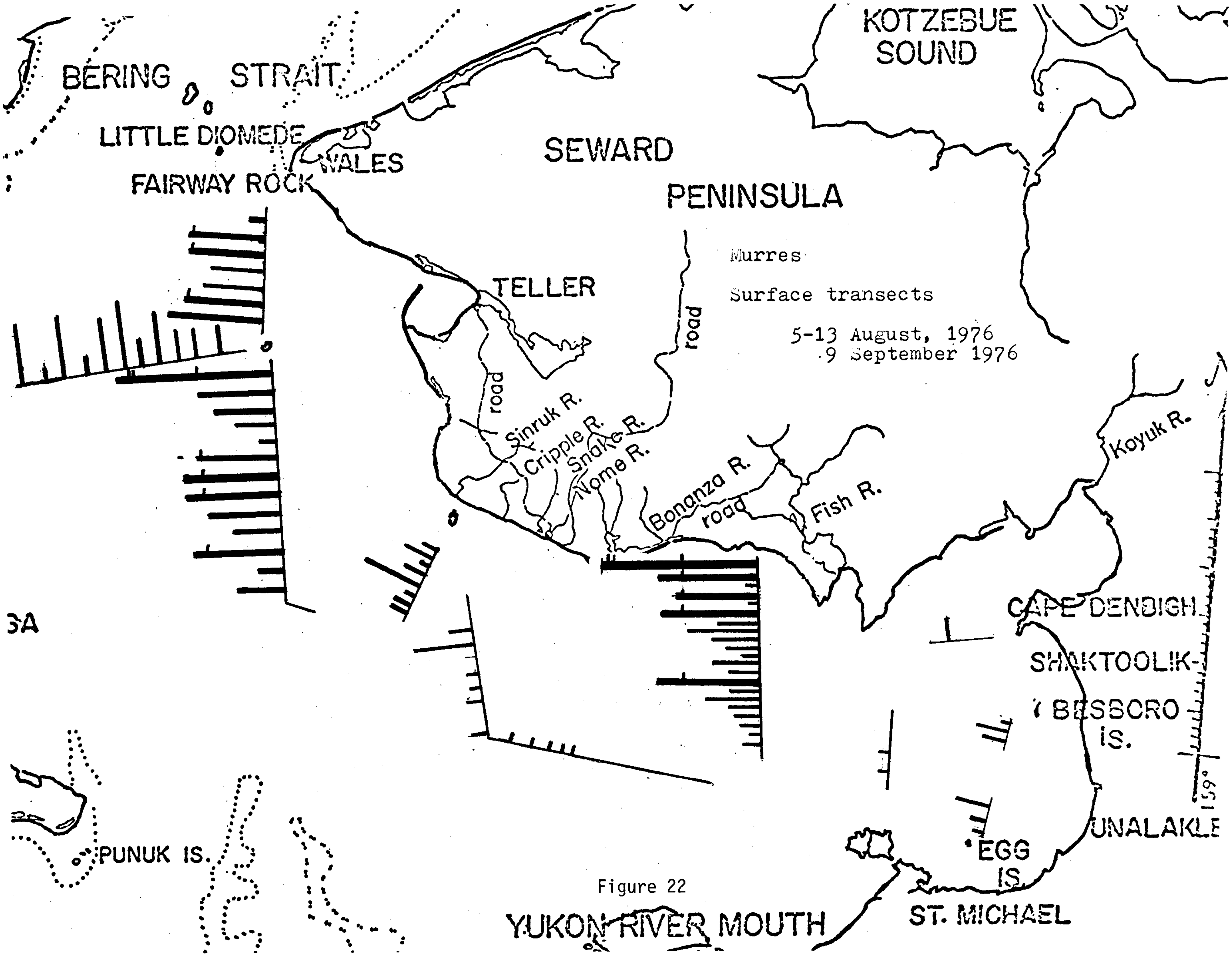

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE
SOUND
TELLER
Murres
Air transect 4 June, 1976
road
road
road
Cripple R.
Snake R.
Nome R.
Bonanza R.
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO
IS.
UNALAKLE
EGG
IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 21



BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
KOTZEBUE SOUND
SEWARD PENINSULA
TELLER
Murres
Surface transects
5-13 August, 1976
9 September 1976
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO IS.
159°
UNALAKLE
EGG IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 22

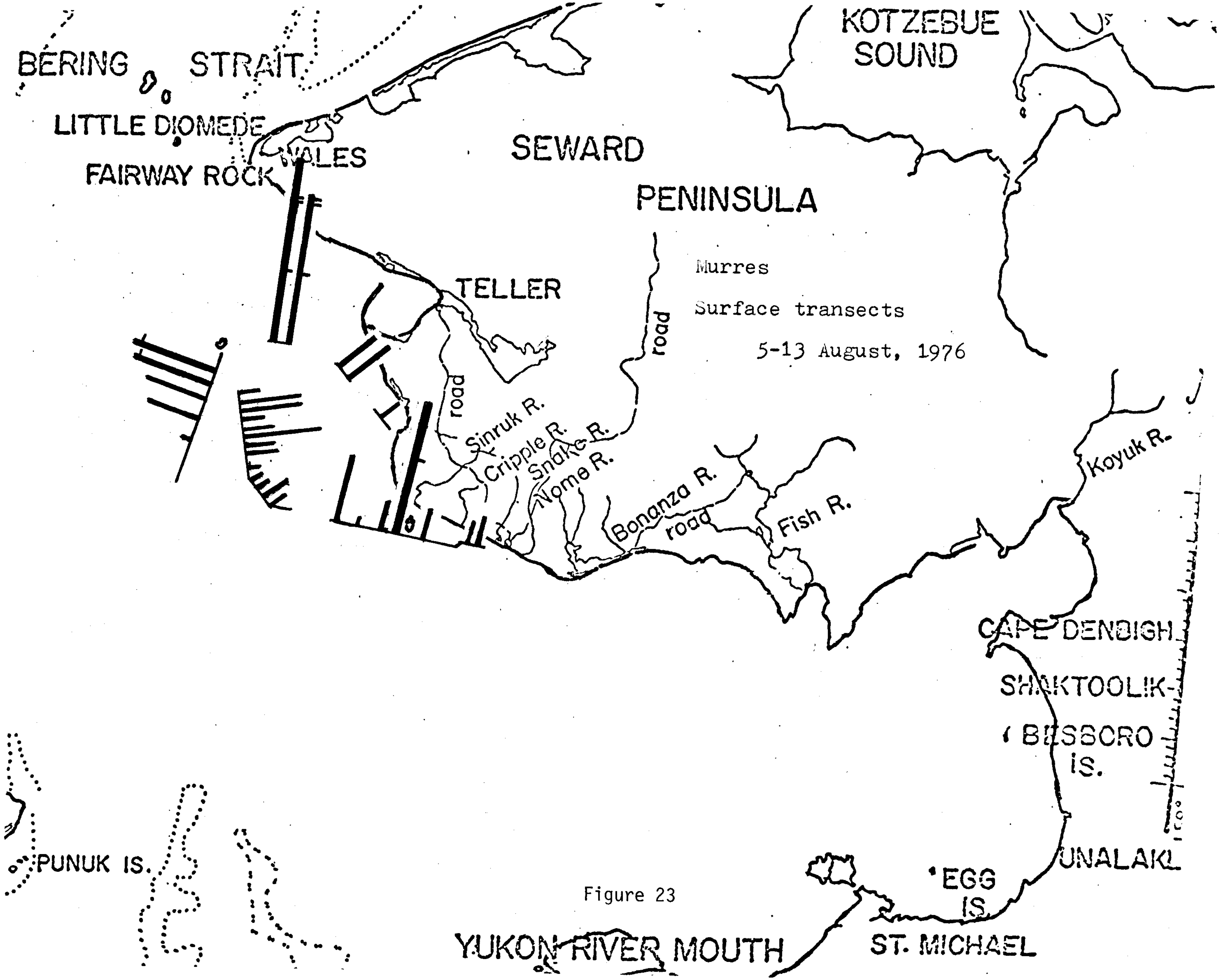

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE
SOUND
TELLER
Murres
Surface transects
5-13 August, 1976
road
road
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO
IS.
UNALAKL
EGG
IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 23

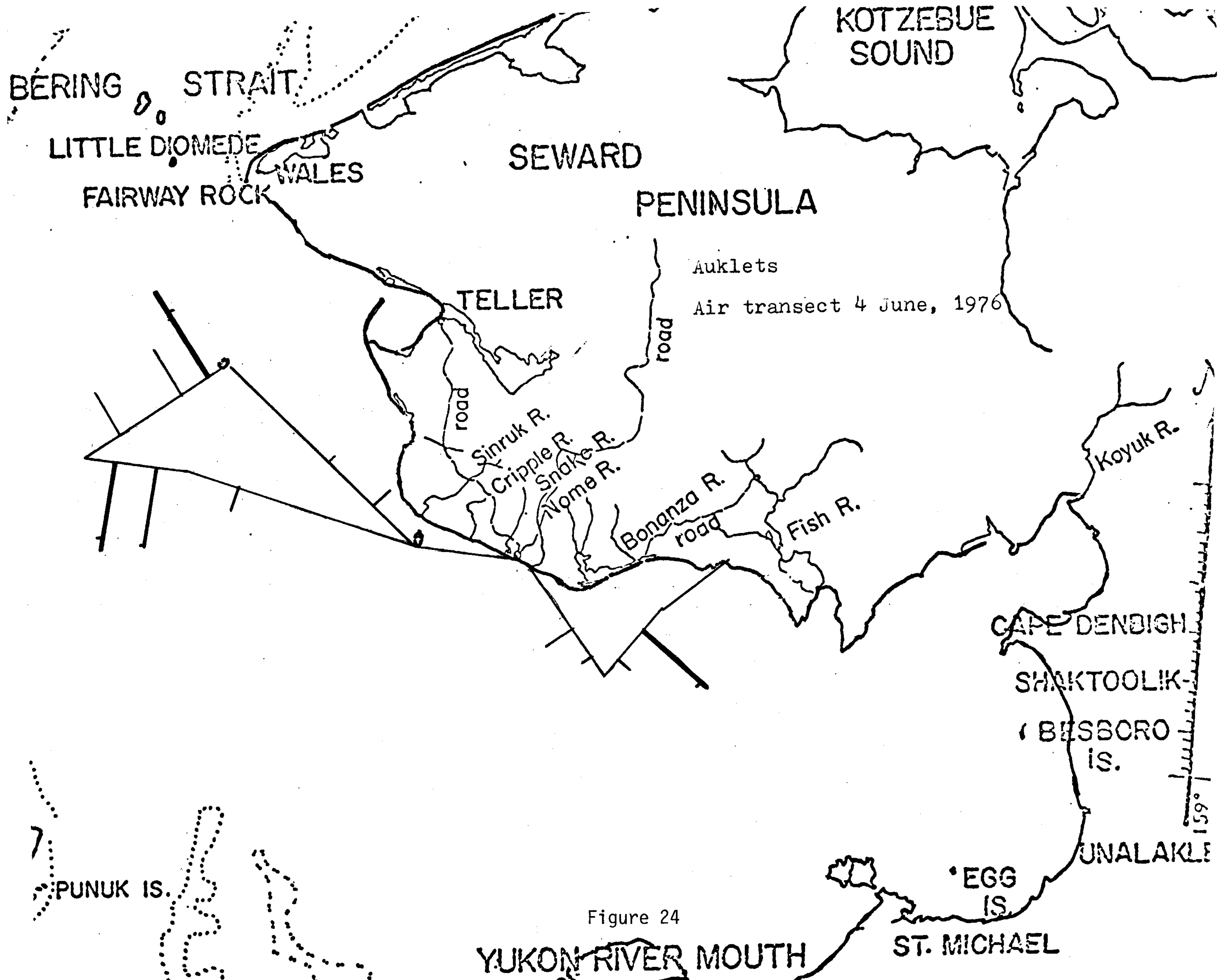

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD PENINSULA
KOTZEBUE SOUND
TELLER
Auklets
Air transect 4 June, 1976
road
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO IS.
159°
UNALAKLEET
EGG IS.
ST. MICHAEL
PUNUK IS.
YUKON RIVER MOUTH

Figure 24

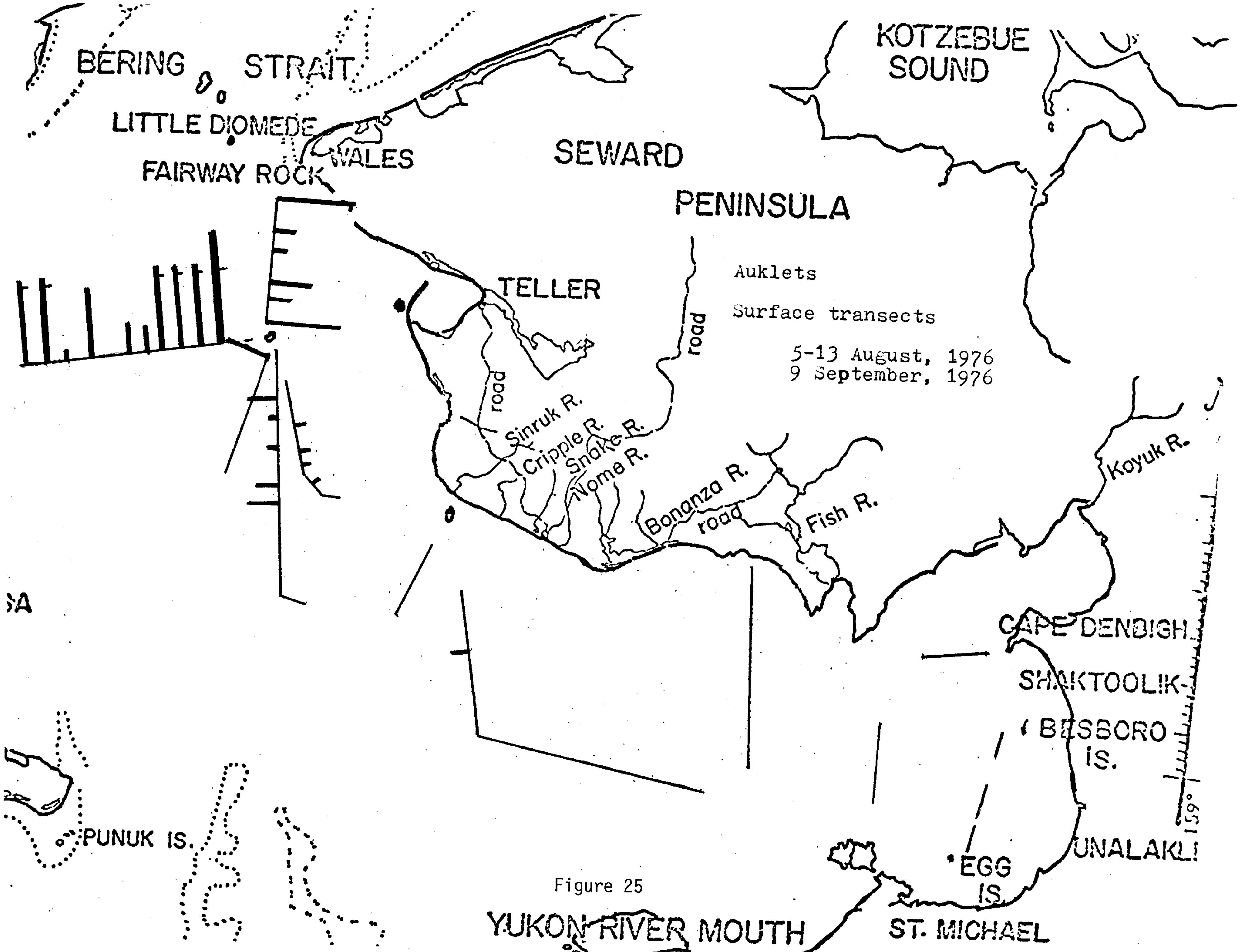
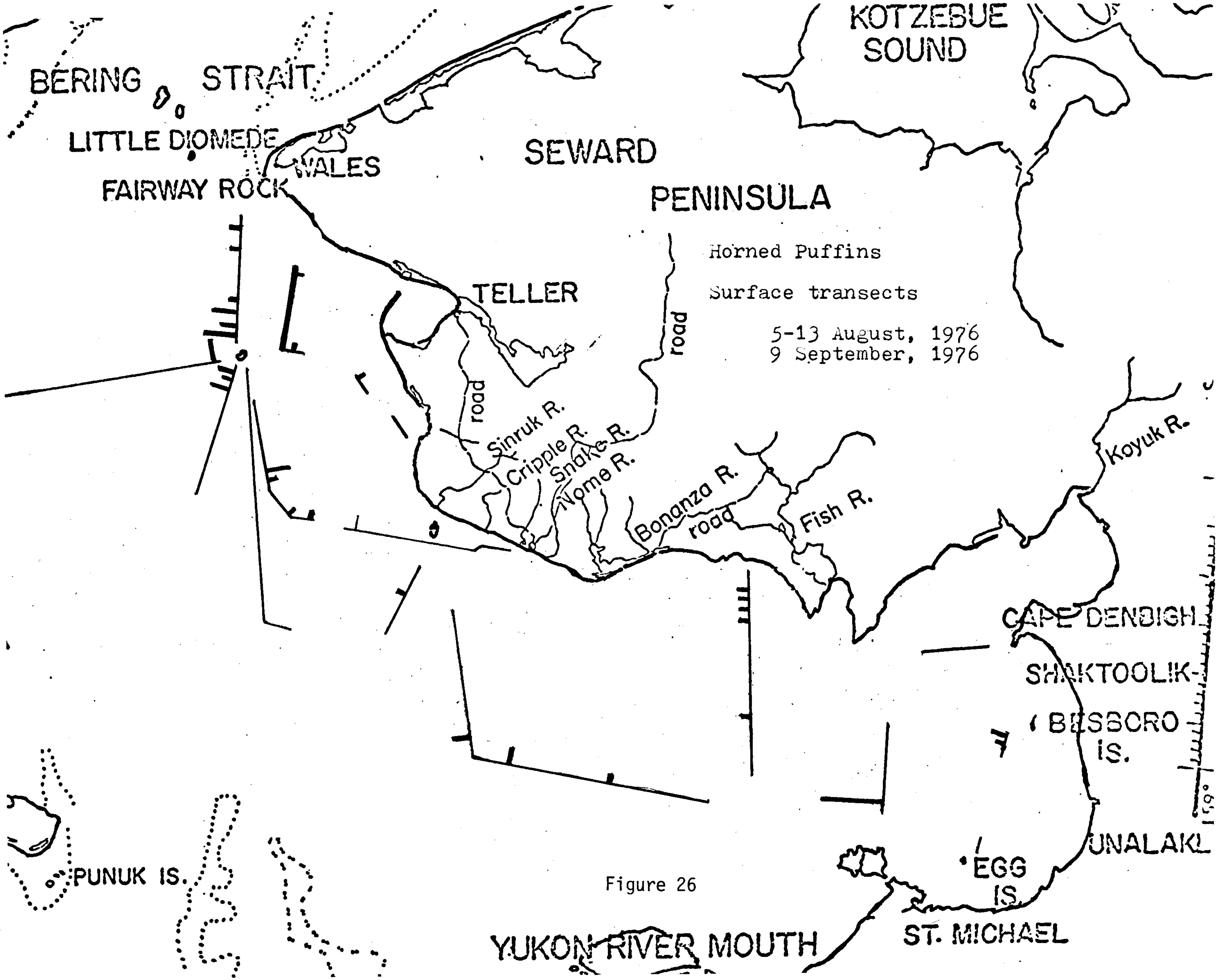

BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD
PENINSULA
KOTZEBUE
SOUND
TELLER
road
Auklets
Surface transects
5-13 August, 1976
9 September, 1976
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
road
Fish R.
Koyuk R.
CAPE DENBIGH
SHAKTOOLIK
BESBORO
IS.
159°
UNALAKLI
EGG
IS.
PUNUK IS.
YUKON RIVER MOUTH
ST. MICHAEL

Figure 25



Horned Puffins

Surface transects

5-13 August, 1976
9 September, 1976

Figure 26

VII. DISCUSSION

1. Estimates of birds at the island.

The figures for the estimates of populations have been plotted on a logarithmic scale. This scale has the advantage of making proportional variations directly comparable -- not masked by absolute population size. The scale perhaps has a disadvantage in that it de-emphasizes daily variations and errors in estimation.

a) Cliff-nesting species.

Two years of experience at Bluff Cliffs indicate that there was a large difference in the attendance of murres at the cliffs between the two years. We do not know whether such marked changes affected the population at King Island and if so, how much. Future censuses, if they can be taken, will resolve this.

Experience at Bluff also suggests that there are important changes in the numbers of murres and puffins from month to month in the course of the breeding season. The data seem most consistent with the interpretation that censuses taken in late July will most closely approximate the number of breeding birds. The birds which readily flew off the cliffs were eliminated from these counts at Bluff. We chose these late July counts because any birds which would produce young would have to have eggs at that time. Numbers estimated before that time seemed much too low.

We concluded that the low numbers reflected absence of birds as a result of food shortage which seemed to affect murres, puffins and kittiwakes. If this food shortage existed in the Chirikov Basin around King Island, our counts made in late June and early July may be too low.

They do, however, approximate the counts made in mid-August. If there was an effect of food shortage it should affect the counts of Common Murres more than the counts of Thick-billed Murres or kittiwakes (see below).

b) <u>Burrow and scree-nesting species</u>

We found very wide variations in the numbers of Horned Puffins at King Island. These variations occur at Bluff Cliffs also. We also found large variations in our counts of Pigeon Guillemots, Tufted Puffins and auklets, the populations of any of which are too small for any quantitative study at Bluff.

It does appear to be the case that favorable weather, especially sunny with light onshore wind, brings these birds in and at such times we can get maximum counts. But we do not know the relation of these maxima to the size of the population of effective breeders. For annual comparisons and comparisons between colonies our estimates will be valid if we compare estimates taken on similar dates under similar weather circumstances.

We estimated numbers of auklets at many places on the island. We also estimated the proportions of species at sampling stations. Using the estimates and proportions and expanding them to the whole island can introduce a lot of error but seems to give consistent figures between our June and August estimates. Another year, if possible, we should count flocks of Crested Auklets that gather at the edge of the shore-fast ice. We should also count birds, primarily Least Auklets, coming in in the evening, as Hickey and Craighead have been doing at Saint Paul in the Pribilof Islands.

2. Reproductive success

a) We have data on kittiwakes i) of the number of nests occupied then abandoned, the number of incubating birds and the number of eggs seen at one study site; and ii) a count of incubating birds on the cliffs seen from the water. We also have data on the proportion of birds in an incubating posture among murres at seven study sites.

b) These data suggest that reproductive success at King Island was even lower there than at Bluff Cliffs, i.e., barely measurable among kittiwakes and among murres about half that at Bluff Cliffs. Observations at King Island suggest that reproductive success in Thick-billed Murres was comparable to that in Common Murres (about 20%) which is different from the case at the Bluff Cliffs.

c) In our report for the studies at Bluff we argue that an important shortage of food kept parents from the cliffs during the middle and latter part of the egg-laying period. The counts of murres at King were made before and after the period of the main impact at the Bluff Cliffs, but if the food shortage was real, and extended into the Chirikov Basin, it would explain why we found murres seeking food so far at sea.

d) The counts of murres at study sites indicated that Thick-billed Murres are very much more numerous at King Island as compared to Common Murres than they are at Bluff Cliffs. Thick-billed Murre numbers varied less than did those of Common Murres. When the Common Murres were absent they may have been looking for food. This possibility is supported by the indication in the studies at Bluff Cliffs that Common Murres were more seriously affected by the resource failure than were Thick-billed Murres. The Thick-billed Murres at Bluff laid eggs earlier and persisted at their ledges during the absence of Common Murres.

Perhaps Thick-billed Murres were able to use alternative food sources, such as the crustacea, to keep going during a period of serious food shortage. The pink tinge to their droppings suggested this. If so, this adaptation could contribute to their being able to survive in High Arctic areas where (chronic, , periodic) food shortages affect Common Murres.

3. Predation

There were Arctic Foxes, Glaucous Gulls and Ravens on King Island. Ravens were seen only during June and early July.

The Glaucous Gulls showed high reproductive success which must mean that they were finding food among the seabirds. There were no sea mammal carcasses on the island. Glaucous Gulls were seen to feed on dead seabirds on the ice, primarily on Crested Auklets and Parakeet Auklets.

We estimated that about five pairs of Arctic Foxes occupied the island. Two or three territories may have been occupied by single animals. One den in which three kits were raised was along the route to three of our study sites, and the animals hunted all over the amphitheater above the village. We saw the parents carrying Parakeet Auklets many times and the ground near the den was littered with wings of seabirds, primarily Parakeet Auklets but also Crested Auklets and one murre. One day we saw both parents and each of the three kits carrying a Parakeet Auklet. We found many wings of Least Auklets scattered about the top of the island.

Fox predation may well have a measurable impact on the numbers and distribution of auklets nesting on King Island. Such predation can have a serious or disastrous effect when numbers of burrow-nesting seabirds are small.

4. Distribution of birds at sea in the Chirikov Basin

Our few data and transects suggest that the observations made from an airplane are comparable to those collected from the large ships. We concluded that flying in a Cessna Skymaster with two observers on each side is best.

Both shipboard and airborne transects have advantages and disadvantages.

The disadvantages of a plane are:

a) Unless the plane has sophisticated navigation equipment, it is difficult to tell exactly where you are.

b) Identification to species is more difficult.

c) Aircraft proceed west across the International Dateline at their peril.

The advantages of a plane are:

a) It takes less time.

b) It is cheaper.

c) Birds do not follow a plane as they sometimes do a ship. We have the impression that, in fair weather, seabirds avoid a large ship and that in overcast weather or poor visibility they (murres, puffins, kittiwakes), may be temporarily attracted to it, i.e., change course for a while.

d) One is freer to choose the best weather -- light wind and calm sea -- for seeing birds on the surface.

Unless it is necessary to get specimens for feeding studies (and this is very difficult from a large ship), the advantages of a plane outweigh the disadvantages.

We looked for seabirds from a helicopter, both Bell and U.S. Coast Guard SAR helicopter, but the noise of the rotor caused birds to dive before we could identify them.

The notable observations were a) murres were dispersed widely at sea; b) murres, auklets and kittiwakes occurred in large numbers in the area between, and southwest of, Sledge Island and King Island; c) seabirds were numerous west and north of King Island; d) auklets were numerous around and west of King Island; e) waterfowl were seen associated with drifting icefields in June; f) one feeding mélé, which included Horned Puffins, Tufted Puffins, Black-legged Kittiwakes, Minke Whales, but also a most unusually large number of murres, was seen east of King Island in August.

It appears from these meager data that more birds are feeding in the Chirikov Basin than in Norton Sound, and more birds are feeding north or west of King Island than to the east. The gathering of birds southwest of Sledge Island was of interest.

Many more surveys are necessary. Our results this year suggest that we can get as good data on common species using aircraft as we can using a ship, especially a very large ship.

In Sections VII, Conclusions, and IX, Needs for Further Study, our work in Norton Basin is treated as a whole. These sections are included in the annual report for Research Unit #237, and are omitted here in those cases when the two reports will go to one person.

ANNUAL REPORT

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AVIAN COMMUNITY ECOLOGY OF THE AKULIK-INGLUTALIK RIVER DELTA, NORTON BAY, ALASKA

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Summary of Task Objectives:

- to determine species and numbers of breeding, non-breeding, and migratory birds on the delta
- to determine dates of arrival and departure for breeding, non-breeding and migratory birds
- to determine mean dates of hatching and fledging of species breeding on the delta
- to determine relative productivity of breeding birds on the delta by the determination of total hatching and fledging success
- to determine general habitat preference of breeding birds
- to determine abundance and distribution of mammals on the delta
- to determine the extent of the interaction of birds and mammals
- to determine the general flora of the delta
- to determine the general climatological conditions of the region
- to provide recommendations as to the relative importance of this area as habitat for resident birds

Introduction

Norton Bay is a northeastern extension of Norton Sound. It is bounded on the east by the Alaskan mainland and on the north and west by the Seward Peninsula. The Akulik, Inglutalik, Koyuk, Kwiniuk, Kwik and Ungalik Rivers empty into this bay. Of these, the Akulik, Inglutalik, and Koyuk form a large low-lying delta at the head of the bay. This delta with its associated tidal flats and slough system attracts large numbers of waterfowl and shorebirds during both migratory and breeding seasons. Avifaunal studies of the area are essentially non-existant and since this area has high potential for oil exploration and development studies designed to determine its relative importance as breeding habitat for resident birds as well as a feeding and resting area for migrants are important. Having made these determinations we will provide recommendations to lessen potential deleterious effects on this area by future oil development and concomitant human habitation. This baseline study will serve as a focal point for future comparative studies directed at monitoring environmental stability. In this regard, bird populations act as indicators, responding to the total environment, which if changed, will cause a slow but perceptible change in the density of certain species, which can indicate the presence or absence of a crisis situation.

A team of four biologists, two senior scientists and two research assistants, arrived in the area on June 4. Field activities were curtailed on August 24 when field gear was transported to the native village of Koyuk for winter storage. This report summarizes the first of two years of study.

The Akulik-Inglutalik River Delta

The study area is located on the tidal flat-wet tundra meadow ecotype between the mouths of the Akulik and Inglutalik rivers (sections 31, 32, and 33, T5N, R11W) Kateel River Meridian about ten air miles southeast of Koyuk, Alaska (Fig. 1). This area was chosen in preference to other potential study plots in this region since it is essentially representative of the delta tidal flat and is subject to relatively little human disturbance. A tent research camp was established in this area near the mouth of the Inglutalik River on June 12 immediately after pack-ice receeded from Norton Bay.

Study Plots

Study plots of differing ecotypic diversity were selected and monitored at regular intervals throughout the breeding and migratory seasons. The first and most extensively studied area was located in homogeneous lowland wet tundra and covered an area of 2km x .1km. This area is characterized by the presence of numerous brackish ponds and tidal pools (Fig. 1). The area is dominated by reed grass, *Calamagrostis*


STUDY AREA
ALASKA
CANADA
INGLUTALIK RIVER
AKULIK RIVER
NORTON BAY
0
1
2 km

Fig. 1

canadensis, alkali grass, Puccinellia phryganodes, and sedge, Carex mackenziei C. ramenskii, C. lyngbyaei and C. aquatilis. The entire area rises only two meters above the normal high tide mark and hence is subject to partial or total inundation during periods when high tides coincide with severe storms from the south. This area was totally inundated with water during the severe winter storm of November, 1974. The region was partially inundated during a severe storm on July 3 of 1976.

This area was monitored daily for presence and status of birds and their nests. The entire area was sectioned into grids 50 m x 50 m. Each grid was numbered in sequence and was deliniated in the field by the placement of a meter long lath at each of its corners. Nests were originally located by flushing birds from their nests on foot or by dragging a 100 ft. rope through each sector and marking nests when they were observed. Each nest was marked with a colored plastic flag and was identified as to sector, species, dates of laying, if known, number of eggs, number of eggs hatched, and number of fledged young. Altricial young were banded in the nest several days before fledging while precocial young were banded soon after they had left the nest. Adult birds captured in mist nests, hoop snap-traps, or drops nests (Johns, 1963) were banded and released. This area served as our intensively studied plot and all nesting data extrapolated for the delta are based on observations in this region.

A second plot .5 x .2 km consisted of an elevated region calculated to be 20 meters at its highest point. This area comprises the only significant relief on the delta (see figure 1) and consists of a succession from carex meadow to arctic willow, Salix arctica and S. pulchra, alder, Alnus crispa, arctic dwarf birch, Betula nana and tussock, Eriophorum vaginatum. This region attracted large numbers of birds particularly during the fall migration. Densities of resident and migratory birds of this area were monitored by mist nets and drop nets.

The Inglutalik-Akulik River system with its accompanying sloughs was monitored by boat at irregular intervals. Travel by boat allowed us to monitor avifauna utilizing the river and slough systems. In addition, it allowed us access to remote areas of the delta which otherwise were inaccessible on foot. Species and number of birds observed during river and slough travel contributed greatly to our overall description of chronology of migration through the area.

At low tide an extensive area (2 km^2) of tidal mud flat was exposed at the mouth of the Inglutalik River. This area was monitored extensively during the month of August in order to describe the chronology of fall migration. Estimates of numbers of birds migrating through this area were made using both spotting scopes and field glasses. In addition, birds were captured in mist nests and banded at intervals during the migration.

Species Listing and Breeding Status on the Delta

Table 1 summarizes the abundance and breeding status of the 83 species of birds observed on the delta during the summer of 1976. The designation cn, common nester, indicates that these species were among our most numerous nesters in localized habitat throughout the delta. Uncommon nesters (un) were observed infrequently during the breeding season or were observed on occasion with broods after the nesting season. Probable nesters were not observed as breeders but occurred in significantly high numbers and are species known to breed in similar habitat elsewhere. Nonnesters (o) were observed either as migrants in spring and fall or if present during the breeding season are species which are not known to breed in this habitat. The designation k is assigned only to birds observed at Koyuk in spring but as migrants on the delta.

Avifaunal Phenology of the Akulik-Inglutalik River Delta

Daily observations of birds on the Norton Bay region began with our arrival in Koyuk on June 4 and ended with our departure from the area on August 24. Observations at Koyuk are essentially restricted to those made during our eight day encampment there while we awaited the breakup of ice-pack on Norton Bay. Observations made at the study site are essentially those made in the low-lying regions between the mouths of the Akulik and Inglutalik Rivers, an area of about 18 km^2. On occasion observations were made in upper regions of the Inglutalik River and these data are included here.

A series of histograms is presented (Fig. 2-20) to show daily phenology of avifauna in the area. Only documented observations are included. Consequently, some data for common breeders are missing for days when direct observations were difficult, during severe storms for example. Note that scales on the population axis differ from species to species. Solid bars represent adults while open bars represent young.

Table 1. Birds observed at Inglutalik-Akulik Study area 1976.

Species	Occurrence	Nesting Status
Yellow-billed Loon (Gavia adamsii)	rare	o
Arctic Loon (Gavia arctica)	common	cn
Red-throated Loon (Gavia stellata)	common	cn
Whistling Swan (Olor columbianus)	common	cn
Canada Goose (Branta Canadensis)	few	o
Black Brant (Branta nigricans)	few	o
Mallard (Anas platyrhynchos)	few	un
Gadwall (Anas strepera)	rare	o
Pintail (Anas acuta)	very common	cn
Green-winged Teal (Anas crecca)	few	pn
American Wigeon (Anas americana)	few	pn
Northern Shoveler (Anas clypeata)	few	pn
Greater Scaup (Aythya marila)	few	pn
Common Goldeneye (Bucephala clangula)	rare	o
Oldsquaw (Clangula hyemalis)	common	cn
Harlequin Duck (Histrionicus histrionicus)	few	o
Common Eider (Somateria mollissima)	few	un
White-winged Scoter (Melanitta deglandi)	rare	o
Surf Scoter (Melanitta perspicillata)	few	un
Black Scoter (Melanitta nigra)	rare	un
Red-breasted Merganser (Mergus serrator)	few	cn
Marsh Hawk (Circus cyaneus)	few	un
Merlin (Falco columbarius)	rare	o
Gyrfalcon (Falco rusticolus)	rare	o
Willow Ptarmigan (Lagopus lagopus)	rare	pn
Sandhill Crane (Grus canadensis)	common	cn
American Golden Plover (Pluvialis dominica)	few	o
Semipalmated Plover (Chardrius semiplamatus)	few	o
Black Turnstone (Arenaria melanocephala)	rare	o
Semiplamated Sandpiper (Calidris pusilla)	very common	cn
Western Sandpiper (Calidris mauri)	few	cn
Least Sandpiper (Calidris minutilla)	common (K)	cn (K)
Dunlin (Calidris alpina)	few	cn
Long-billed Dowitcher (Limnodromus scolopaceus)	common	o
Lesser Yellowlegs (Tringa flavipes)	few	o

Table 1. Continued

Species	Occurrence	Nesting Status
Bar-tailed Godwit (Limosa lapponica)	common	o
Hudsonian Godwit (Limosa haemastica)	common	o
Whimbrel (Numenius phaeopus)	few	o
Common Snipe (Capella gallinago)	few	o
Red Phalarope (Phalaropus fulicarius)	rare	o
Northern Phalarope (Lobipes lobatus)	very common	cn
Pomarine Jaeger (Stercorarius pomarinus)	common	o
Parasitic Jaeger (Stercorarius parasiticus)	common	un
Long-tailed Jaeger (Stercorarius longicaudus)	common	o
Glaucous Gull (Larus hyperboreus)	common	cn
Glaucous-winged Gull (Larus glaucenscens)	rare	o
Herring Gull (Larus argentatus)	common	o
Mew Gull (Larus canus)	common	un
Black-legged Kittiwake (Rissa tridactyla)	few	o
Bonaparte's Gull (Larus philadelphia)	rare	o
Sabine's Gull (Xema sabini)	few	un
Arctic Tern (Sterna paradisaea)	common	cn
Snowy Owl (Nyctea scandiaca)	rare	pn
Short-eared Owl (Asio otus)	few	pn
Belted Kingfisher (Megaceryle alcyon)	rare	un
Tree Swallow (Iriodoprocne bicolor)	few	o
Bank Swallow (Riparia riparia)	common	cn
Gray Jay (Perisoreus canadensis)	few	cn (K)
Raven (Corvus corax)	common	pn (K)
Robin (Turdus migratorius)	common (K)	cn (K)
Gray-cheeked Thrush (Catharus minimus)	common (K)	cn (K)
Varied Thrush (Ixoreus naevius)	common (K)	cn (K)
Wheatear (Oenanthe oenanthe)	rare	o
Yellow Wagtail (Notacilla flava)	common	cn
Bohemian Waxwing (Bombycillida garrulus)	few	o
Northern Shrike (Lanius excubitor)	few	o
Orange-crowned Warbler (Vermivora celata)	few	o
Yellow Warbler (Dendroica petechia)	common	o
Northern Waterthrush (Seiurus noveboracensis)	few	o
Wilson's Warbler (Wilsonia pusilla)	few	o

Table 1. Continued

Species	Occurrence	Nesting Status
Ruby-crowned Kinglet (Regulus calendula)	rare (K)	pn
Blackpoll Warbler (Dendroica striata)	few	un
Rusty Blackbird (Euphagus carolinus)	few	o
Pine Grosbeak (Pinicola enucleator)	few	o
White-winged Crossbill (Loxia leucoptera)	rare (K)	pn (K)
Hoary Redpoll (Carduelis hornemanni)	very common	cn
Common Redpoll (Carduelis flammea)	very common	cn
Savannah Sparrow (Passerculus sandwichensis)	very common	cn
Dark-eyed Junco (Junco hyemalis)	few	o
Tree Sparrow (Spizella arborea)	few	un
White-crowned Sparrow (Zonotrichia leucophrys)	few	un
Fox Sparrow (Passerella iliaca)	few	o
Lapland Longspur (Calcarius lapponicus)	very common	cn

1. Yellow-billed Loon (<u>Gavia adamsii</u>)

One large loon was seen on June 10 near the mouth of the Inglutalik river. We do not have a positive identification on this bird but this species is the only large loon which occurs in this region.

2. Arctic Loon (<u>Gavia arctica</u>)

This species is an abundant breeder throughout the entire delta. Loons with eggs were present on the delta when we arrived. Arctic loons appeared to be restricted to the larger ponds and lakes. A number of Arctic Loons remained in the study area during the breeding season but did not breed. It is clear that our presence affected the success of breeding loons. Once the loons are flushed from the nest they will not return until the intruder leaves the area. This absence exposes the eggs to predation by Parasitic Jaegers which we observed a number of times. Fall migration for our area started at or about the sixth of August. Local loons remained while migrants entered the region from the north. Large flocks of migrant loons were a common sight during mid and late August.

3. Red-throated Loon (<u>Gavia stellata</u>)

This species is a common breeder on the delta. It appeared to be restricted to the smaller ponds. We have no indication of migration in the fall for this species up to the 24th of August. Local birds were in the area at this time and we saw no increase in birds from the north.

4. Whistling Swan (<u>Olor columbianus</u>)

Large numbers (flocks of up to 50 birds) of swans were observed adjacent to the Koyuk River on June 7. We assume that this flock was migratory and only individuals and pairs were observed later. We observed whistlers on the study area essentially throughout the breeding season. We, however, observed only one brood of four chicks. We observed no migration in the fall on the delta.

5. Canada Goose (<u>Branta canadensis</u>)

We have no evidence that Canada geese breed on the delta. A small number of migratory stragglers were observed at Koyuk on June 8-9. A pair of non-breeders was observed in late June. Fall migration appeared to begin on August 21 when small flocks of birds began arriving from the north.

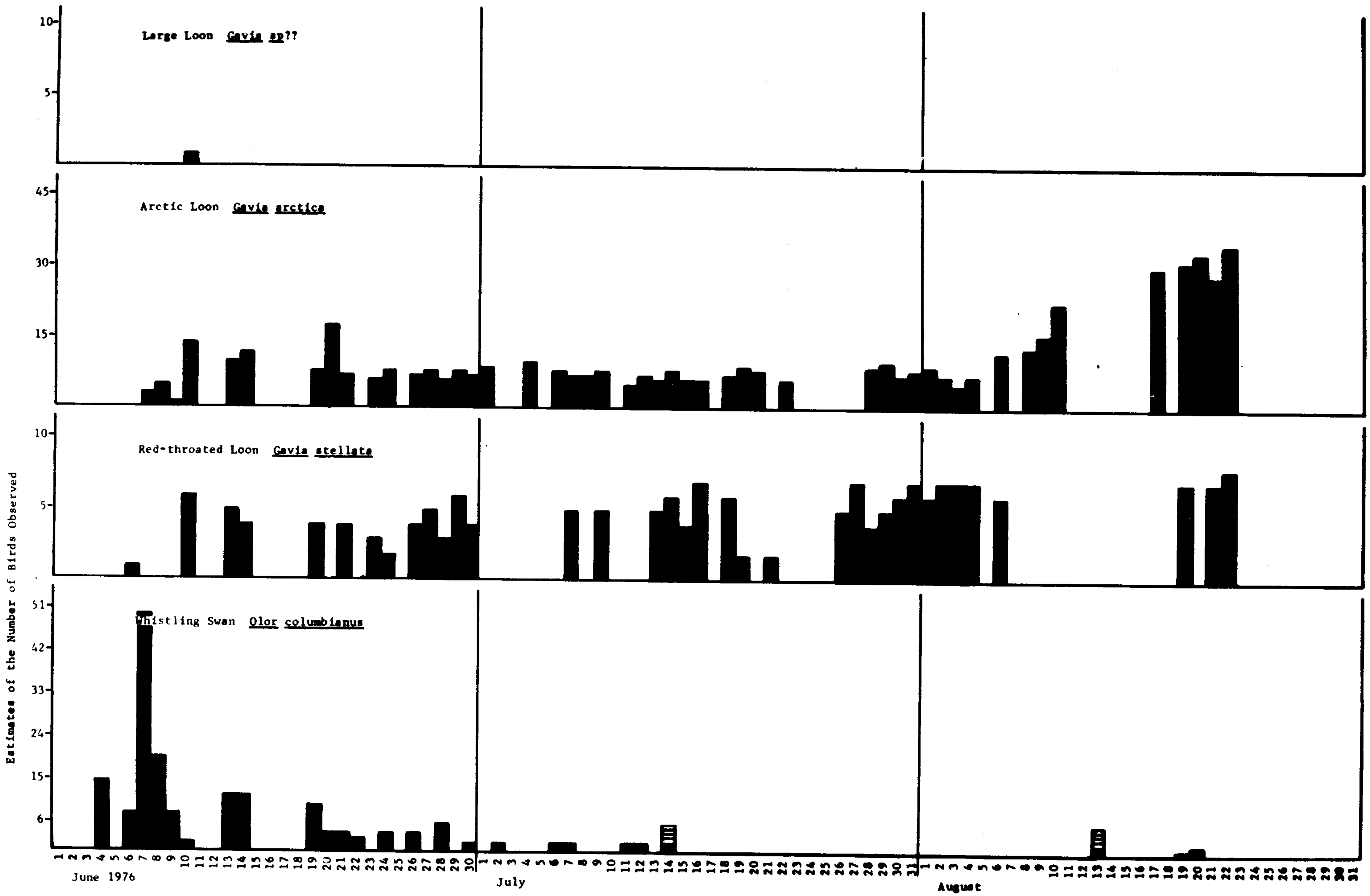

Large Loon Gavia sp??
Arctic Loon Gavia arctica
Red-throated Loon Gavia stellata
Whistling Swan Olor columbianus
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 2

6. Black Brant (Branta nigricans)

We have no evidence for breeders on the study area. Flocks of 6-8 birds were observed at Koyuk in early June and small flocks were again observed on the study area during early August. We assume that these birds were non-breeding migrants. We saw no evidence of fall migration for Brants.

7. Mallard (Anas platyrhynchos)

Several pairs were observed at Koyuk during the second week of June. A female with seven chicks was observed on the Inglutalik River on the twentyieth of June. A second female with four chicks was observed on the study area on August 2. Excepting these two broods we have no other evidence of breeding mallards on the study area. We have no evidence of migratory movement of mallards in the fall.

8. Gadwall (Anas strepera)

One pair was seen on the study area on July 28. We have no evidence that Gadwalls breed in the area. Nor do we have data on fall migration.

9. Pintail (Anas acuta)

Pintails are a common but unsuccessful breeder on the delta. Several nests of this species were observed on the study area which were destroyed probably by red fox. Numbers of post-breeding males were observed in flocks on the study area during mid-June onward. We have no evidence of flightless pintails on the study area. Large numbers of pintails arrived on the study area about the 2 of August and their number increased throughout the month. This species is among the most numerous of the fall migrants.

10. Green-winged Teal (Anus crecca)

Although we occasionally observed paired teal we have no evidence that they breed on the delta. We have no evidence for fall migration of teal.

11. American Wigeon (Anas americana)

Several pairs of wigeon were observed at Koyuk in early June. A flock of fifteen males was observed on the study area on the 30th of June. We have no evidence of wigeons breeding on the delta.

12. Northern Shoveler (Anas clypeata)

We have no evidence of shovelers breeding on the study area. Several observations of individual birds were made during June and early August. We have no evidence of fall migration.

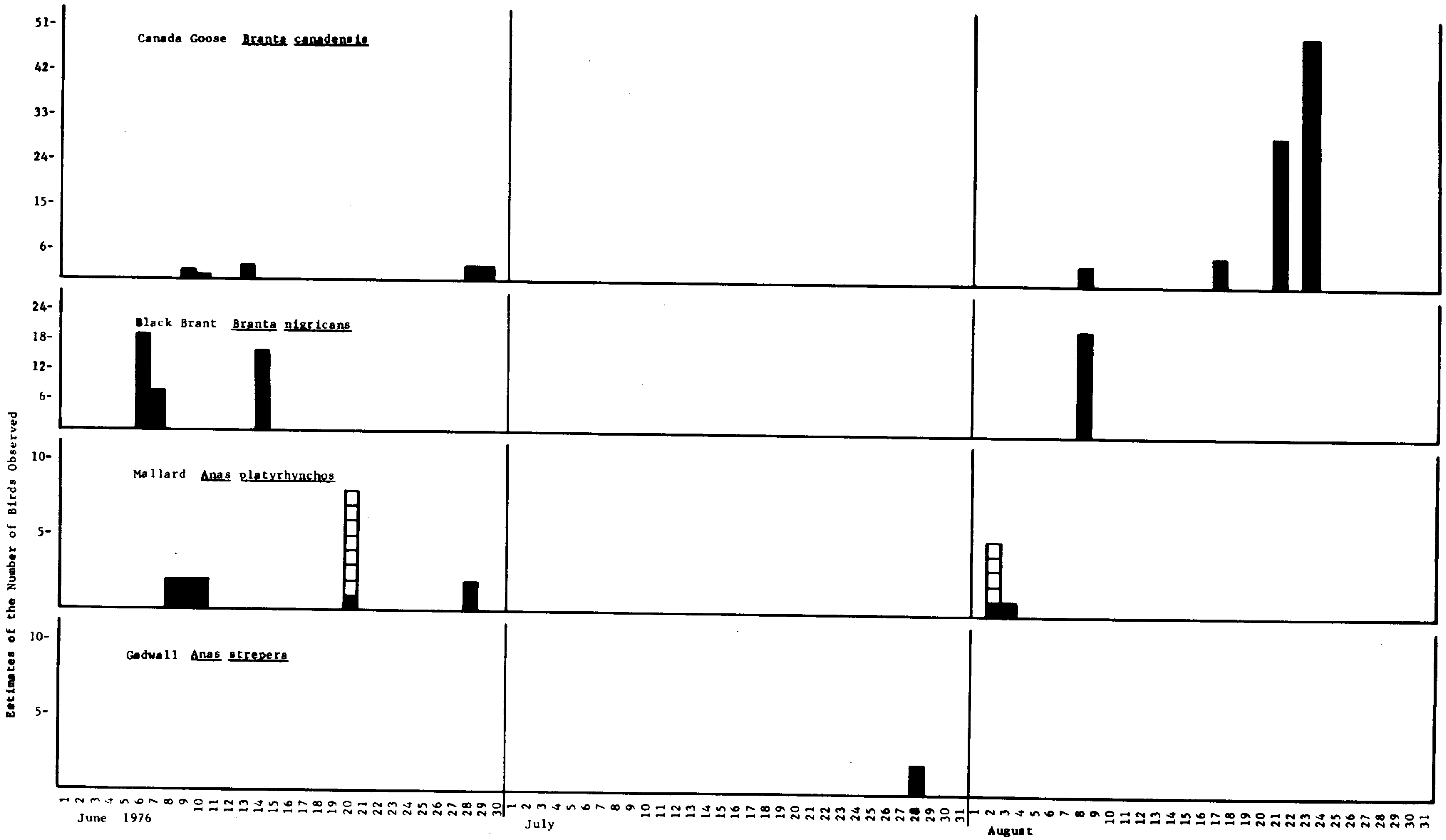

Canada Goose Branta canadensis
Black Brant Branta nigricans
Mallard Anas platyrhynchos
Gadwall Anas strepera
Estimates of the Number of Birds Observed
51-
42-
33-
24-
15-
6-
24-
18-
12-
6-
10-
5-
10-
5-
June 1976
July
August

Fig. 3

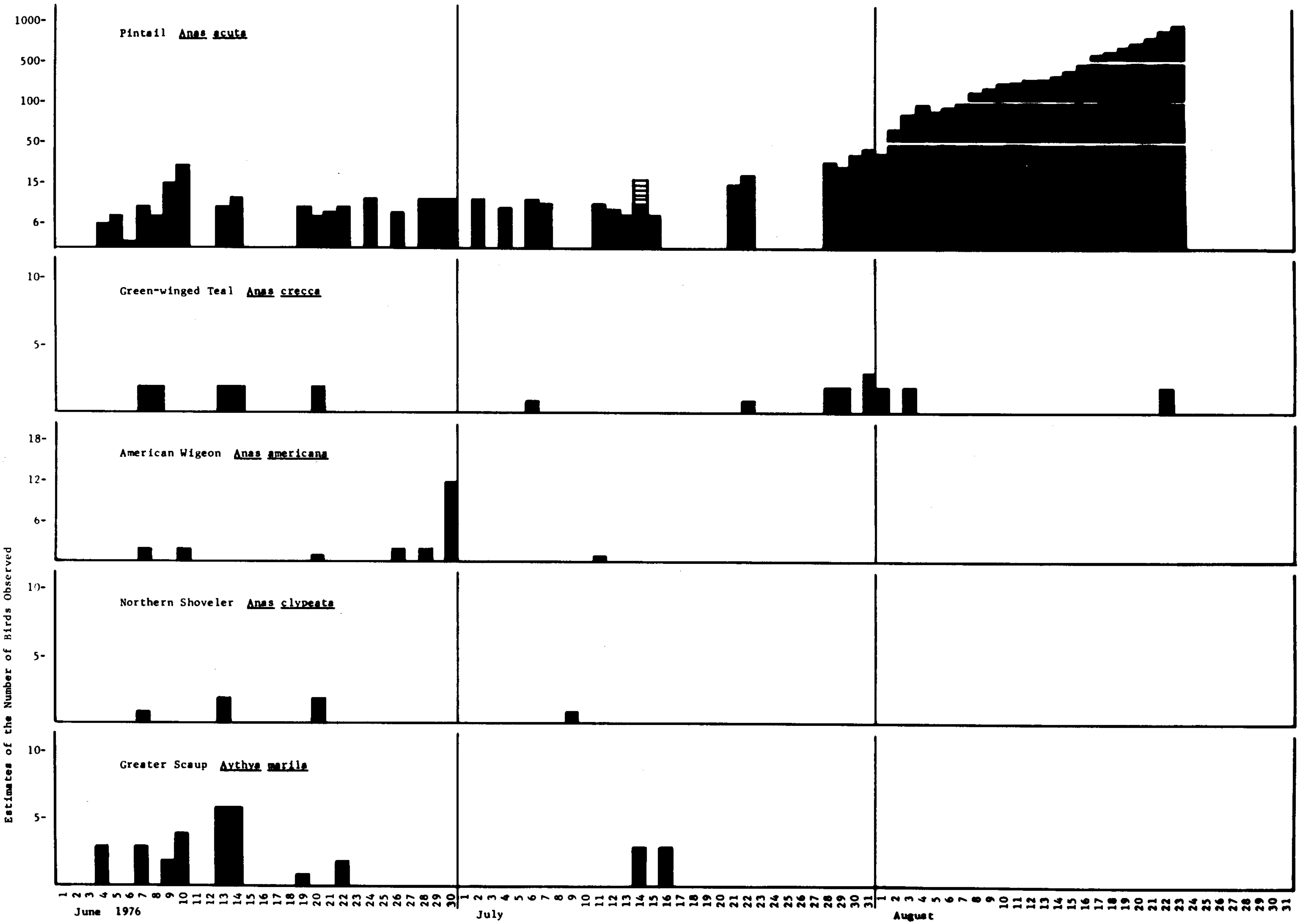

Pintail Anas acuta
Green-winged Teal Anas crecca
American Wigeon Anas americana
Northern Shoveler Anas clypeata
Greater Scaup Aythya marila
Estimates of the Number of Birds Observed
1000-
500-
100-
50-
15-
6-
10-
5-
18-
12-
June 1976
July
August

Fig. 4

13. Greater Scaup (Aythya Marila)

Several birds were observed on the Koyuk River during early and mid June. Several individuals were observed on the study area in mid July. We have no evidence of breeding or fall migration for scaup.

14. Common Goldeneye (Bucephala clangula)

A pair of Goldeneye was observed near the mouth of the Inglutalik River on 10 June. We did not see this species again.

15. Oldsquaw (Clangula hyemalis)

This species is an uncommon breeder on the delta. We found no nests of this species but we did see several broods during mid and late June. We assume that these birds are moving out of the immediate area after hatching. We observed small numbers of Oldsquaw throughout the breeding season on the study area. Fall migration for this species began on August 21 and flocks of 6-8 birds were observed in the area in late August.

16. Harlequin Duck (Histrionicus histrionicus)

Two males and one female Harlequin Duck were seen on the Koyuk River near the village on the eighth of June.

17. Common Eider (Somateria mollissima)

Several Eiders were observed on the Koyuk River on June 7. Eiders were observed on both the Akulik and Inglutalik Rivers throughout the breeding season. Several males were observed on the Akulik River and we believe that these birds had mates and nests. Several females with chicks were observed on the Inglutalik River in early August.

18. White-winged Scoter (Melanitta deglandi)

Two males were seen on the Inglutalik River on July 11.

19. Surf Scoter (Melanitta perspicillata)

Several pairs of surf scoters were seen on the Koyuk River on June 5 and several pairs were seen on the Akulik River June 7-10. Several pairs were seen on the Inglutalik River on June 20. We have no evidence that these birds breed on the delta.

20. Common Scoter (Melanitta nigra)

Several pairs were observed on the Inglutalik River on June 20 and 22 and again on July 14. We have no evidence that these birds breed on the delta.

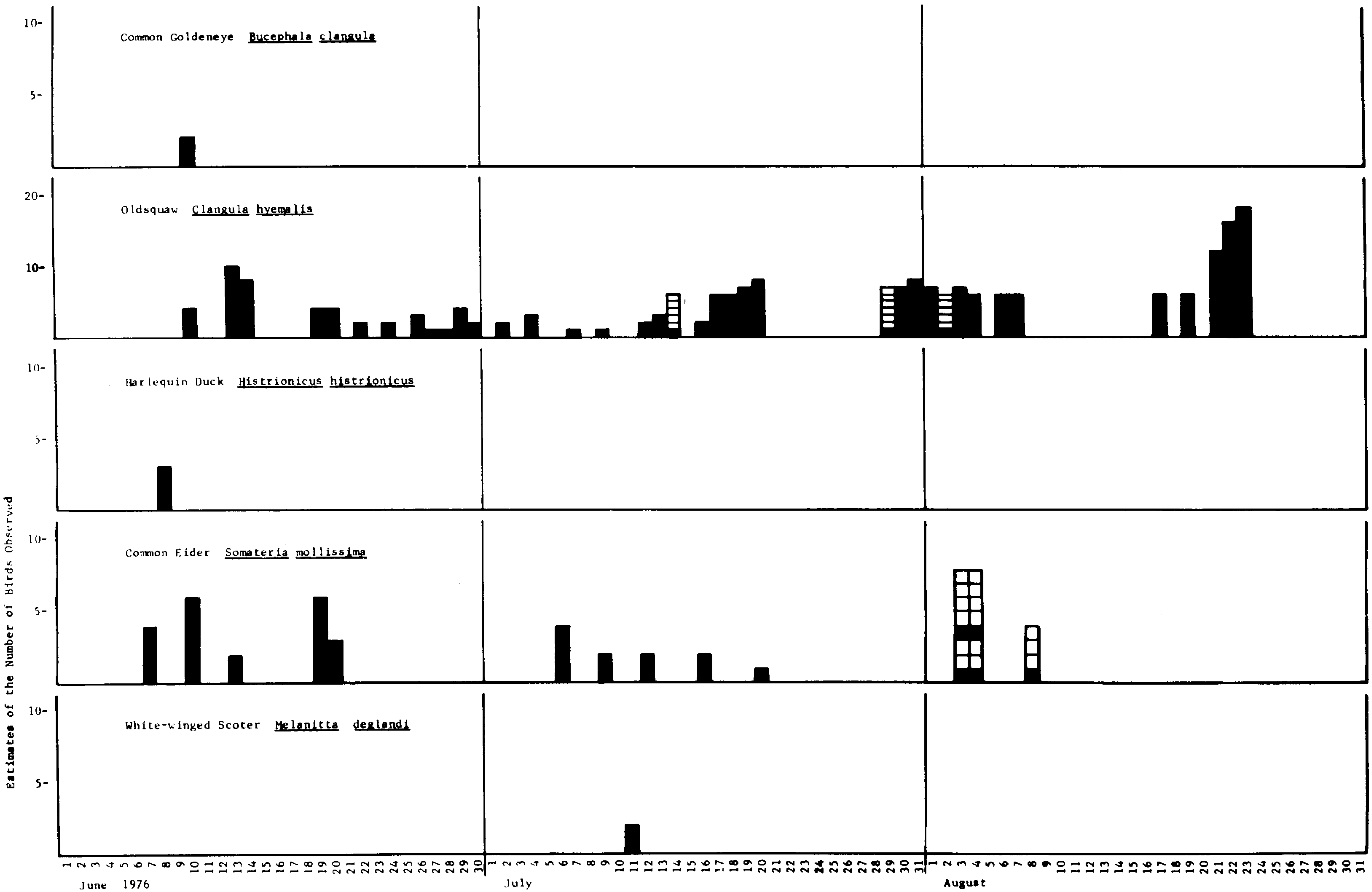

Common Goldeneye Bucephala clangula
Oldsquaw Clangula hyemalis
Harlequin Duck Histrionicus histrionicus
Common Eider Somateria mollissima
White-winged Scoter Melanitta deglandi
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 5

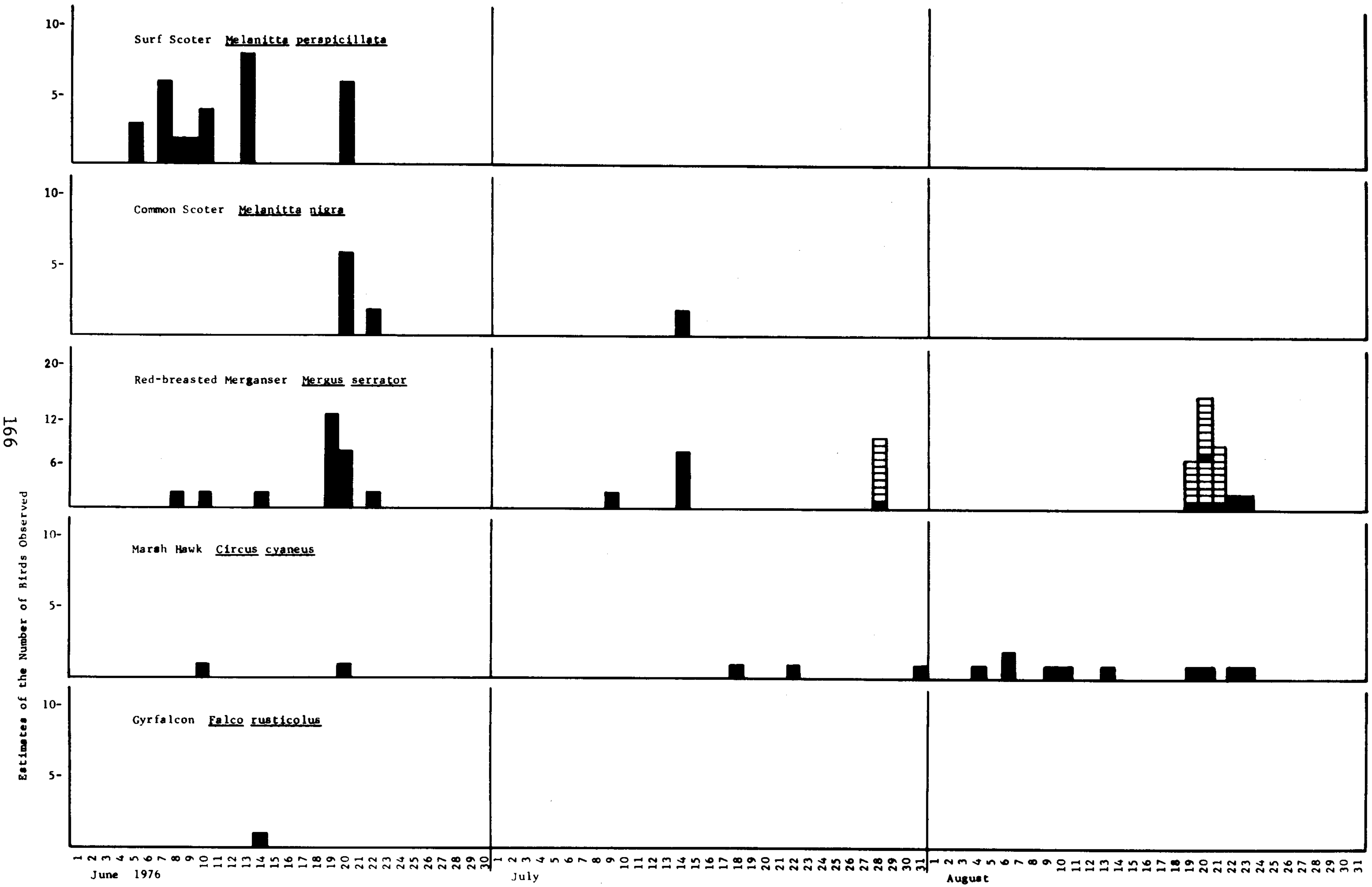

Surf Scoter Melanitta perspicillata
Common Scoter Melanitta nigra
Red-breasted Merganser Mergus serrator
Marsh Hawk Circus cyaneus
Gyrfalcon Falco rusticolus
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 6

21. Red-breasted Merganser (<u>Mergus serrator</u>)

This species is an uncommon breeder on the delta. A pair of mergansers was seen on the Koyuk River on 8 June. We observed pairs and females with young on the Inglutalik River during July and August. No evidence of migration.

22. Marsh Hawk (<u>Circus cyaneus</u>)

A female Marsh Hawk was observed on the study area at intervals throughout the summer. We assume that these observations were of a single bird since she consistantly entered and left the study area from the south. A male and female were observed on August 6 and we assume that the pair nested south of the Inglutalik River.

23. Gryfalcon (<u>Falco rusticolus</u>)

A single bird was seen on the study area on June 14. The bird entered the study area from the north, flew south, landed on the bank of the Inglutalik River near its mouth, and then continued to fly south.

24. Merlin (<u>Falco columbarius</u>)

A female Merlin was seen on August 4. The same bird was mist-netted, banded, and released on August 13.

25. Willow Ptarmigan (<u>Lagopus lagopus</u>)

A single bird was flushed from the tundra near the camp site on July 24. Natives at Koyuk speak of very large numbers of Ptarmigan near the village up to and including the year 1970. We assume that this population has been hunted out.

26. Sandhill Crane (<u>Grus canadensis</u>)

This species is a common breeder on the delta. Breeding pairs had established territories and eggs when we arrived on the study area on June 10. Small flocks of non-breeding adults were seen on the delta throughout the summer. Our presence affected the breeding success of this species at least on the study area. Breeding cranes simply do not tolerate disturbance and when disturbed both members of a pair will leave the immediate area exposing eggs or chicks to predation either by jaegers or red fox. Migration began on August 19 when flocks of 6-12 birds were seen flying along the coast.

27. Semipalmated Plover (<u>Charadrius semipalmatus</u>)

This species was seen only in the Koyuk area. Pre-copulatory display and nests with eggs were observed on June 7.

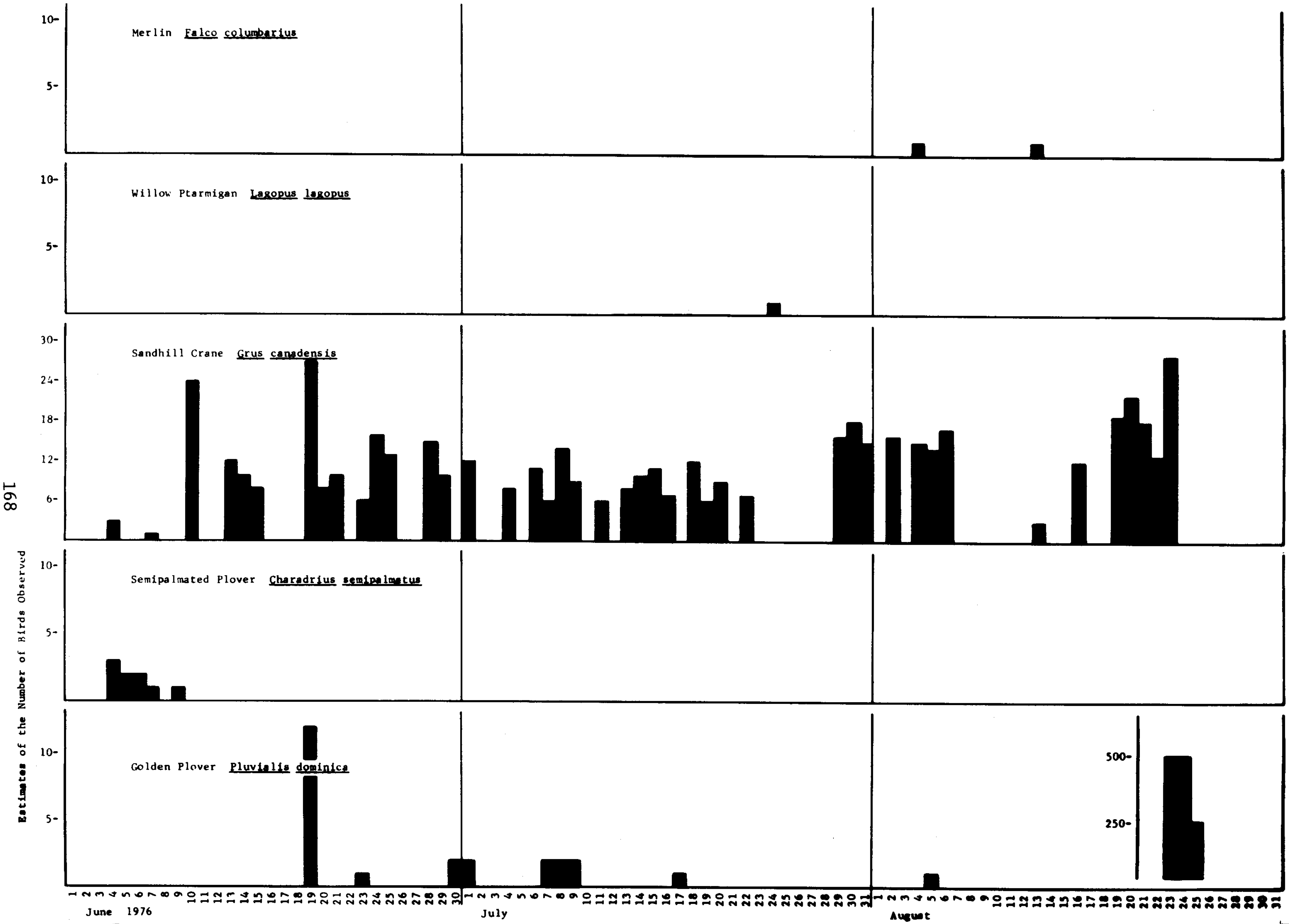

Merlin Falco columbarius
Willow Ptarmigan Lagopus lagopus
Sandhill Crane Grus canadensis
Semipalmated Plover Charadrius semipalmatus
Golden Plover Pluvialis dominica
Estimates of the Number of Birds Observed
10-
5-
30-
24-
18-
12-
6-
500-
250-
June 1976
July
August

Fig. 7

28. American Golden Plover (Pluvialis dominica)

Small groups of birds some of which were not in full nuptial plumage were observed on the study area in late June and early July. We have no evidence that this species breed on the delta. Migration began on August 23 when hundreds of birds were seen flying along the coast at the mouth of the Inglutalik River.

29. Black Turnstone (Arenaria melanocephala)

Individual birds were seen both at Koyuk and on the study area in June. We have no evidence that this species breed on the delta.

30. Common Snipe (Capella gallingo)

Individuals were seen both at Koyuk and on the study area. Groups of from two to seven birds were observed migrating through the study area from August 1 to August 10. We observed winnowing snipes at Koyuk on June 7 and assume that they nested there. We have no evidence that snipes breed on the delta.

31. Whimbrel (Numenius phaeopus)

Individual birds were seen on the study area in July. Flocks of 3 to 9 birds were observed in migration from August 8-11 and from August 20 to the 22. We have no evidence that this species breed on the delta.

32. Lesser Yellowlegs (Tringa flavipes)

Individual non-breeders were seen on the study area during July. Small migratory flocks were observed on August 5 and August 7. We have no evidence that this species breed on the delta.

33. Least Sandpiper (Calidris minutilla)

Individual breeding birds were captured and banded at Koyuk during the first week of June. Nests with eggs were observed at this time. We have no evidence that this species breed on the delta. Migration began on August 4 and peaked on August 22 when hundreds of birds migrated through the study area.

34. Dunlin (Calidris alpina)

This species was a common breeder on the delta. Hatching for local birds began on July 12 and continued for a week. Local concentrations of birds in feeding groups began during this period and peaked on July 20. Local birds were not seen on the study site after this date. We observed very large number of migrant Dunlins on the tidal flats near the mouth of the Inglutalik River during the period of August 22-24.

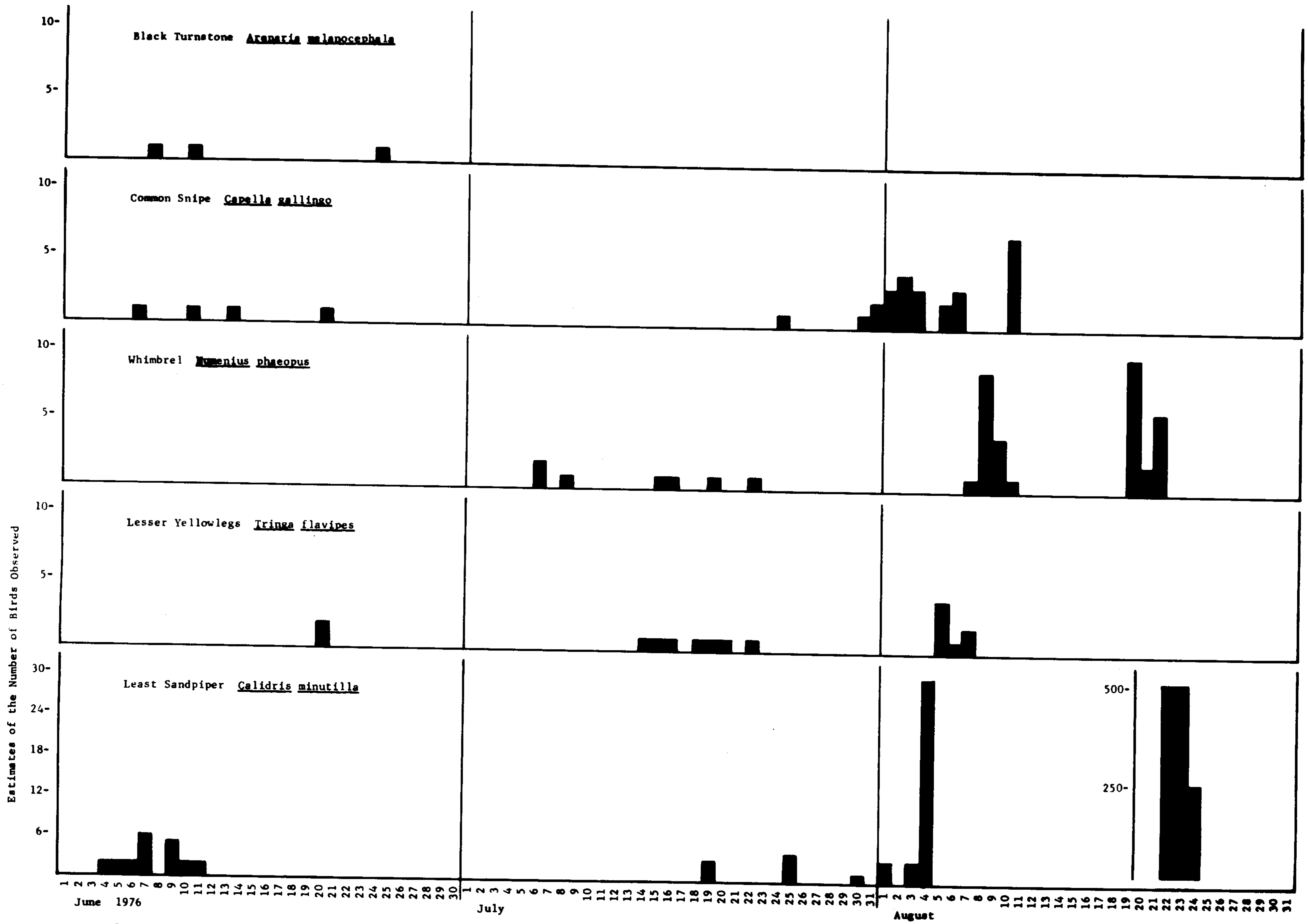
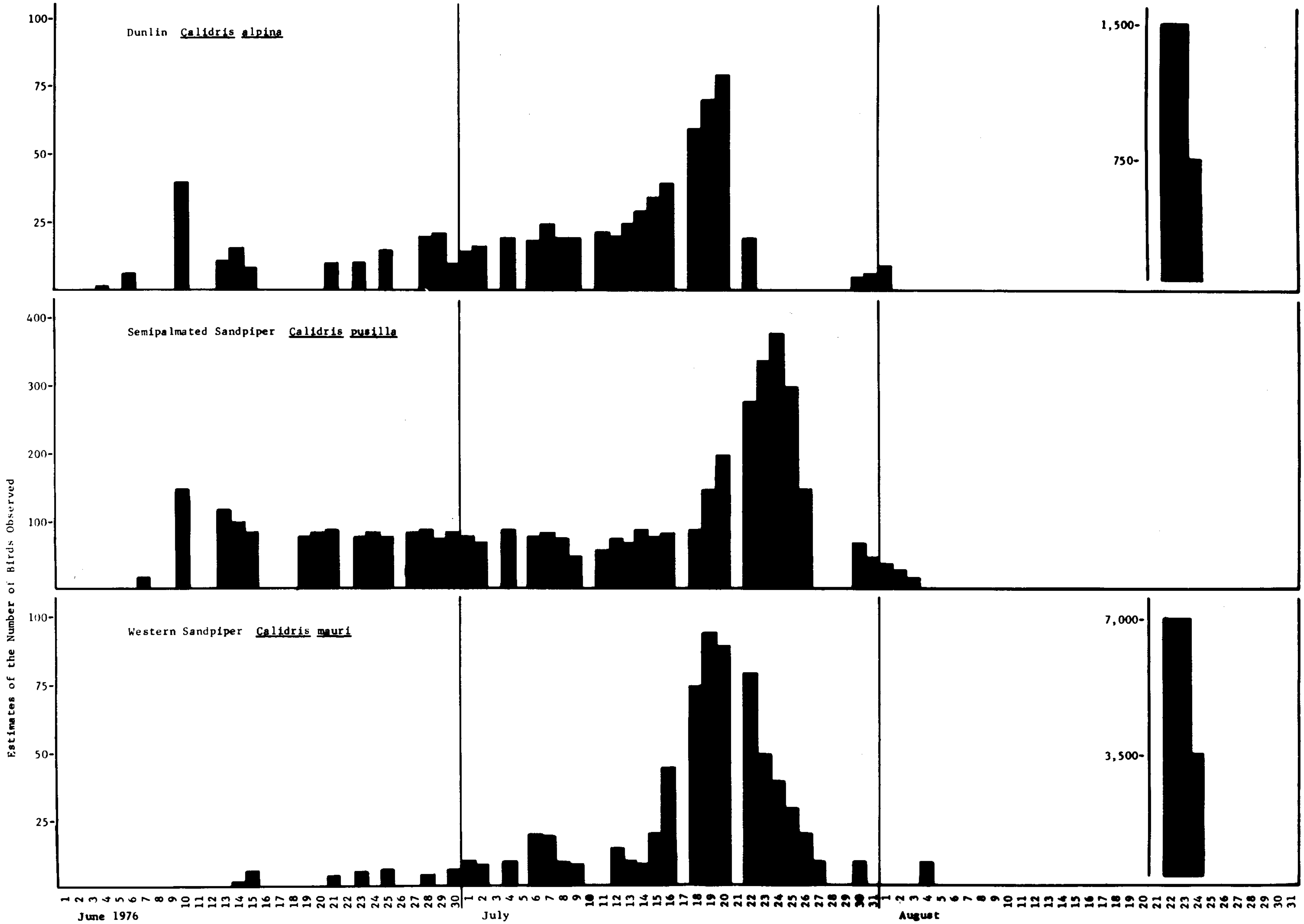

Black Turnstone Arenaria melanocephala
Common Snipe Capella gallinago
Whimbrel Numenius phaeopus
Lesser Yellowlegs Tringa flavipes
Least Sandpiper Calidris minutilla
Estimates of the Number of Birds Observed
10-
5-
30-
24-
18-
12-
6-
500-
250-
June 1976
July
August

Fig. 8



Dunlin Calidris alpina
Semipalmated Sandpiper Calidris pusilla
Western Sandpiper Calidris mauri
Estimates of the Number of Birds Observed
1,500
750
7,000
3,500
June 1976
July
August

Fig. 9

35. Semipalmated Sandpiper (Calidris pusilla)

This was the most abundant breeding bird on the delta. Hatching for local birds began on June 17 and continued until July 12. Daily chronological observations of birds moving through the study area indicate that local birds left the study area soon after fledging. We observed no intense migration of Semipalmated Sandpipers comparable to those of the Dunlin and Western Sandpiper.

36. Western Sandpiper (Calidris mauri)

This species was a common nester on the study area. Local migratory movement began on July 16 and continued until August 4. Thousands of non-resident migratory Western Sandpipers moved through the area during the period from August 22-24.

37. Long-billed Dowitcher (Limnodromus scolopaceus)

This species was observed only as a migrant in the fall on the delta. Flocks of 6-8 birds were seen regularly moving through the study site from July 28-August 6.

38. Bar-tailed Godwit (Limosa lapponica)

This species was seen as a common migrant on the delta in both spring and fall. Large flocks of up to one hundred birds were seen on the east bank of the Koyuk River and on the study area from June 7-13. On occasion bar-tailed Godwits flocked with Hudsonian Godwits. Small flocks of fall migrants (both adults and young) were seen on the delta in July and early August.

39. Hudsonian Godwit (Limosa heamastica)

This species was also seen as a common spring and fall migrant on the delta. We have no evidence that this species breed on the delta.

40. Red Phalarope (Phalaropus fulicarius)

A single adult was seen in a large flock of Northern Phalarope on the study area on June 29.

41. Northern Phalarope (Lobipes lobatus)

This species was an abundant breeder on the delta. Breeding pairs were observed when we arrived on the study area on June 10. Hatching began on June 29 and lasted only until July 2 when all phalarope nests on the study area were unoccupied. All nestlings of this species were banded within a week of hatching. Local migration began on July 25 and continued until August 2 afterwhich few phalaropes were seen on the delta. A wave of non-resident migrants passed through the delta from August 21 to August 24.

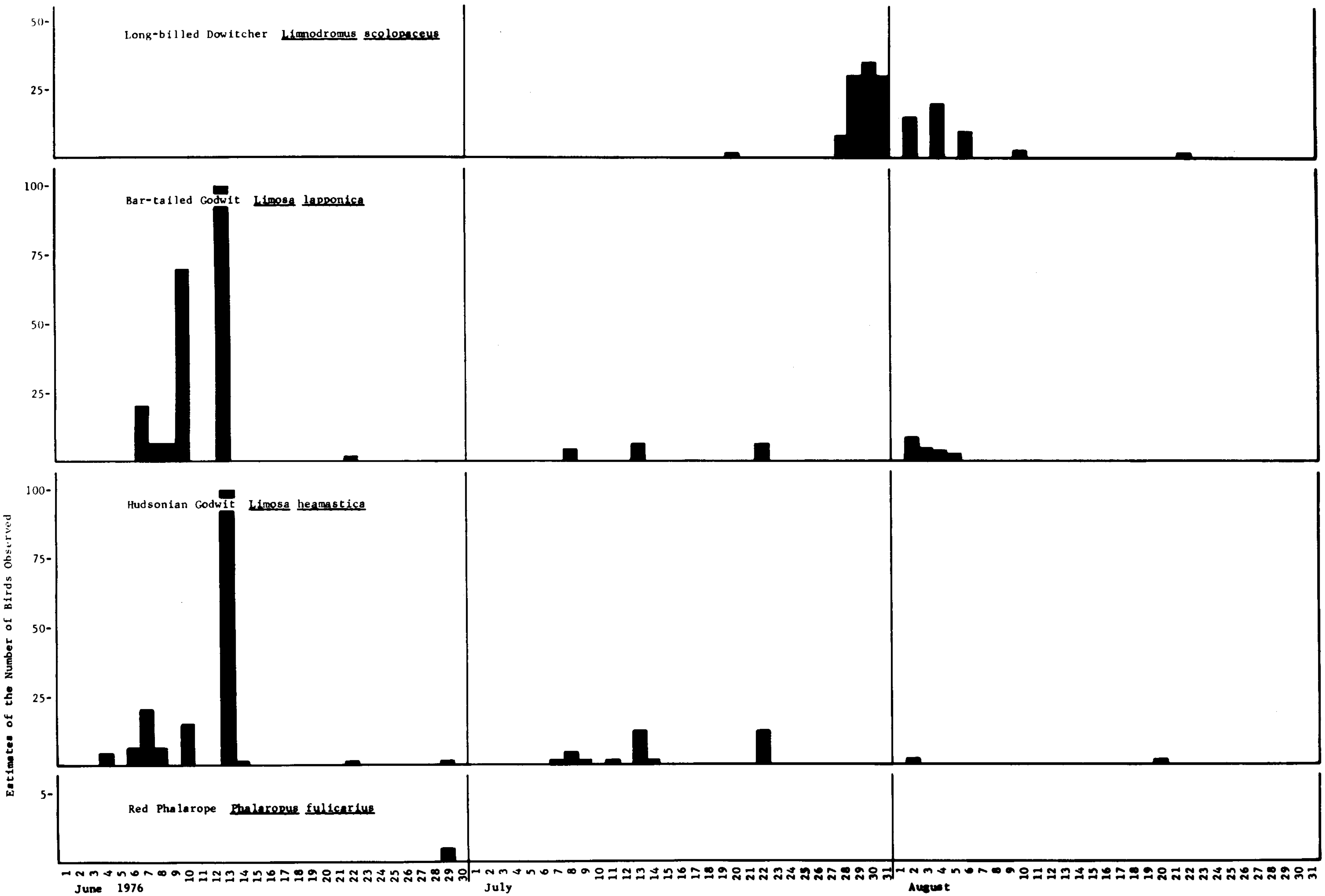

Long-billed Dowitcher Limnodromus scolopaceus
Bar-tailed Godwit Limosa lapponica
Hudsonian Godwit Limosa heamastica
Red Phalarope Phalaropus fulicarius
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 10

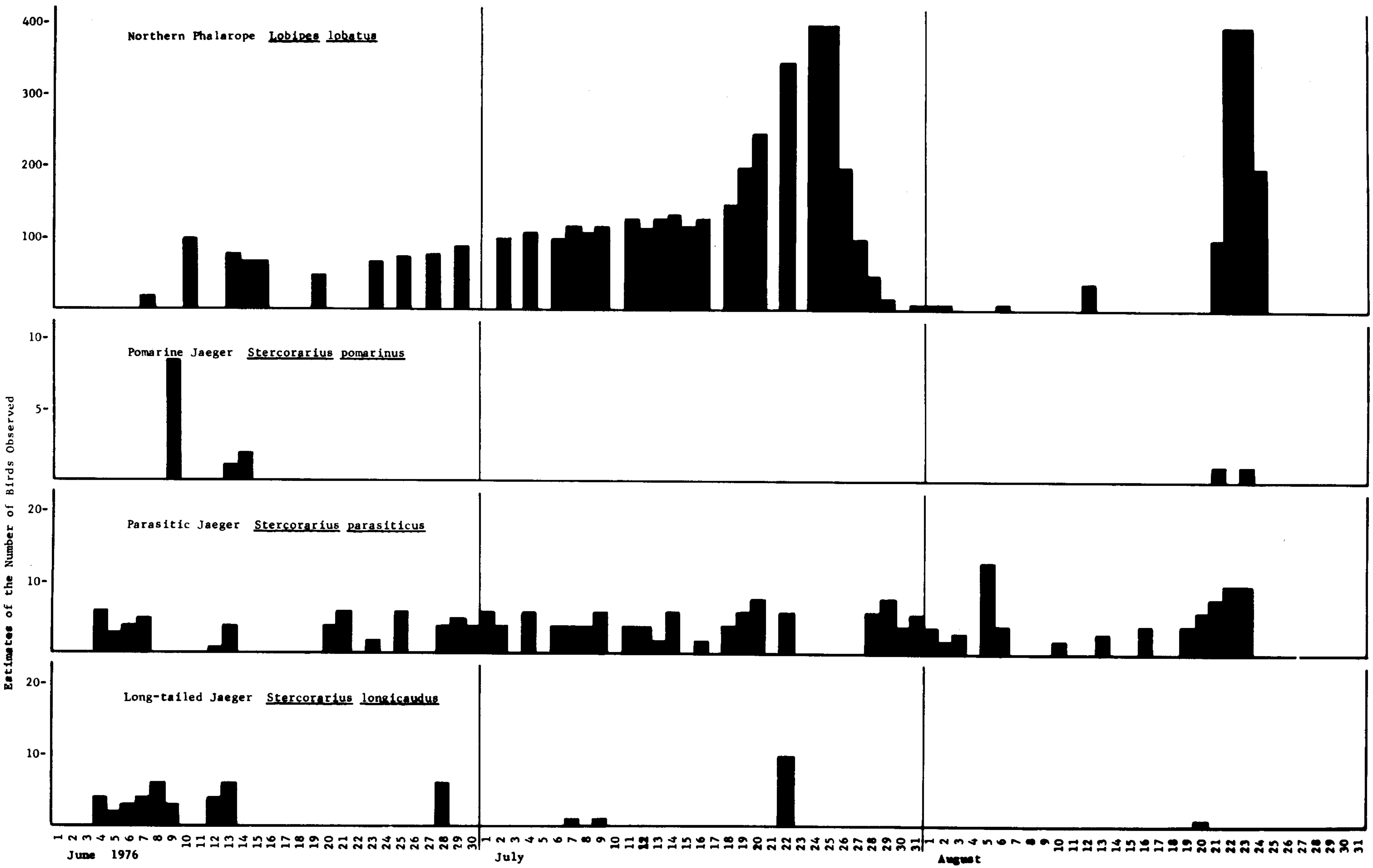

Northern Phalarope Lobipes lobatus
Pomarine Jaeger Stercorarius pomarinus
Parasitic Jaeger Stercorarius parasiticus
Long-tailed Jaeger Stercorarius longicaudus
Estimates of the Number of Birds Observed
400-
300-
200-
100-
10-
5-
20-
10-
20-
10-
June 1976
July
August

Fig. 11

42. Pomarine Jaeger (Stercorarius pomarinus)

This species was seen only as a spring and fall migrant on the study area. We have no evidence that this species breeds there.

43. Parasitic Jaeger (Stercorarius parasiticus)

This species was seen on the study area throughout the breeding season. We have evidence that a single pair raised one chick near the study area; we suspect that this species breeds in small numbers on the delta. We observed both single and individual birds hunting on the delta. On occasion light and dark phased morphs were paired. This species preyed heavily on eggs of loons and Arctic Terns. We also have evidence that Parasitic Jaegers hunting in pairs took both young and adult Semipalmated Sandpipers. Migration appeared to begin on or near August 5 when flocks of from 4-7 birds were seen flying south over the delta.

44. Long-tailed Jaeger (Stercorarius longicaudus)

Long-tailed Jaegers were seen hunting on the banks of the Koyuk River during the first week of June. On occasion birds were seen on the delta but we have no evidence that this species breed there. We have no evidence of fall migration.

45. Glaucous Gull (Larus hyperboreus)

This species was a common breeder on the delta. Pairs with eggs were observed on the study area when we arrived there on June 10. We have no evidence of fall migration as resident birds remained on the study area when we curtailed observations in late August.

46. Glaucous-winged Gull (Larus glaucenscens)

A single adult was seen on the study area on June 23.

47. Herring Gull (Larus argentatus)

Adults were seen only on the Koyuk River in early June. It appeared as if the birds were migrating inland in a northeasterly direction. We have no breeding evidence for this species on the delta.

48. Mew Gull (Larus canus)

Mew Gulls were common residents on the delta throughout the year. One chick was seen flying with an adult on August 2.

49. Bonaparte's Gull (Larus philadelphia)

Single individuals were seen on the study site from July 7-9. We have no evidence of breeding.

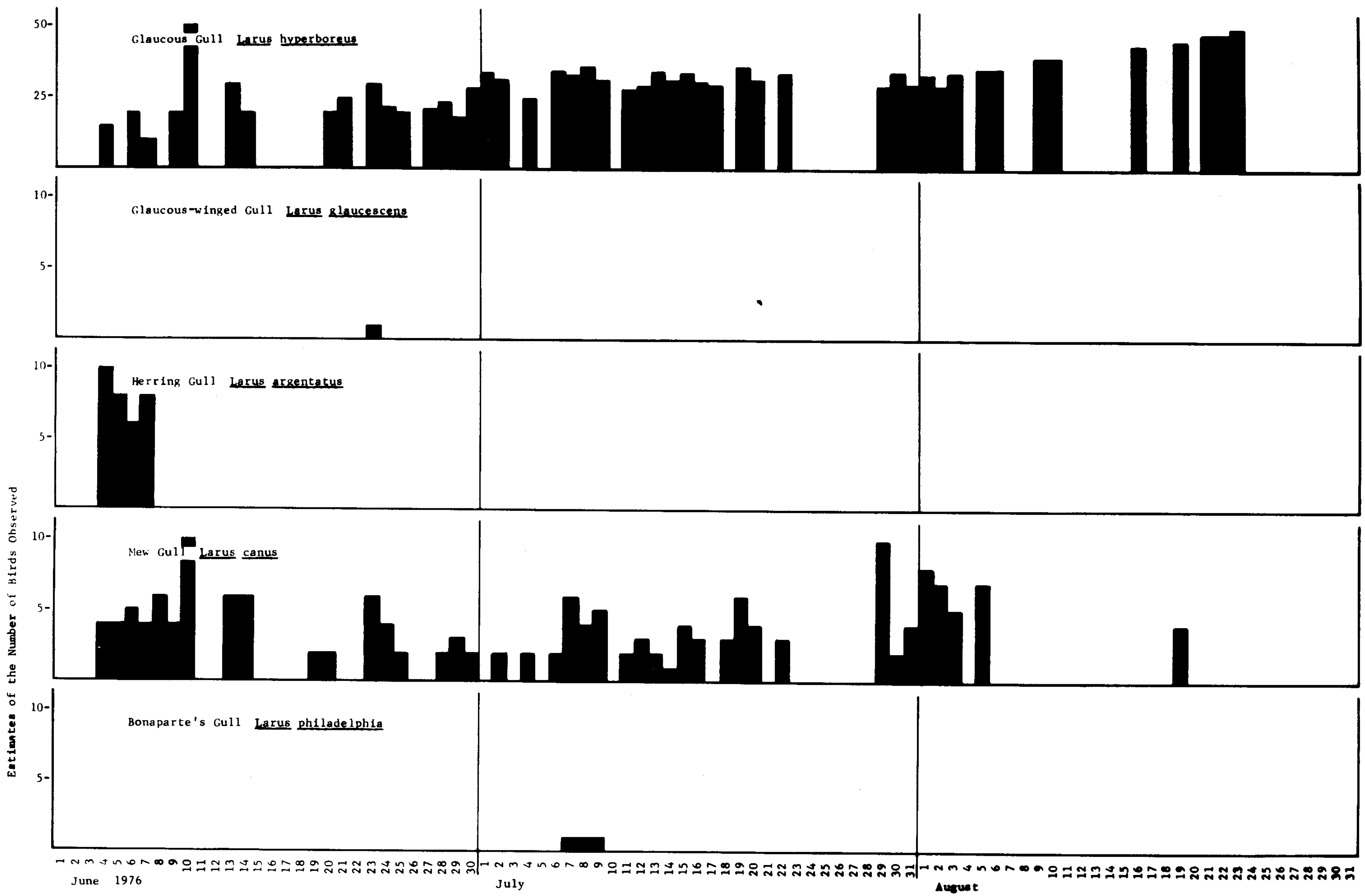

Glaucous Gull Larus hyperboreus
Glaucous-winged Gull Larus glaucescens
Herring Gull Larus argentatus
Mew Gull Larus canus
Bonaparte's Gull Larus philadelphia
Estimates of the Number of Birds Observed
50
25
10
5
June 1976
July
August

Fig. 12

50. Black-legged Kittiwake (Rissa tridactyla)

Individuals were seen in Koyuk and on the study site in June. We have no evidence of breeding or fall migration.

51. Sabine's Gull (Xema sabini)

This species was a common resident and uncommon breeder on the delta. A pair with two chicks was seen on the study site on July 22. We have no evidence of fall migration.

52. Arctic Tern (Sterna paradisaea)

This species is a common resident and breeder on the delta. The breeding success of this species was affected by our presence especially on the study area. We observed predation by Parasitic Jaegers on tern eggs as a result of our disturbance. Local birds were not seen on the study area after August 5.

53. Snowy Owl (Nyctea scandiaca)

A single adult was observed on the study area on July 18.

54. Short-eared Owl (Asio flammeus)

Individual birds were observed in the Koyuk area in early June. Individuals were occasionally observed on the study area in late July and August. We have no evidence that this species breeds on the delta but assume that it breeds in the dryer regions near Koyuk.

55. Belted Kingfisher (Megaceryle alcyon)

A pair was observed hunting in shallow pools of the Inglutalik River on August 19. We assume that they were breeders and had young.

56. Tree Swallow (Iridoprocne bicolor)

Large numbers of Tree Swallows were breeding at Koyuk. We saw only individual birds on the study area.

57. Bank Swallow (Riparia riparia)

Three Bank Swallow colonies were observed on the banks of the Inglutalik River. All were within the delta region and all were potentially subject to inundation at high tide. All were successful, however, and it is estimated that fifty young were fledged from each of these colonies.

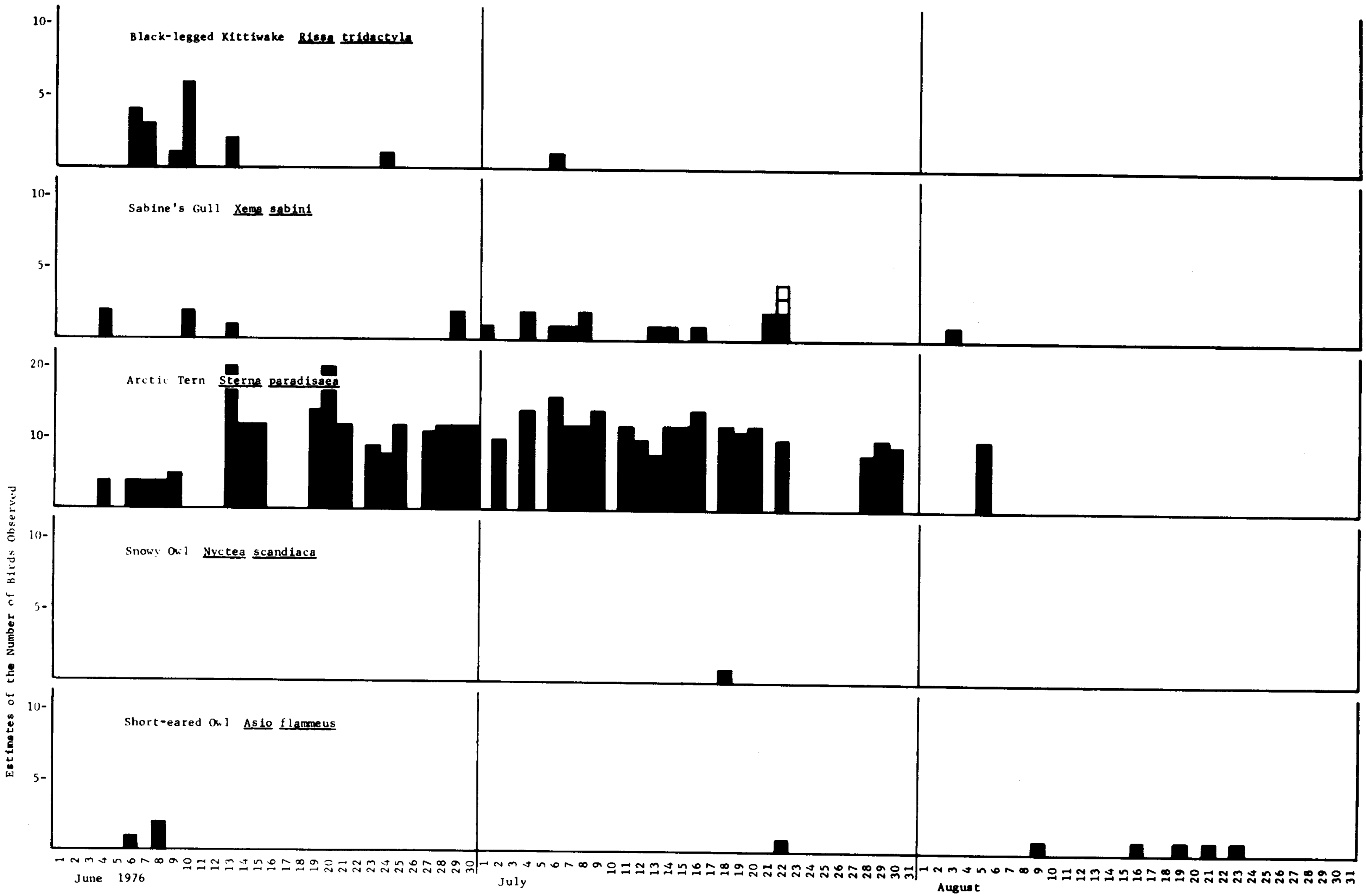

Black-legged Kittiwake *Rissa tridactyla*
Sabine's Gull *Xema sabini*
Arctic Tern *Sterna paradisaea*
Snowy Owl *Nyctea scandiaca*
Short-eared Owl *Asio flammeus*
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 13

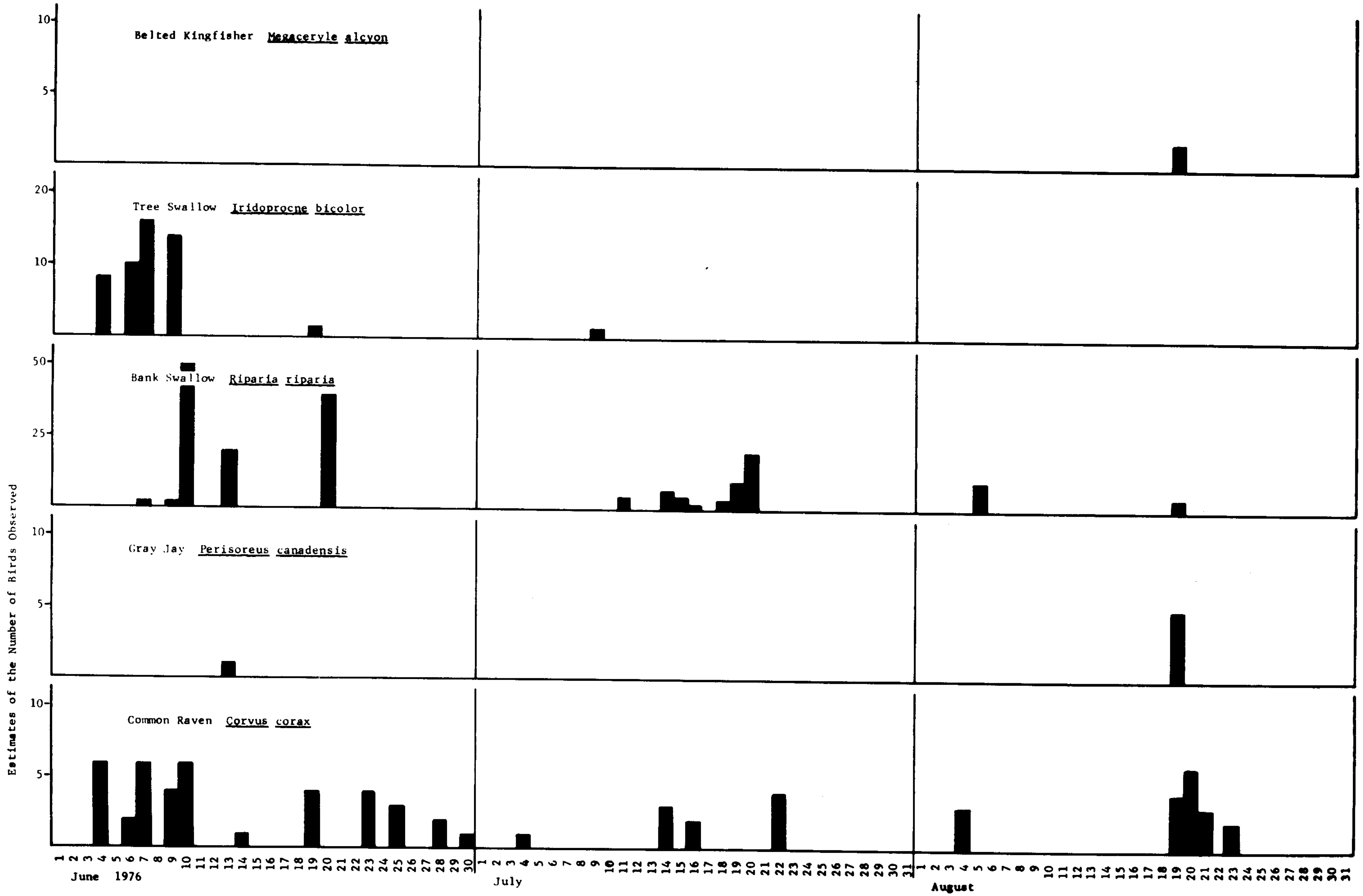

Belted Kingfisher Megaceryle alcyon
Tree Swallow Iridoprocne bicolor
Bank Swallow Riparia riparia
Gray Jay Perisoreus canadensis
Common Raven Corvus corax
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 14

58. Gray Jay (Perisoreus canadensis)

A single bird was observed on the study area on June 13. A small number of migrants was observed on August 19.

59. Common Raven (Corvus corax)

This species is common on the delta. Individual birds were seen throughout the summer and we assume that this species breeds in the Koyuk area.

60. American Robin (Turdus migratorius)

This species is a common breeder in the Koyuk area. We observed several individuals in the upper regions of the Inglutalik River on June 20 and assume that they are breeding there. We have no evidence that this species breeds on the delta.

61. Varied Thrush (Ixoreus naevius)

This species is a common breeder in the Koyuk area. We have no evidence that it breeds on the delta.

62. Gray-cheeked Thrush (Catharus minimus)

This species is a common breeder in the Koyuk area and in the upper regions of the Inglutalik River. Migrants were observed on the study area throughout late July and in August.

63. Wheatear (Oenanthe oenanthe)

A single individual was observed at Koyuk on June 9. A pair was seen in migration on the delta on August 21.

64. Ruby-crowned Kinglet (Regulus calendula)

Several individuals were observed at Koyuk in early June.

65. Yellow Wagtail (Motacilla flava)

This species is a common breeder in the willow, alder, dwarf birch ecotype which characterizes the higher regions near the mouth of the Inglutalik River. We observed three broods each of which fledged four young successfully. All were banded and released. Increases in mist-netted birds during August indicated a movement of non-resident birds into the area at that time.

66. Bohemian Waxwing (Bombycilla garrulus)

Several individuals were seen in the spruce foothills near Koyuk. We assume that they breed there.

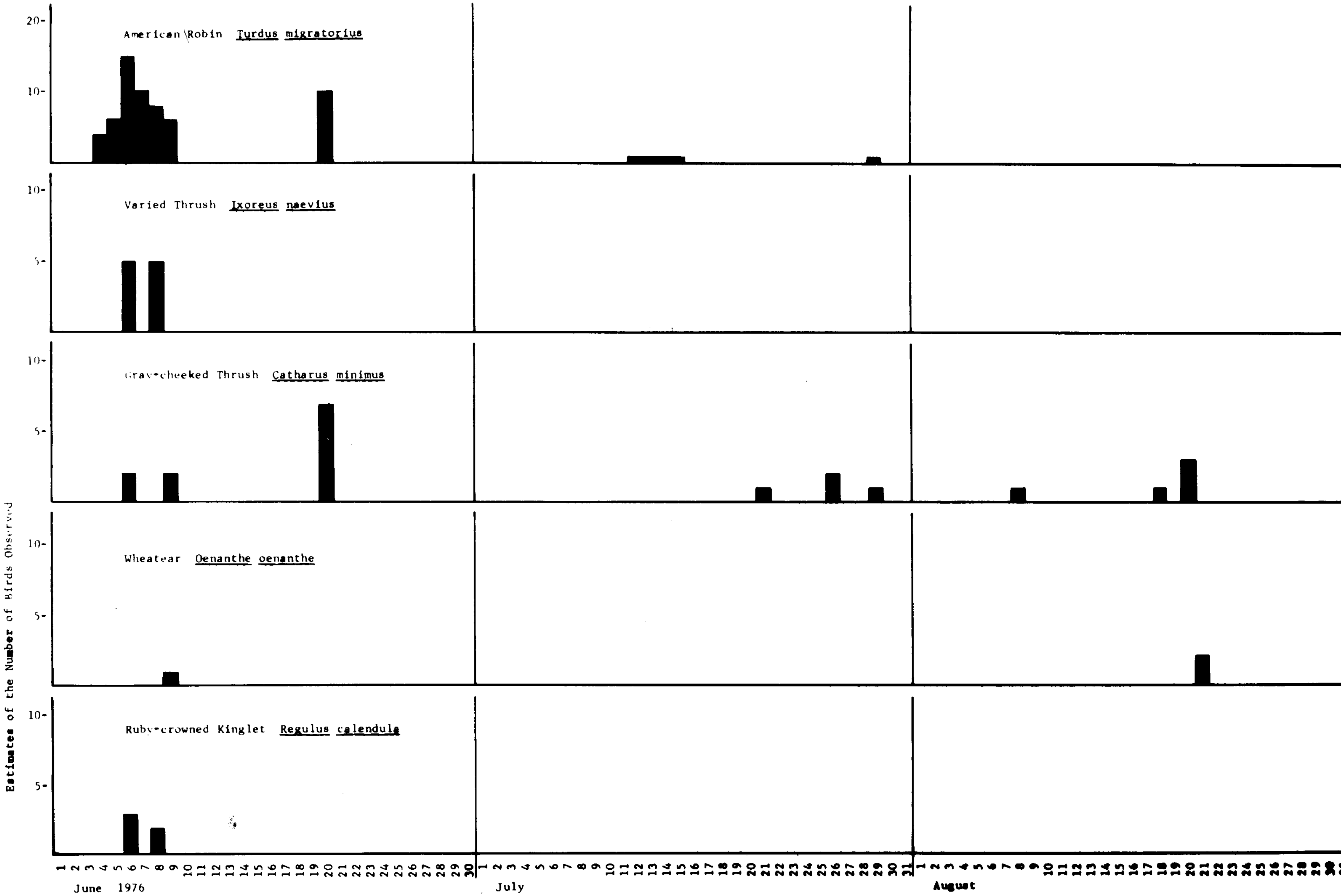

American Robin Turdus migratorius
Varied Thrush Ixoreus naevius
Gray-cheeked Thrush Catharus minimus
Wheatear Oenanthe oenanthe
Ruby-crowned Kinglet Regulus calendula
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 15

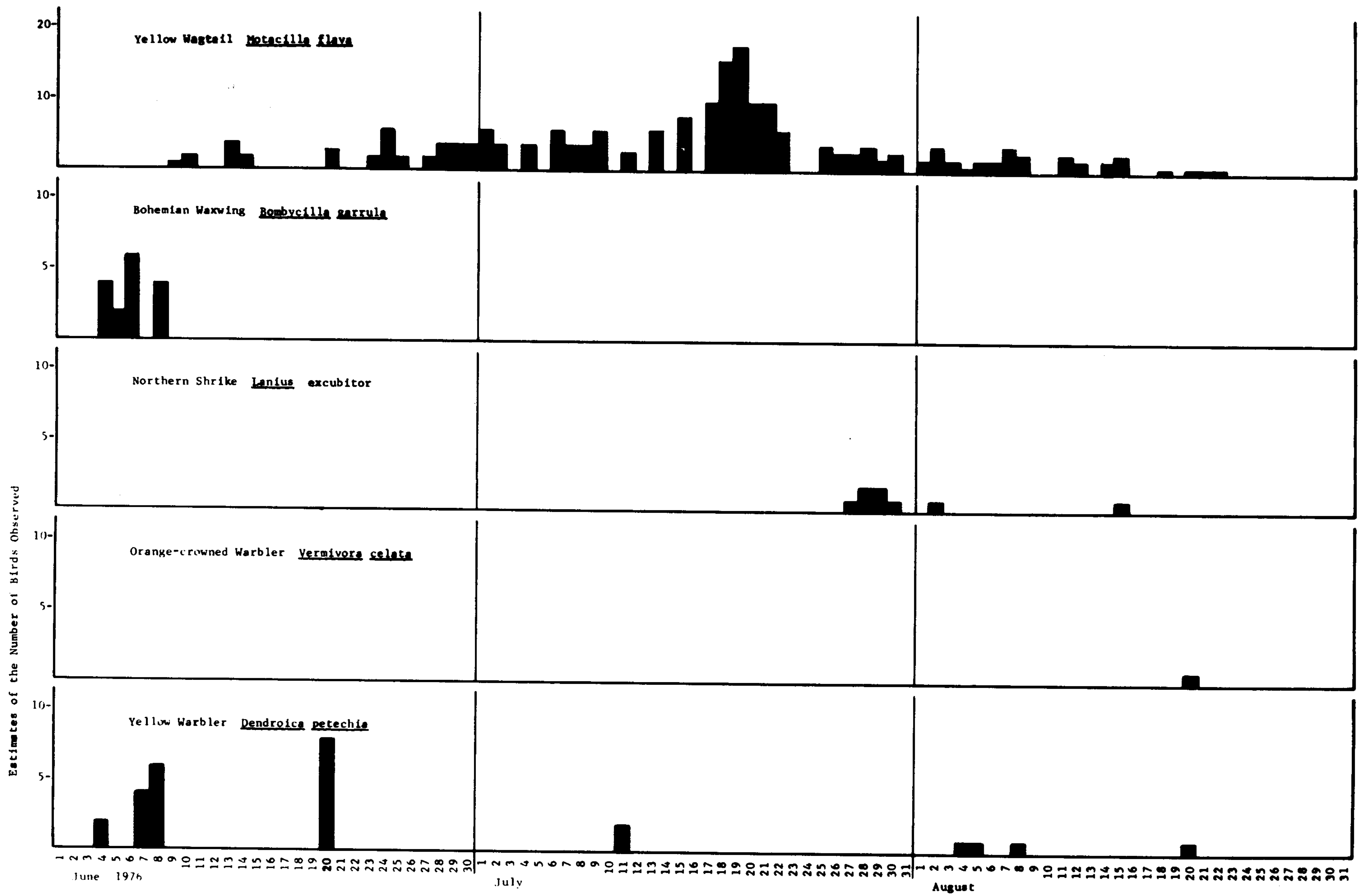

Yellow Wagtail Motacilla flava
Bohemian Waxwing Bombycilla garrula
Northern Shrike Lanius excubitor
Orange-crowned Warbler Vermivora celata
Yellow Warbler Dendroica petechia
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 16

67. Northern Shrike (_Lanius excubitor_)

Individuals were seen hunting on the study area from July 27-30. Activity of these birds, an adult and a juvenile, was restricted to the willow, alder, dwarf birch ecotype. We observed shrike predation on several nests of redpoll (_Carduelis_ sp.). We also observed shrike predation on a flying, banded juvenile Northern Phalarope. We assume that these shrikes breed near Koyuk.

68. Orange-crowned Warbler (_Vermivora celata_)

This species was observed only as a fall migrant on the study area.

69. Yellow Warbler (_Dendroica petechia_)

This species, a common breeder in the Koyuk area, was seen only as a migrant on the study area.

70. Blackpoll Warbler (_Dendroica striata_)

This species is an uncommon breeder at Koyuk.

71. Northern Waterthrush (_Seiurus noveboracensis_)

This species is an uncommon breeder at Koyuk. A single migrant was observed on the study area.

72. Wilson's Warbler (_Wilsonia pusilla_)

This species is a common breeder at Koyuk. It was observed only as an August migrant on the delta.

73. Rusty Blackbird (_Euphagus carolinus_)

This species is an uncommon breeder at Koyuk and in the upper regions of the Ingluatlik River. It was observed only as a migrant on the study area.

74. Pine Grosbeak (_Pinicola enucleator_)

Several individuals were observed at Koyuk in early June. We assume that they breed there.

75. Common Redpoll (_Carduelis flammea_) and 76. Hoary Redpoll (_C. hornemanni_)

These taxa are common breeders in both Koyuk and the willow, alder, dwarf birch ecotype on the delta. Observations of mist-netted, banded birds indicate that the breeding population remained in the area at least until our departure on August 24. Also, there was significant movement of non-resident birds into this area in August.

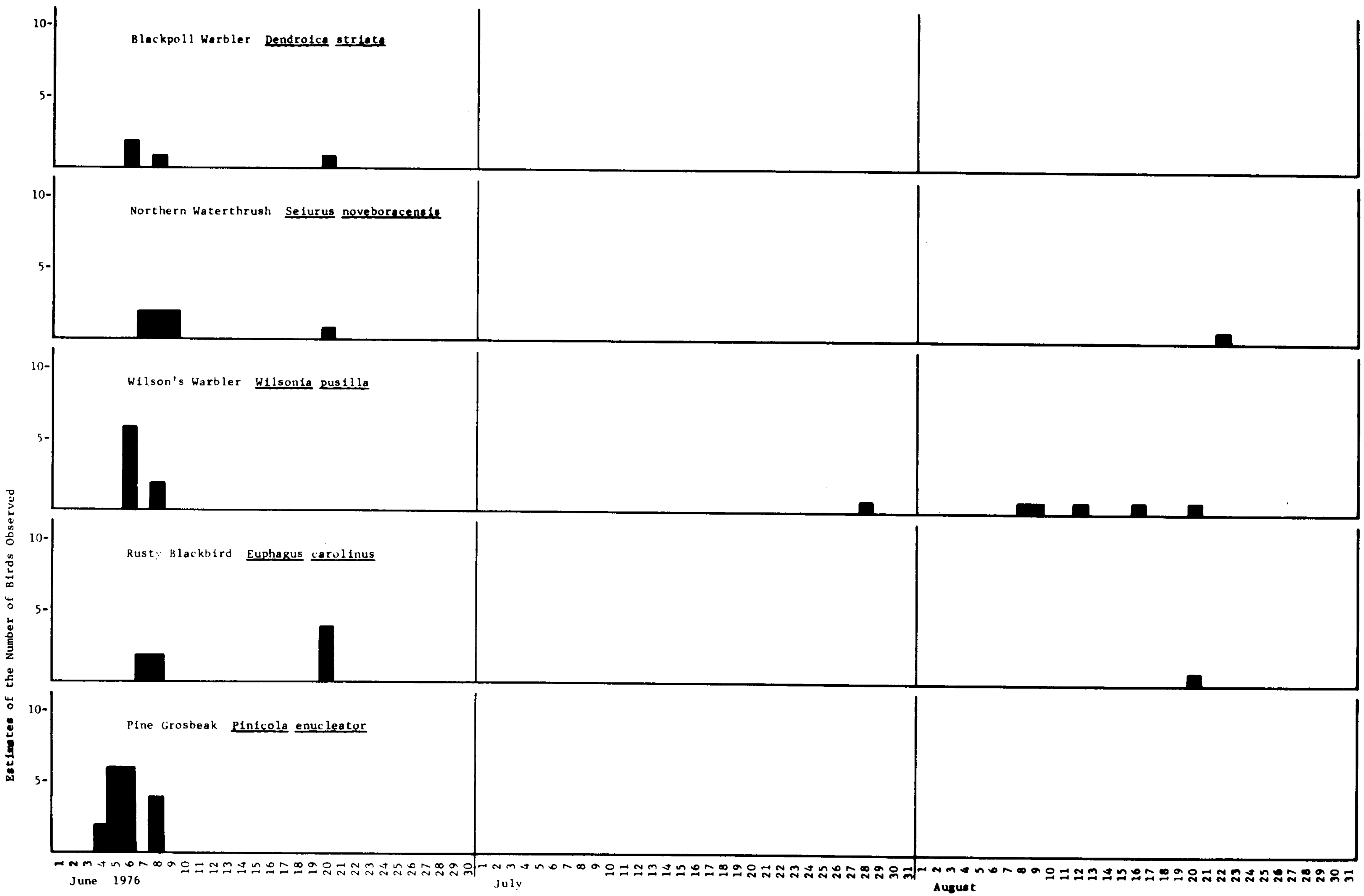

Blackpoll Warbler Dendroica striata
Northern Waterthrush Seiurus noveboracensis
Wilson's Warbler Wilsonia pusilla
Rusty Blackbird Euphagus carolinus
Pine Grosbeak Pinicola enucleator
Estimates of the Number of Birds Observed
10
5
June 1976
July
August

Fig. 17

77. White-winged Crossbill (Loxia leucoptera)

Several individuals were observed on June 6 at Koyuk. We assume that they breed there.

78. Savannah Sparrow (Passerculus sandwichensis)

This species was a very common breeder on the delta. Breeding pairs with eggs occurred on the study site when we arrived there on June 10. Hatching peaked on June 21 and we observed a heavy movement of delta breeding birds into our study area throughout late July and August. Observations on banded birds recaptured in mist-nets indicate that local birds remain in the area at least until August. We observed no heavy migration of Savannah Sparrows.

79. Dark-eyed Junco (Junco hyemalis)

Several singing males were observed in Koyuk on June 6. Migrants were netted on the study area on July 29 and August 20.

80. Tree Sparrow (Spizella arborea)

This species is an uncommon local breeder in the willow, alder, dwarf birch ecotype on the delta.

81. White-crowned Sparrow (Zonotrichia leucophrys)

This species is an uncommon breeder in the willow, alder, dwarf birch ecotype on the delta.

82. Fox Sparrow (Passerella iliaca)

This species does not breed on the delta. Several adults were seen in Koyuk and in the upper regions of the Inglutalik River. Migrants were observed during August on the delta with a peak on August 20.

83. Lapland Longspur (Calcarius lapponicus)

This species is a very common nester on the delta. Breeding pairs with eggs were observed on the study site when we arrived there on June 10. Large flocks of up to 100 birds were observed on the study site in late August.

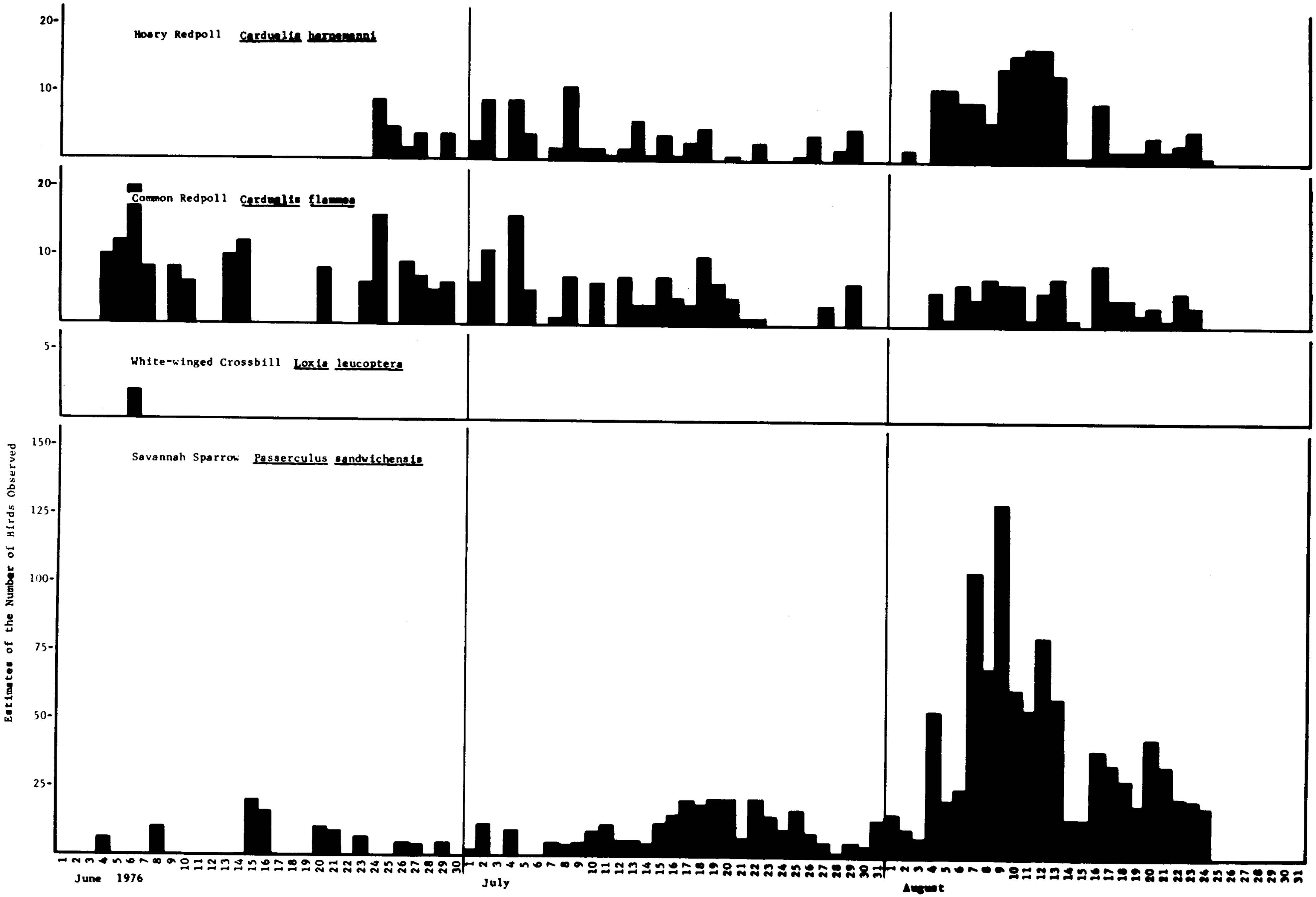

Hoary Redpoll Carduelis hornemanni
Common Redpoll Carduelis flammea
White-winged Crossbill Loxia leucoptera
Savannah Sparrow Passerculus sandwichensis
Estimates of the Number of Birds Observed
June 1976
July
August

Fig. 18

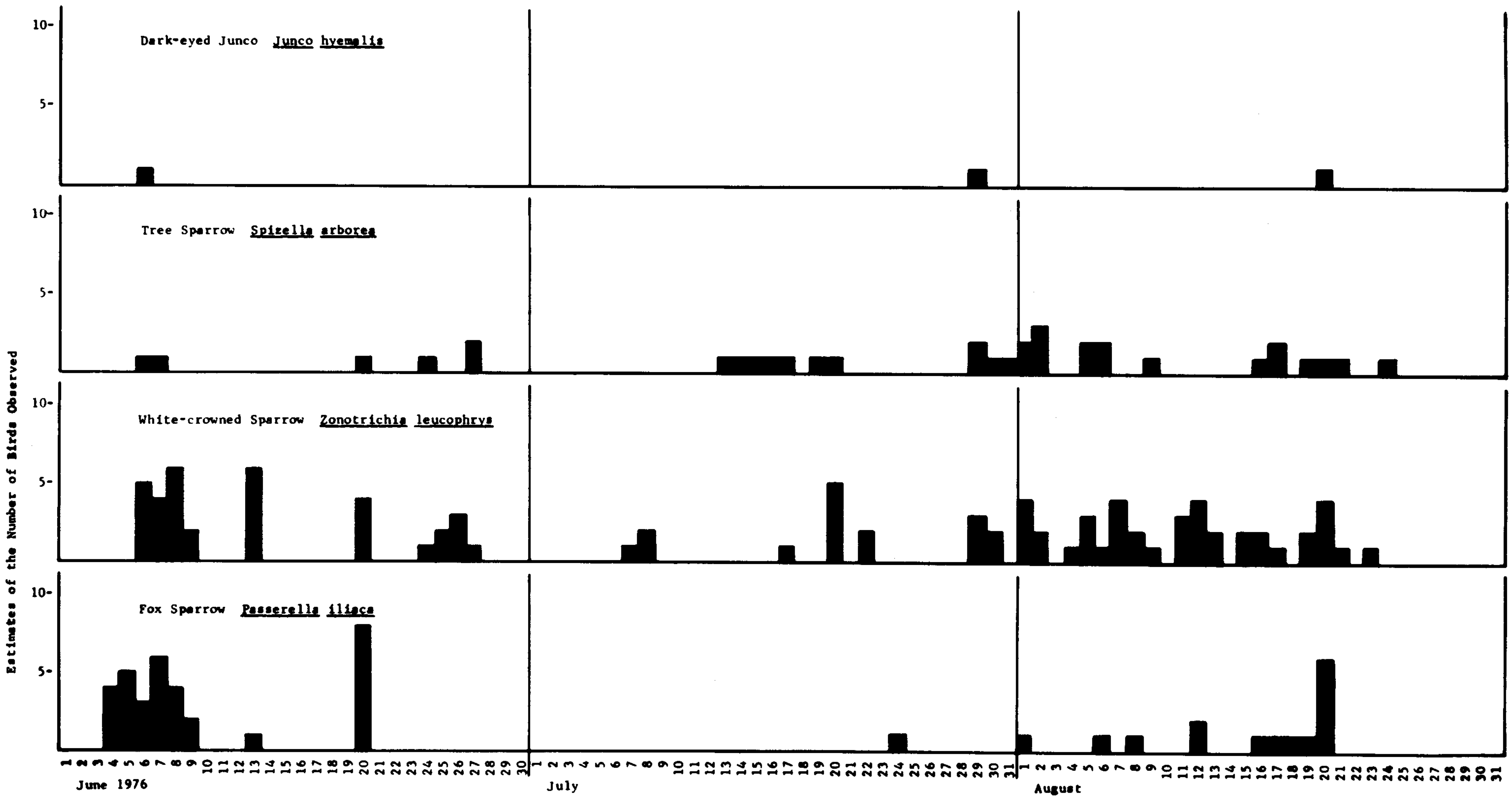

Estimates of the Number of Birds Observed
10
5
Dark-eyed Junco Junco hyemalis
Tree Sparrow Spizella arborea
White-crowned Sparrow Zonotrichia leucophrys
Fox Sparrow Passerella iliaca
June 1976
July
August

Fig. 19

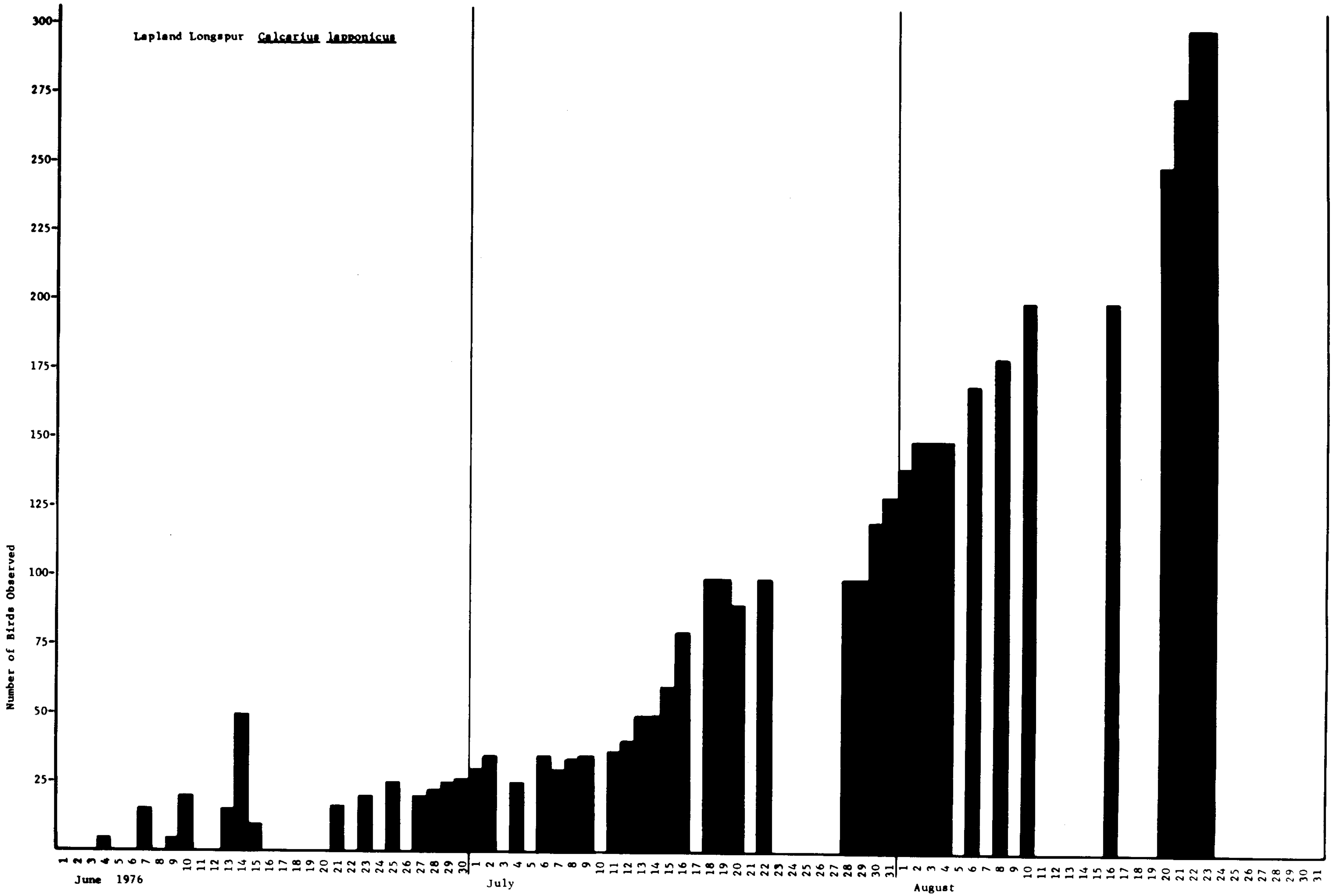

Lapland Longspur *Calcarius lapponicus*
Number of Birds Observed
300
275
250
225
200
175
150
125
100
75
50
25
June 1976
July
August

Fig. 20

Nesting Densities

All estimates of nesting density are preliminary and more accurate determinations must await more detailed ecotypic analyses of vegetation types on the delta. In addition, all estimates are based on a single sample taken from the intensively studied area for a single breeding season. We report these values only as a summation of species nesting densities for 1976 and emphasize the fact that they may vary greatly when compared with an additional years data. Table 2 summarizes nesting densities for the most common breeding birds on the delta. Values are expressed in numbers of nests per km^2 for most species. Others are expressed in numbers of nests for the entire delta which is estimated to be 18 km^2.

Nesting densities determined in Table 2 are extrapolated for the entire delta in Table 3 as potential productivity in terms of eggs per species. Again, these values are only estimates for a single sample area extrapolated over the entire delta. They are subject to revision to the same degree as are the original data.

Hatching Data

Mean hatching dates and ranges for each species are shown in Table 4. These estimates are based on the average of dates for each species. Data for precocial species are means of dates when hatching occurred. Dates for altricial species are based on means of dates when the last egg of the clutch hatched. Percent hatching success and percent fledging success are shown in Table 5. Values for hatching success were empirically determined while those for fledging success are largely a combination of empirical observation and inference based on observed predation and death of nestlings. It may be appropriate to base productivity values on percent fledging success but our data are too fragmentary at this time.

Banding Data

A total of 2,042 birds comprising 31 species was banded on the study site between June 10 and August 24 of 1976. Table 6 summarizes these data. Banding data were submitted to the U.S. Fish and Wildlife Service, Bird Banding Laboratory, Laurel, Maryland in September of 1976. These data can be used to determine territorial fidelity for the coming year. But equally as important is the fact that dates of residence and migration for specific birds can be determined by the recovery of banded birds. A large portion of the data on migration (see phenology section) is based on observations of banded birds. In addition, migratory routes of banded recoveries can be determined. To date we have received data on a single recovery, a Semipalmated Sandpiper, collected at Hartney Bay, Cordova, Alaska by Mr. Stan Senner 10 days after it was banded on the study area on July 30th.

Table 2. Nesting Densities of Tundra Breeding Birds, Inglutalik River, Norton Bay, Alaska.

Common Name	Scientific Name	Nesting Density
Arctic Loon	*Gavia arctica*	4/km^2
Red-throated Loon	*Gavia stellata*	2/km^2
Whistling Swan	*Olor columbianus*	1/18 km^2
Mallard	*Anas platyrhynchos*	1/18 km^2
Pintail	*Anas acuta*	2/18 km^2
Oldsquaw	*Clangula hyemalis*	1/18 km^2
Common Eider	*Somateria mollissima*	2/18 km^2
Red-breasted Merganser	*Mergus serrator*	2/18 km^2
Marsh Hawk	*Circus cyaneus*	1/18 km^2
Sandhill Crane	*Grus canadensis*	2/km^2
Semipalmated Sandpiper	*Calidris pusilla*	85/km^2
Western Sandpiper	*Calidris mauri*	20/km^2
Dunlin	*Calidris alpina*	20/km^2
Northern Phalarope	*Lobipes lobatus*	35/km^2
Parasitic Jaeger	*Stercorarius parasiticus*	1/18 km^2
Glaucous Gull	*Larus hyperboreus*	1/km^2
Sabine's Gull	*Xema sabini*	1/18 km^2
Arctic Tern	*Sterna paradisaea*	10/km^2
Savannah Sparrow	*Passerculus sandwichensis*	30/km^2
Lapland Longspur	*Calcarius lapponicus*	20/km^2

Table 3. Potential productivity expressed as the number of eggs laid per species extrapolated for the entire delta.

Species	Potential Productivity (km^2)	Potential Productivity (Delta)
Arctic Loon	8	144
Red-throated Loon	4	72
Sandhill Crane	4	72
Semipalmated Sandpiper	285	5130
Western Sandpiper	75	1350
Dunlin	75	1350
Northern Phalarope	135	2426
Glaucous Gull	3	54
Arctic Tern	20	360
Savannah Sparrow	141	2538
Lapland Longspur	85	1530

Table 4. Hatching dates for the most abundant species on the delta.

Species	Nests	Mean	Range
Arctic Loon	4	July 10	June 30 - July 16
Red-throated Loon	2	July 3	June 30 - July 5
Sandhill Crane	4	June 13	June 11 - June 14
Semipalmated Sandpiper	17	June 28	June 17 - July 12
Western Sandpiper	4	July 1	July 1 - July 2
Dunlin	4	July 15	July 12 - July 19
Northern Phalarope	7	July 2	July 1 - July 2
Glaucous Gull	7	June 13	June 11 - June 17
Arctic Tern	4	June 18	June 17 - July 20
Savannah Sparrow	6	June 21	June 18 - June 28
Lapland Longspur	4	June 22	June 13 - June 25

Table 5. Hatching and fledging success for the most abundant species on the delta.

Species	Average Clutch Size	Percent Hatching Success	Percent Fledging Success
Arctic Loon	2	20	20
Red-throated Loon	2	25	25
Sandhill Crane	2	50	25
Semipalmated Sandpiper	3.35	87.7	78.9
Western Sandpiper	3.75	46.7	46.7
Dunlin	3.75	46.7	46.7
Northern Phalarope	3.85	95.1	70.0
Glaucous Gull	3	100.0	100.0
Arctic Tern	2	62.5	12.5
Savannah Sparrow	4.70	78.6	64.3
Lapland Longspur	4.25	70.5	70.5

Table 6. Birds Banded on the Akulik-Inglutalik River Delta Summer, 1976

Common Name	Scientific Name	AOU No.	No. Banded
Red-throated Loon	Gavia stellata	11	1
Whistling Swan	Olor columbianus	180	1
Common Eider	Somateria molliasima	161	1
Merlin	Falco columbarius	357	1
Common Snipe	Capella gallinago	230	3
Long-billed Dowitcher	Limnodromus scolopaceus	232	12
Least Sandpiper	Calidris minutilla	242	17
Dunlin	Calidris alpina	243	13
Semipalmated Sandpiper	Calidris pusillus	246	116
Western Sandpiper	Calidris mauri	247	82
Northern Phalarope	Lobipus lobatus	223	56
Glaucous Gull	Larus hyperboreus	42	7
Arctic Tern	Sterna Paradisaea	71	4
Tree Swallow	Iridoprocne bicolor	614	1
Bank Swallow	Riparia riparia	616	1
American robin	Turdus migratorius	761	4
Gray-cheeked Thrush	Catharus minima	757	8
Yellow Wagtail	Montacilla flava	696	28
Northern Shrike	Lanius excubitor	621	1
Orange-crowned Warbler	Vermivora celata	646	1
Yellow Warbler	Dendroica petechia	652	8

Common Name	Scientific Name	AOU No.	No. Banded
Northern Waterthrush	Seiurus noveboracensis	675	1
Wilson's Warbler	Wilsonia pusilla	685	4
Hoary Redpoll	Carduelis hornemanni	527	169
Common Redpoll	Carduelis flammea	528	187
Savannah Sparrow	Passerculus sandwichensis	542	1,134
Dark-eyed Junco	Junco hyemalis	567	2
Tree Sparrow	Spizella arborea	585	13
White-crowned Sparrow	Zonotrichia leucophrys	554	42
Fox Sparrow	Passerella iliaca	585	13
Lapland Longspur	Calcarius lapponicus	536	108
	Total number of birds banded		2,042
	Number of species banded		31

Observation of mammals

Small mammals

Small mammal snap-traps were run at weekly intervals throughout the summer in both the wet tundra and willow, alder, dwarf birch ecotypes. Traps were baited with peanut butter and placed in appropriate regions. Traps were run in both areas for 133 trap days (one trap day equals one trap set for 24 hours). No small mammals were trapped in the wet tundra area. A total of 24 Redback Tundra Voles, *Clethrionomys rutilus*, was captured in the willow, alder, dwarf birch ecotype during this time period. Of these, six were recaptures. We observed no predation on this population by birds or other mammals.

On occasion, a single Arctic Ground Squirrel, *Citellus undulatus*, was observed in the willow, alder, dwarf birch ecotype. We made no effort to trap and mark this individual.

The entire area between the mouths of the Akulik and Inglutalik Rivers was searched for Red Fox, *Vulpes fulva*, and dens. Three active dens were observed on the delta and all were located on slightly raised sandy regions of the wet tundra ecotype. We observed two kits at one den but were unable to determine if the remaining dens supported young. Adult Red Fox actively hunted on the study area particularly during the evening hours. We have direct observations that Red Fox successfully preyed on the eggs of: Sandhill Crane, Arctic and Red-throated Loons, Pintail, and Oldsquaw. In addition, we observed adult Red Foxes preying on nestlings of Savannah Sparrows and young Arctic Terns. A Red Fox vixen occasionally used the upland willow, alder, dwarf birch mound near the study area to bury captured prey. No other small mammals were observed on the study area.

Large mammals

A single adult Grizzly Bear, *Ursus horribilis*, crossed the study area on the night of July 10. The bear entered the study area from the east, walked along the bank of the Inglutalik River, and left the area as it continued in a northerly direction. A single cow moose, *Alces alces*, entered the study area during the morning of July 28. It entered from the north, swam the mouth of the Inglutalik River and continued running along the coastline of Norton Bay in a southerly direction. A herd of Reindeer, *Rangifer tarandus*, estimated at 665 animals, is tended by Mr. Archie Henry of Koyuk in an area near Corral Creek on the south bank of the Koyuk River. We have no evidence that this herd was allowed to graze on the Akulik-Inglutalik River delta during 1976. Reindeer tracks estimated to be at least a year old, however, were observed on the study area.

Floral Identification and Species Listing

Plants were collected during late July and August in an effort to preliminarily describe various habitat types. Mature plants were uprooted, preliminarily identified in the field, assigned to habitat type, and preserved as pressed specimens. These were later identified in consultation with staff of the herbarium of the University of Alaska and the preserved specimens reside there. No attempt is made here to describe phenology of the flora since our data are largely incomplete. Detailed phenological accounts will be completed at the end of the coming field season. An incomplete listing of all plants collected on the delta is given in Table 7. At the present time U-2 color infrared aerial photographs of the Akulik-Inglutalik River delta provided by the Geophysical Institute of the University of Alaska are being used to aid in the description of vegetation types and extrapolation over the entire delta. Plants are here assigned either to a wet tundra meadow ecotype (WTM) or an upland tundra ecotype (UPT) (Viereck and Little, 1972; Hulten, 1968; Hopkins and Sigafoos, 1950).

Weather Data

A temporary weather station was constructed on the study site. Daily observations were made of the following parameters: temperature (max. - min.), relative humidity, cloud cover, wind (direction, and speed), and the amount of precipitation. These data have been submitted to the National Weather Service, Fairbanks as a permanent record of conditions at the study site and eastern Norton Bay. Figure 21 shows maximum and minimum temperatures recorded at the study site.

Interpretation of Results

All results submitted here must be considered preliminary. Nesting data are based essentially on observations taken within a restricted area and extrapolation of such data over the entire delta must be done with extreme caution. Most common nestors on the delta have specific ecotypic preferences and our data for these and vegetative analysis of the delta are incomplete. Several species on the delta are colonial and unequal distributions over this large area are difficult to quantify.

Data on fledging success are difficult to quantify. In many cases, birds banded as nestlings remained in our area for only brief periods and unless we observed predation on them or their death on the study area they were considered successful. We feel reasonably assurred that our species phenological accounts are reasonably accurate and that they indicate general utilization of the delta by migratory and breeding birds.

Table 7. Plant Species Collected at the Akulik-Inglutalik Study Area (1976).

Taxa	Ecotype
Potamogetonaceae	
Potamogeton filiformis (Pondweed)	WTM
Juncaginaceae	
Triglochin maritimum (Arrow Grass)	WTM
T. palustris (Arrow Grass)	WTM
Gramineae	
Calamagrostis canadensis (Reed Bent Grass)	WTM
Deschampsia caespitosa (Reed Grass)	WTM
Puccinellia phryganodes (Alkali Grass)	WTM
Elymus mollis (Lyme Grass)	WTM
Cyperaceae	
Eriophorum vaginatum (Hare's-tail Grass)	UPT-WTM
Carex mackenziei (Sedge)	WTM
C. ramenskii (Sedge)	WTM
C. lyngbyaei (Sedge)	WTM
C. aquatilis (Sedge)	WTM
Liliaceae	
Allium schoenoprasum (Wild Chive)	WTM
Iridaceae	
Iris setosa (Wild Flag)	WTM

Salicaceae

Salix arctica (Arctic Willow)	UPT
S. pulchra (Arctic Willow)	UPT

Betulaceae

Betula nana (Dwarf Birch)	UPT
Alnus crispa (Mountain Alder)	UPT

Polygonaceae

Polygonum viviparum (Buckwheat)	WTM
Rumex arcticus (Sorrel)	WTM

Chenopodiaceae

Atriplex gmelini (Goosefoot)	WTM

Caryophllaceae

Stellaria humifusa (Chickweed)	WTM
Moehringia lateriflora (Grove Sandwart)	WTM

Ranunculaceae

Aconitum delphinifolium (Monkshood)	WTM
Anemone richardsonii (Buttercup)	WTM
Ranunculus lapponicus (Crowfoot)	WTM
R. hyperboreus (Crowfoot)	WTM

Cruciferae

Cochlearia offincinalis (Scurvy Grass)	WTM
Barbarea orthoceras (Winter Cress)	WTM
Rorippa hispida (Yellow Cress)	WTM
Cardamine pratensis (Cuckoo Flower)	WTM
Descurainia sophioides (Tansy Mustard)	WTM

Crassulaceae

Sedum rosea (Roseroot)	UPT

Saxifragaceae

Parnassia palustris (Bog Star)	WTM

Rosaceae

Spiraea stevenii (Alaska Spiraea)	WTM
Rubus chamaemorus (Cloudberry)	WTM
R. arcticus (Cloudberry)	WTM
Potentilla egedii (Silverweed)	WTM

Leguminosae

Hedysarum hedysaroides

H. alpinum

Onagraceae

Epilobium angutifolium (Fireweed)	WTM

Haloragaceae

Hippuris tetraphylla (Mare's Tail)	WTM
Myriophyllum spicatum (Water Milfoil)	WTM

Umbelliferae

Ligusticum scoticum (Beach Lovage)	WTM
Angelica lucida (Parsley)	WTM

Cornaceae

Cornus suecica (Swedish Dwarf Cornel)	WTM
Empetrum nigrum (Crowberry)	WTM-UPT

Ericaceae

Ledum palustre (Labrador Tea) WTM

Vaccinium vitis-idaea (Lingonberry) UPT

V. uliginosum (Alpine Blueberry) UPT

Primulaceae

Androsace chamaejasme (Primrose) WTM

Trientalis europaea (Starflower) WTM

Polemoniaceae

Polemonium acutiflorum (Jacob's Ladder) WTM

Boraginaceae

Mertensia paniculata (Bluebell) WTM

Scrophulariaceae

Pedicularis sedetica (Lousewort) WTM

Castilleja caudata (Indian Paintbrush) WTM

Valerianaceae

Valeriana capitala (Valerian) WTM

Compositae

Petasites frigidus (Sweet Coltsfoot) WTM

Artemisia tilesii (Wormwood) WTM

Senecio congestus (Marsh Fleabane) WTM

Saussurea nuda WTM

Chrysanthemum arcticum (Arctic Daisy) WTM

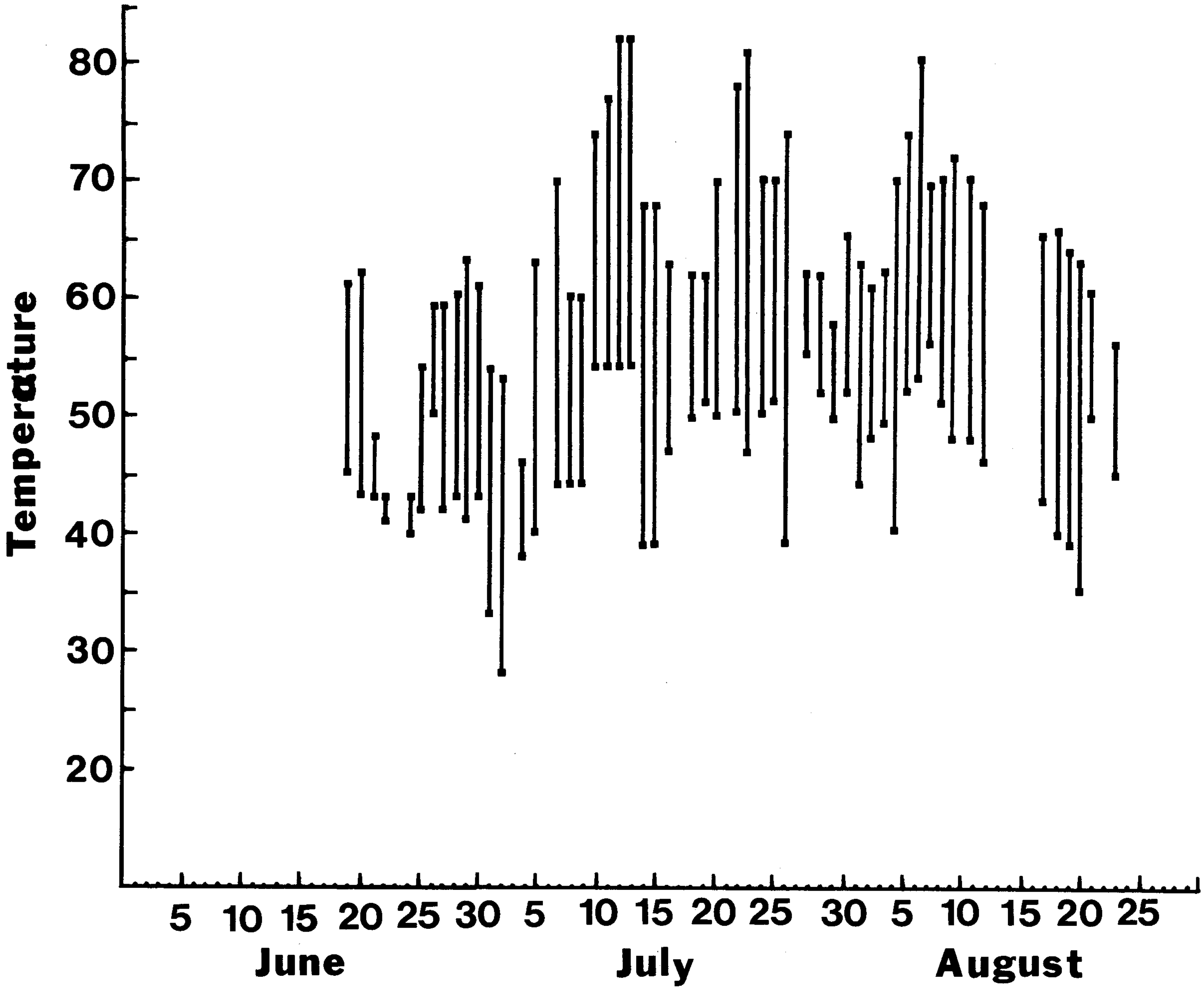

Temperature
80
70
60
50
40
30
20
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25
June
July
August

Figure 1.

No published data are available concerning utilization of this large area by migratory or breeding birds and until an additional field season analysis is complete we prefer no further interpretation of results.

Recommendations for the Coming Field Season

This project was funded on May 15, 1976 and as a result field preparations were delayed. In addition, Norton Bay was ice-bound until June 10 when we traveled by boat to establish the study area. Consequently, we have little data on spring migration, breeding behavior and dates of egg laying. Nearly all breeding species had complete clutches when we arrived on the delta.

These problems will be overcome during the field season of 1977. Arrangements have been made to transport research staff and field equipment to the study site by helicopter during the first week of May. This should allow us to establish our camp and study grids before most species migrate into the area. Additionally, non-teaching research staff will remain on the study site at least until mid September when a better description of fall migration will have been made.

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OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 28 R. U. #458

PRINCIPAL INVESTIGATORS: Dr. G. F. Shields and Mr. L. J. Peyton

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
1976 Field Season	6/14/76	8/24/76	5/15/77	None	6/30/77	4/15/77

	Batch 5			
1976 Field Season	4/15/77			

1 Data management plan has been submitted and approved by F. Cava; we await contractual approval.

ANNUAL REPORT

NOAA OCSEAP
Contract No. 03-6-022-35210
Research Unit No. 460/461

A COMPARATIVE SEA-CLIFF BIRD INVENTORY OF THE CAPE THOMPSON VICINITY, ALASKA

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Submitted 1 April 1977

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

A. Objectives

The objective of this study is to provide current information on the ecology of seabirds nesting at Cape Thompson and at Cape Lisburne. The data obtained at Cape Thompson will be compared to recent historical studies in an attempt to describe "predevelopment" changes which may have occurred. Investigations at Cape Lisburne will further increase our understanding of seabird biology in the Chukchi Sea. By broadening the ecological data base, effects of resource development in this region may be more accurately measured.

B. Conclusions

1. Approximately 50% fewer murres were present at Cape Thompson this year than in 1960 and 1961.

2. Black-legged Kittiwakes at Cape Thompson and Cape Lisburne experienced an essentially complete reproductive failure this year.

3. The food fish resource of murres and kittiwakes may have been lower than in other years and may have contributed to the kittiwake reproductive failure.

4. The timing of the events in the reproductive cycle of most species at Cape Thompson was 7 to 15 days later than in 1960 and 1961, but appeared similar to 1959.

5. Conditions which affect the timing of the breeding effort and the reproductive success of the seabird populations at Cape Thompson appear to be significantly different than those which operate on the birds nesting at Cape Lisburne.

C. Implications with respect to OCS oil and gas development

The colonies at Cape Thompson and Cape Lisburne support most of the breeding seabirds in the eastern Chukchi Sea. The birds constitute a major component of the ecosystem in this region. Perturbations of the environment by resource development in the Hope Basin could threaten the health and stability of these seabird populations.

II. INTRODUCTION

A. General nature and scope of study

The sea cliffs at Cape Thompson and Cape Lisburne provide nesting habitat for nine species of seabirds, three species of raptors and ravens. These colonies contain the largest concentrations of murres and kittiwakes in the eastern Chukchi Sea; as many as 400,000 murres and 24,000 kittiwakes may nest at Cape Thompson alone. The Cape Lisburne colony is unique also in that it is the farthest north seabird colony in western

North America.

No detailed, systematic studies of the Cape Thompson colonies were made until the Project Chariot investigations in 1959-1961 and essentially nothing has been done there since. Comprehensive investigations of the Cape Lisburne colony have yet to be made. The present study attempts to bridge gaps in our knowledge of seabird ecology within this region of Alaska.

B. Specific objectives

The specific objectives of this study are to:

1. Determine the numbers of cliff-nesting seabirds breeding at the Cape Thompson and Cape Lisburne colonies;

2. Determine the phenology of breeding activities and reproductive success of these birds;

3. Obtain data on food habits of the principal species in these colonies;

4. Provide current data for comparison with recent historical data;

5. Expand the ecological data base of the Cape Thompson and Cape Lisburne region.

C. Relevance to problems of petroleum development

The Hope Basin is subject to lease sales to allow oil and gas exploration and development. Within this part of the Chukchi Sea exist areas of critical habitat for several species of seabirds. These birds are not randomly distributed throughout the region but are concentrated at breeding colonies and at feeding areas. This clumped distribution pattern makes them particularly susceptible to oil pollution and habitat destruction.

Hunt (1976) reviewed much of the information concerning effects of oil on seabirds; little doubt exists about the consequences of oil spills near seabird rookeries. Seabirds in the far north are subject to the same threats as are birds in more temperate regions. Moreover, because of the presence of sea ice much of the year, birds nesting in northern colonies may have additional problems unique to these latitudes.

Petroleum, especially the higher molecular weight fractions, is susceptible to the congealing effects of low temperatures. In northern waters such as the Chukchi Sea, this may be of some advantage to containment of large spills, particularly during the ice-free months. However, because these waters are ice-covered much of the year and are often lashed by strong winds during the summer and fall, many recovery or containment operations will be severely limited.

Recent OCSEAP studies have produced evidence that winter-spilled oil may lie "dormant" underneath sea ice. While trapped under the ice, petroleum undergoes less weathering and retains its toxicity longer than it does when exposed to the atmosphere and to sunlight. Such oil also migrates upward through the ice and can become entrapped for long periods of time (Beaufort/Chukchi Sea Synthesis Meeting, Pt. Barrow, 7-11 February 1977). In addition to becoming a unique long-term source of chronic pollution, oil which has been trapped in or under the ice could appear in leads near rookeries or in critical feeding areas. Leads are important to murres and to other seabirds because they represent the only open water available for courtship and for winter and spring feeding. Oil filled leads and ice edges coated with oil would reduce the extent of already limited habitat and would present a direct danger to birds concentrated there.

Ice is not the only complicating factor involving oil and birds in the Chukchi Sea. The direction of currents flowing in the southern and eastern Chukchi Sea will tend to move oil spilled nearly anywhere in the southern Hope Basin across feeding areas and onto, or just in front of, the shore at Cape Thompson. Fleming and Heggarty (1966) reported drift-bottle reco veries which showed general circulation patterns of these waters. Currents out of the Bering Sea flow north through the straits then turn east towards Shishmaref and Cape Espenberg. From there they swing around to the northwest, parallel to the coast, and flow through the center of a region thought to be an important feeding ground for murres (see discussion of murre feeding habits). Both feeding birds and food web organisms would be threatened by oil carried in these currents.

Activities associated with development of onshore and offshore facilities may also jeopardize the birds nesting at Cape Thompson and Cape Lisburne. The effects of aircraft operating near seabird colonies are becoming well known. Other potential problems associated with resource development are treated in detail in the forthcoming Beaufort Sea Synthesis Report (in preparation by the OCS Arctic Project Office, Fairbanks).

III. CURRENT STATE OF KNOWLEDGE

Virtually nothing of biological interest was known about the colonies at Cape Thompson until Swartz (1966) conducted his studies during the Project Chariot investigations. Swartz summarized the few references which existed prior to his study; these are appended to this report.

Nine species of seabirds were found breeding at Cape Thompson in 1959-1961 (Swartz 1966). These were, in order of decreasing numbers, Thick-billed Murres (*Uria lomvia*), Common Murres (*Uria aalge*), Black-legged Kittiwakes (*Rissa tridactyla*), Horned Puffins (*Fratercula corniculata*), Glaucous Gulls (*Larus hyperboreus*), Tufted Puffins (*Lunda cirrhata*), Pelagic Cormorants (*Phalacrocorax pelagicus*), Black Guillemots (*Cepphus grylle*) and Pigeon Guillemots (*Cepphus columba*). In addition to these species, Golden Eagles (*Aquila chrysaetos*), Gyrfalcons (*Falco rusticolus*), Peregrine Falcons (*Falco peregrinus*) and Ravens (*Corvus corax*) were found nesting in small numbers on the cliffs.

The majority of the birds are in the immediate vicinity of the sea cliffs from late April through mid-September. Nearly all of the nutrition which supports the colony is obtained from the sea and amounts to an estimated 13,000 metric tons per 130-day breeding season (Swartz 1966).

IV. STUDY AREA

The general locations of the Cape Thompson and Cape Lisburne seabird rookeries are illustrated in Figure 1. The Cape Thompson study area lies at the southern terminus of the Kemegrak Hills and includes about 11 kilometers of coastline between Ogotoruk Creek and Point Hope. The same massive ridge of limestone and shale which comprises the Kemegrak Hills also forms the Lisburne Hills to the north where Cape Lisburne is located.

The seabirds inhabiting the Cape Thompson colony occur in five distinct, concentrated groups between Crowbill Point and the northern end of Imnakpak Cliff. These colonies tend to be on the higher, more stable cliffs and are separated by terrain of lower relief varying from a few hundred meters to about 2.4 kilometers in length (Figure 2). The extent of the habitat available to seabirds at Cape Lisburne has yet to be described.

Detailed information on the weather and climate, oceanography, geology and biology of the Cape Thompson region can be found in Willimovsky and Wolfe (1966).

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

A. Census

1. General- Swartz (1966) divided the Cape Thompson region into five sections, or colonies, and further divided the colonies into 137 smaller plots. The locations of each colony and plot were recorded on photographs made during the study. Copies of these photographs were taken with us into the field and, with only a few exceptions, were relocated this summer. By delimiting small areas to census individually, error introduced by becoming confused was reduced; and by using the same plots which Swartz used, we hoped that more meaningful comparisons could be drawn between his results and ours.

2. Murres - The number of birds in each plot was either counted or estimated by tens or hundreds, depending upon the size of the plot. Each plot was directly counted or estimated by two or three observers stationed offshore in a Zodiac raft. The raft was either anchored in front of or allowed to drift slowly past a section of the cliff. Because of the size of the cliffs and the numbers of birds present, only one colony was counted in a day. Censusing was timed to coincide with the period of maximum attendance by the birds at the cliffs and, with the exception of colony 3, occurred during the second half of incubation (see Nettleship 1975).

On the same days that colonies 2, 3 and 4 were censused, two observers were placed on shore to conduct diurnal activity counts. One or

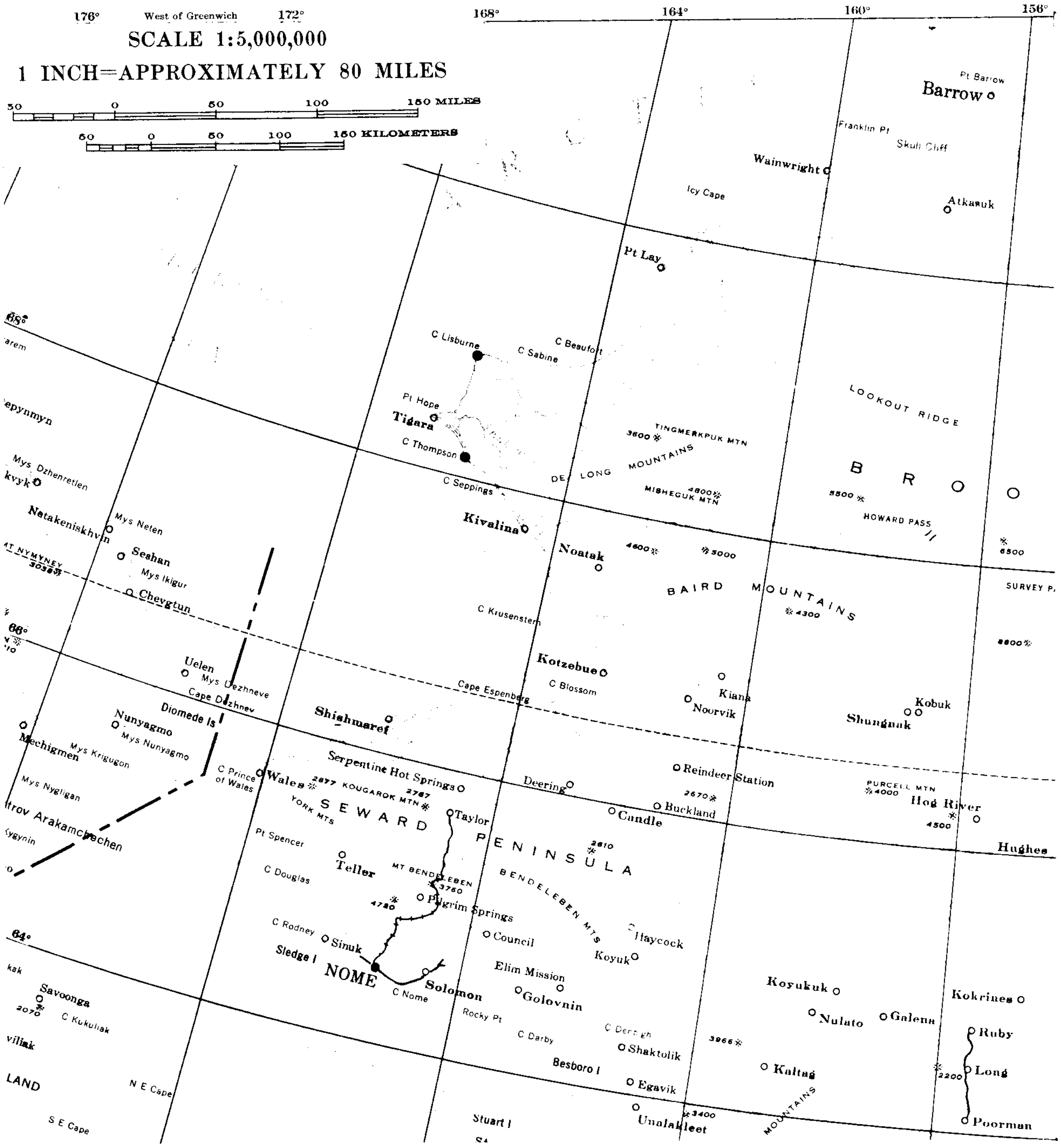

Figure 1. Locations of the Cape Thompson and Cape Lisburne seabird colonies in northwestern Alaska.

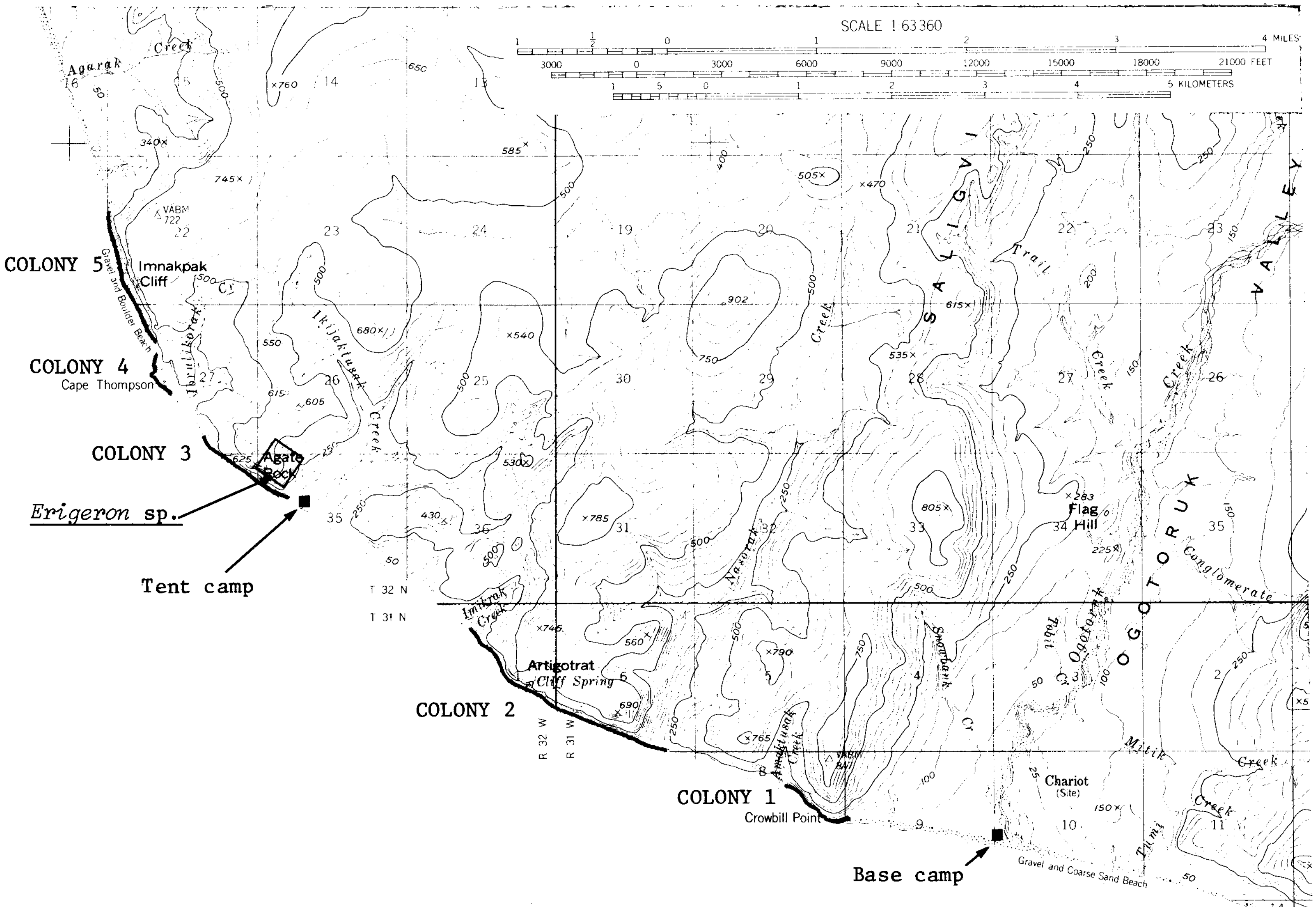

Figure 2. Colony locations at the Cape Thompson study area.

two sections of the colony were selected for both visibility and bird density and were counted every hour for 24 hours. Numbers of birds determined for different plots at different times during the day by the offshore observers were then adjusted for daily activity patterns by dividing the raw score by $\frac{\text{number of birds on compensation plot at time t}}{\text{max. number observed on compensation plot}}$ where t = time a given census plot was counted. Compensation of colony 5 was done on the basis of the activity patterns determined for colony 4. Scores for colony 1 were not compensated; the numbers presented are the highest obtained during several complete counts.

Numbers which were arrived at by estimation as opposed to direct counts were also adjusted by the observer's handicap. These handicaps were determined by each person first estimating the number of birds on given sections of cliff and then comparing these values to the average number counted by all observers. Handicaps for observers A and B were 90%, and 92% for observer C.

3. Black-legged Kittiwakes - Kittiwakes were counted individually by a separate observer at the same time that murres were being censused. No corrections for daily activity patterns were made.

4. Puffins - Counts of Horned and Tufted Puffins were made during all murre and kittiwake censusing activities. Puffins were also frequently counted at various times of the day while we were going to and from study areas. Twenty-four-hour counts of Horned Puffins were taken at plots in each of two colonies. For colonies which were counted completely more than once, we have presented only the highest count obtained.

5. Others - The population sizes of gulls, cormorants, Ravens, Golden Eagles and Gyrfalcons were determined by locating nests. Numbers of guillemots were arrived at by compiling all observations throughout the summer.

B. Phenology of breeding activities

Regular visits were made to the colonies to determine laying and hatching dates for eggs of all species nesting at Cape Thompson. Specimens of Common and Thick-billed Murres and of kittiwakes were collected throughout the summer with a shotgun or when found wounded on the beach. Each specimen was examined for degree of brood patch and gonadal development.

C. Food habits

Specimens were collected when they were returning to the colonies from feeding areas. Their stomachs were removed as soon as possible and the lining of the ventriculus together with the contents were preserved in 70% EtOH. A visual estimate of the per cent fullness of each stomach was made and the prey items were identified using standard taxonomic keys and preserved material.

VI AND VII. RESULTS AND DISCUSSION

A. Murres

Results of the murre counts, the corrected values and numbers obtained by Swartz (1966; unpublished data) for each colony are summarized in Table 1. Our plot counts of all colonies and those of Swartz for the same plots in three colonies are detailed in Tables 2-6; we were unable to relocate all of the plots Swartz used in colonies 3 and 5. From our data we estimate the size of the murre population at Cape Thompson during the summer of 1976 to have been between 150,000 and 200,000.

The most reliable estimate Swartz obtained of the number of murres at Cape Thompson was in 1960. In 1959 censusing efforts were not begun until after many of the young had fledged and the adults had left the colonies. A complete census was taken of only colonies 1 and 4 in 1961; the numbers of birds in colonies 2, 3 and 5 were based on between-years changes which occurred in selected plots on the ends and in the center of each colony. We obtained Swartz's original data for all years and from them derived the following estimates. Five plots in colony 3 were counted in 1961 and contained about 6500 birds. The direction of change from 1960 to 1961 was the same for all five plots and constituted an increase of 64%. One thousand and thirty eight birds were counted in six plots at colony 5; the direction of change varied and the net difference was only one per cent greater in 1961 than in 1960. A 13% decrease at colony 2 was observed between 1960 and 1961; the numbers from which this figure was determined are presented in Table 3. By applying the calculated percentage change of each colony in 1961 to the total obtained for the same colonies in 1960, we estimate that as many as 404,000 murres could have been present on the cliffs at Cape Thompson in 1961. This was essentially the same number as was reported there the previous year.

Table 1. Murre census summary, Cape Thompson.

Colony	Raw+	Time and Handicap Compensated+	1961	1960
1	2,090	2,090	5,630	4,186
2	46,722	61,908	108,598*	122,716
3	18,598	30,726	72,031*	44,000
4	6,894	7,792	8,552	11,835
5	79,983	98,349	210,100*	208,000
TOTAL	154,287	200,865	404,011*	390,737

*estimate

+mean values of all observers

Table 2. Colony 1 murre census, uncompensated scores.

	1976					1961						1960
	20 July		6 August			25 July		3 August				
Plot	Time	Observer A	Time	Observer A	Observer B	Time	$\bar{x}$	Time	$\bar{x}$	Time	$\bar{x}$	$\bar{x}$
A	1830	12	1000	6	6	2310	8	1405	23	1625	15	34
B		0		0	0		170		299		356	197
C		340		370	280		339		517		459	336
D		240		298	352		244		697		959	721
E		1006*		980	929		1104		2923		2857	2089
F		0		0	0		0		15		0	5
G		550		540	392		624		965		1101	768
H		55		13	13		0		43		49	36
I	1930	0	1300	0	0	0010	0	1545	0	1830	0	0
TOTAL		2203*		2207	1973		3589		5464		5796	4186

*Estimate

Table 3. Colony 2 murre census.

		18 August 1976								
		Observer A		Observer C		Time Compensation* Handicap				
Plot	Time	Raw	Time Comp.	Raw	Time Comp.	Ob. A	Ob. C	$\bar{x}$	1961	1960
A_1	0910	5	5	5	5	5	5	5	51	52
A_2		29	30	29	30	30	30	30		72
B		157	163	134	139	163	139	151	214	239
C		675	702	660	686	780	746	763	1441	1791
D		70	73	80	83	73	83	78		127
E	1020	1020	1020	780	780	1133	848	995		3803
F	1320	430	546	430	546	607	593	600		1218
G		1350	1670	1240	1575	1856	1712	1784		5488
H	1350	1870	2375	2170	2734	2639	2972	2805		6438
I	1400	1070	1446	980	1323	1605	1438	1521		4206
J	1035	1480	1480	1170	1170	1644	1300	1472		4415
K		720	720	710	710	800	789	794		802
L	1100	1515	1651	1130	1232	1835	1339	1587		5376
M		2510	2736	2160	2354	3040	2559	2800		5094
N	1150	540	587	510	556	654	604	629		3377
O	1215	1200	1512	850	1071	1680	1164	1422		4249
P		1350	1701	1160	1462	1890	1589	1740		2477
Q		1470	1852	1580	1991	2058	2164	2111		7282
R	1200	440	559	530	673	621	732	677		1348
S	2110	2230	2408	1750	1890	2676	2054	2365		3746
T	2045	4440	5017	3630	4102	5575	4459	5017		8142
U	2015	3400	3842	3440	3887	4269	4225	4247		5816
V		4180	4807	3600	4140	5341	4500	4921		7625
W	1830	1960	2411	2460	3026	2679	3289	2984		5325
X		1730	2232	2030	3715	2480	4038	3259		4072
Y	1705	4220	5444	2710	3496	6049	3800	4925		6475
Z	1700	1860	2288	1200	1476	2542	1604	2073		3485
AA	1645	830	1021	750	923	1134	1025	1080		2053
BB	1700	2550	3290	1520	1961	3655	2131	2893		3038
CC	1710	500	645	500	645	717	701	709		2273
DD	1725	1645	2122	1650	2129	2358	2313	2336		7992
EE	1730	900	1161	600	774	1290	841	1066		2197
FF		500	645	390	503	717	547	632		1220
GG		590	761	500	645	846	701	773	713	667
HH II	1740	530	636	440	568	707	617	662	450 224	500 236
Total		49,966	59,558	43,478	52,970	64,708	57,651	61,908	108,598+	122,716

+estimate

*values of plots where birds were counted one by one are not compensated for observer handicap

Table 4. Colony 3 murre census.

		23 July 1976					
		Observer D		Observer E		$\bar{x}$	Time Comp.
Plot	Time	Raw	Time Comp.	Raw	Time Comp.	Time Comp.	Handicap Ob. E
A	2117	183	212	170	198	205	220
B		400	465	575	669	567	743
C		500	581	600	698	639	776
D		720	837	550	640	739	711
E		610	709	450	523	616	581
F	2050	430	538	430	538	538	598
G		2100	2625	2500	3125	2875	3472
H	2010	750	938	650	812	875	902
I	1955	1500	2027	1400	1892	1960	2102
J		1400	1891	1150	1554	1723	1727
K	1920	1200	1622	1150	1554	1588	1727
L	1900	1250	1689	1350	1824	1756	2027
M		1850	3557	1950	3750	3654	4167
N							
O	1615	655	1260	832	1600	1430	1778
P	1635	1616	3108	1680	3230	3169	3589
Q	2150	1795	2087	1960	2279	2183	3532
R	2140	703	817	1021	1187	1002	1318
S	2115	531	1021	585	680	851	756
Total		18,193	25,984	19,003	26,753	26,370	30,726

Table 5. Colony 4 murre census.

		9 August 1976								
		Observer A		Observer E		Time Compensation* Handicap				
Plot	Time	Raw	Time Comp.	Raw	Time Comp.	Ob. A	Ob. E	$\bar{x}$	1961	1960
A	1846	140	151	135	146	151	146	149	89	175
B		260	281	270	292	312	324	318	651	839
C	1900	840	907	980	1058	1008	1176	1092	559	1097
D	1930	180	184	150	153	204	170	187	356	489
E	1910	860	877	900	918	974	1020	997	1335	1566
F	1917	310	316	360	367	351	407	379	651	791
G		990	1009	835	852	1121	946	1033	1429	2046
H		390	398	360	367	442	407	424	443	458
I		50	51	30	31	51	31	41	54	76
J		820	836	788	804	928	893	910	252	775
K		130	133	140	143	133	143	138	225	285
L	2000	130	130	120	120	130	120	125	205	225
M		570	570	568	568	633	631	632	1125	1388
N		310	310	344	344	344	382	363	227	377
O		90	90	125	125	90	125	108	25	1
P		460	460	520	520	511	577	544	622	841
Q		280	280	240	240	311	266	289	190	236
R	2045	55	55	58	58	55	58	57	114	170
Total		6865	7038	6923	7106	7756	7829	7792	8552	11,835

*values of plots where birds were counted one by one are not compensated for observer handicap

Table 6. Colony 5 murre census.

	19 August 1976										
		Observer A		Observer E		Observer C		Time Compensation Handicap			
Plot	Time	Raw	Time Comp.*	Raw	Time Comp.*	Raw	Time Comp.*	Ob. A	Ob. E	Ob. C	$\bar{x}$
A	1810	1500	1620	1000	1080	1700	1836	1800	1200	1995	1665
B		3200	3456	2200	2376	3600	3888	3840	2640	4226	3569
C		5400	5832	2900	3132	5000	5400	6480	3480	5870	5277
D		4100	4428	2000	3600	2700	2916	4920	4000	3170	4030
E	1800	10,900	11,772	7700	8316	11,500	12,420	13,080	9240	13,500	11,940
F	1740	12,400	13,764	10,650	11,822	10,300	11,433	15,293	13,135	12,427	13,618
G		11,300	12,543	9200	10,212	10,700	11,877	13,936	11,346	12,909	12,730
H	1715	11,500	12,765	13,500	14,985	9600	10,656	14,183	16,650	11,583	14,139
I	1655	12,700	14,351	12,400	14,102	8700	9831	15,946	15,569	10,686	14,067
J		8100	9153	13,000	14,690	6800	7684	10,170	16,322	8352	11,615
K		3100	3503	2450	2769	2300	2599	3892	3076	2825	3264
L	1615	1700	1921	2750	3108	1400	1582	2134	3453	1720	2435
Total		85,900	95,108	79,750	90,192	74,300	82,122	105,674	100,111	89,263	98,349

*compensated on basis of Colony 4 diurnal activity pattern

In computing colony totals, Swartz compensated his raw scores as we did, by daily activity rhythms. The principal difficulty with this method is the assumption that the behavior of the birds on relatively small compensation plots was representative of the colony as a whole. We believe this assumption to be justified, however, because of the following observations. Tuck (1960), Swartz (1966), Hickey (1976) and Hunt (1976) all have shown that diurnal rhythms of ledge attendance do exist, at least in certain murre colonies. That they are not seen in other colonies (Uspenski 1958; Pennycuick 1956) suggests locally different tides or abundance of school fish (Tuck 1960). These activity patterns change with the progression of the reproductive cycle and are also modified by daily weather changes (Tuck 1960). However, the factors which determine activity patterns of murres on a daily basis probably do not operate differently on birds from slightly different sections of the cliff. By counting the number of birds on control plots for 24 consecutive hours on the day of the census, or, as Swartz did, at regular, shorter intervals during the time the census occurred, the effects of localized, random movements and flushes should be apparent and a picture of the general activity pattern throughout that day should emerge (Table 7).

Events in the schedule of breeding activities of murres at Cape Thompson in 1976 were later by about 7 to 14 days than in 1960 and 1961, but were nearly the same as in 1959 (Table 8). This conclusion is supported by data on physiological changes associated with reproduction which were obtained from the specimens we collected.

Table 8. Phenology of nesting activities of Thick-billed Murres at Cape Thompson.

Year	First Egg	First Chick	First Sea-going
1959	9 July	11 August	25 August
1960	27 June	30 July	18 August
1961	23 June	27 July	19 August
1976	4 July	9 August	*

*no sea-going seen prior to our departure

Tables 9-11 present testes volumes, follicle sizes and brood patch development, respectively, of Thick-billed Murres collected at intervals during last summer and similar data from murres collected in 1960. The volumes of the testes were calculated by using the formula for the volume of a prolate spheroid ($V = 4/3\pi ab^2$) and the values for the development of the brood patch were derived from the scale used by Swartz:

Table 7. Compensation counts of murres - percents of maxima*.

Time	1976			1961
	18 Aug. Colony 2	27 July Colony 3	9 Aug Colony 4	Colony 4
0100			44	
0200			52	
0300	67	87	74	
0400	75		64	
0500	78		81	
0600	81	100	79	
0700	82		79	
0800	91	77	82	
0900	96	72	81	
1000	100		79	
1100	92	60	76	
1200	79	55	76	76
1300	79	49	79	85
1400	74	50	86	88
1500	82	52	88	92
1600	81	52	89	88
1700	78	50	90	
1800	81	78	93	
1900	87	74	98	100
2000	88	80	100	100
2100	93	86	93	
2200	78	94		96
2300	63	91	69	
2400			58	

*Maxima - 1976
Colony 2 - 499
Colony 3 - 741
Colony 4 - 627

Class 0 No evidence of brood-patch development.
Class 1 Loss of down and some contour feathers, beginning in separate areas on either side of the midline.
Class 2 Almost complete loss of down and most contour feathers; vascularization beginning.
Class 3 Complete loss of feathers; heavy vascularization (maximum development).
Class 4 Regression beginning with down appearing, especially around edges; sheaths of new contour feathers appearing.
Class 5 Most of area down-covered, contour feathers beginning to break out of sheaths.
Class 6 Complete regression, appearance as in class 0.

Even without early season information, our data indicate that on the average testicular recrudescense was delayed in males as was the maturation of follicles in females and the development of the brood patch in both sexes. Moreover, the variance of our samples of testes and follicles is much greater than that of Swartz's which suggests that the synchrony of the breeding effort of the population was looser this year than it was in 1960. The synchronization of the "sexual rhythm" in murres has been discussed by Tuck (1960).

All of the murres we collected this summer were sexually active. Our sample was small but these data support the statement by Swartz (1966) that most if not all of the murres at Cape Thompson were attempting to breed.

The ratio of Thick-billed to Common Murres at Cape Thompson does not seem to be different now than it was in 1960. Swartz estimated that 60% of the murres were thick-billed. Our counts in a wide variety of cliff and ledge types throughout the summer yielded a ratio of 57:43 thick-bills to commons.

We do not have an estimate of the reproductive success of murres. It is difficult to find positions on the ground where the ledges proper can be viewed. Problems were also encountered in flushing birds from the few ledges which were visible. Often as many as half of the birds on a ledge containing 200 to 300 murres would not fly even when considerable disturbance was created nearby. This disturbance would, however, cause many birds on other ledges to flush and the potential loss of eggs resulting from such practices was not considered worthwhile. Our general impression, based on the following observations, was that egg production at least was relatively good.

On 26 July a total of 79 Thick-billed and Common Murres occupied five small but visible ledges at colony 3. When disturbed, almost all of these birds flushed or stood up which revealed 33 eggs. Several of these eggs were quickly lost to passing gulls. A small section of cliff at colony 4 was occupied by 153 murres of mixed species on the same date. Ninety three of these birds were on wide ledges near the cliff top while the remainder were on narrower ledges about 10 meters below. When we disturbed this group, the majority either flew or stood and we counted 26

Table 9. Volume of testes (in cubic centimeters) of Thick-billed Murres at Cape Thompson.

Period	Left		Right	
	No.	Avg. Volume	No.	Avg. Volume
		1960*		
May	8	0.65 ± 0.16	8	0.51 ± 0.17
June 1-15	6	7.16 ± 2.26	6	5.08 ± 2.20
June 16-30	23	4.48 ± 0.41	21	3.35 ± 0.30
July 1-15	14	2.07 ± 0.44	14	1.77 ± 0.26
July 16-31	7	0.76 ± 0.21	6	0.72 ± 0.13
Aug. 1-15	8	0.26 ± 0.03	8	0.23 ± 0.03
Aug. 16-31	10	0.17 ± 0.03	10	0.10 ± 0.01
Sep. 1-15	3	0.14 ± 0.02	3	0.16 ± 0.03
		1976		
June 24-30	9	3.78 ± 1.50	8	2.78 ± 1.36
July 13-14	7	2.82 ± 1.91	7	2.40 ± 1.12
July 22	8	1.00 ± 1.02	8	0.96 ± 0.30

*data from Swartz (1966)

Table 10. Average diameter (in millimeters) of largest ovarian follicles of Thick-billed Murres at Cape Thompson.

Period	No.	Avg. Diameter	Range
		1960*	
May	10	3.67 ± 0.46	
June 1-15	7	5.43 ± 0.68	
June 16-30	11	8.06 ± 1.37	
July 1-15	14	6.57 ± 0.61	
July 16-31	4	4.52 ± 0.45	
Aug. 1-15	2	3.10 ± 0.40	
Aug. 16-31	4	2.88 ± 0.24	
Sep. 1-15	7	1.99 ± 0.25	
		1976	
June 24-30	4	5.95 ± 1.4	3.5-7.2
July 13-14	3	5.60 ± 1.9	3.3-7.8
July 22	9	6.7 ± 1.8	4.0-10.6

*data from Swartz (1966)

Table 11. Brood patch development of Thick-billed Murres at Cape Thompson.

Period	Males No.	Males Avg. Class Value	Females No.	Females Avg. Class Value
		1960*		
May	8	0.0	10	0.0
June 1-15	6	0.0	7	0.0
June 15-30	25	0.9	11	1.0
July 1-15	16	2.2	14	2.6
July 16-31	7	3.0	4	3.0
Aug. 1-15	8	2.9	2	3.2
Aug. 16-31	10	4.2	4	3.9
Sep. 1-15	3	5.5	8	4.4
		1976		
June 30	8	1.0	4	0.5
July 13-14	7	1.1	3	1.3
July 22	8	2.3	8	2.0

*data from Swartz (1966)

eggs on the upper section and 50 on the lower section. Eight eggs (10.5%) were dislodged and fell into the sea when the birds flushed. A second area of the same colony contained 280 murres, most of which were thick-bills. When disturbed, approximately half of the birds flew and we counted 98 eggs.

No data were obtained on hatching or fledging success. We estimate that fewer than 50% of the eggs had hatched by 20 August and our field work at Cape Thompson was terminated five days later.

Whatever the production was, it was not, to our knowledge, affected by native "egging" parties. Although several groups came past the colonies and at least two groups fired shotguns repeatedly at the cliffs, we did not observe anyone taking eggs. Swartz reported that during the three years of his study, Eskimos from Kivalina and Pt. Hope took about 2,000 eggs annually. Sverre Pedersen (pers. comm.) told us that in recent years people from Pt. Hope have gone to Cape Lisburne, where the cliffs are not as dangerous. Traditional egg-taking by Eskimos, however, does not appear to significantly affect the murre population.

Prey items were identified from the stomach contents of 51 Thick-billed Murres and 20 Common Murres. The results of these examinations are presented in Table 12. Despite efforts to collect birds soon after feeding, many stomachs were either empty or contained little food. Even if all stomachs had been full, the size of the sample would have been too small to warrant statistical treatment. Nevertheless, certain interesting comparisons may be made between our data and those which Swartz obtained in 1960.

Swartz presented good evidence of trophic differences which may exist between the two murre species. Our data support this suggestion. Of the murres Swartz collected which had food in their stomachs, 63.9% of the thick-bills had eaten fish and 33.8% had eaten invertebrates while 95.5% of the commons had eaten fish and only 6.1% had eaten invertebrates. The number of thick-bills which had eaten invertebrates in 1976 was nearly the same as the number which had eaten fish (78%:76%); however, only 33% of the Common Murre stomachs contained invertebrates while 92% contained fish.

The numerically dominant marine fish in the Chukchi Sea, Arctic cod (*Boreogadus saida*) (Alverson and Willimovsky 1966) was also the most frequently encountered fish in stomachs of both murre species collected during 1960 and 1976. This cod had been eaten by 45.1% of the thick-bills and 80.3% of the commons in 1960 and 25% of the thick-bills and 42% of the commons in 1976. Sand launce (*Ammodytes* sp. and *A. hexapterus*) was the second most common prey fish of both murres in 1960 (9.8% in thick-bills and 30.3% in commons) and was the only fish besides cod which could be considered important to the murre population that year. Other fish, taken together, were found in only 12.3% at most of thick-bills' stomachs and 10.6% at most of commons' stomachs. This situation did not seem to exist in 1976; *Ammodytes* was not taken as frequently as in 1960 nor was it the second most common prey fish of either murre. In fact, this species appears to have been of relatively minor importance, especially to Thick-billed Murres, when compared to other fish which were identified in stomach contents (see Table 12).

Table 12. Food of murres and kittiwakes. Per cent occurrence of food items refers only to those stomachs containing food (>1% fullness); values in parentheses refer to the total sample.

	Thick-billed Murre		Common Murre		Black-legged Kittiwake	
	n	%	n	%	n	%
Total examined	52*		20		22	
No. empty	1	(2)	8	(40)	7	(32)
Frequency of invertebrates	40	78	4	33	8	53
Frequency of fish	39	76	11	92	10	67
FISH:						
Gadidae			1	8		
Boreogadus saida	13	25	5	42	5	33
Eleginus gracilis	4	8	4	33	5	33
Cottidae	5	10	2	17		
Myoxocephalus sp.	8	16				
M. quadricornis	1	2				
Artediellus sp.	4	8				
Zoarcidae	1	2				
Bothrocara sp.	6	12				
Lycodes sp.	1	2	1	8		
Pleuronectidae					1	7
Liparidae (?)	1	2				
Ammodytes hexapterus	2	4	2	17		
Mallotus villosus	1	2				
Pungitius pungitius					1	7
unidentifiable	8	16	1	8	1	7
INVERTEBRATES:						
Polychaeta					1	7
Nereis sp.	9	18				
Gastropoda	7	14			2	13
Trochidae					1	7
Decapoda						
Pandalus goniurus	7	14			1	7
P. montagui	3	6				

Table 12, continued

	Thick-billed Murre		Common Murre		Black-legged Kittiwake	
	n	%	n	%	n	%
INVERTEBRATES, cont.						
Decapoda, cont.						
Pandalus sp.	2	4	1	8	1	7
Eualus gaimardi	6	12	1	8	1	7
Lebbius groenlandicus	3	6				
Crangionidae	3	6				
"shrimp" remains	15	29				
Paguridae	1	2				
crab remains	2	4				
unidentifiable	6	12			2	13
Isopoda						
Saduria entomon					1	7
Amphipoda	1	2	1	8		
Gammaridea	4	8	2	17		
Insecta						
Coleoptera					1	7
Hymenoptera (?)					1	7
MISCELLANEOUS:						
Algae	2	4				
Pebbles	14	27	4	33	1	7

*51 Thick-billed Murre stomachs plus 1 capelin recovered from a Thick-billed Murre on its nest ledge. This specimen was treated as a separate sample, and added to the total.

Notable differences may also exist between the types and frequencies of invertebrate prey taken by thick-bills in 1960 and 1976. The majority of the invertebrate food in 1960 belonged to three general categories; "Polychaetes", Mollusca (Pteropods, Trochidae and Naticidae) and caridean shrimp (Hippolytidae and Crangionidae). Nine per cent of the stomachs contained "Polychäetes",10.7% at most contained mollusks and 6.8% at most contained shrimp. In 1976, a much larger percentage of the thick-bills' stomachs contained polychaetes (Polychaeta, 18%; Nereis sp., 14%) and no mollusks at all were found. The greatest difference between years, however, was in the utilization of shrimp which appear to have been of relatively high importance to Thick-billed Murres in 1976 (see Table 12).

Murres were common on the water in front of the cliffs throughout the summer of 1976 and appeared to feed there to some extent. The majority of the birds, however, seemed to feed some distance to the south and east of Cape Thompson.

Late afternoon and evening flights of murres returning to the cliffs from the southeast and south were common all summer. Fifteen minute counts of birds flying past Ogotoruk Creek were made every hour for 24 hours on 19-20 June and an estimate of the total number of birds per hour which passed this point was obtained from these counts (Table 13). In addition to indicating the number of murres feeding away from the colonies and possibly the direction of the feeding area, these observations further support the theory that diurnal activity patterns are well established in the murre population at Cape Thompson.

Direct evidence that murres feed to the south and southeast of Cape Thompson has also been obtained. Observers on aerial transects which were flown on 19 June 1975 estimated as many as 150 birds per square kilometer at approximately $67^{o}30'$ N. Lat. and 166^{o} W. Long. (about 70 kilometers south of Cape Thompson), the majority of which were murres (Harrison, pers. comm.). On 21 August 1976 fewer but substantial numbers (30-50 birds/km^2) of murres were seen at the same location (Harrison pers. comm.) and observers on shipboard transects reported seeing similar concentrations of murres in this general area in early September, 1976 (Gould pers. comm.).

Albinism occurs occasionally in murres; Tuck (1960) summarized reports of both partial and complete albinism in the two species. Swartz (1966) reported the presence of a complete albino Thick-billed Murre chick at the Cape Thompson colonies during his study. A partial albino adult murre which had a normal-appearing chick also was sighted at the Cape Thompson colonies in 1960 (Swartz, pers. comm.). The species of that individual was not determined.

On 20 August 1976, a partial albino adult murre in a flock of 20-30 typically colored individuals was noted as it flew past observers at the mid-point of colony 5. The bird had cream-white wings and dorsal surfaces. Its species and breeding status were not determined.

B. Black-legged Kittiwakes

We were unable to obtain a reliable estimate of the size of the

Table 13. Number of murres flying north past Ogotoruk Creek, 19-20 June 1976.

Time	Number per hour
2100	4644
2200	1572
2300	144
0100	64
0200	52
0300	88
0400	72
0500	36
0600	36
0900	32
1100	10
1300	10
1500	1136
1700	3648
1800	7808
1900	7696
2000	3748
2100	3068
2200	1572
2300	2032
2400	944

kittiwake population at Cape Thompson this year. Although many birds were paired and singles and pairs defended sites, few nests were constructed and attendance at the cliffs was erratic. An example of this attendance pattern is shown in Table 14. Uncompensated counts of birds on colonies 2-5 yielded a total of 10,500 individuals; kittiwakes do not nest at colony 1. These data are presented in Tables 15-18.

Table 14. Numbers of kittiwakes present on plots A, B & C of Colony 4 at similar times on different days.

Date	Time	No.
9 August	1845	467
14 August	1750	75
15 August	1835	734

A virtually complete breeding failure occurred in the kittiwake population in 1976. All specimens collected showed evidence of gonadal development and most birds at the cliffs exhibited characteristic breeding behavior. Brood patch development was not observed in any of the birds we collected, however, and we have direct evidence to account for only 13 eggs.

When we arrived at the site in mid June, kittiwakes were abundant. "Crying" and "choking" were both well developed at this time and a few birds were seen carrying mud and grass to the colonies from Ogotoruk Creek. Several birds were observed stamping mud into place on ledges and we saw birds carrying new nesting material as late as 20 August, however, no nests typical of those described by Swartz (1966) and Cullen (1957) were found. Copulation was never observed.

The first egg was observed on 4 July and the first chick, which hatched from this egg, was seen on 9 August. On 13 July three nests were found; two contained one egg and one contained two eggs. Four kittiwakes at colony 4 were seen sitting as if brooding or incubating on 10 August. Eggs were finally seen under three of them, one egg of which was a miniature. The fourth bird was also incubating, because on 20 August an egg was seen in its nest. By this date the miniature egg had disappeared and the other two eggs had hatched. We saw only five other chicks, one in each of five nests, at colony 2 on 12 August. These were probably not the only eggs and chicks produced; other scattered birds were seen sitting in positions which suggested that they were either incubating or brooding. The total production, however, can be considered insignificant compared to that reported by Swartz for this population in 1960.

Table 15. Colony 2 kittiwake census

Plot	18 August 1976					
	Ob. E	Ob. A	Ob. B	$\bar{x}$	1961*	1960*
A	0	0	0	0	0	0
B	0	0	0	0	0	0
C	0	0	0	0	0	0
D	0	0	0	0	0	0
E	235	238	310	261	484	652
F	230	218	275	241	502	536
G	133	135	134	134		260
H	36	30	42	36	102	118
I	126	92	111	110		268
J	133	144	136	138	114	340
K	38	27	35	33		52
L	242	242	263	249	834	840
M	467	533	538	513		958
N	31	31	31	31	792	840
O	46	51	38	45		160
P	41	47	41	43	126	118
Q	206	207	195	203		626
R	8	7	8	8	0	6
S	93	71	92	85		172
T	239	243	241	241	630	608
U	345	345	345	345		1532
V	188	170	196	185	620	644
W	158	147	139	148		464
X	38	42		40	190	152
Y	87	80	84	84		296
Z	28	28	27	28	150	158
AA	22	21	24	23		90
BB	2	2	2	2	10	12
CC	11	10	11	11		28
DD	104	59	75	79	170	172
EE	39	39	39	39		208
FF					16	18
GG						6
HH II	18	18	17	18	30	24
Total	3344	3277	3449	3373	9432+	10,358

*values are 2 times the number of nests

+estimated

Table 16. Colony 3 kittiwake census.

Plot*	23 July 1976	1961	1960
A	0	0	0
B	0	0	0
C	20	38	44
D	2	0	412
E	90	82	108
F	17	18	0
G	550		30
H	275	754	548
I	375		248
J	300	2210	1562
K	650		1910
L	0	26	80
M	250		270
N		0	0
O	158		170
P	138	30	0
Q	146		86
R	28	220	86
S	69		286
T		150	150
U			67
V		54	54
W		24	26
Total	3086	7210+	7210

+estimated

*plots for 1976 do not necessarily correspond to plots used in 1960 and 1961

Table 17. Colony 4 kittiwake census.

Plot	9 Aug. 1976	1961	1960
A	121	190	472
B	80	162	614
C	266	544	750
D	15	722	76
E	265	74	1128
F	79	332	894
G	155	468	
H	107	446	224
I	146	942	506
J	96	214	328
K	87	284	292
L	69	600	410
M	50	264	170
N	75	320	296
O	11	20	16
P	27	162	86
Q	0	312	0
R	0	80	0
Total	1649	6136	6262

Table 18. Colony 5 kittiwake census.

	19 August 1976		
Plot	No. of Singles	No. of Pairs	Total Birds
A	33	0	33
B	75	14	103
C	83	16	115
D	32	8	48
E	594	75	744
F	396	28	452
G	430	30	490
H	293	27	347
I	60	9	78
J	8	2	12
K	4	0	4
L	4	1	6
Total	2012	210	2432

Food habits of kittiwakes in 1976 (Table 12) also appear different compared to 1960. Twenty five per cent of the kittiwake stomachs holding food which Swartz examined in 1960 contained invertebrates and 91.3% contained fish. In 1976, 53% held invertebrates and only 67% held fish. The most commonly encountered prey fish in 1960 was *B. saida* (54.3%) while in 1976 *B. saida* tied for first place with another cod, *Eleginus gracilis*, at 33% each. *E. gracilis* was not identified among the stomach contents of kittiwakes collected in 1960. *A. hexapterus* was the second most popular fish in 1960 but was not found in 1976.

No trends are apparent in the invertebrate prey taken by kittiwakes in either year. We did make an interesting observation, however, in 1976 during one of only three kittiwake feeding melees seen all summer. On 27 July a rather large number of kittiwakes were watched as they fed on medusae (*Cyanea* ?) which were "blooming" in the water near colony 3. The medusae varied in size from about 3 mm in diameter to 3 cm. Such food would undoubtedly digest very rapidly once ingested and as a result would probably rarely be seen in stomach contents. The overall importance of this food resource to the kittiwake population is, therefore, unknown.

The relationships among the prey taken by all three species of birds in 1960 and 1976 should be noted with caution because of the small sample size, especially in 1976. However, we do not consider it entirely inappropriate to speculate to some extent on the role which prey availability may have played in the reproductive failure of kittiwakes at Cape Thompson in 1976.

All three species of birds ate a higher percentage of invertebrates in 1976 than in 1960. The relatively greater increase in utilization of invertebrates by Thick-billed Murres than by Common Murres or kittiwakes is consistent with prey preferences of these species (Belopolskii 1957; Uspenski 1958; Swartz 1966). *B. saida*, the principal prey fish of these birds, was encountered less frequently in 1976 than in 1960 as was *A. hexapterus*, the second most preferred prey fish. The relative importance of other fish species in the diets of murres and kittiwakes was much higher in 1976 than in 1960. These observations suggest that the abundance of potential forage fish of murres and kittiwakes, particularly *B. saida*, in the Cape Thompson region was lower in 1976 than in 1960. The impact of this possible food shortage may have been greater on the kittiwake population than on either of the murre populations.

Quast (1974) showed that the number of juvenile Arctic cod increased with depth at all multidepth stations which he sampled in the eastern Chukchi Sea. This change in the density of cod described a triangle with its vertex towards the surface and was termed a "density structure." Quast advanced the hypothesis that the density structure developed from a negative phototaxis and was a behavioral response to predation by piscivorous birds. An alternate explanation for this distribution is that it may be congruent with the density *vs.* depth profile of the zooplankton upon which the cod feed. Whatever the reason, the effect is that fewer juvenile cod are found in the surface waters where kittiwakes feed than are found in deeper water from which kittiwakes are excluded. In years of abundant prey fish populations, this may be of relatively less consequence to kittiwakes than in years when fish populations are smaller. Murres, however, would probably be affected less by lean fish years because of their ability to feed at considerably greater depths where a larger proportion of the available cod resource could be found.

A similar situation may exist with the relative availability of sand launce to kittiwakes and murres; fewer sand launce are probably available to kittiwakes than to murres in any year. This difference would tend to be exaggerated in years of low population levels of this fish. That sand launce were recovered from stomach contents of both murres in 1976 but not from stomachs of kittiwakes supports this possibility.

C. Horned Puffins

The population of Horned Puffins at Cape Thompson does not seem to have appreciably changed in size in the past 15 years. Our counts and comparative data from 1960 are presented in Tables 19-23. We counted 1345 puffins at all five colonies and an additional 75 between colonies 1 and 2. When counts of colonies 2, 3 and 5 are compensated for daily activity patterns (Tables 24 and 25: the values of colonies 1 and 4 are the highest of several complete counts), a total of 1918 is obtained. Counts which Swartz compensated much the same way we did yielded 1902 puffins in 1960. These compensated totals may be higher than the number of birds actually present at the cliffs; the real number probably lies between the raw and compensated scores.

The breeding cycle seemed to get underway later for puffins this year also. A few birds could be seen on the cliffs and in the water in front of the cliffs when we arrived on 19 June, but they were not numerous until the first week of July. We were able to locate nine nests which were accessible for observation. Each nest contained one egg, one of which was laid between 16-20 July and another of which was probably laid after 20 July. Laying began about 25 June in 1960 and during the first week of July in 1961 and the first egg hatched on 12 August in 1960. None of the eggs we observed had hatched by 25 August.

D. Glaucous Gulls

We obtained Glaucous Gull nest totals for only three of the five colonies at Cape Thompson in 1976. The major nesting area at colony 3 was inaccessible to us and counts of probable nests made from offshore on 20 June could not be substantiated. We did not investigate colony 5 until late in the season. Our data and those of Swartz's from 1960 and 1961 are presented in Table 26. Although the distribution of nests among the colonies was somewhat different this year, the total nesting pairs was about the same as in 1960 and 1961.

Plot	1976	1960
A	26	17
B		147
C	65	40
D	12	23
E	72	87
F	11	0
G	19	25
H	35	50
I	1	28
J		0
Total	241	417

Table 20. Colony 2 Horned Puffin census

	10 August 1976			
Plot	Time	Raw	Time Comp.	1960
A_1	2330	7	17	2
A_2		0	0	10
B		11	26	0
C		9	21	15
D		22	52	19
E		39	93	35
F		5	12	9
G		17	40	15
H	2200	31	74	46
J		28	39	69
K		22	31	6
L				9
M		13	18	13
N		9	13	9
O		8	11	14
P		12	17	16
Q		9	13	13
R		2	3	2
S		36	51	28
T				13
U		5	7	8
V	2100	14	19	5
W		7	8	7
X		22	25	8
Y		16	18	27
Z		3	3	3
AA		0	0	0
BB		8	9	22
CC		0	0	2
DD		0	0	7
EE		2	2	7
FF		1	1	2
GG	2020	5	6	0
Total		387	663	465

Table 21. Colony 3 Horned Puffin census.

Plot*	23 July 1976 Time	Raw	Time Comp.	1960
A	2115	6	7	11
B	2105	1	1	0
C	2100	0	0	25
D	2100	0	0	3
E	2055	8	13	3
F	2050	0	0	0
G	2025	17	27	42
H	2010	11	18	14
I	1955	5	11	22
J	1945	1	2	17
K	1920	0	0	14
L	1900	0	0	0
M	1845	0	0	3
N				0
O	1600	6	50	0
P	1600	2	17	0
Q	1520	4	33	8
R	1450	0	0	3
S	1430	4	21	0
T				3
U				3
V				0
W				8
Total		65	200	179

*plots used in 1976 do not necessarily correspond to plots used in 1960

Table 22. Colony 4 Horned Puffin census.

Plot	Time	9 Aug. 1976	1960
A	1845	4	2
B	1845	0	14
C	1900	47	17
D	1930	11	3
E	1910	11	8
F	1917	0	0
G	1923	4	0
H	1940	14	11
I	1940	0	0
J	2010	13	17
K	2000	2	6
L	2016	5	8
M	2035	9	16
N	2017	32	20
O	2015	5	2
P	2025	8	18
Q	2038	5	16
R	2045	10	10
Total		180	168

Table 23. Colony 5 Horned Puffin census.

Time	Plot	22 August 1976 Raw	22 August 1976 Time Comp.*	1960
1810	A	12	12	
	B	15	15	
1820	C	31	31	
	D	15	15	
1900 approx	E	26	26	
	F	53	61	
	G	54	62	
1940	H	36	41	
2000 approx	I	63	72	
	J	45	52	
	K	85	98	
2050	L	64	74	
Total		499	559	540

*compensated on the basis of Colony 2 diurnal activity curve

Table 24. Horned Puffin diurnal activity pattern, Colony 2, 18-19 August 1976.

Time	Average no. during hour	Maximum no. during hour	Percent of maximum
1800	33	45	100
1900	31	39	87
2000	30	39	87
2100	27	32	71
2200	14	19	42
2300	4	4	9
2400			
0100			
0200	1	1	2
0300	0	0	
0400			
0500	2	2	4
0600			
0700	2	2	4
0800	1	1	2
0900	2	3	7
1000	3	7	16
1100	11	12	27
1200	10	12	27
1300	15	15	33
1400	14	16	36
1500	20	22	49
1600	21	21	47
1700	19	20	44

Table 25. Horned Puffin diurnal activity pattern, Colony 3, 25-28 July 1976.

Time	No.	% of Max.
0100		
0200		
0300	4	25
0400		
0500		
0600	6	37
0700		
0800	3	19
0900	4	25
1000		
1100	1	6
1200	1	6
1300	2	12
1400	3	19
1500	2	12
1600	2	12
1700	2	12
1800	2	12
1900	7	44
2000	2	12 (62*)
2100	13	81
2200	16	100
2300	15	94
2400	16	100

$$*62 = \frac{\%\ 1900 + \%\ 2100}{2}$$

Table 26. Number of nesting pairs of Glaucous Gulls at Cape Thompson.

Colony	1976	1961	1960
1	41	60	52
2	30	20	27
3	57*	52	61
4	16	2	3
5		16	7

*unconfirmed count

Inclement weather prevailed for several days after our arrival at Cape Thompson and the gulls were not disturbed, therefore, until late June and early July. Many of the eggs had hatched by that time and we were able to obtain clutch sizes for only half of the accessible nests. On 28 June and 4 July, 29 nests in colonies 1 and 4 were examined for contents (see Table 27). Of the nests which contained eggs only, two egg clutches were the most common; the mean clutch size for 15 nests was 2.07. Swartz reported 40 out of 50 nests in 1960 contained three eggs and the mean clutch size was 2.86. Because egg loss frequently occurrs during incubation, the mean clutch size we report may be misleading. If egg counts had been made earlier in the season, the difference between our data and those of Swartz would probably have been less.

Table 27. Contents of Glaucous Gull nests at colonies 1 and 4 on 28 June and 4 July, respectively.

Number of one-egg nests	Number of two-egg nests	Number of three-egg nests	Number of nests with 1 egg and 1 chick	Number of one-chick nests	Number of two-chick nests	Number of three-chick nests
1	9	4	3	6	3	3

One chick broods which were most frequently encountered probably represent loss of one or more eggs or chicks from larger nests rather than the number of one egg clutches. Repeated visits throughout the summer were made to the principal nesting area at colony 1 and contents of accessible nests were counted. The results of these visits are presented in Table 28. These data suggest some loss of eggs and nestlings prior to fledging; they should not be interpreted as fledging success, however.

Table 28. Success of Glaucus Gull nests at colony 1 between 28 June and 4 August.

Date	Number of nests	Number of eggs	Number of chicks	Total eggs and chicks per nest
28 June	16	20	13	2.1
16 July	19	2	33	1.9
4 August	21	0	29	1.4

Progression of the breeding cycle in gulls, like murres and puffins, also was later in 1976 than during the Project Chariot years. Swartz (1966) reported that most of the gull eggs hatched during the last half of June in 1959-1961. Fewer than half of the eggs in 1976 had hatched by late June (see Table 28).

Depredation of gull nests by foxes was substantial during the years of Swartz's study, especially at colony 9. Swartz reported that only one or two young fledged each year from all of Crowbill Point were 55 to 60 nesting attempts were made. The other colonies were affected to a lesser extent. We have evidence of only one instance of fox predation on gull nests. Four nests containing a total of eight eggs at colony 4 were lost between 7-13 July. All of the nests were located in the same small area of the colony which was easily accessible. A red fox (Vulpes fulva) had been seen in the vicinity of these nests during the same time. The sighting of this fox was one of only three reported throughout the summer. Swartz reported that foxes were common all years of his study.

Subadult Glaucous Gulls do not associate with birds at the breeding colonies at Cape Thompson until later in the summer; none were seen until 1 August. By 20 August gulls were beginning to flock and subadult birds accounted for about 7% of 164 gulls observed in four groups on that date. Seventy one per cent of these gulls were adults and 23% were immatures. These percentages do not accurately reflect the age structure of this population, however, because many of the adults were still remaining on nesting territories and not all of the young had fledged.

D. Pelagic Cormorants

Table 29 lists the numbers of cormorant nests found in 1976 and during the years of Swartz's studies. Somewhat fewer birds bred this year than in 1960 and 1961 with the greatest difference being seen at colony 2. In 1960 a concentration of nests was found at colony 2 which had not been seen the year before. Swartz suggested, therefore, that the change in the number of nests from 1959 to 1960 may not reflect a real increase. We found only two nests in colony 2 in 1976 and the same concentration was perhaps overlooked by us. A thorough search was conducted of this colony, however, and we do not think that we missed many nests.

Only two nests were situated so we could not see into them at least well enough to count the chicks once they were fairly large. In three nests at colony 1 we were able to count eggs and see when they hatched. The progression of events in these nests is presented in Table 30. Of the 15 nesting attempts by cormorants this summer, one failed when a large rock fell into it and a second failed for unknown reasons. Both failures occurred during incubation. The adults of a third nest were still incubating or brooding late in the season and we do not know what the contents of this nest were. By 16 August three of the remaining 10 nests contained three chicks each, six contained two chicks each and one had only one chick. The average production of these ten nests plus the two which failed was 1.8 young per attempt. Drury (1976) reported breeding successes of 1.9 chicks per nest at Sledge Island, 1.6 at Topkok and 1.5 at Bluff.

F. Tufted Puffins

Tufted Puffins were counted during all census activities and at other times when we traveled past the cliffs. The numbers presented in Table 31 are the highest counts we obtained for each colony during the summer. No major differences between our data and Swartz's are apparent.

We were able to reach one burrow located at colony 2, and could see that it contained one egg on 17 August. Swartz was unable to confirm actual breeding of this species at the Cape Thompson colonies.

Table 31. Population of Tufted Puffins at Cape Thompson 1959-1961 and 1976.

Year	1	2	3	4	5	Total
1959	4	18	0	0	0	22
1960	20	12	0	0	4	36
1961	6	34	0	0	0	40
1976	24	13	1	0	6	44

G. Guillemots

Pigeon and Black Guillemots were seen occasionally in June and early July, but were uncommon later in the summer. Fewer than 20 observations of each were made and no evidence of nesting by these species was seen.

Table 29. Nests of Pelagic Cormorants at Cape Thompson, 1959-1961 and 1976.

	Colony					
Year	1	2	3	4	5	Total
1959	1	1	0	4	0	6
1960	3	18	0	1	1	23
1961	4	18	0	1	0	23
1976	7	2	0	5	0	14

Table 30. Events at three Pelagic Cormorant nests at Cape Thompson, 1976.

Date	Nest A	Nest B	Nest C
6 July	4 eggs	4 eggs	--
11 July	4 eggs	2 eggs (1 pipping) and 1 chick	2 eggs and 2 chicks
16 July	3 eggs	2 eggs and 2 chicks	2 chicks
4 August	2 chicks	2 chicks	2 chicks
16 August	2 chicks	2 chicks	2 chicks

H. Raptors and Ravens

One pair of Gyrfalcons nested at Cape Thompson in 1976. The site they occupied was the same one used by gyrs in 1961 and by peregrines in 1959. Three chicks fledged from this nest between 17-24 July and were frequently seen in the area during the remainder of our stay. A single adult female gyr was seen at colony 5 on 20 August.

Prey remains were obtained from below the nest in mid-July. Out of approximately 20 kills, two female Common Eiders (Somateria mollissima) and about ten murres were identified. The other remains were of ptarmigan (Lagopus sp.) and Arctic ground squirrels (Citellus undulatus) and were about evenly divided between these species. Ptarmigan and ground squirrels are the staple food of gyrs on the Seward Peninsula (Roseneau 1972).

A pair of Golden Eagles successfully fledged one young from a typical stick nest situated at the north end of colony 2. The chick was nearly fully feathered on 21 August and probably made its first flight about that time. At least one pair of adult eagles were present at the colonies each year of Swartz's study although he found no evidence that they bred (Swartz pers. comm.).

Sub-adult eagles were seen occasionally throughout the summer of 1976 as they were during 1959-1961 (Swartz pers. comm.). Considering the abundance of food, it is not surprising that eagles would be attracted to these colonies.

No Peregrine Falcons were seen in 1976. Two pairs were regularly seen in 1959 and one of them fledged two young. One pair was present in both 1960 and 1961; two chicks fledged in 1960 and three fledged in 1961 (Swartz 1966).

Ravens were common all summer at Cape Thompson and at least one pair nested there. The nest of this pair, which had four recently fledged young on 28 June, was located between colonies 1 and 2. A second family group of four or five birds was seen near colony 3 on 2 July and this pair may also have nested somewhere on the seacliffs.

The number of ravens in the area increased steadily during July and August. On 20 August one group of 14 individuals was seen at the north end of colony 5 and several others had been observed earlier between there and Crowbill Point. These birds fed heavily, perhaps exclusively, on murre eggs and chicks.

I. Cape Lisburne

A brief reconnaissance of the rookeries at Cape Lisburne was conducted between 25 August and 1 September. Because only fragmentary information on the extent of this colony exists, we wanted to prepare ourselves for intensive studies which will be conducted this summer. And because of the "unusual" season we had just observed at Cape Thompson, we were eager to obtain data on the general timing of the breeding activities and reproductive success of the birds nesting there.

Murres were the only species for which a population estimate was actually made; the order of abundance and relative numbers of the other species at Cape Lisburne appeared to be similar to those at Cape Thompson. The whole of the area used by murres was divided into 75 plots; the boundaries of these plots were marked on polaroid photographs taken at the time. The number of murres in each plot was then estimated by 10's or 100's. No attempt was made to compensate these counts by observer handicap or time of day. Our raw scores for all plots totaled about 130,800 murres.

The reproductive success of kittiwakes at Cape Lisburne, although also poor, was better than at Cape Thompson. Many more nests had been constructed and these were much larger than any we had seen at Cape Thompson. On 27 August we looked into 140 kittiwake nests: three contained single eggs, one of which was addled; 12 contained one live chick each; eight contained one dead chick each; and eight were covered by sitting adults. These data are presented in Table 32. The low overall success and the high relative number of dead chicks suggest low food availability for kittiwakes in this region as well.

Table 32. Contents of kittiwake nests at Cape Lisburne, 1976.

Date	Time	Area	Number nests	Number eggs	Number live chicks	Number dead chicks	Adults sitting tight
27 Aug.	1025	1	78	1	7	3	7
27 Aug.	1325	2	23	1	4	2	0
27 Aug.	1330	3	14	0	0	2	1
27 Aug.	1345	4	25	1 (addled)	1	1	0

Our observations at Cape Lisburne indicate that the timing of breeding activities there was about one to two weeks ahead of Cape Thompson. On 28 August we observed probably the first sea-going of murre chicks; the oldest chicks at Cape Thompson the week prior to this observation were about 7-10 days old. The majority of the live kittiwake chicks we observed at Cape Lisburne were also about a week older than those at Cape Thompson.

J. Miscellaneous Observations

Observations other than those of seabirds were made throughout the summer of 1976. Certain of these were of general or specific biological interest and are reported in Appendices 2-5.

VIII. CONCLUSIONS

The seabirds, especially the murres and kittiwakes, which nest at Cape Thompson and at Cape Lisburne constitute major components of the southeastern Chukchi Sea ecosystem. These birds have, additionally, some economic value to the people living in the area as well as aesthetic value to many others.

Approximately 50% fewer murres were present at the Cape Thompson colonies in 1976 than were there in 1960 and 1961. The number of kittiwakes could also have been as much as half that of 1960 and 1961. No large differences were seen in the numbers of other birds nesting at this colony in 1976 compared to previous years.

The timing of phenological events of most species nesting at Cape Thompson was about 7 to 14 days later in 1976 than in 1960 or 1961, but was similar to 1959.

Few kittiwakes bred at Cape Thompson in 1976 although gonadal activity and behavior characteristic of breeding were partially developed.

The kinds and frequencies of prey identified in stomach contents of murres and kittiwakes suggest that the relative availability of food fish, particularly Arctic cod and sand launce, may have been low in 1976. This possible food shortage may have contributed to the kittiwake reproductive failure.

The reproductive success of kittiwakes at Cape Lisburne was only somewhat better than at Cape Thompson. Food shortage is also implicated as a causative factor in this breeding failure.

The schedule of breeding activities was about two weeks earlier at Cape Lisburne than at Cape Thompson.

The birds nesting at Cape Thompson and at Cape Lisburne could be threatened by OCS development in several ways. Murres especially concentrate in leads in the sea ice during early summer. Breeding activities begin long before the ice has broken up or gone out from shore and the only open water available to the birds is in leads. If these leads were contaminated by spilled oil, large numbers of birds would be affected.

Currents originating south of Bering Strait could bring spilled oil through feeding areas and on to the beaches and nearshore regions at Cape Thompson. Contamination of individual birds as well as the food web could occur.

Summer storms coming out of the west could move oil spilled in the Hope Basin into critical seabird habitat. These storms and the presence of ice for much of the year would make oil cleanup operations difficult.

IX. NEEDS FOR FURTHER STUDY

We do not feel it appropriate to base any speculations on current population trends in the Cape Thompson colonies on data obtained this summer. Those factors which delayed the breeding season of most species, and which possibly affected the reproductive success of kittiwakes may have also affected the population size of murres. It would certainly be premature to suggest that there are now only half as many murres at Cape Thompson as there were in the early 1960's. Efforts should be made to determine the population size of murres in another year when conditions might be more favorable for breeding.

The same is true of kittiwakes. Based on our results from this summer, we can make no statements regarding the current status of the population. Kittiwakes are known to have failed at other colonies in other years and at many colonies in 1976. Valuable information could be gathered next summer on the response of these populations to years of little or no reproductive success.

Additional data concerning the observed differences in the timing of the breeding cycles and the success of the kittiwake breeding efforts at Cape Thompson and Cape Lisburne need to be obtained. Precautions taken to avoid disturbing the colonies in one area may necessarily have to be different than those taken in other areas.

A better understanding of the feeding areas of the birds nesting at these colonies is required to help elucidate the ecology of the Cape Thompson-Cape Lisburne region. Petroleum development in these and "down-current" areas could threaten feeding birds as well as the food base upon which the birds depend.

A relatively good data base exists which serves to identify important prey species of murres and kittiwakes. The continued acquisition of food habits data will be helpful, especially in detecting seasonal dietary changes which may be critical to these birds. Life history information pertaining to prey species, their habitat requirements, food habits and requirements, regional, local and seasonal abundance and their susceptibility to petroleum is also needed. Because many prey animals important to seabirds at Cape Thompson and Cape Lisburne are also important to several of the marine mammals which inhabit the same waters (Lowry and Burns 1976; Lowry pers. comm.), knowledge of this type would be especially useful.

There is need for additional information similar to that obtained by Fleming and Haggerty (1966) on wind-driven, surface and subsurface currents in the Chukchi Sea. These data could help predict the destination of floating or ice-borne oil (see Hufford et al. 1976) and would be valuable in obtaining a perspective on the relationship between resource development in the Hope Basin and the seabird colonies at Cape Thompson and Cape Lisburne. Additionally, the studies of Fleming and Haggarty (1966) and recent satellite imagery suggest that a gyre effect in the sea currents may occur at approximately 69°30'N, 166°W and 67°N, 166°W; this needs further investigation.

X. SUMMARY OF 4TH QUARTER OPERATIONS

A. Ship or laboratory activities

1. No field work was conducted during the 4th quarter.

2. The scientific party for the 4th quarter included: Alan M. Springer, PI; David G. Roseneau, PI; Craig M. Lowe, Biologist; Dr. Peter Craig, Fisheries Biologist; and Garry McGonigal, Systems Analyst.

3. Identification of remaining food samples were made using standard taxonomic keys and comparative material. Assistance on specific problems was obtained from George Mueller (University of Alaska, Fairbanks), Kathy Frost (ADF&G, Fairbanks) and Dr. James Morrow (University of Alaska, Fairbanks).

4. No samples were taken during the 4th quarter.

5. No field data were collected during the 4th quarter. Identification of prey species from murre and kittiwake stomach samples was completed by Dr. Peter Craig, Aquatic Environments Ltd. Several parasite specimens, including one tick obtained from a Common Murre, were sent to Dr. Robert Rausch, University of Saskatchewan, for positive identification. Compilation of all pertinent data into tabular form was completed. A meeting with Mike Crane, EDS Liaison Officer (AEIDC) and Garry McGonigal, RRCS Systems Analyst, was held on 25 February in Fairbanks, Alaska. Computerization of data and compatibility with present programs were discussed. Taxonomic codes were finally obtained in mid-March. Data sheets and a data management plan are now being prepared in preparation for coding and entering data. Maps and tabular data pertinent to the Cape Thompson and Cape Lisburne seabird colonies, including colony locations and population estimates and general phenological data were submitted to the OCS Arctic Project Office, Beaufort/Chukchi Sea Synthesis Meeting held in Pt. Barrow, Alaska on 7-11 February 1977. These data and comments will be incorporated in a forthcoming synthesis report.

6. Field work at Cape Lisburne was rescheduled for summer, 1977, and a plan to modify data collection at Cape Thompson to include the 1977 field season was developed (see "A Modification of Field Plans, Cape Thompson/Cape Lisburne Seabird Investigations" RU No. 460/461 submitted to the OCS Arctic Project Office 16 February 1977). This schedule change is a result of 1976 sea-ice conditions, the lateness of many of the phenological events and the nearly total reproductive failure of Black-legged Kittiwakes at Cape Thompson and Cape Lisburne in 1976.

Schedule updates are as follows: Now that taxonomic codes and data formats are available, coding and keypunching of 1976 data will commence in the 1st quarter of 1977. Data submission should be complete by the end of that quarter. Final data submissions and reports are to be submitted at the end of the 3rd quarter. A preliminary reconnaissance of the Cape Lisburne seabird colonies was made 25-29 August in preparation for 1977 field work.

B. Problems encountered/recommended changes

No major logistical, scientific or management problems were encountered beyond the influences of weather, the lateness of 1976 phenological events and the difficulties associated with the kittiwake reproductive failure.

We strongly recommend serious consideration be given to adjusting the final completion date of 30 September 1977, to allow adequate time for comparative analysis of 1976-1977 data. The comparisons between years and between the Cape Lisburne and Cape Thompson colonies will be invaluable.

C. Estimate of funds expended

Cape Thompson	
Personnel	$36,584.26
Expenses	20,663.30
Total	$57,247.56
Cape Lisburne	
Personnel	$ 434.94
Expenses	0
Total	$ 434.94
Grand Total, RU 460/461	$57,682.50

XI. APPENDICES

Appendix 1. References pertinent to the Cape Thompson seabird colonies: from Swartz (1966)

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Appendix 2. Whale observations in the Cape Thompson vicinity, 19 June-25 August 1976

The inshore waters between the Televirak Hills and Kemegrak Lagoon may be important to grey whales (Eschrichtius robustus) during late summer. Whales were observed on four occasions between 9 August and 20 August in this area. One additional sighting occurred on 2 July when a "small, dark" whale sounded in loose ice about three kilometers offshore. The species of this whale was not determined.

Martha Robus (pers. comm.) observed three large whales stop traveling south of Ogotoruk Creek and move in close to the beach on 9 August. They then began to "play" by blowing, rolling and sticking their heads out of the water and continued to do so for some time. Although the whales were not positively identified, her description suggested that they were grey whales.

Three grey whales, two larger ones and a smaller one, were observed just south of Cape Thompson on 10 August. The whales stopped their northward travel near a gravel beach at about 1600 hours and became very active. For the next 2.5 hours all three animals were observed performing various movements between 10 and 50 meters from the beach. The activities consisted of incomplete lateral rolls, sounding and remaining on or near the bottom, surfacing and extending their heads 2-3 meters straight out of the water and "wallowing" near shore. At 1925 hours first one and then the other two whales moved off northward past Cape Thompson. At least two more grey whales were seen blowing while moving rapidly north about 100-200 meters offshore during the next hour.

One or more greys were seen off of Crowbill Point on 13 August and on 20 August a large grey whale was encountered within 100 meters of the beach in front of colony 2. The whale was traveling northward and after several minutes of pacing our slowed boat, it dropped behind and stopped close inshore near a gravel beach. This whale also executed a variety of movements similar to those seen on 10 August.

While feeding during the summer in these northern waters, grey whales and possibly other species may be attracted to the relatively steep gravel beaches which occur intermittently with the sea cliffs and bluffs in the Cape Thompson region. The steep slope continues away from shore and allows these large whales to approach closely where they may utilize the coarse gravel bottom to rub barnacles and other ectoparasites from the epidermis. These observations suggest the Cape Thompson vicinity also may be important to the social behavior of grey whales. Elsner (pers. comm.) has seen similar behavior in wintering grey whales in shallow Mexican bays.

Appendix 3. Hoary Marmot (Marmota caligata) observations at Cape Thompson and Cape Lisburne, 1976

Pruitt (1966) listed one specimen of this mammal obtained at Inuktak Creek, near the Cape Thompson area in 1970. He also discussed the distribution of this species and its historical significance to the local people of the area. On 24 July we observed one adult on top of the northern end of colony 3 and discovered a den in a rock outcropping. On 26 July the site was revisited, and one adult and three young were present. The largest young appeared to be approximately one-third the size of the adult; the smallest about one-quarter the size. On 27 August a hoary marmot was observed in a boulder pile on the beach about 0.4 kilometers east of Nipple Point near Cape Lisburne. Ten minutes later and a short distance farther west, two additional individuals were observed in another boulder pile.

Appendix 4. Porcupine (Erethizon dorsatum) observations at Cape Thompson, 1976

Pruitt (1966) comments on the remarkable number of records he compiled of this species in the study area. He suggests that the occurrence of this mammal in the summer is understandable from the perspective of food availability, but that "...it is almost inconceivable that an herbivorous mammal of such a size, without apparent behavioral or morphological adaptations for subnivean existence, could survive the winter in a tundra environment." Pruitt further speculates that individuals found in the Cape Thompson area may be "...wanderers, nonbreeders, and probably young animals." On 2 July we discovered the partial skeletal remains of a porcupine on Cape Thompson. The condition of the remains suggested it was probably an individual which had died the previous winter.

Appendix 5. Rediscovery of *Erigeron grandiflorus Muirii* in its type locality

The Cape Thompson vicinity is the type locality of *Erigeron grandiflorus* Hook, subspecies *Muirii* (Gray) Hult., a member of the Composite family (Hultén, 1968). This fleabane was first discovered by Muir (1883) in 1881 during his cruise aboard the revenue-steamer Corwin to the northwest Arctic Ocean and Chikchi Sea. Muir collected only a single specimen of this plant at Cape Thompson; another specimen that may have been this same plant was collected on Wrangell Island during the same journey. The Cape Thompson specimen was described and named by Gray in 1882; it appears as *E. muirii* in the Proceedings of the American Academy, 17:210.

Since Muir's time, specimens of this rare taxon have never been relocated in its type locality or on Wrangell Island (Murray pers. comm.). During the extensive botanical field investigation conducted by Johnson *et al.* (1966) at the Ogotoruk Creek Project Chariot site in 1959-1961, no specimens were found. L. M. Belson (unpublished field notes), working in 1960 at the Cape Thompson seabird colonies, reported the possible occurrence of this plant in a creek bottom between colony 3 and colony 4. He collected a specimen, later examined by A. W. Johnson, Project Chariot botanist, who determined it to be a more common *Erigeron* species.

Erigeron grandiflorus Muirii is both quite rare and very localized in its occurrence (Murray pers. comm.). Wiggins and Thomas (1961) reported the few specimens examined from Kanayut Lake, Anaktuvuk Pass and Cape Thompson. Hultén (1968) suggested a few additional locations where this taxon may occur. During the past several summers a few new specimens have been discovered in the Brooks Range, at one location in the Canning River drainage and at one location along the Alyeska Haul Road near the Sagwon bluffs (Murray pers. comm.).

On 25-26 July 1976, 95 years after the original type specimen was collected at Cape Thompson by Muir, this plant was rediscovered by chance in its type locality during our seabird investigations there. A few specimens were collected in full flower and returned to the University of Alaska, Fairbanks, where our tentative identification was confirmed by Dr. D. F. Murray, Herbarium Curator.

Our specimens came from a small area estimated to be approximately 100 x 100 meters in extent along the seaward edge of the southwestern end of colony 3 just below its upper elevations. The plot was centered between about the 150-180 meter contour interval (Fig. 2). The majority of the specimens were found to inhabit a much smaller "core" area approximately 10 x 30 meters within the above plot. Throughout our 1976 field work, numerous hikes were conducted along the tops of colonies 1-5 and on the intervening hills and ridges. Several excursions also were made to the top of the hills near the Tumi Creek headwaters. No other occurrence of this taxon was discovered in any of these similar locations.

Comments received with regard to this find emphasize that this plant may prove to be endemic to the Cape Thompson-Brooks Range region (Murray pers. comm.). Murray (pers. comm.) also suggests this taxon may prove to be distinct at the level of species; he does not necessarily agree with the subspecific treatment, based partially on European specimens, given it by Hultén (1968).

The 100-200 specimens we located on the colony 3 hillside above Ikijaktusak Creek also appear to represent by far the largest and densest concentration of these plants located to date; other locations have contained relatively few specimens (Murray pers. comm.). The rarity of this taxon and the obvious botanical value of this particular concentration of this plant species in its type locality strongly suggest that this area receive special attention and any protective measures necessary to ensure the plants continued survival there.

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FINAL REPORT

SOME ASPECTS OF THE ECOLOGY OF CLIFF-NESTING SEABIRDS AT KONGKOK BAY, ST. LAWRENCE ISLAND, ALASKA, DURING 1976

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INTRODUCTION

The process of selling oil leases along the outer continental shelf of Alaska has already begun. Leases in the northern Bering Sea-Norton Sound area are expected to be sold during 1979. Offshore oil-drilling activities in the northern Bering Sea region will probably begin soon thereafter. Before such activities begin it is important to know what effects they may have on the marine ecosystem. It is especially important to know both the potential for disturbance to nesting seabirds from such activities and the potential for the destruction of these birds from accidental oil spills.

The National Oceanic and Atmospheric Administration (NOAA) has initiated a program to provide baseline data on the species and populations of birds that may be exposed to impacts from petroleum development on the outer continental shelf of Alaska. During 1975, NOAA initiated a series of studies of seabird colonies at various sites along the coast of Alaska. Only one of these studies was located in the northern Bering Sea-Norton Sound area. In order to expand the scope of the studies in the Bering Sea-Norton Sound area, the present study was initiated during 1976 to provide data on the phenology, abundance, productivity and food habits of the major seabird species that nest on St. Lawrence Island.

The seabirds of St. Lawrence Island were little studied previous to 1964. Since then, four species or species groups have been studied; two of these studies were of auklets (Bédard 1967, 1969a,b; Sealy 1968, 1975; Sealy and Bédard 1973), one of murres (Johnson and West 1975), and one of Horned Puffins (*Fratercula corniculata*) (Sealy 1973). Ornithological observations prior to these studies have been summarized by Fay and Cade (1959). Recent phenological data for seabirds on St. Lawrence Island have been reported by Thompson (1967), Sealy (1967), and Johnson (in press). Throughout this report, I have made an attempt to compare the data collected during 1976 with the existing published and unpublished data for seabirds on St. Lawrence Island.

The primary objectives of the present study were to document

1. the breeding season phenology of seabirds at Kongkok Bay with major emphasis on
   (a) the arrival of birds in the St. Lawrence Island area,
   (b) the arrival of birds on the cliffs and talus slopes,
   (c) the initiation and peak of laying,
   (d) the initiation and peak of hatching, and
   (e) the initiation and peak of fledging;
2. the numbers of birds in the Kongkok Bay area;
3. the reproductive success of
   (a) Least Auklets (*Aethia pusilla*) and Crested Auklets (*Aethia cristatella*),
   (b) Common Murres (*Uria aalge*) and Thick-billed Murres (*Uria lomvia*), and
   (c) Black-legged Kittiwakes (*Rissa tridactyla*); and
4. the food habitats and feeding areas of
   (a) Least and Crested Auklets, and
   (b) Common and Thick-billed Murres.

Secondary objectives of this study were to document

1. the relation of auklet density to the physical features of their habitat; and
2. the rates and patterns of growth of chicks of Least and Crested Auklets.

The results of this study, when combined with those of other NOAA seabird studies, will provide baseline information that can be used both to assess the potential impacts of the proposed offshore oil developments on the seabird populations of the area and to develop environmental recommendations to mitigate these impacts.

The emphasis of the following report has been placed on the most abundant seabird species in the Kongkok Bay area. These species include Least Auklet, Crested Auklet, Common Murre and Thick-billed Murre and Black-legged Kittiwake. In order to avoid unnecessary repetition, the report is organized according to the following major headings: Phenology, population estimates, breeding biology and food habits and feeding areas.

STUDY AREA

St. Lawrence Island, Alaska, lies in the Bering Sea approximately 200 km southwest of Nome, Alaska, and 64 km southeast of the Chukotsk Peninsula, U.S.S.R. The area of St. Lawrence Island is approximately 5100 km^2. More than two-thirds of the island is low-- <60 m above sea level (ASL)--and wet. Most upland portions of St. Lawrence Island are located in three mountain ranges: the Kinipaghulghat Mountains, the Kookooligit Mountains, and the Poovoot Range. Most of the sea-cliffs and talus slopes that are heavily used by seabirds are part of the latter two mountain ranges.

The locations of the major breeding colonies of seabirds on St. Lawrence Island are presented in Figure 1. The information presented in Figure 1 is not a complete atlas of seabird colonies on St. Lawrence Island, but rather it represents a summary of colony locations that have been reported in the literature.

This study was conducted in the Kongkok Bay area (63°24'N; 171°49'W) on the southwestern portion of St. Lawrence Island, at the southwest end of the Poovoot Range. The study area included the region from Galuk to near Tatik Point (Figure 2); the main areas investigated were the cliffs and talus slopes of Owalit Mountain and a large cirque basin, locally known as Kongkok Basin, which is located on the side of Ivekan Mountain. St. Lawrence Island has an arctic maritime climate characterized by milder winters and cooler summers than are experienced in arctic continental areas (Fay and Cade 1959:76). Although summer temperatures at Gambell seldom exceed 10° to 15°C, the temperatures at Kongkok Bay are normally higher. Appendix 1 gives the maximum and minimum temperatures that were recorded at Kongkok Bay during the period from 31 May to 1 September 1976.

A general account of the vegetation and climate of St. Lawrence Island and a review of botanical work is included in Fay and Cade (1959). Hultén (1969) and Young (1971) described the vascular flora of St. Lawrence Island. With the exception of these general works, almost no botanical information is available for Kongkok Bay. The predominant vegetation in the Kongkok Bay area is composed of lichens, grasses and several species of forbs.

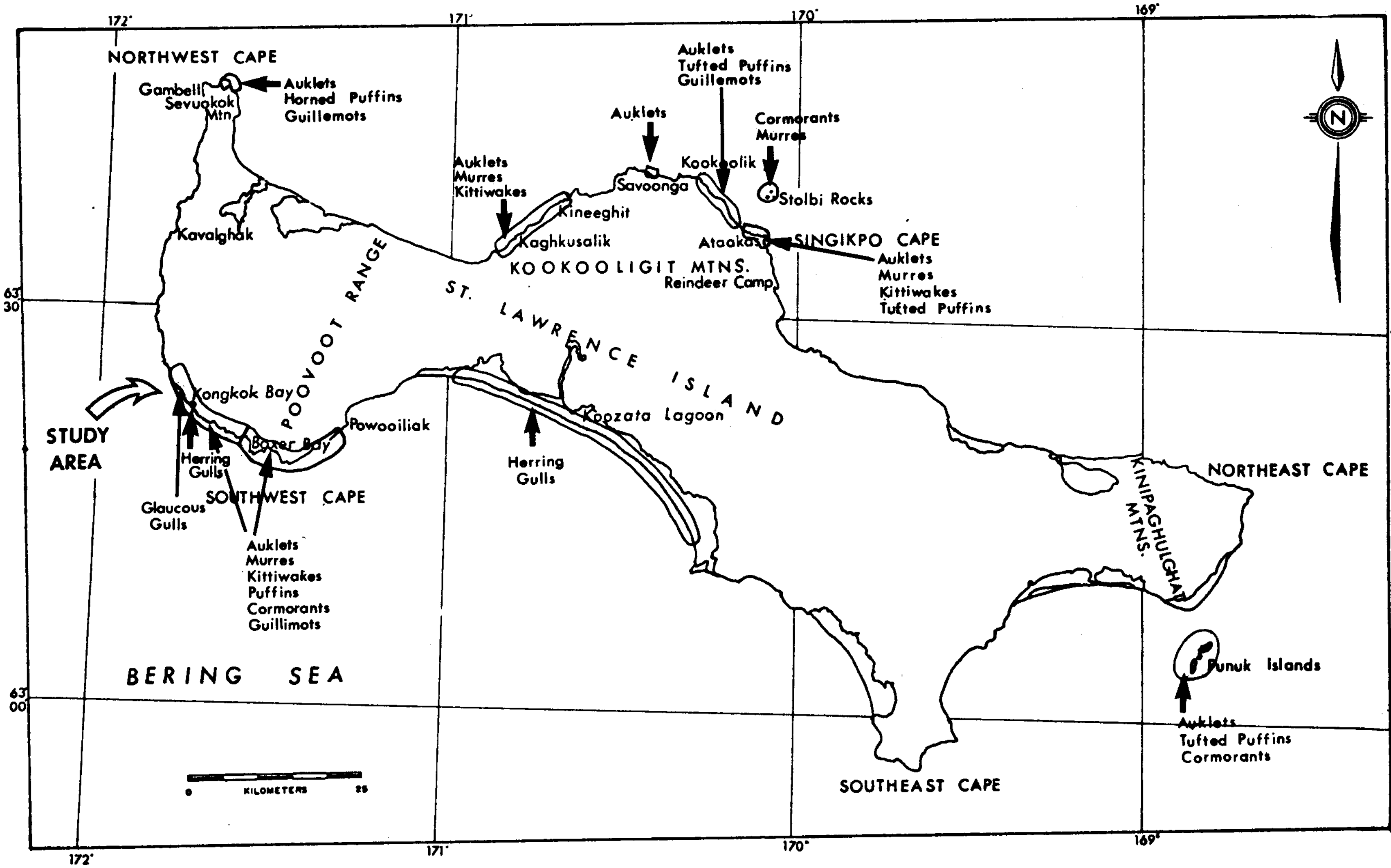

FIGURE 1. Map of St. Lawrence Island and Location of Study Area. Overlay depicts location of known seabird colonies and the species present at each.

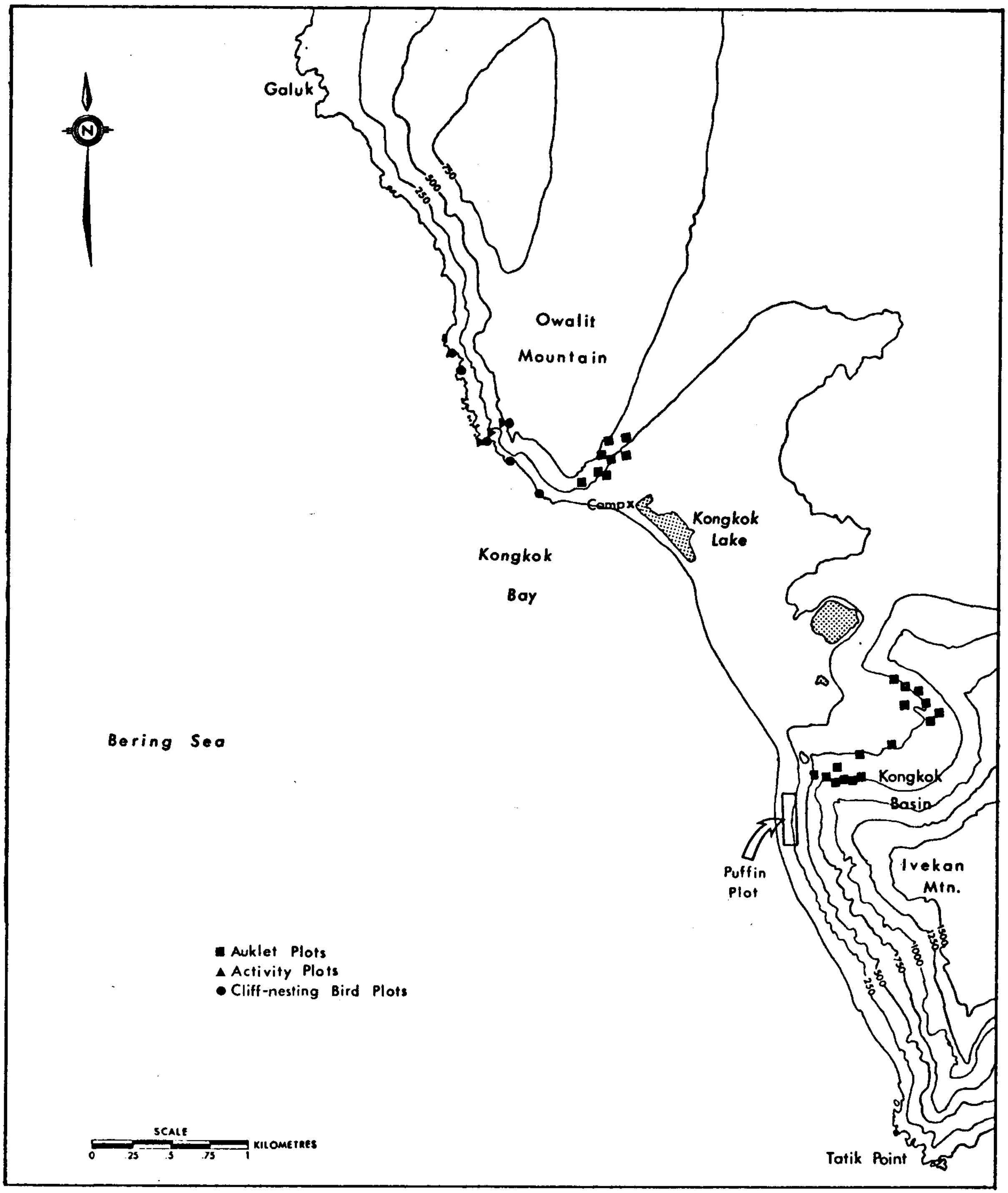

FIGURE 2. Location of Study Plots at Kongkok Bay. See Figure 1 for location of study area relative to St. Lawrence Island.

Seabird Nesting Habitat

Inland Talus Slopes

Kongkok Basin is an immense area of inland talus slope in the shape of a huge amphitheater (see Plate 1, page 22); it rises from about 75 m ASL to over 400 m in height. Almost all of the area on the sides and floor of the basin is covered with scree. The talus slope on the southeast-facing (inland) side of Owalit Mountain (see Plate 2a, page 25) begins about 30 m ASL and extends to approximately 200 m ASL and to a distance of about 750 m inland. A more detailed analysis of the talus characteristics is found in the results section below.

Three species of auklets, Crested, Least, and Parakeet Auklets (*Cyclorrhynchus psittacula*), nest on the talus slopes in the Kongkok Bay area. Crested and Least Auklets, the most abundant of the three species, occupy the talus slopes on both Owalit and Ivekan mountains.

Maritime Talus Slope

The outer (seaward) wall of Kongkok Basin is a very unstable talus slope rising directly from the ocean. The lower portion of this slope is steeper than the inland talus slopes and contains several outcrops of non-fractured parent rock. These areas are used extensively by Horned Puffins and are used to a lesser extent by Tufted Puffins (*Lunda cirrhata*) and Pigeon Guillemots (*Cepphus columba*). Several very large stacks also occur in this area. These stacks are occupied by nesting Horned and Tufted Puffins, Pigeon Guillemots, Pelagic Cormorants (*Phalacrocorax pelagicus*), Glaucous Gulls (*Larus hyperboreus*) and Herring Gulls (*Larus argentatus*). Parakeet Auklets are present in small numbers on the cliffs and maritime slopes of Owalit Mountain.

Sea-cliffs

The southwest face of Owalit Mountain falls off to sea-cliffs that range in height from less than 20 m to more than 200 m (see Plate 2b, page 25). Although sea-cliffs extend from Galuk to Boxer Bay (a distance of more than 15 km), only 4 km of these cliffs were included in the study area, and only about 1 km was intensively investigated. Nine species of seabirds nested on these cliffs:

- Thick-billed Murres
- Common Murres
- Black-legged Kittiwakes
- Pelagic Cormorants
- Glaucous Gulls
- Parakeet Auklets
- Tufted Puffins
- Horned Puffins
- Pigeon Guillemots

METHODS

Phenology

The study was initiated on 14 May 1976 and continued until 3 September 1976. Initial observations of the arrival of birds in the St. Lawrence Island area were made at Gambell (14 May to 26 May 1976). One preliminary trip was made to Kongkok Bay on 19 May 1976; a field camp there was occupied almost continuously from 27 May until 3 September.

Detailed observations were made throughout the study in order to determine the initiation dates and peak dates of

1. arrival in the St. Lawrence Island area,
2. arrival on the nesting cliffs and slopes,
3. nest building (when applicable),
4. egg-laying,
5. hatching, and
6. fledging

for as many species as possible. Throughout this study, primary emphasis was placed on Least and Crested Auklets, Common and Thick-billed Murres, and Black-legged Kittiwakes. Information was collected opportunistically about the other, less abundant species.

Population Estimates

Talus-nesting Birds

In order to calculate the density of breeding Least and Crested Auklets in the Kongkok Bay area, 24 quadrats were established on the talus slopes. Eight of these quadrats were randomly located along the east slope of Owalit Mountain and 16 quadrats were located in Kongkok Basin (Figure 2). Previous to selection of plot locations in Kongkok Basin, the basin was divided into two strata based on gross characteristics of the scree. Eight quadrats were randomly selected in each stratum.

In order to compare data collected on auklets during the present study with data collected by Bédard (1967, 1969a), the methods used to census auklets during this study were identical to those used by Bédard. Each plot was a square 14.2 m to a side (approximately 200 m^2). The four corners of each plot were marked with wooden stakes (topped with brightly coloured flags); plots were subsequently permanently marked with cement spikes.

To avoid disturbance, birds were counted through a spotting telescope at a minimum distance of 50 m. The numbers of Least and Crested Auklets were tallied every 1/2 hr. Counts were made between 05:00 and 08:00 Bering Daylight Time (BDT)* from 2 to 19 June (see Appendix 2). These time and date intervals were chosen to minimize the number of immature auklets that would be counted on the plots. The number of immature auklets on the breeding slopes varies with the time of year and the time of day. Bédard (1967;101) found that immature auklets did not occur in significant numbers until 5 to 10 June and did not reach peak abundance until about 20 June. Furthermore, he noted that during mid-June the peak numbers of adult Least and Crested Auklets were present on the slopes between 05:00 and 08:00 while the peak numbers of immature auklets on the nesting slopes did not occur until after 08:00. All censuses were completed well before immature auklets became abundant on the nesting slopes.

The estimated number of auklets on each plot was taken as the average of the second, third and fourth highest counts made on that particular plot. This method was proposed by Bédard (1969a:387). While I disagree with Bédard's reasons for eliminating one, and only one, of the high counts (because high counts may not occur once, or only once), I concur that low counts are not meaningful when one attempts to estimate auklet numbers. To permit comparisons with Bédard's data, I calculated the number of auklets per plot using Bédard's method.

In order to find potential correlations between the density of auklets and the physical features of their nesting habitat, the following characteristics of each plot were measured:

1. direction towards which the plot faces (0-360°),

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*05:00 BDT = 15:00 Greenwich Mean Time. BDT used throughout this report.

2. approximate altitude of the plot (in feet ASL),
3. average slope (in degrees from horizontal),
4. percent of plot covered with scree,
5. distance of the plot to the edge of continuous talus cover (in metres),
6. depth of scree (in centimetres),
7. sphericity of the particles (1 = angular to 5 = round),
8. approximate average volume of the particles (in m^3), and
9. average diameter of the particles (in decimetres).

The percent scree cover; depth of scree; and sphericity, volume, and diameter of the particles were measured for each plot by establishing 10 randomly selected subplots of 1 m^2 and by measuring all characteristics of each reachable rock within each subplot. This method was thought to be superior to Bédard's (1969a) technique of selecting rocks for measurements of particle size by stretching a string along one rim of the quadrat and by measuring every reachable rock intersected by the string. (Bédard also selected rocks for sphericity measurements in a similar manner.) Although both transect and subplot methods are biased (larger particles have a greater probability of being sampled and will therefore result in overestimates of the characteristics being measured), it was felt that the subplot method sampled both large and small particles more evenly than transect methods and therefore reduced the bias caused by particle size.

The percent of each 200 m^2 plot covered with scree was also estimated; both estimates of scree cover (whole plot estimate plus subplot estimate) were averaged to obtain a final value.

Stepwise multiple regression analyses (SMRA) of auklet densities in relation to the physical characteristics of the plots were conducted through use of the BMD02R program (Dixon 1973). Potential predictor variables (e.g., slope, volume of scree, etc.) were added to the regression model one at a time until the addition of a new variable failed to significantly reduce ($P \leq 0.1$) the variance of the estimate of the dependent variable. Plots of the residuals for each variable were analyzed to ensure that none of the assumptions of SMRA were violated (Draper and Smith 1966).

Cliff-nesting Birds

Two types of surveys were used to estimate the number of birds on Owalit Mountain. The first method involved counts of birds on plots and was conducted throughout the entire season. The second method involved a one-day survey of the cliffs of Owalit Mountain during which only the numbers of murres and kittiwakes were counted.

In order to obtain estimates of the number of birds that nested on the cliffs of Owalit Mountain and the changes in their numbers over the season, six plots of variable sizes were established (Figure 2). All plots extended from top to bottom of the cliff projection on which they were situated. These plots were situated in areas where a suitable landing site for the boat existed--hence were not randomly located. In several cases, landing sites became unusable due to growth of algae which coated the steeply inclined rocks and made landing impossible. When this occurred, censuses of plots that were surveyed from these landing sites had to be discontinued. Appendix 3 lists the area of each plot and the dates on which each plot was surveyed. Plots were surveyed at approximately the same time of day (10:00-12:00) throughout the season.

Where possible, the numbers of individuals, pairs, young, and nests were counted for each species that was observed on the plots. Photographs of the plots were taken to obtain a permanent record.

The numbers of birds on the plots were converted to approximate densities and extrapolations were made over the entire cliff area of Owalit Mountain. The estimated number of birds was adjusted when necessary by multiplying the estimate by a correction factor developed from the graphs of activity cycles discussed below.

During the late incubation period of murres (26 July) a survey of the cliffs from Galuk to Kongkok Bay was conducted. A second observer was present during this survey and each observer made independent counts of both murres and kittiwakes. A similar survey from Kongkok Bay to Boxer Bay was planned but an extended period of rough seas prevented its completion.

Counts of murres and kittiwakes made during the entire cliff survey were conducted between 10:00 and 12:00. The results of the cliff survey were adjusted in the same way as the estimates from the counts of birds on the plots. A correction factor developed from graphs of activity cycles was applied to the number of birds counted during the cliff survey. This resulted in an adjusted estimate of the numbers of murres and kittiwakes that were present during the cliff survey.

Activity Cycles

The numbers of birds on the cliffs vary with time of day and for some species from day to day (Tuck 1960; Drent 1965; Swartz 1966; Nettleship 1972; Birkhead 1976; and others). Studies were conducted to determine the diel cycles in the occupancy of nesting sites by cliff-nesting seabirds on St. Lawrence Island in order to correct the population estimates for this variation. Periodic censuses (see Appendix 4 for dates and times of counts) of birds on three plots were made. The locations of these plots are shown in Figure 2. Counts were conducted during the periods 11-27 June and 11-19 July.

Although Horned and Tufted Puffins and Pigeon Guillemots were included in the above plots, a series of counts conducted from 30 July to 6 August was obtained specifically for these three species. These counts were normally conducted three times per day over a plot 310 m long and 35 m high (total area = 10850 m^2) located on the seaward face of Kongkok Basin (Figure 2). Counts of birds were made while walking along the beach beneath these low cliffs.

Where definite diel rhythms of abundance were evident, a correction factor was calculated from the ratio of birds present on activity plots during the count period (10:00-12:00) to the number of birds present on activity plots at the peak of the diel cycle. This correction factor was then applied to the extrapolated estimates of the numbers of birds of each species that were present on the sea-cliffs of Owalit Mountain.

Breeding Biology

Least and Crested Auklets

Auklet eggs were located by searching beneath boulders on the talus slope. These efforts were begun on 23 June and were continued until the first young was found. When a nest was discovered, the site was marked and the egg was periodically checked until it pipped, whereupon it was checked daily until hatching. Chicks were weighed and measured at intervals of 2 to 4 days until they left the nest sites.

Murres

The locations of all murre eggs on two plots were marked on a sketch map. The selection of these plots was determined by their accessibility and by the visibility of the nesting ledges. The status of each egg was recorded periodically throughout the incubation period. Similarly, upon hatching, the chicks were monitored until they fledged. This method of measuring productivity is not entirely accurate because, on crowded ledges, it is difficult to be certain that the same egg or chick is being monitored throughout the season due to movement of birds on the ledges. The alternative to this method of monitoring breeding success involves marking eggs and banding young. However, the process of marking eggs and young causes considerable disturbance to the murre colony and greatly affects productivity (Birkhead 1976). Also, due to physical changes in the cliffs, ledges that had been accessible in past years were no longer reachable (S.R. Johnson, pers. comm.*). Observation of eggs and chicks on plots proved to be reasonably accurate and resulted in only minimal disturbance to nesting murres.

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Food Habits and Feeding Areas

Collection

A small number of Least and Crested Auklets and Common and Thick-billed Murres were shot with a 12-gauge shotgun or obtained from Eskimo hunters in order to determine the types of foods that were being eaten by these species. Least and Crested Auklets were collected from 8 to 16 July. I attempted to collect these species when they were feeding offshore. Murres were collected from 9 to 18 June. Because the feeding areas of murres were located more than 25 km from shore, these species were collected while they were *en route* to the cliffs from their feeding areas.

During late August, a small number of Least and Crested Auklets were netted while bringing food to their young; these birds were forced to regurgitate the food material from their sublingual pouch (see Bédard [1969b: 1028]; Speich and Manuwal [1974] for a description of the sublingual pouch of auklets).

Within 6 hours of collection, the oesophagi, proventriculi and gizzards from birds that were collected and the regurgitated food samples from auklets that were captured were preserved in 10% formalin.

Sorting and Counting

The oesophagus, proventriculus, and gizzard of each bird was opened, scraped and washed with water; the contents were sieved through a #20 plankton net (75μ mesh size). Specimens or parts of specimens were sorted to the lowest possible taxon with the aid of a dissecting microscope and stored in 5% formalin. The numbers of food organisms were calculated either by direct counts or by estimation using subsampling techniques. When it was not possible to count individuals, the organism was recorded only as "present".

Feeding Areas

Notes were kept on the movements of birds to and from feeding areas and on the feeding flocks of birds in and around the Kongkok Bay area. These notes provided a partial delimitation of the feeding locations used by seabirds that nested in the Kongkok Bay region.

RESULTS AND DISCUSSION

Phenology

Least and Crested Auklets

The chronology of events in the breeding cycle of the Least Auklet on St. Lawrence Island during 5 years is summarized in Table 1. The arrival of Least Auklets during 1976 apparently occurred later than the average arrival date based on the period from 1964 to 1967. Because the dates of first hatching and fledging during 1976 were apparently similar to or slightly earlier than these dates during 1964 to 1966, it is probable that a few eggs were laid earlier than 1 July when the first eggs were found. Back-dating from the date of first observed hatch during 1976 (using Sealy's [1968] calculated incubation period of 31.2 days) suggests that the first Least Auklet eggs were laid on 24 June. Because information on the date of initiation of hatching can be more accurately (and more easily) obtained than information on the date of initiation of laying (or of fledging), the back-dated calculation of 24 June is probably the best estimate of the exact date of first egg-laying. Although Least Auklets arrived on the nesting slopes 5 to 9 days later during 1976 than during the period from 1964 to 1966, the initiation of laying occurred at a similar or slightly earlier date. However, laying by this species began almost 2 weeks later during 1976 than during 1967 (an "early" year, see below). Few dates of initiation of egg-laying by Least Auklets are reported in the literature for other areas of the Bering Sea; these records are summarized by Sealy (1968).

Although Crested Auklets arrived in the vicinity of St. Lawrence Island at approximately the same time during the 5 years for which data are available, Crested Auklets, like Least Auklets, began landing on the nesting slopes of Owalit Mountain approximately one week later than during previous years (29 May; Table 2) when the slopes were approximately 50% snow-covered (Plate 2a, page 25). Neither Least Auklets nor Crested

TABLE 1. Breeding Phenology of Least Auklets on St. Lawrence Island.

EVENT	YEAR				
	1964	1965	1966	1967	1976
First seen in offshore leads	-	-	15 May[1]	10 May[1]	-
First seen from shore	15 May[1]	18 May[1]	21 May[1]	-	-
First seen on nesting slopes	20 May[1]	22 May[1]	24 May[1]	20 May[2]	29 May
First eggs found (first eggs laid)[3]	(26 June)[1]	(28 June)[1]	24 June[2]	12 June[2]	1 July (24 June)
Peak of laying	-	-	2 July[2]	16 June[2]	-
First young found	28 July[1]	30 July[1]	~27 July[2]	~15 July[2]	25 July
Peak of hatching	-	-	~ 1 August[2]	~22 July[2]	29 July
First young fledged	26 August[1]	28 August[1]	28 August[2]	15 August[2]	24 August
Peak of fledging	-	-	1 September[2]	20 August[2]	-

[1]Bédard (1967)

[2]Sealy (1968)

[3]Back-dated using mean incubation period of 31.2 days (Sealy 1968)

TABLE 2. Breeding Phenology of Crested Auklets on St. Lawrence Island.

EVENT	YEAR 1964	1965	1966	1967	1976
First seen in offshore leads	-	-	18 May[1]	13 May[2]	-
First seen from shore	15 May[1]	18 May[1]	20 May[1]	-	21 May
First seen on nesting slopes	20 May[1]	22 May[1]	24 May[1]	18 May[2]	29 May
First eggs found (first eggs laid)[3]	(22 June)[1]	(24 June)[1]	30 June[2]	14 June[2]	1 July (27 June)
Peak of laying	-	-	3 July[2]	24 June[2]	-
First young found	28 July[1]	30 July[1]	~2 August[2]	~19 July[2]	2 August
Peak of hatching	-	-	~11 August[2]	~29 July[2]	11 August
First young fledged	26 August[1]	27 August[1]	5 September[2]	1 September[2]	Later than 3 September
Peak of fledging	-	-	9 September[2]	3 September[2]	-

[1] Bédard (1967)

[2] Sealy (1968)

[3] Back-dated using mean incubation period of 35.6 days (Sealy 1968)

Auklets landed in Kongkok Basin until 2 June at which time the slopes there were still approximately 60% snow-covered.

The events in the breeding cycle of Crested Auklets during 1976 were generally 1 to 2 weeks later than during the years 1964 to 1967. As with Least Auklets, some difficulty exists in identifying the initiation of nesting of Crested Auklets. The first egg was found on 1 July. However, back-dating (using Sealy's [1968] calculated incubation period of 35.6 days) yields a nest initiation date of 27 June.

The timing of hatching for Least and Crested Auklet eggs is presented in Figure 3. Although the date of initiation of laying was approximately the same for both species, the peak of hatching was almost 2 weeks later in Crested Auklets.

Early and late nesting seasons are apparently related to the amount of snow on the breeding cliffs and the rate at which it disappears. This relationship has been described for auklets on St. Lawrence Island by Sealy (1975). During 1966 and 1967 a "late" and an "early" season occurred, respectively. During 1966 snow covered 95% of the breeding slopes when auklets arrived; the breeding season was delayed and eventually some birds laid their eggs on the snow (Sealy 1975). The timing of onset of laying during 1976 was quite similar to the timing that occurred during 1966. Plate 1a shows that snow cover was very heavy in Kongkok Basin on 9 June 1976 and still persisted to a large extent as late as 24 June (Plate 1b) and 28 June (Plate 1c). Eggs were first found in the snow-free areas on 1 July; no eggs were found on the snow. Snow cover was still present along the rim of the basin on 20 August (Plate 1d).

Crested Auklets typically nest in areas of deeper scree with larger boulders than do Least Auklets (see "Population Estimates" section and Bédard 1969a). These areas provide larger interstices among talus boulders, which Crested Auklets require as nest sites. However, these interstices fill with snow and ice during the winter, and, due to their greater depth, they become snow-free later than sites used by Least Auklets. The date of

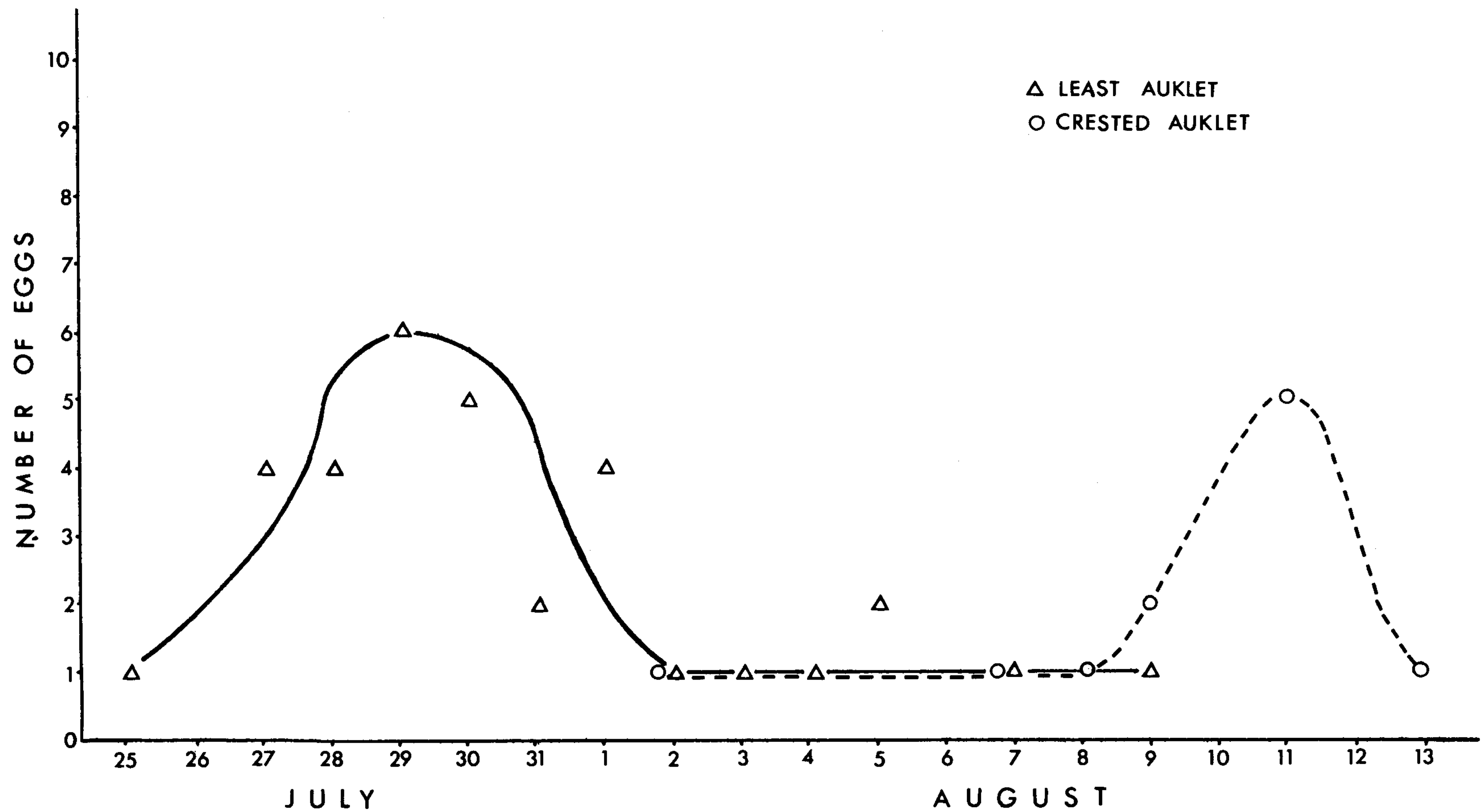


FIGURE 3. Number of Monitored Least and Crested Auklet Eggs that Hatched each Day during 1976.

A. 9 June 1976

B. 24 June 1976

C. 28 June 1976

D. 20 August 1976

PLATE 1. Snow Cover Conditions in Kongkok Basin during Summer, 1976.

first laying of Crested Auklets during 1976 was about 3 days later than that of Least Auklets. Also, Crested Auklets have an incubation period which lasts about 4 days longer than the Least Auklets' incubation period. The difference in the timing of initiation of laying and the length of the incubation period accounts for a 1 week difference between the initiation of hatching of Least and Crested Auklets. However, the majority of Crested Auklet eggs did not hatch until 2 weeks after those of Least Auklets (Table 1 and 2, Figure 3); this difference was probably caused by a delay in the laying of eggs by *most* Crested Auklets due to the late presence of snow and ice in their nest sites.

Common and Thick-billed Murres

Although some murres spend the winter in the open water near Kongkok Bay (Fay and Cade 1959:122), most murres that nest on St. Lawrence Island winter south of the pack ice (Gabrielson and Lincoln 1959:481). Johnson (in press) found 483 Thick-billed Murres and only one Common Murre in a sample of murres killed by hunters at St. Lawrence Island during the spring of 1973. Thus it appears that, in the vicinity of St. Lawrence Island, Common Murres arrive later than do Thick-billed Murres. The first offshore concentrations of murres seen by Gambell residents during 1976 were recorded during late April (see Table 3 for phenology of events in the breeding season of murres). During 1953, Fay and Cade (1959) reported first seeing murres in numbers during the latter half of April. Johnson (in press) reported that large numbers of murres were present off the west coast of St. Lawrence Island in mid-April 1973. Although murres were present in the western St. Lawrence Island area by the latter part of April, during 1976, they did not begin to frequent the nest ledges until 28 May.

Much of the sea-cliff area was covered with snow during early June (Plate 2b). Many seabird species including murres (Tuck 1960:111-112; Birkhead 1976), kittiwakes (Belopol'skii 1957:115; Uspenski 1956:99), and puffins (Nettleship 1972:250) have courtship displays and activities that

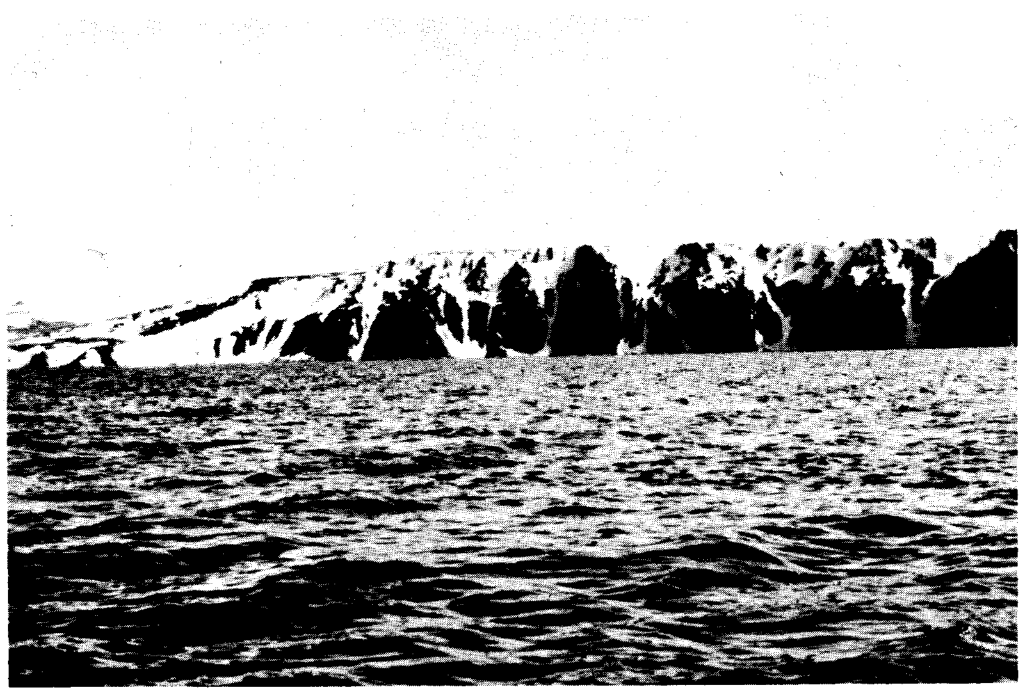
TABLE 3. Breeding Phenology of Cliff-nesting Species on St. Lawrence Island during 1976.

EVENT	BLACK-LEGGED KITTIWAKE	PELAGIC CORMORANT	MURRE SPP.	GLAUCOUS GULL
First seen in offshore leads	-	-	Late April	Winter Resident
First seen from shore	16 May	Late April	14 May*	Winter Resident
First seen on cliffs	27 May[†]	27 May[†]	28 May	27 May[†]
Initiation of nesting	8 June	2 June	N/A	30 May
First eggs found	29 June	13 June	28 June	2 June
Peak of laying	-	-	1-9 July	2-13 June
First young seen	-	29 June	31 July	-
Peak of hatching	-	-	4-9 August	-
First fledgling seen	22 August	12 August	21 August	13 July
Peak of fledging	-	-	27 August	-

*First day of observations at Gambell, St. Lawrence Island was 14 May 1976.

†No seabirds were observed at Kongkok Bay on 19 May 1976. First day of continuous observations at Kongkok Bay was 27 May 1976.

A. 29 May 1976



B. 19 June 1976

PLATE 2. Snow Cover Conditions on Owalit Mountain during Summer, 1976.

take place on the nesting slopes and ledges. Because courtship activities could not begin until the birds were able to occupy ledges, the presence of snow on the nesting cliffs until mid-June may have been the proximate factor that delayed the nesting activities of most seabirds at Kongkok Bay during 1976. Uspenski (1956:35) states that the onset of sexual activity of murres is in part controlled by the external stimulus of the nesting ledges. Unlike auklets which, during late seasons, are able to lay eggs soon after the snow cover leaves (Sealy 1975:534), murres require a certain amount of time after the ledges become free of snow to complete their courtship activities. The onset of laying in murres would thus be delayed to a greater extent than the onset of laying in auklets during years of late snow cover.

Over a 7-year-period between 1950 and 1957, Fay and Cade (1959) reported that Common Murres laid eggs between the middle and the end of June. They stated that Thick-billed Murres may nest even earlier. During 1976, however, murres did not begin laying until 28 June and the peak of laying did not occur until the first week of July.

Similarly, the peak of hatching occurred somewhat later during 1976 than during 1950 to 1957. Fay and Cade (1959) reported a peak of hatching during the first week of August. During 1976, although hatching began on 31 July, the peak did not occur until 9 August (Figure 4). Hatching during 1976 was also later than hatching during 1972 which began on 30 July (peak on 4 August) (S.R. Johnson, pers. comm.). During 1972, departure of chicks from the cliffs commenced on 18 August and reached a peak 3 days later on 21 August (Johnson and West 1975). In contrast, departure of chicks during 1976 commenced on 21 August and did not reach a peak until 27 August (Figure 4). Some chicks still had not fledged when this study ended on 3 September 1976.

Black-legged Kittiwakes

The timing of events in the breeding season of the Black-legged Kittiwake is summarized in Table 3. Fay and Cade (1959) reported that kittiwakes were first seen near Gambell on 9 May during 1953 and 11 May during

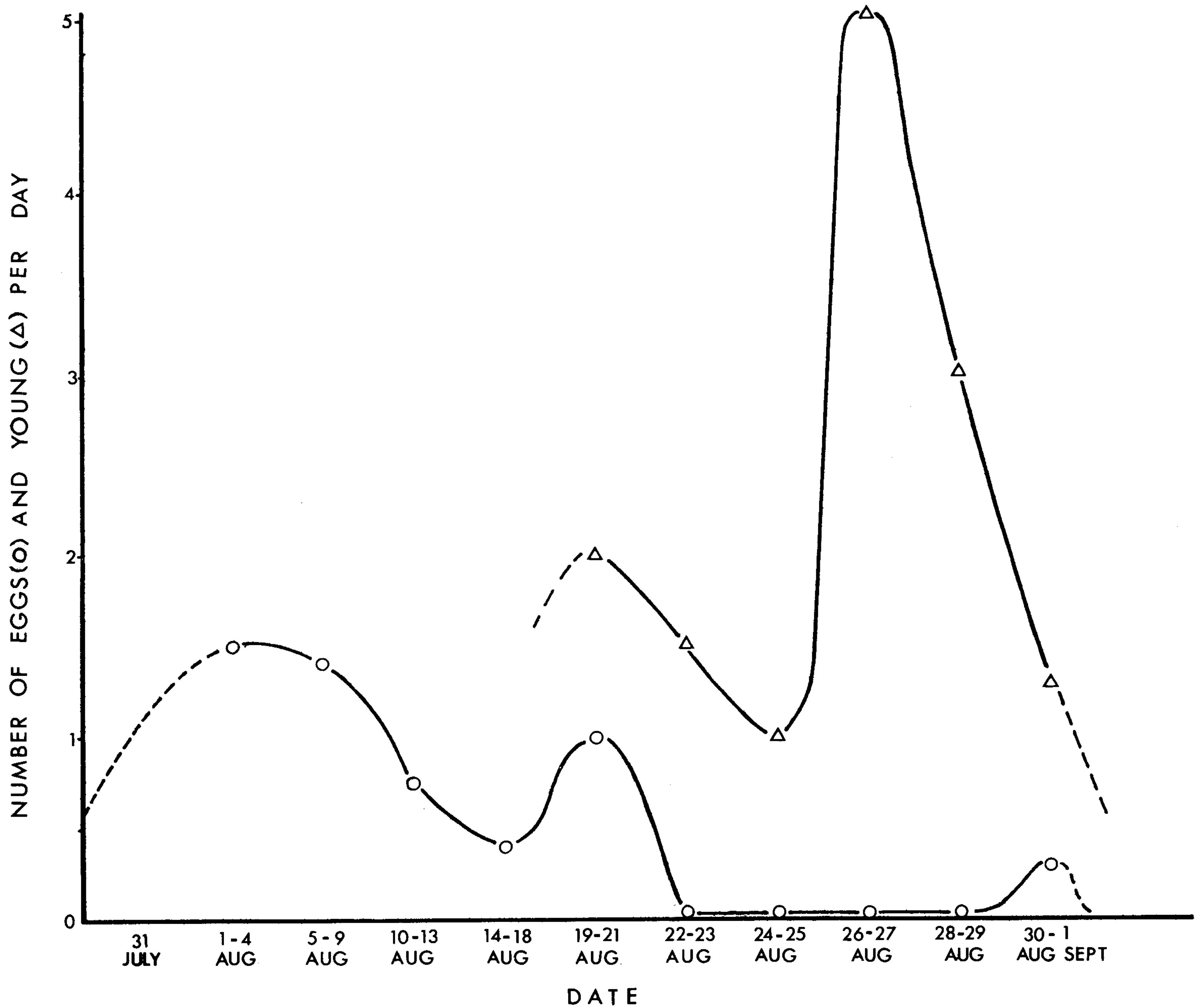


FIGURE 4. Number of Monitored Murre Eggs that Hatched and Murre Young that Fledged each Day during 1976.

1954. During 1973, kittiwakes were present at St. Lawrence Island by 29 April (Johnson in press). During 1976 I arrived at Gambell on 14 May but did not observe kittiwakes until 16 May. No kittiwakes were present on the cliffs at Kongkok Bay during my visit there on 19 May, but small numbers were present on the breeding ledges when I returned on 27 May.

The first sign of nest building during 1976 was noted on 8 June, the first eggs were located on 29 June, and the first fledgling was seen on 22 August. Based upon data gathered from 1950 to 1957, Fay and Cade (1959) stated that kittiwakes do not begin nesting until late June. This presumably refers to the initiation of egg-laying rather than actual nest construction. The nesting chronology of Black-legged Kittiwakes on St. Lawrence Island was apparently not delayed during 1976, whereas other cliff-nesting species arrived about one week later than normal.

The probable explanation is as follows:

1. Most kittiwakes that arrived at the cliffs during late May and early June occupied stacks (which were snow-free) rather than ledges (which were snow-covered).
2. Kittiwakes nested on the lower portions of the cliffs, which became snow-free earlier than upper portions.

The nesting chronology of kittiwakes at Kongkok Bay during 1976 will be further discussed in the 'Breeding Biology' section below.

Other Species

The phenology of events in the breeding season of Pelagic Cormorants and Glaucous Gulls is summarized in Table 3. In addition, scattered phenological information was obtained for the less abundant species at Kongkok Bay.

Parakeet Auklets were first seen from shore at Gambell on 17 May; they were not observed on the cliffs at Kongkok Bay on 19 May, but were present there when I returned to Kongkok Bay on 27 May. Arrival dates given by Fay and Cade (1959) for this species are 17 May 1952, 15 May 1953, 11 May

1954 and 12 May 1956. Arrival dates of Parakeet Auklets during other years are presented in Table 4.

TABLE 4. Arrival Dates in May of Parakeet Auklets near Gambell, St. Lawrence Island.

First Seen	1964[1]	1965[1]	1966[1]	1967[1]	1973[2]	1976[3]
In Offshore Leads	-	13	9	4	14	-
From Shore	15	18	20	-	-	17
On the Nesting Slopes	19	21	24	-	-	27[4]

[1]Sealy and Bédard (1973:61).

[2]Johnson (in press).

[3]Present study.

[4]At Kongkok Bay.

During 1976, Parakeet Auklets apparently arrived in the St. Lawrence Island area about the same time as they arrived during other years, but, like Least and Crested Auklets, they did not occupy their nesting slopes until later than usual. The breeding seasons of all three auklets on St. Lawrence Island during 1976 were even later than the late breeding seasons of 1966. Although no eggs were found on the snow, Parakeet Auklets were still seen on snow-covered nest sites during mid-July. It is suspected that many Parakeet Auklets were prevented from nesting during 1976 because of the heavy and prolonged snow conditions on the brow of Owalit Mountain.

During 1976, Tufted Puffins were first observed from shore on 17 May. Horned Puffins were not seen until 25 May but may have been present earlier. Fay and Cade (1959) stated that during their period of study (1950-1958) Horned Puffins arrived between 15 and 20 May--3 to 4 weeks earlier than the arrival of Tufted Puffins. During 1966 and 1967, Sealy (1973:109) first recorded Horned Puffins at St. Lawrence Island on 28 and 26 May, respectively. Eskimo hunters first saw this species offshore from Gambell on 8 May during 1973 (Johnson in press). During 1976, Horned

Puffins were present on the cliffs at Kongkok Bay when I arrived on 27 May; Tufted Puffins were first seen on the cliffs on 28 May. A summary of arrival dates of Horned and Tufted Puffins on St. Lawrence Island is presented in Table 5.

TABLE 5. Spring Arrival Dates of Horned and Tufted Puffins on St. Lawrence Island, Alaska (adapted from Sealy 1973:109).

Year	Horned Puffin Arrival Date	Tufted Puffin Arrival Date
1952	17 May	4 June
1953	15 May	?
1954	22 May	?
1958	?	23 May
1961	5 May	?
1966	28 May	23 May
1967	26 May	26 May
1973*	8 May	early May
1976†	25 May	17 May

*Johnson (In press).

† Present Study

Pigeon Guillemots were first observed from shore on 16 May but according to local residents they had been present in offshore areas since late April. A few Black Guillemots (*Cepphus grylle*) or Pigeon Guillemots may winter in the St. Lawrence Island area (Ryder cited by Fay and Cade 1959). During 1966, Sealy (1967) first observed Pigeon Guillemots at Gambell on 17 May. Pigeon Guillemots were present on the cliffs at Kongkok Bay when I arrived on 27 May. The first young of this species were seen on 24 August but they did not become abundant on the water at Kongkok Bay until 26 August.

Herring Gulls were first seen at Gambell on 15 May, but they may have been present earlier. They were present near Gambell after the first week in May during 1973 (Johnson in press). None were seen at Kongkok Bay on 19 May 1976 but several Herring Gulls were present there when I returned on 27 May.

Population Estimates

Least and Crested Auklets

Table 6 presents the estimated number of auklets in the Kongkok Bay colonies during 1966 (Bédard 1969a:391) and 1976. The three dimensional nature of auklet nesting habitat precludes total counts of auklets even in a small area because an unknown percentage of birds remain out of sight beneath the talus boulders. Therefore, these estimates should be taken more as an index of population size rather than as a population estimate.

The extent of snow cover is an important factor that influences the number of auklets that can be counted. Data from two plots indicate the degree to which the number of auklets present on snow-free plots were underestimated. Approximately 380 auklets were counted on plot AB02 when this plot was 99% snow-covered but only 90 auklets were counted when the snow-cover receded to 50% of the plot. Similarly, the number of auklets that were counted on plot AB06 declined from about 270 when the plot was 99% snow-covered to 190 when the plot was only 5% snow-covered*. As rock crevices become available, many auklets spend a great portion of their time out of sight among the rocks. Therefore, counts of auklets on plots with over 90% snow-cover are probably more accurate representations of the number of auklets that nest on the plots than are counts of auklets on plots with less snow cover. Counts of auklets on plots with less than 90% snow cover probably result in an underestimate of the true number of birds that are present. However, because most plots were snow-free, or nearly so, when auklets began to land on the talus slopes, the majority of plots could not usefully be censused for auklets when they were more than 90% snow-covered. Therefore, for comparative analysis of the number

*Unfortunately, censuses of other plots either were not initiated until the snow covered less than 50% of the plots or censuses were terminated when plots were more than 50% covered. In both situations, the number of auklets counted did not change significantly from day to day.

TABLE 6. Summary of the Number of Least and Crested Auklets in the Kongkok Bay Colonies during 1966 and 1976.

Location	Area (m^2) of Nesting Habitat[c]	Density of Breeding Birds/200m^2		Total Number Breeding Birds[c]		Total Number Birds, Breeding and Non-breeding[g]		Number of Birds In Colony
		Least	Crested	Least	Crested	Least	Crested	
Kongkok Basin[a]	715,000	34.4	29.9	123,000	107,000	189,000	165,000	354,000
Kongkok Basin[b]	715,000[d]	-	-	240,000[f]	127,000[f]	369,000	195,000	564,000[f]
Stratum 1	624,000[h]	67.0	35.6	209,000	111,000	322,000	171,000	
Stratum 2	45,000[h]	39.0	5.6	9,000	1,000	14,000	2,000	
Total	669,000[h]	65.1[e]	33.6[e]	218,000	112,000	336,000	173,000	509,000
Owalit Mtn.[b]	35,000	63.8	13.6	11,000	2,000	17,000	3,000	20,000

[a]Data from Bédard (1969a) for 1966

[b]Data for 1976 from present study

[c]Figures rounded to nearest 1000

[d]Based upon area of basin given by Bédard (1969a:391)

[e]Weighted mean of strata 1 and 2

[f]Extrapolation from Stratum 1 only in order to maintain comparison with Bédard (1969a)

[g]Assumes 35% of population are non-breeding birds (Bédard 1969a:386)

[h]Area of basin calculated in field during 1976

of auklets that are present on each plot, it was necessary to use only the numbers of birds that were counted on plots that were relatively snow-free. Accordingly, results of censuses from plots were used only when the plots were less than 50% covered with snow. Using this method, the results are comparable from plot to plot even though they are an underestimate of the total number of auklets that are present.

The data from the two plots with 99% snow-cover suggest that the estimate of approximately 500,000 auklets in Kongkok Basin underestimates the actual number of auklets there by 33% to 50%. If this is so, then the actual number of auklets present in Kongkok Basin is between 750,000 and 1 million birds.

During the 10 years between 1966 and 1976, auklet numbers in the Kongkok Basin colony increased a total of 59%. Much of this increase was due to a 95% increase in the number of Least Auklets. However, Crested Auklets also showed an 18% increase. Unfortunately, there are no data between 1966 and 1976 that would indicate whether the population change has been a steady increase, a rapid increase, or a combination of increases and decreases. Also, there is no information available to determine whether the population is still increasing, whether it has stabilized, or whether it has begun to decrease in numbers.

In order to arrive at the population estimates presented in Table 6, extrapolations were made over the area from which plots were randomly selected. However, large areas of talus also exist on the seaward side of both Owalit and Ivekan mountains; these areas could not be sampled from shore. Densities of auklets in these areas appeared to be similar to the inland talus slopes that were sampled. The auklets present on these slopes add greatly to the total number of auklets present in the Kongkok Bay area.

Relation of Density to Habitat Characteristics

Bédard (1969a) investigated several environmental characteristics that could operate with a complex of regulators to determine the set point of auklet numbers on St. Lawrence Island. Set point refers to the mean level about which the population level fluctuates (Wilbert 1969). Bédard

(1967, 1969a) used a correlation approach in order to identify the characteristics which were most closely associated with auklet density. I attempted to investigate the correlation between auklet numbers and their breeding habitat in more detail. I compared auklet density to the physical characteristics of 24 plots by using stepwise multiple regression analysis (SMRA) as described above. Table 7 presents the simple correlation coefficient between each pair of variables.

Least Auklets

After analysis of the residuals, no evidence of violations of the normality, homoscedasticity or linearity assumptions was found. The results of SMRA are presented in Table 8. The density of Least Auklets was very strongly related to the predictor variables. The regression model apparently accounted for 77.9% of the variance, but this value is undoubtably an overestimate of the real predictability of population density from the physical characteristics of the plots; too few plots were censused (in relation to the number of predictor variables considered) to permit determination of the actual percentage of the variance explained (Lane 1971).

Least Auklets were positively correlated with the number of Crested Auklets. The number of Crested Auklets, however, is also related to several habitat characteristics such as depth, etc. (see below and Table 7), and the number of Least Auklets may be related to some of these same habitat features. Aggressive encounters between Least and Crested Auklets, though limited, might tend to result in a negative correlation between the numbers of both species. Bédard (1969a) found such a negative correlation to exist. However, as depth (and therefore the number of Crested Auklets) increases, the number of interstices (i.e., potential Least Auklet nest sites) also increases; thus, the density of Least Auklets, the density of Crested Auklets and depth should all be positively correlated when auklets are present in relatively high densities. Under low density conditions, Least Auklets may be able to nest to a greater extent in areas free, or nearly so, of Crested Auklets.

TABLE 7. Matrix of Simple Correlation Coefficients for Variables Considered as Potential Predictors of Auklet Densities.*

	VARIABLE	PLOT CHARACTERISTICS: DIRECTION	ALTITUDE	SLOPE	PERCENT SCREE	DISTANCE TO EDGE	DEPTH OF SCREE	DEPTH S.D.	SCREE CHARACTERISTICS: SPHERICITY	SPHERICITY S.D.
PLOT CHARACTERISTICS	Direction	1.000	-0.586	0.162	-0.048	-0.502	-0.405	-0.261	0.279	0.385
	Altitude		1.000	0.024	-0.405	0.590	-0.265	-0.102	-0.556	-0.684
	Slope			1.000	-0.180	0.019	-0.150	-0.016	0.004	0.104
	Percent Scree				1.000	-0.145	0.624	0.110	0.131	0.342
	Distance To Edge					1.000	0.266	0.455	-0.341	-0.337
	Depth of Scree						1.000	0.705	0.266	0.359
	Depth S.D.							1.000	0.412	0.361
SCREE CHARACTERISTICS	Sphericity								1.000	0.840
	Sphericity S.D.									1.000

	VARIABLE	SCREE CHARACTERISTICS: VOLUME	VOLUME S.D. (BETWEEN SUBPLOTS)	VOLUME S.D. (WITHIN SUBPLOTS)	DIAMETER	DIAMETER S.D. (BETWEEN SUBPLOTS)	DIAMETER S.D. (WITHIN SUBPLOTS)	AUKLET NUMBERS: NUMBER OF CRESTED AUKLETS	NUMBER OF LEAST AUKLETS
PLOT CHARACTERISTICS	Direction	0.046	0.139	0.065	-0.163	0.082	-0.105	-0.735	-0.340
	Altitude	-0.254	-0.253	-0.216	-0.226	-0.403	-0.291	0.210	-0.070
	Slope	0.056	0.067	0.135	-0.032	-0.029	0.038	-0.247	0.271
	Percent Scree	0.110	0.054	0.189	0.239	0.098	0.272	0.538	0.333
	Distance to Edge	0.042	-0.060	0.080	0.211	-0.158	0.071	0.347	-0.273
	Depth of Scree	0.431	0.281	0.444	0.669	0.354	0.629	0.744	0.412
	Depth S.D.	0.691	0.590	0.692	0.771	0.560	0.753	0.379	0.071
SCREE CHARACTERISTICS	Sphericity	0.711	0.718	0.543	0.431	0.799	0.529	-0.035	-0.031
	Sphericity S.D.	0.557	0.537	0.533	0.390	0.616	0.563	0.006	-0.016
	Volume	1.000	0.975	0.922	0.842	0.894	0.829	0.072	-0.031
	Volume S.D. (Between Subplots)		1.000	0.898	0.727	0.910	0.753	-0.023	-0.077
	Volume S.D. (Within Subplots)			1.000	0.827	0.738	0.899	0.101	0.005
	Diameter				1.000	0.700	0.883	0.230	0.138
	Diameter S.D. (Between Subplots)					1.000	0.720	0.030	-0.019
	Diameter S.D. (Within Subplots)						1.000	0.264	0.150
AUKLET NUMBERS	Number of Crested Auklets							1.000	0.440
	Number of Least Auklets								1.000

*Correlations are significant at $P \leq 0.05$ if their absolute values lie between 0.404 and 0.515,
$P \leq 0.01$ if their absolute values lie between 0.515 and 0.630,
$P \leq 0.001$ if their absolute values exceed 0.630.

TABLE 8. Multiple Regression Equation for the Density of Observed Least Auklets. A stepwise analysis of 16 potential predictor variables (Table 7) was used.†

Dependent Variable	Constant	Independent (Predictor) Variable	Significance Level of Partial Correlation	Simple Correlation Coefficient
Number of Least Auklets	=2.14	+(1.49 ± 0.33) (Slope)	***	+ 0.271
		-(0.31 ± 0.05) (Distance to edge of talus)	***	- 0.273
		+(0.78 ± 0.27) (Depth of scree)	***	+ 0.412
		-(188.76 ± 51.18) (Sphericity S.D.)	***	- 0.016
		+(0.59 ± 0.28) (Number of Crested Auklets)	**	+ 0.440
R= 0.88		Variance Explained = 77.9%	SE= 17.21	

†Table presents the coefficient of each predictor variable within the equation, its standard error, the significance level of the partial correlation for each variable,

(*) $0.1 \geq P > 0.05$

* $0.05 \geq P > 0.01$

** $0.01 \geq P > 0.001$

*** $P \leq 0.001$

and the simple correlation coefficient of each variable with the independent variable.

The bottom line of the table presents the multiple correlation coefficient, the percentage of the variance that is accounted for by the regression equation and the standard error of the estimate.

After the effect of the number of Crested Auklets present on the plot was considered, Least Auklet numbers were correlated with the distance of the plot from the nearest edge of continuous scree. This correlation was negative. The numbers of Least Auklets on the plots were positively correlated with the angle of slope. Therefore, numbers of Least Auklets were largest on very steeply oriented plots and smallest on the more nearly level plots. The angle of slope normally would be expected to affect the size of the boulders that are present because large rocks would presumably tend to accumulate in areas of lower slope. However, examination of Table 7 and the steps of SMRA (Table 9) revealed no strong correlations between slope and rock size. Perhaps geologic agents such as frost heaving, etc. result in extensive mixing of the talus (Bédard 1969a:387) which serves to destroy any correlation between slope and rock size.

The number of Least Auklets was negatively correlated with the standard deviation of the sphericity of the talus boulders. (Because there is a high degree of correlation [0.840] between the standard deviation of the sphericity and the sphericity measurement itself [once the standard deviation of the sphericity was considered in the equation], the sphericity measurement would not improve the fit of the regression line significantly and therefore did not enter the equation. For the purposes of this discussion, the standard deviation of the sphericity is considered to be equivalent to the sphericity.) Thus, more Least Auklets were found on plots with angular rocks than on plots in which the rocks tended toward an oval or round shape.

The density of Least Auklets was also highly correlated with the depth of scree. More auklets tended to occur on plots with deeper scree. Probably either the increased number of interstices between rocks in deeper talus creates more nest sites, or, if territories are partitioned on a three-dimensional scale, an increased depth would also increase the number of territories that could be located within a 200 m^2 plot.

TABLE 9. Stepwise Multiple Regression Analysis of the Density of Least Auklets[1].

Variable	STEP 1	2	3	4	5
VARIABLES INCLUDED					
Number of Crested Auklets	+*	+***	+***	+***	+**
Distance to Edge of Scree		-**	-***	-***	-***
Slope			+***	+***	+***
Sphericity S.D.				-*	-***
Depth					+***
VARIABLES EXCLUDED					
Direction	-ns	-ns	-(*)	-ns	-ns
Altitude	-ns	+ns	+ns	-ns	+ns
Slope	+*	+***	-	-	-
Percent Scree	+ns	-ns	-ns	+ns	-ns
Distance to Edge of Scree	-*	-	-	-	-
Depth of Scree	+ns	+ns	+ns	+***	-
Depth S.D.	-ns	+ns	+ns	+**	+ns
Sphericity	-ns	-ns	-*	+ns	+ns
Sphericity S.D.	-ns	-ns	-ns	-	-
Volume	-ns	-ns	-ns	+ns	-ns
Volume S.D. (Between Subplots)	-ns	-ns	-ns	+ns	-ns
Volume S.D. (Within Subplots)	-ns	-ns	-ns	+ns	-ns
Diameter	+ns	+ns	+ns	+**	+ns
Diameter S.D. (Between Subplots)	-ns	-ns	-ns	+ns	-ns
Diameter S.D. (Within Subplots)	+ns	+ns	-ns	+ns	+ns

[1]Columns labeled 1-5 are the partial correlations of the predictors to the density of Least Auklets. The significance levels (as in Table 8) refer to the partial correlations after the variables in the upper section have been included in the model.

Crested Auklets

The basic assumptions of SMRA were not violated during the regression analysis involving the density of Crested Auklets as the dependent variable. The results of SMRA are presented in Table 10. The density of Crested Auklets was very strongly correlated to the variables used as predictors (Tables 10 and 11). The resultant regression equation apparently accounted for 89.4% of the variance, but, as for the regression analysis involving the density of Least Auklets, the value is undoubtably overestimated.

The number of Crested Auklets observed on the plots was negatively correlated with the extent to which the plot was oriented away from SSW (the direction of nearest water). Therefore, plots that faced SSW had the highest density of Crested Auklets.

Crested Auklet density was also correlated with the depth, the standard deviation of the volume (considered to be identical to volume), and the diameter of the boulders. However, all three of these variables are highly correlated with each other. Thus deeper scree was found in areas where there were larger particles; higher numbers of Crested Auklets were present in these areas than on plots with more shallow scree composed of smaller sized particles.

The density of Crested Auklets was also significantly correlated ($P < 0.01$) with the percent of the plot that was covered with scree. The percent of scree cover was also correlated with the depth of scree. However, once depth was considered in the regression model, percent of scree cover did not significantly reduce the variance; thus, percent of scree cover was not incorporated into the regression equation.

The results of SMRA of the habitat characteristics of Least and Crested Auklets differ from the results of Bédard (1967, 1969a). However, Bédard assumed that the density of auklets was correlated with the percentage of the quadrat that was occupied by the birds (approximately

TABLE 10. Multiple Regression Equation for the Density of Observed Crested Auklets. A stepwise analysis of 16 potential predictor variables (Table 7) was used.†

Dependent Variable	Constant	Independent (Predictor) Variable	Significance Level of Partial Correlation	Simple Correlation Coefficient
Number of Crested Auklets	=57.10	$-(0.30 \pm 0.05)$ (Direction)	***	- 0.735
		$+(0.75 \pm 0.10)$ (Depth of scree)	***	+ 0.744
		$+(0.05 \pm 0.02)$ (Volume S.D., within subplots)	**	+ 0.101
		$-(15.23 \pm 3.58)$ (Diameter of scree)	***	+ 0.230
R=0.945		Variance Explained = 89.4%	SE= 7.81	

†Presented as in Table 8.

TABLE 11. Stepwise Multiple Regression Analysis of the Density of Crested Auklets*.

Variable	Step 1	2	3	4
VARIABLES INCLUDED				
Depth of Scree	+***	+***	+***	+***
Direction		-***	-***	-***
Diameter			-***	-***
Volume S.D. (Within Subplots)				+**
VARIABLES EXCLUDED				
Direction	-***	-	-	-
Altitude	+**	+ns	+ns	+ns
Slope	-ns	-ns	-ns	-ns
Percent Scree	+ns	+**	+*	+*
Distance to Edge of Scree	+ns	-ns	-ns	-ns
Depth S.D.	-ns	-*	-ns	-ns
Sphericity	-(*)	-ns	+ns	+ns
Sphericity S.D.	-*	+ns	+ns	-ns
Volume	-*	-(*)	+*	+ns
Volume S.D. (Between Subplots)	-(*)	-ns	+*	+ns
Volume S.D. (Within Subplots)	-(*)	-ns	+**	-
Diameter	-**	-***	-	-
Diameter S.D. (Between Subplots)	-(*)	-ns	+ns	+ns
Diameter S.D. (Within Subplots)	-(*)	-(*)	+ns	-ns
Number of Least Auklets	+ns	+ns	-ns	+ns

*Columns labeled 1-4 are the partial correlations of the predictors to the density of Crested Auklets. The significance levels (as in Table 8) refer to the partial correlations after the variables in the upper section have been included in the model.

equal to the percent scree cover) and the depth of the scree; he adjusted the densities to correct for variations in these parameters. Bédard then used these adjusted densities and found them to be highly correlated with the average diameter of the talus boulders on the plots. Apparently, the only other parameter Bédard measured at Kongkok Basin was the altitude of the plots (Bédard did not measure the angle of slope at Kongkok where the slope can differ widely). The resultant simple linear regression between the common logarithm of the corrected density and the average diameter of boulders on the plots accounted for 98.6% and 82.4% of the variability for Least and Crested Auklets, respectively (Bédard 1969a). The models constructed for the 1976 auklet data which used uncorrected auklet densities explained less of the variance for Least Auklet densities but explained a slightly higher portion of the variance for Crested Auklet densities.

It should be noted that the simple correlations expressed in Table 7 and column 4 of Tables 8 and 10 are not the same as the partial correlations expressed in Tables 9 and 11 and column 3 of Tables 8 and 10. A partial correlation measures the degree of correlation between pairs of variables when other variables are held constant (Sokal and Rohlf 1969: 540). Simple linear correlation measures the correlation between pairs of variables when other variables are ignored (Fryer 1966:438). When dealing with intercorrelated variables, the addition of one variable to the model will lower the partial correlation of other related variables. The degree to which the partial correlation is affected by the inclusion of one variable in the model is proportional to the amount of correlation between the two predictor variables (Richardson 1974:314). Many of the independent variables considered in the previous regression analyses are correlated with each other and therefore could be substituted for one another in the model. Parameters that have entered the model, therefore, are representative of groups of interrelated variables and may not themselves represent a cause-and-effect relationship with density.

Common and Thick-billed Murres

Activity Cycles

The pattern of daily murre presence on the breeding cliffs during June and July is presented in Figures 5 and 6. During June maximum numbers were present on the cliffs between 04:00 and 12:00; numbers gradually declined in the afternoon and evening then increased from low or near low numbers at 24:00 to high or near high numbers at 04:00. The pattern of activity was similar but less distinct during July.

Tuck (1960:120) found that the numbers of Thick-billed Murres on the cliffs during June at Cape Hay, Bylot Island, N.W.T., Canada, (74°N latitude) changed little throughout the day. His results during July, were similar to those recorded at Kongkok Bay, St. Lawrence Island, (63°N latitude) during June, 1976. Birkhead's (1976:156) data from Skomer Island, Wales, (52°N latitude) show that Common Murres were present in high and nearly constant numbers from 08:00 to 20:00 throughout the season and were nearly absent from the cliffs at night.

Because of the rather high and stable numbers of murres on the breeding cliffs of Owalit Mountain during the morning hours, no correction factor was necessary for the following estimates of the number of murres present on the cliffs.

Estimates

Estimates of the number of murres were based upon counts made during mid to late July (see Nettleship 1976a:21; Birkhead 1976:154). The density of murres on five plots was calculated to be 10.6/100 m^2. Densities ranged from a low of 1.8/100 m^2 to a maximum of 45.7/100 m^2. Extrapolation of the average density of murres over the 150,000 m^2 cliff area of Owalit Mountain resulted in an estimated total of 15,900 murres.

Counts made independently by two observers during a cliff survey on 26 July 1976 yielded 15,495 and 15,875 murres. These are probably underestimates of the total number of murres present on the cliffs because all

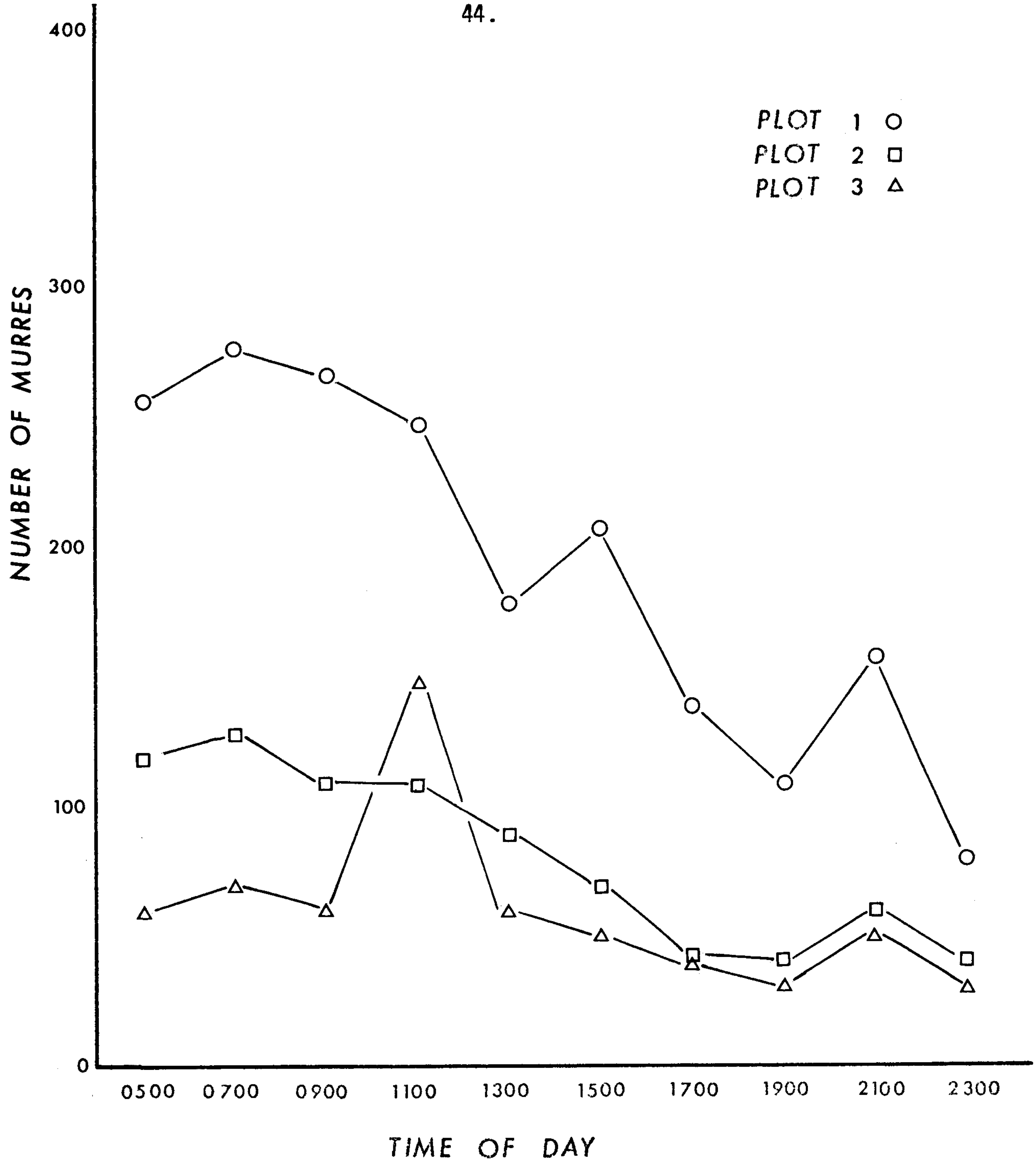


FIGURE 5. Average Number of Murres Present on the Three Activity Plots at Various Times during the Day between 11 and 27 June 1976.*

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* Appendix 4 presents the number of birds per hour present on the activity plots during each day of observation.

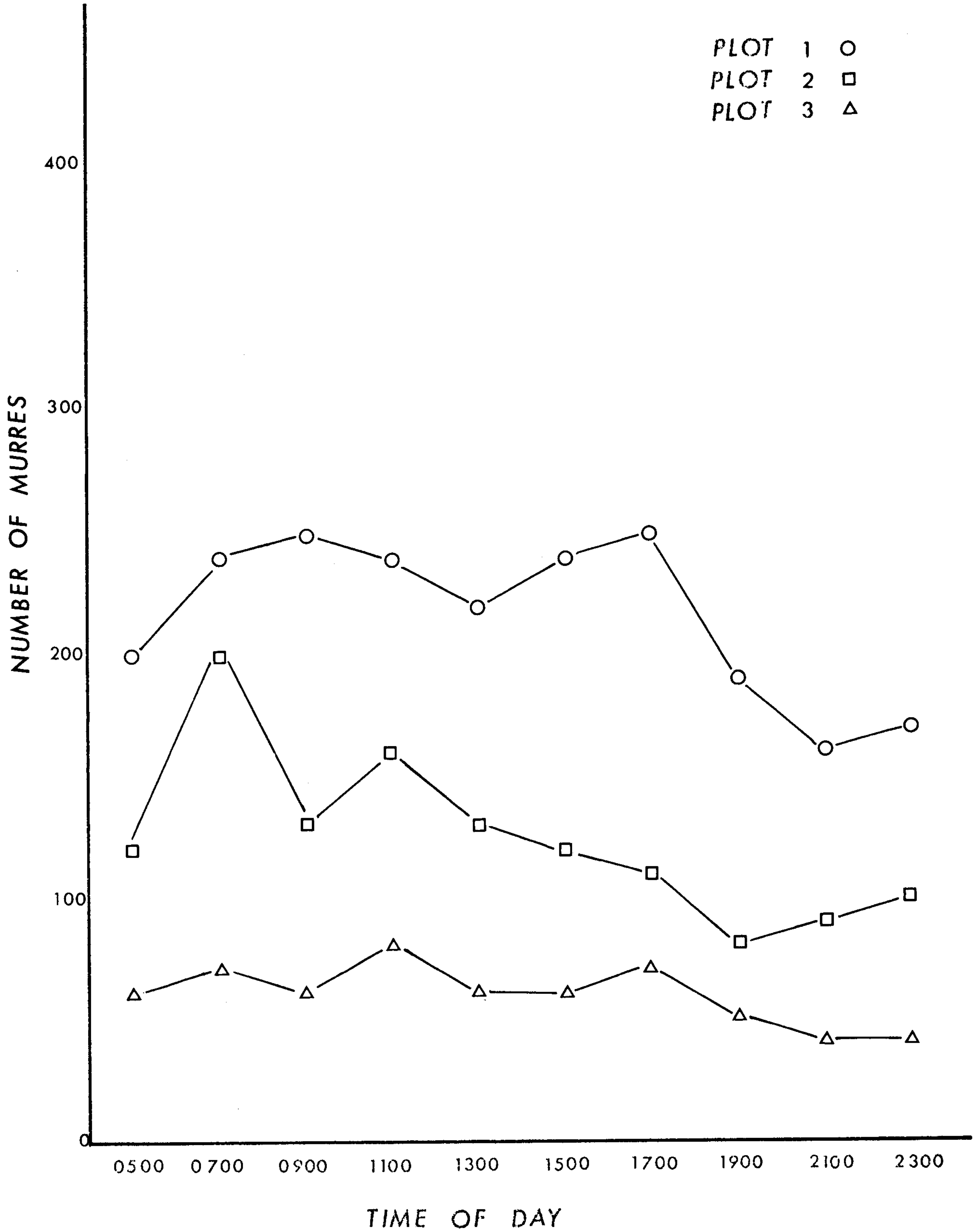

FIGURE 6. Average Number of Murres Present on Three Activity Plots at Various Times during the Day between 11 and 19 July 1976 (see also Appendix 4).

murres on ledges could not be seen from the boat; however, the closeness of the two counts to each other and to the extrapolated estimate from the plots is striking.

One previous estimate of the number of murres on the cliffs of Owalit Mountain was made by S.R. Johnson (pers. comm.) during 1972. During surveys made on 12 and 14 August 1972 Johnson estimated approximately 60,000 murres on Owalit Mountain--almost four times the number present during 1976.

Although the reduction in the number of murres on the breeding ledges at Kongkok Bay from 1972 to 1976 was possibly due to an actual population decline, the reduction may also have been the result of the late presence of snow cover on the breeding ledges. The prolonged snow cover could have caused reduced numbers of murres on the ledges in several ways:

1. Birds may not have attempted to land on the snow-covered ledges. After the ledges had remained snow-covered for a longer than normal period of time, many birds may have left the Kongkok Bay area.
2. Birds that eventually landed on the cliffs after the snow had melted may not have been able to breed successfully (due to regression of the follicles, etc.) and may have left the Kongkok Bay area early.
3. Birds that failed to breed due to the prolonged presence of snow on the cliffs may have remained in the Kongkok Bay area but may have spent less time on the ledges than did incubating birds. Hence, I probably have underestimated the total number of birds present on the ledges by extrapolating from the weekly counts of birds on the plots.

Based upon a sample of 2560 murres that were identified to species, the ratio of Common to Thick-billed Murres on Owalit Mountain during 1976 was approximately 1:2. Fay and Cade (1959) reported that they found large fluctuations in the ratio of Common to Thick-billed Murres ranging from 1:2 to 1:100. Apparently, the ratio that is obtained is dependent upon where (on the cliffs) the counts are made. Although my data are few in this respect, no Common Murres were seen on the cliffs above 50 m. This is probably due to the fact that Common Murres prefer wider ledges than do Thick-billed Murres (Tuck 1960:80; Birkhead 1975:58; and others); nearly all of the ledges above 50 m were extremely narrow.

Black-legged Kittiwakes

Activity Cycles

The numbers of kittiwakes that were present on the breeding cliffs throughout the day differed greatly between June and July (Figures 7 and 8). More kittiwakes were present in the morning than in the evening during June, but this trend was reversed during July. The maximum number of kittiwakes that was counted on activity plots during July was 1.39 times the number counted on the activity plots between 10:00 and 12:00--the period during which the cliff plots were censused. Therefore, the estimates of kittiwake numbers that are presented below have been adjusted by a correction factor of 1.39.

Estimates

Extrapolated estimates of the number of kittiwakes present on the cliffs were based upon counts made during mid to late July. The average density of kittiwakes on the six plots was 0.8/100 m^2 and ranged from 0.0/100 m^2 to 5.2/100 m^2. The total corrected estimate of kittiwakes on the sea cliffs of Owalit Mountain based upon counts of birds on the plots was 1670. The average density of kittiwake nests on the plots was 0.4/100 m^2. Assuming that there is one pair of kittiwakes per nest, the extrapolated estimate of the number of breeding kittiwakes for the Owalit Mountain area is 1200 associated with 600 nests. During the cliff survey on 26 July, approximately 1380 kittiwakes were counted by both observers; the corrected estimate of the number of kittiwakes present on that date was 1920. Therefore, there were between 1700 and 1900 kittiwakes on the cliffs during mid to late July 1976, but only 60% to 70% of these birds were associated with nests.

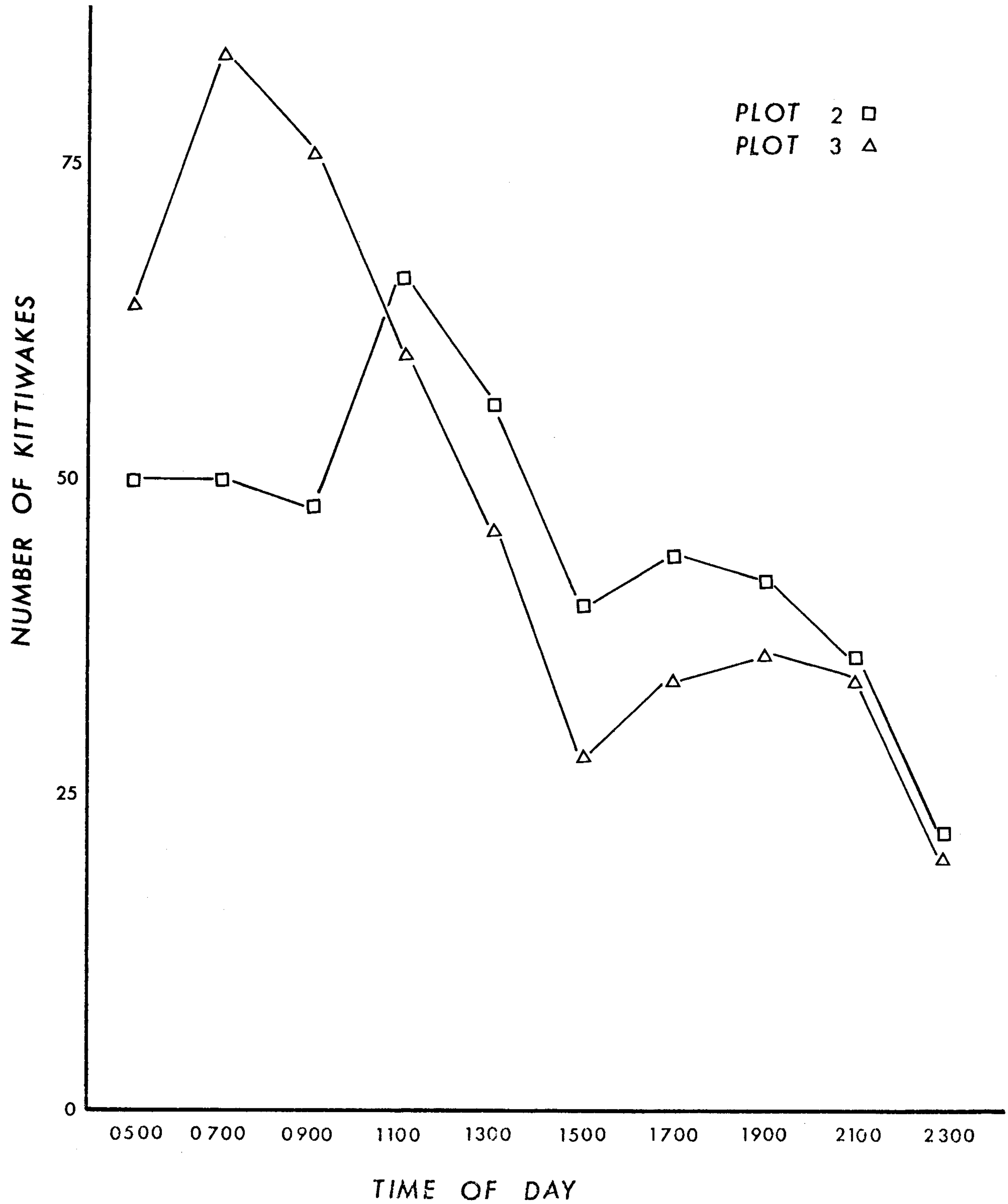

FIGURE 7. Average Number of Black-legged Kittiwakes Present on Two Activity Plots at Various Times during the Day between 11 and 27 June 1976 (no kittiwakes were present on Plot 1; see also Appendix 4).

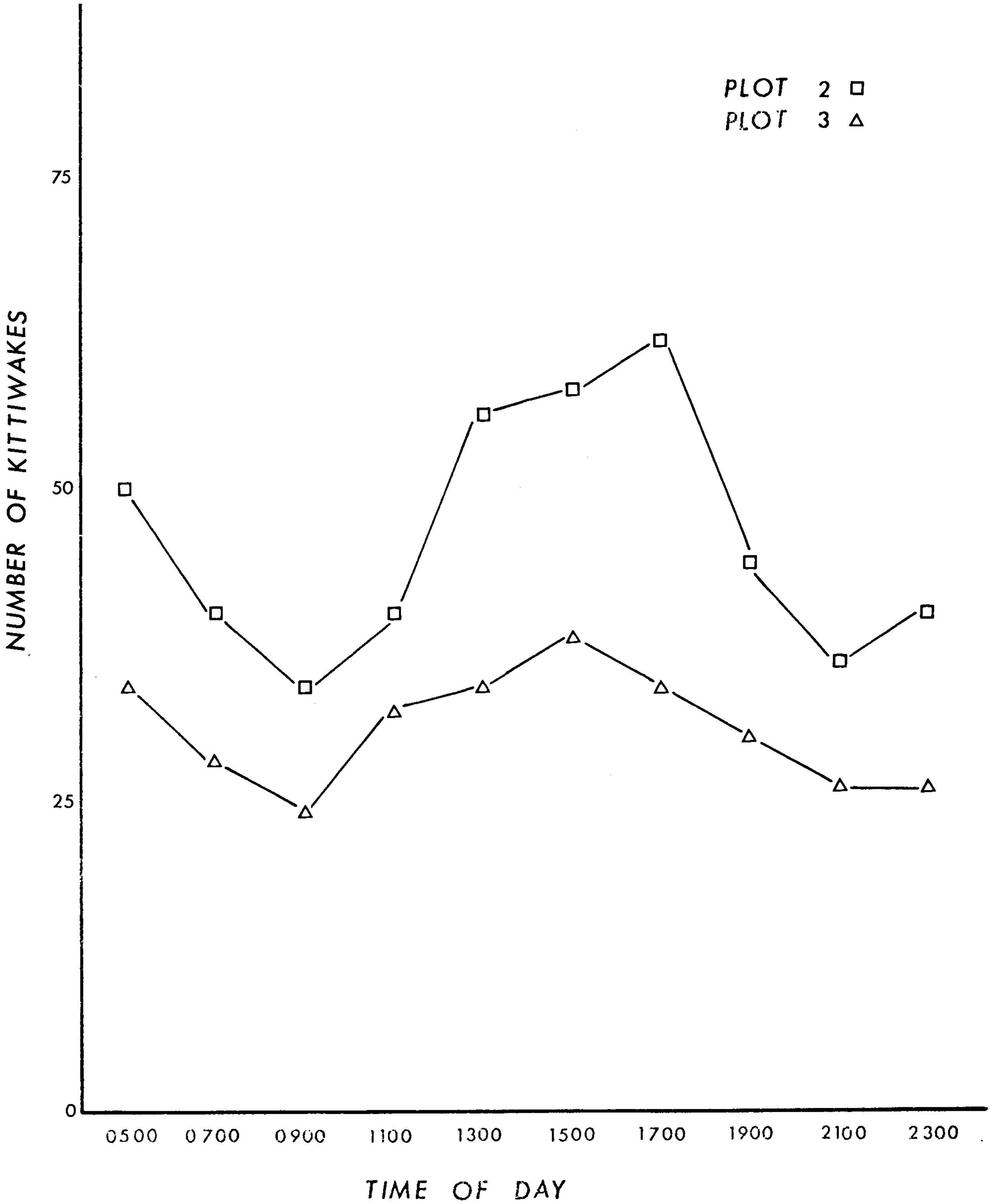

FIGURE 8. Average Number of Black-legged Kittiwakes Present on Two Activity Plots at Various Times during the Day between 11 and 19 July 1976 (no kittiwakes were present on Plot 1; see also Appendix 4).

Some of the difficulty of accurately estimating kittiwake numbers during 1976 was probably due to the fact that many kittiwakes did not lay eggs and a significant number did not even build nests. The latter situation may account for the discrepancy between estimates of kittiwake numbers based upon the number of nests and those based upon counts of birds. Therefore, the estimate based upon the number of nests is a better estimate of the number of breeding kittiwakes. However, because many kittiwakes that built nests did not lay eggs, even this estimate may be an overestimate of the number of kittiwakes that bred.

S.R. Johnson (pers. comm.) counted approximately 2000 kittiwakes during 1972 on a portion of the same cliffs that I surveyed during 1976. My count on this portion of the cliffs was only 225 kittiwakes. An even greater contrast between years exists when the number of kittiwake nests is considered. Johnson counted 1458 nests in this area during 1972 compared to an estimated 85 nests that were present there during 1976. The lower number of kittiwakes per nest during 1972 (1.3) than during 1976 (2.6) was probably another result of the differences in breeding success of kittiwakes during the two years. During 1972, most kittiwakes that nested apparently bred successfully (S.R. Johnson pers. comm.). Each member of an incubating pair is likely to spend a considerable amount of time feeding away from the nest; these birds have a lower probability of being counted. During years of partial breeding failure such as 1976, although kittiwakes may spend less total time on the ledges than during years in which they breed more successfully, both members of a pair may be present at their nest during periods when kittiwakes are present at the cliffs in peak numbers. Also, non-nesting (subadult) birds would be present on the cliffs (Coulson and White 1958); these "extra" birds could account for the excess of two birds per nest that was noted during the present study.

Large fluctuations in the number of breeding kittiwakes from one year to the next have been described in a colony in eastern Canada (Maunder and Threlfall 1972:790). It is unknown whether large declines in the number of breeding kittiwakes result from a reduction in the population of kittiwakes or merely from the absence of kittiwakes at the cliffs. Failure to arrive or remain at the cliffs may be due to factors such as late seasons, lack of sufficient food resources, lack of nesting space, or a change in the age ratio that favours young birds which may not remain on the breeding cliffs.

Pelagic Cormorants

Activity Cycles

The activity patterns of Pelagic Cormorants were inconsistent between plots (Figures 9 and 10). The number of cormorants on both Plots 1 and 2 did not fluctuate greatly during the day because most birds that were counted during both June and July were incubating eggs or young. There were no nests of Pelagic Cormorants on Plot 3. Cormorants on this plot were possibly members of nesting pairs that were preening and drying their feathers on the flat portion of the plot. The large increase in the numbers of Pelagic Cormorants on Plot 3 between 09:00 and 17:00 was probably due to the influx of birds returning from feeding trips. A low number of birds on the plot (e.g., between 04:00 and 10:00) probably indicates that a large number of birds were at sea feeding. Because of the variable nature of the data, no correction factor was developed for the estimate of the number of Pelagic Cormorants.

Estimates

Estimates of the number of Pelagic Cormorants that bred on the Owalit Mountain cliffs were based upon counts of birds and nests on six plots during June and early July. The average density of cormorants on the plots was 0.2/100 m^2 and ranged from 0.0/100 m^2 to 0.6/100 m^2. Extrapolation of these densities on the entire cliff area of Owalit Mountain resulted in a total estimate of 300 Pelagic Cormorants.

The average density of cormorant nests on the plots was 0.1/100 m^2. Therefore, the number of breeding cormorants was estimated to be 300 on 150 nests. Additional, non-breeding cormorants were probably also present

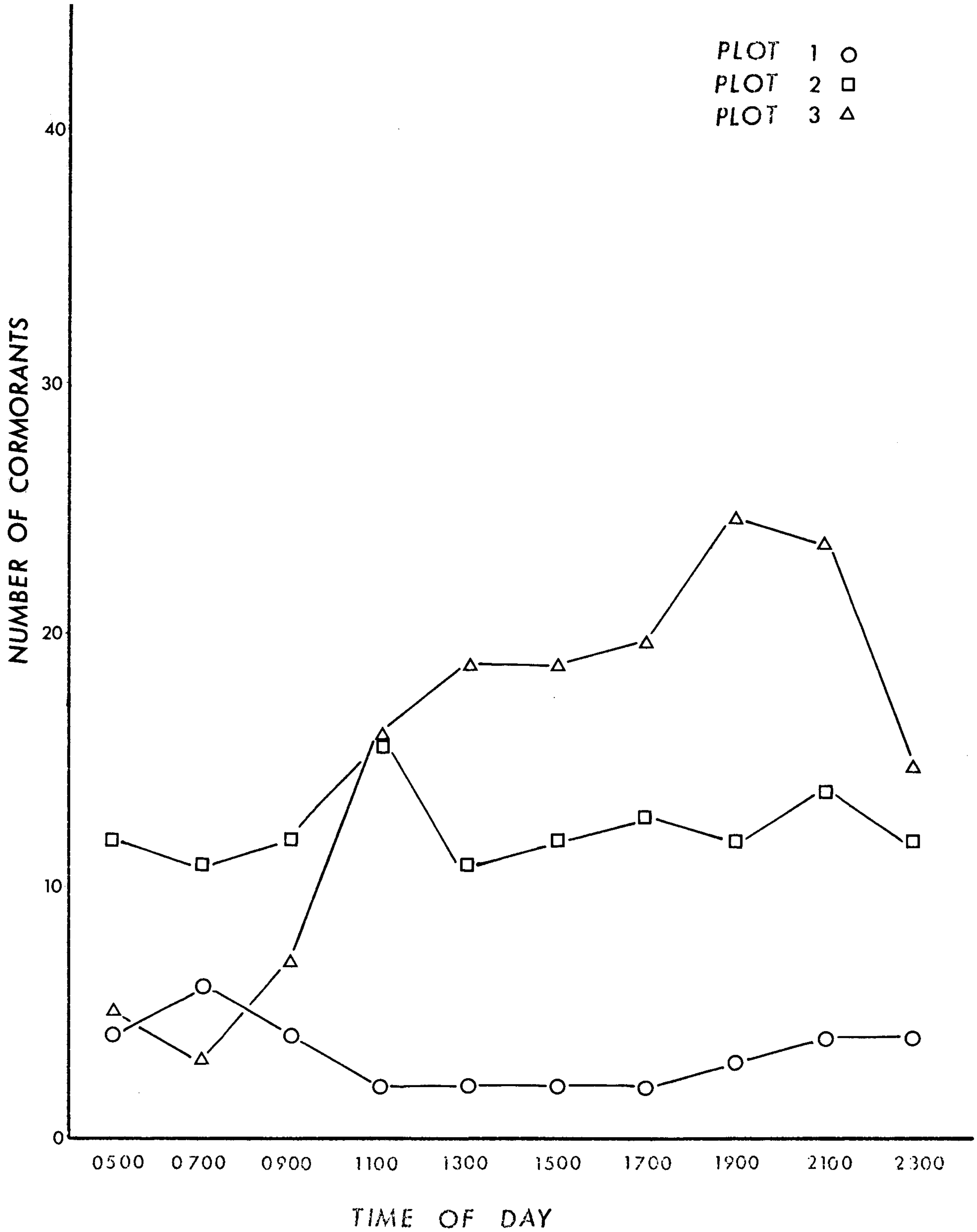

FIGURE 9. Average Number of Pelagic Cormorants Present on the Three Activity Plots at Various Times during the Day between 11 and 27 June 1976 (see also Appendix 4).

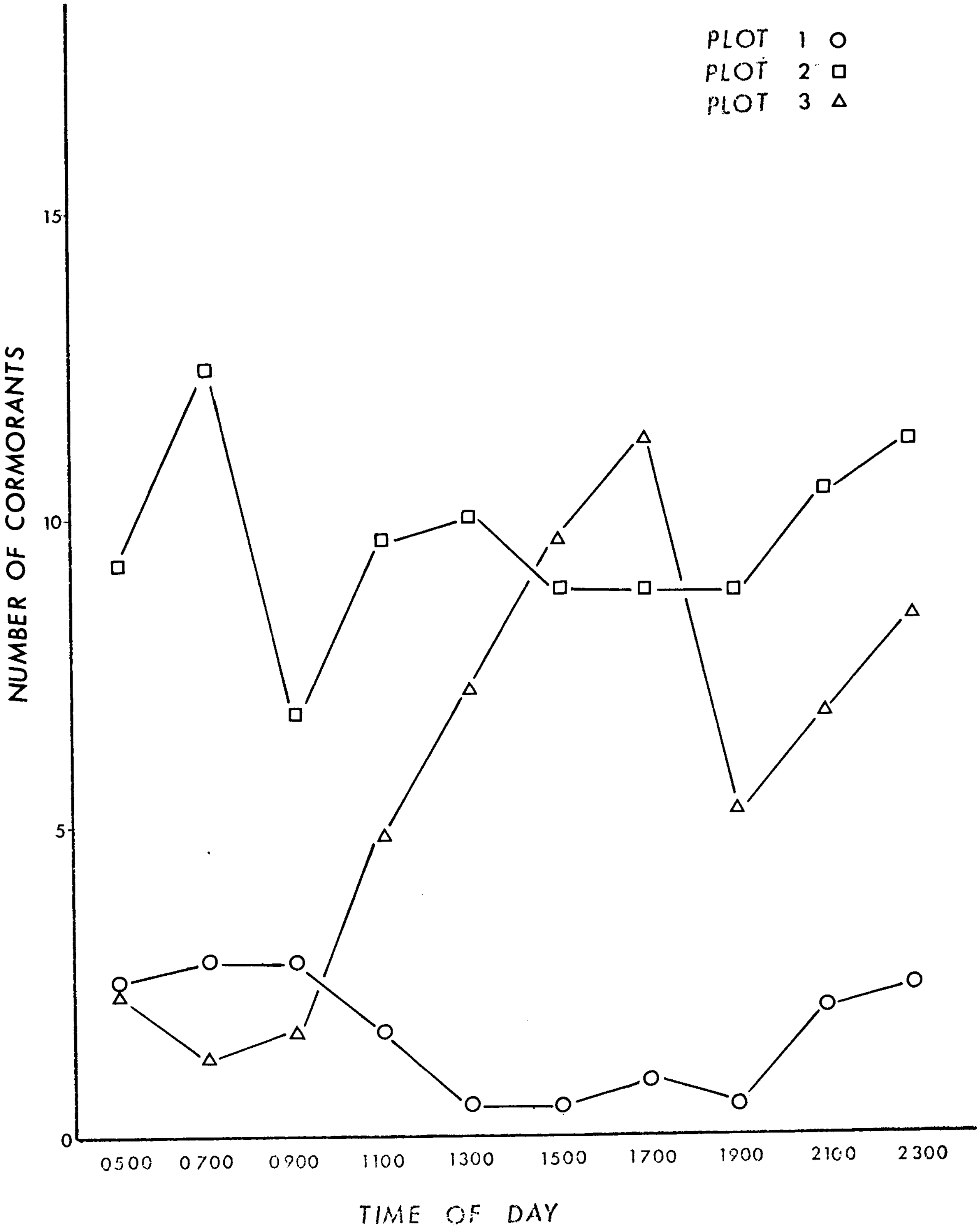

FIGURE 10. Average Number of Pelagic Cormorants Present on the Three Activity Plots at Various Times during the Day between 11 and 19 July 1976 (see also Appendix 4).

on the breeding cliffs (Palmer 1962:353). During August 1972, S.R. Johnson (pers. comm.) counted 58 nests on a portion of the Owalit Mountain cliffs (less than 1/3 of the total cliff area of Owalit Mountain); he estimated that 116 adult cormorants were associated with these nests.

Glaucous Gulls

Too few Glaucous Gulls were present on the plots to obtain an accurate density figure on which to base an estimate of the numbers present on the study area. Eight Glaucous Gull nests with eggs were located on two sea stacks in the study area and several more nests were present but were not accessible to me. I observed up to 20 Glaucous Gulls together at the base of Owalit Mounatin and I suspect that between 25 and 30 Glaucous Gulls were present and breeding on the cliffs of Owalit Mountain. In addition, an unknown number of immature gulls were present but they apparently roamed widely and could not be associated solely with the Owalit Mountain cliffs.

Parakeet Auklets

Activity Cycles

Parakeet Auklets were present on the cliffs in peak numbers between 06:00 and 08:00 each day during both June and July (Figures 11 and 12). During June, the numbers of Parakeet Auklets decreased during the late morning hours to a point where virtually no Parakeet Auklets were present on the cliffs after 14:00. During July, however, Parakeet Auklets remained on the cliffs later in the day; their numbers did not decline markedly until after 15:00. The number of Parakeet Auklets counted at the peak period was 1.27 times the number of auklets counted between 10:00 and 12:00. This correction factor was applied to the estimates of Parakeet Auklets below.

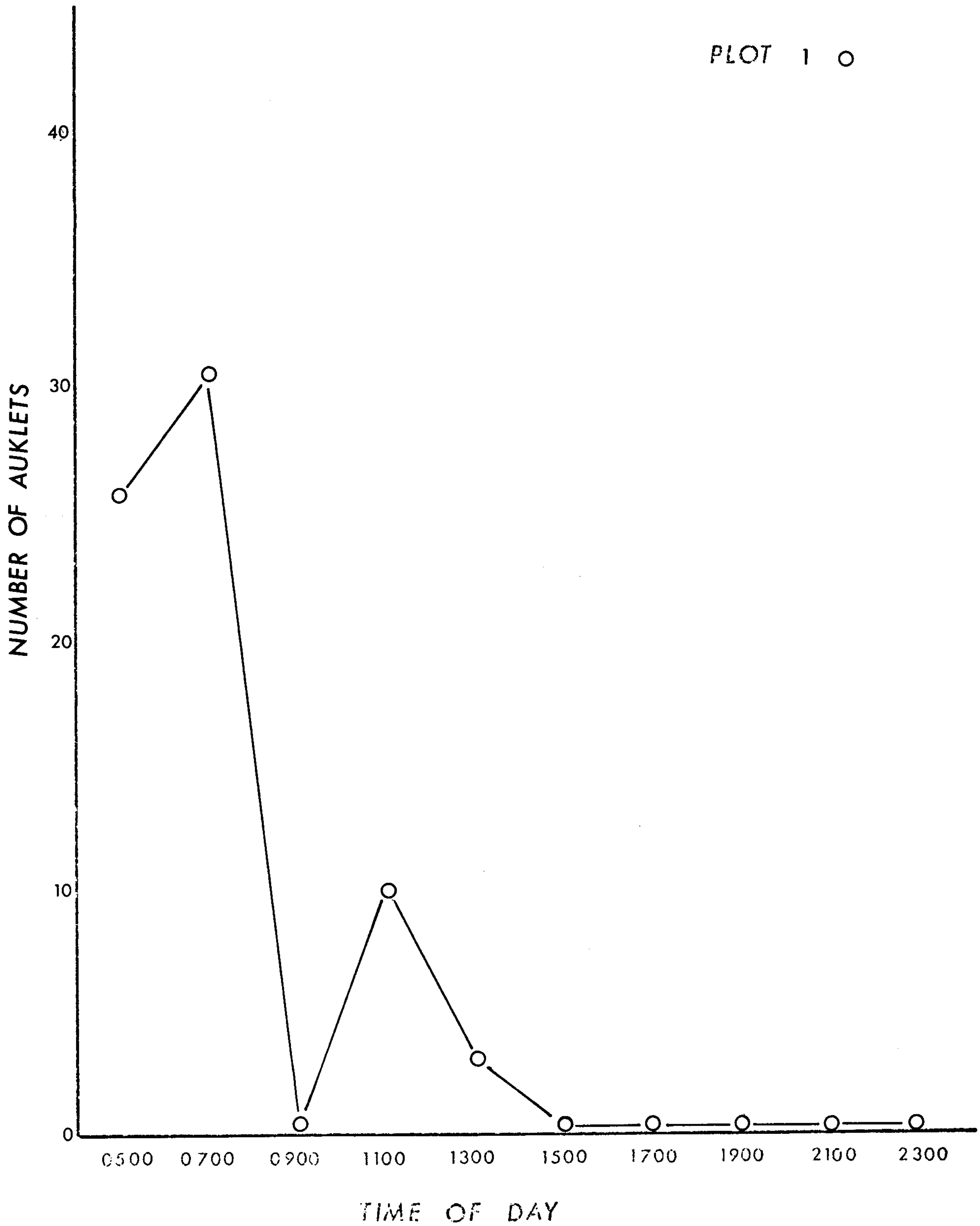

FIGURE 11. Average Number of Parakeet Auklets Present on One Activity Plot at Various Times during the Day between 11 and 27 June 1976 (no auklets were present on Plots 2 or 3; see also Appendix 4).

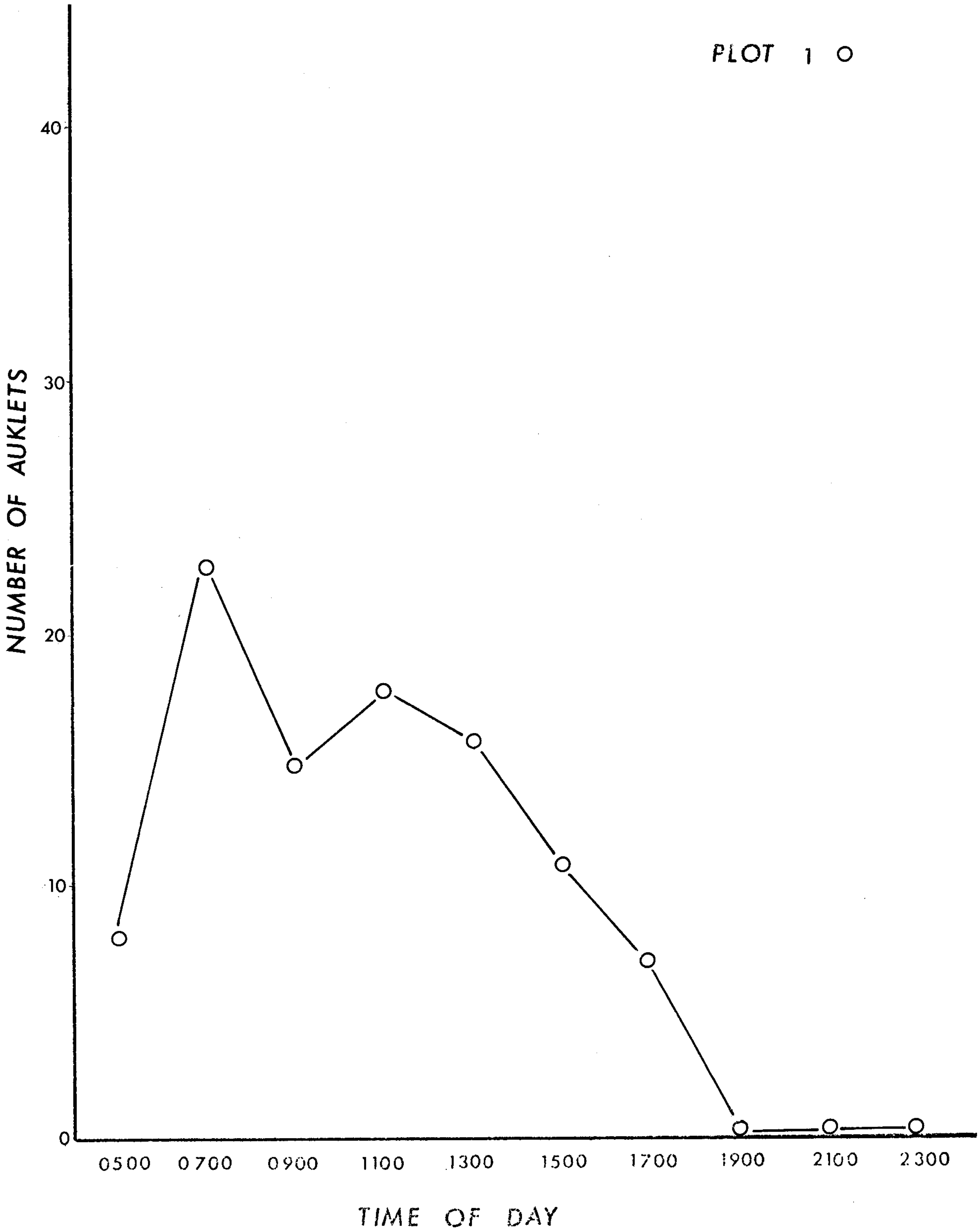

FIGURE 12. Average Number of Parakeet Auklets Present on One Activity Plot at Various Times during the Day between 11 and 19 July 1976 (no auklets were present on Plots 2 or 3; see also Appendix 4).

Estimates

The density of Parakeet Auklets on six plots that were surveyed during mid-July ranged from 0.0/100 m^2 to 2.6/100 m^2 and averaged 0.3/100 m^2. After applying the correction factor, an estimated 600 Parakeet Auklets were present on the cliff area of Owalit Mountain during peak attendance. Counts of Parakeet Auklets on the cliff plots were made incidental to counts of true cliff-nesting species. Most Parakeet Auklets nested under large boulders near the crest of Owalit Mountain and therefore were not counted on the cliff plots. I suspect that estimates of Parakeet Auklet numbers on Owalit Mountain that are based on the densities found on the plots are underestimated by 50 to 66 percent. Thus, it is very likely that between 1200 and 1800 Parakeet Auklets nested on Owalit Mountain. Parakeet Auklets were by far the least numerous of the auklets; they comprised less than 1% of the auklet population of the Kongkok Bay area.

Tufted Puffins

Activity Cycles

A very distinct diurnal pattern of Tufted Puffin presence on the cliffs was evident during June (Figure 13). Peak numbers of Tufted Puffins were present on the cliffs between 08:00 and 10:00 and again between 20:00 and 22:00. Low numbers occurred during midday (approximately between 14:00 and 16:00) and probably throughout the night (24:00-06:00). The activity pattern during July was less distinct and did not show a low during midday (Figure 14). However, the pattern of low numbers present at night was still evident. A correction factor of 1.57 was used to calculate the numbers of Tufted Puffins present at peak periods during the day from counts at 10:00 to 12:00.

Estimates

Tufted Puffins nested in the steeply sloping grassy areas immediately above the cliff ledges as well as in cracks on the ledges themselves. Because all plots that were censused extended from the grassy top (when

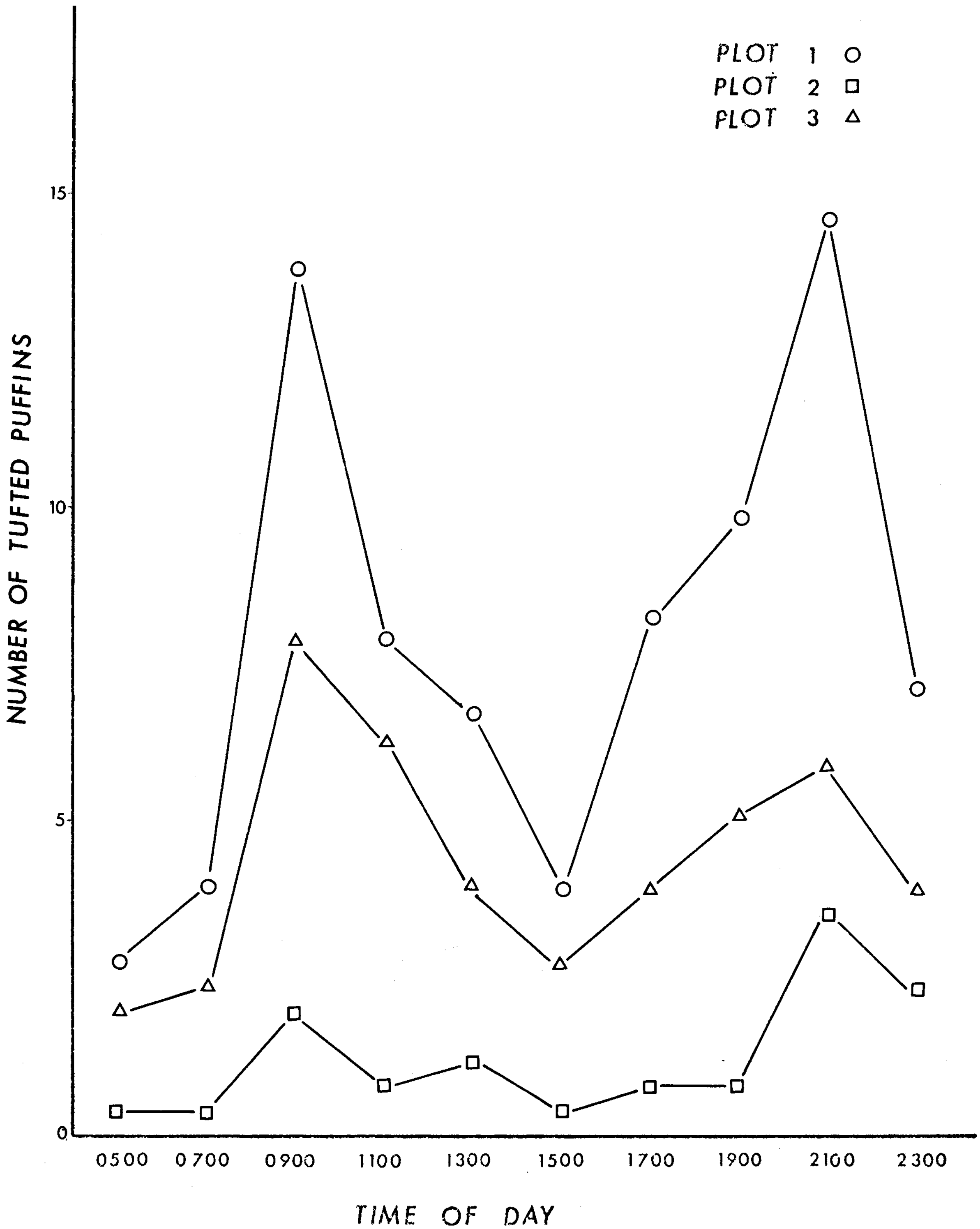

FIGURE 13. Average Number of Tufted Puffins Present on the Three Activity Plots at Various Times during the Day between 11 and 27 June 1976 (see also Appendix 4).

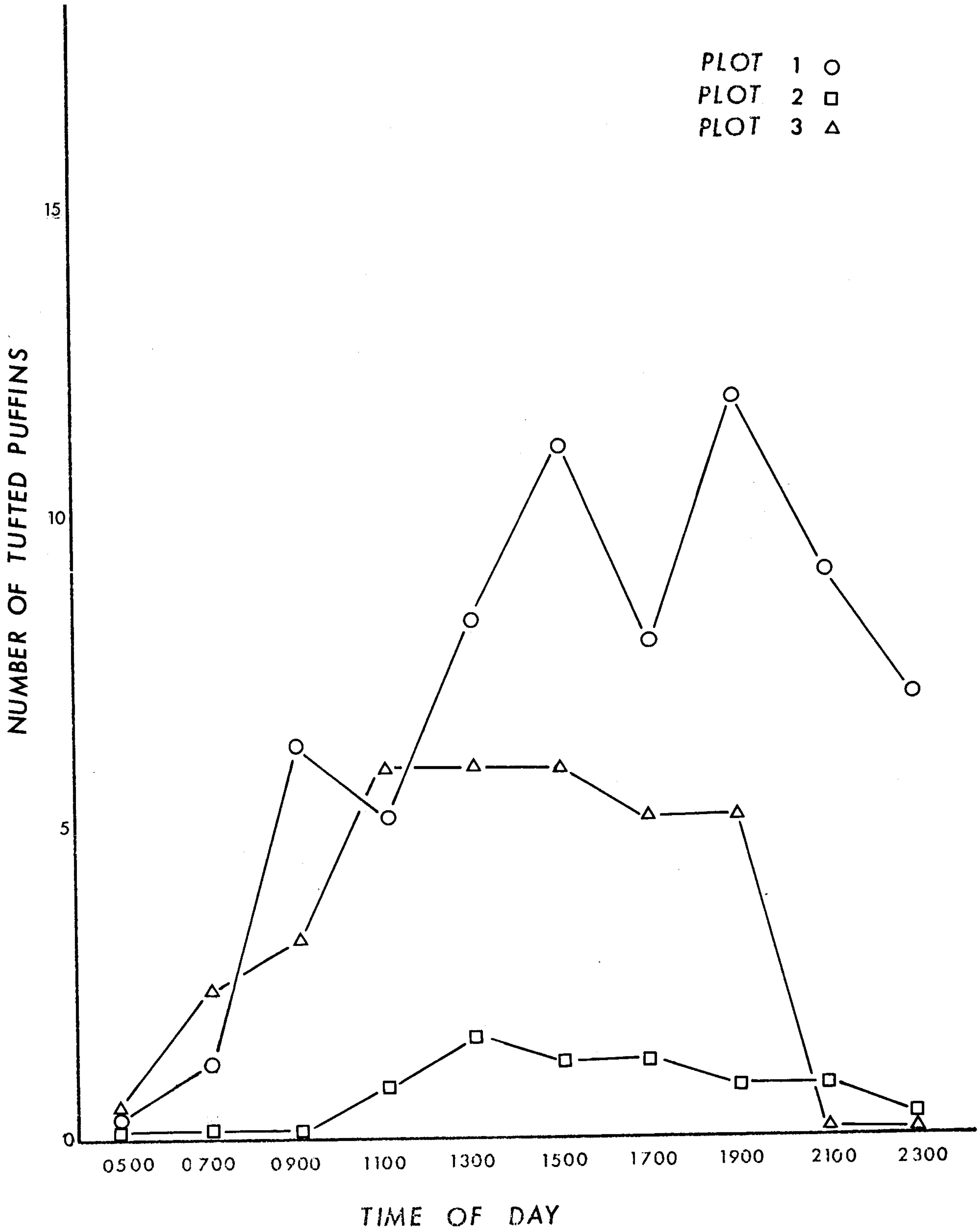

FIGURE 14. Average Number of Tufted Puffins Present on the Three Activity Plots at Various Times during the Day between 11 and 19 July 1976 (see also Appendix 4).

present) of the cliffs to the bottom of the cliffs, a reasonably accurate estimate of Tufted Puffin numbers should result from extrapolations of the density of Tufted Puffins on the plots. However, estimates of puffin numbers based on counts of birds are complicated by the quasi-cyclical nature of puffin activity (Nettleship 1972:249-250). In order to account for these quasi-cyclical fluctuations in puffin numbers (see Horned Puffins below) the maximum density of Tufted Puffins observed during censuses conducted on several different days during the pre-egglaying phase was used as the basis of the estimates (see Nettleship 1976a:23).

The density of Tufted Puffins ranged from 0.0/100 m^2 to 1.4/100 m^2 on six plots and averaged 0.3/100 m^2. The corrected estimate of the number of Tufted Puffins on Owalit Mountain is approximately 740.

Horned Puffins

Activity Cycles

Horned Puffins were present on the cliffs in largest numbers between 18:00 and 22:00 during June and July (Figures 15 and 16). In order to determine whether Horned Puffin numbers on St. Lawrence Island fluctuated on a 4 to 5-day-cycle as noted by Nettleship (1972:249-250) for Common Puffins (*Fratercula arctica*) at Great Island, Newfoundland, a count of Horned Puffins was made three times each day, from 30 July to 6 August. (Nettleship [1976a:23] suggests that the best time to census Common Puffins is during the pre-egglaying period. However, due to large amounts of snow under avalanche conditions near the puffin plot at Kongkok Bay, the plot was inaccessible until after egg-laying began.) The results are presented in Figure 17. Peak Horned Puffin numbers again occurred during the evening period (approximately 20:00) with low numbers normally occurring during the early morning hours. Large fluctuations in the number of Horned Puffins were noted over a 6-day-period beginning with a day of low numbers, then 4 days of high numbers, followed by another day of low numbers. During the low period, the number of puffins counted was near zero, even though birds were present on the plot (incubating) at this time. Thus, there is a

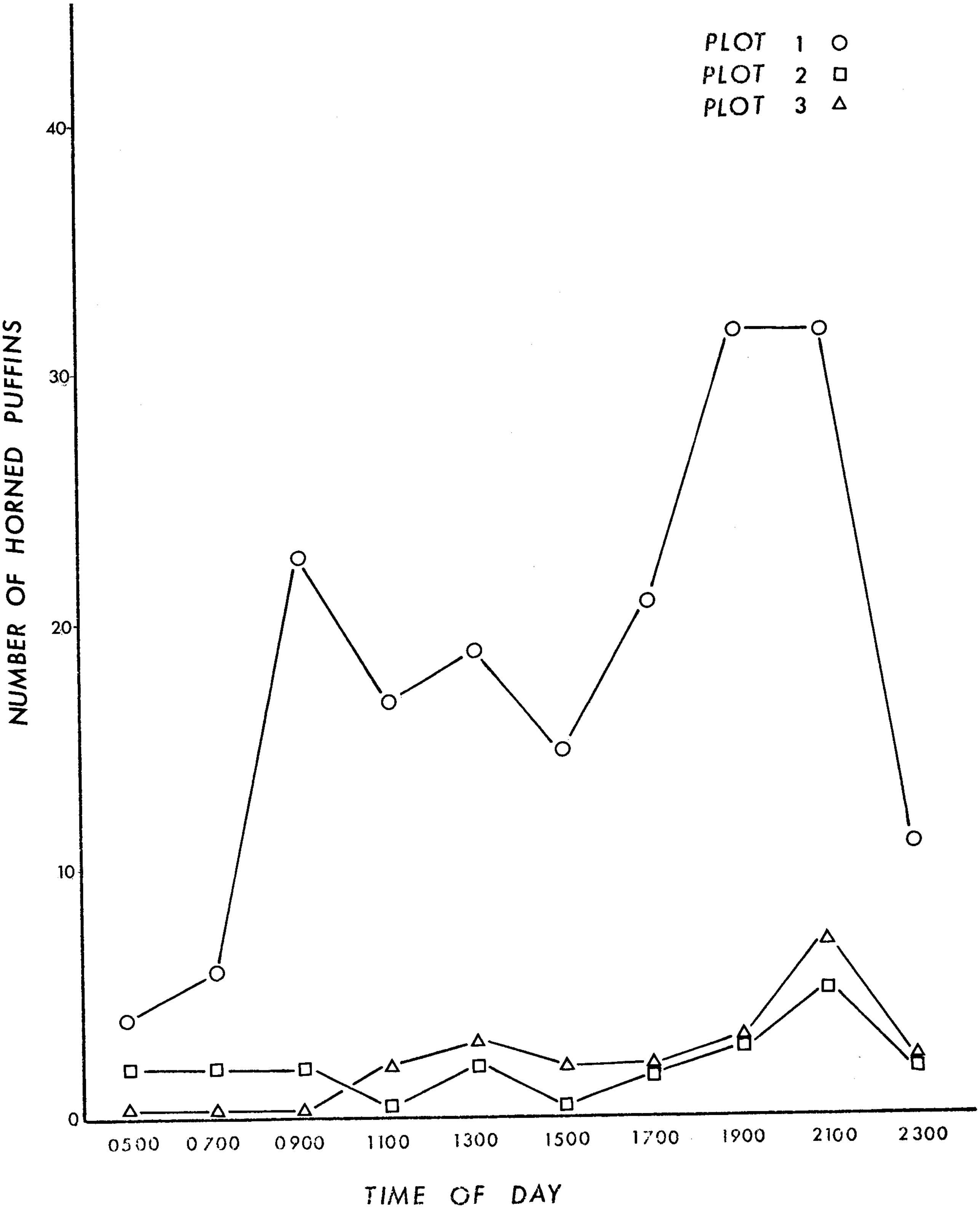

FIGURE 15. Average Number of Horned Puffins Present on the Three Activity Plots at Various Times during the Day between 11 and 27 June 1976 (see also Appendix 4).

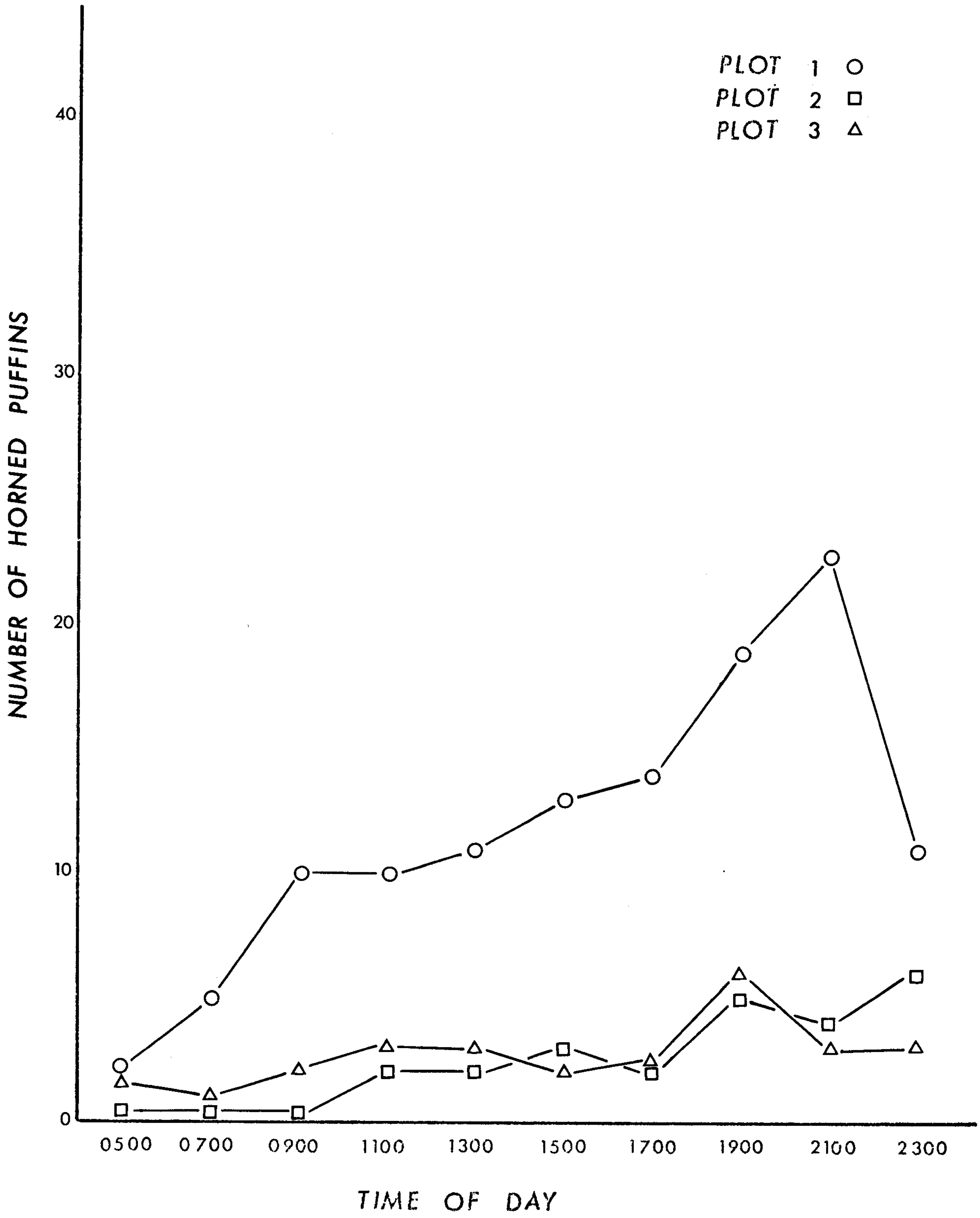

FIGURE 16. Average Number of Horned Puffins Present on the Three Activity Plots at Various Times during the Day between 11 and 19 July 1976 (see also Appendix 4).

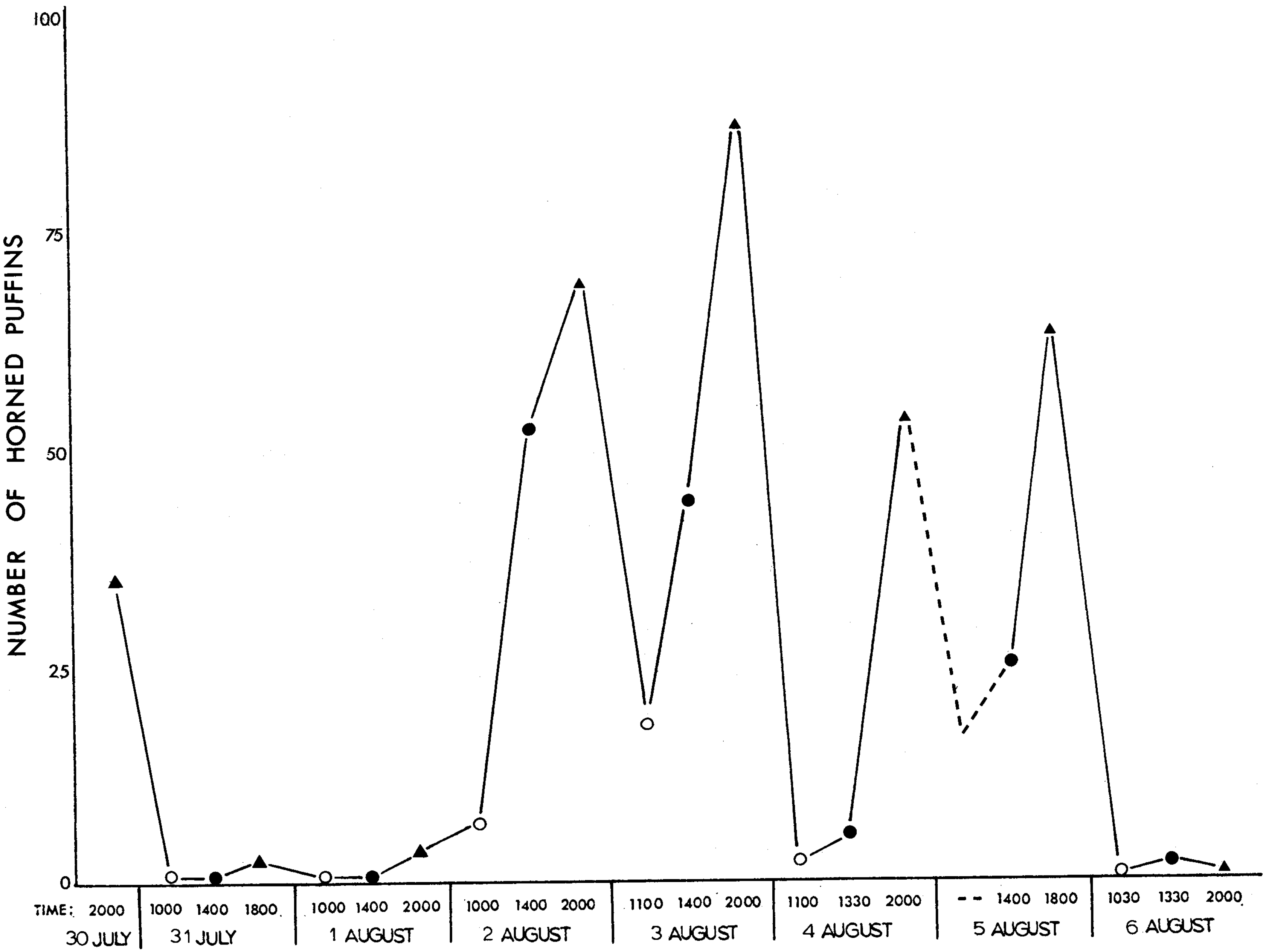

FIGURE 17. Number of Horned Puffins Observed during Daily Plot Censuses Conducted between 30 July and 6 August 1976.

diurnal cycle and there are strong day-to-day fluctuations in numbers detectable apparently varying on a 6-day-cycle. A correction factor of 1.89 was calculated for use in estimating Horned Puffin numbers.

Estimates

The complexity of puffin activity cycles makes estimation of their numbers by counting individual birds very difficult. However, due to the inaccessibility of puffin nest sites on Owalit Mountain, it was impossible to estimate numbers by counting burrows as suggested by Nettleship (1976: 22). Therefore, population estimates of puffins had to be based on counts of birds. In order to account for the day-to-day fluctuations in detectability, estimates were based upon the maximum density of birds observed on plots during several days during the pre-egglaying stage (early June).

The density of Horned Puffins on six plots ranged from 0.1/100 m^2 to 0.3/100 m^2. A corrected estimate of 570 Horned Puffins on Owalit Mountain was calculated from the average density of 0.2/100 m^2.

Pigeon Guillemots

Activity Cycles

The pattern of activity of Pigeon Guillemots was somewhat similar for the June and July periods (Figures 18 and 19). Pigeon Guillemots were generally found in the largest numbers during the morning. The numbers of Pigeon Guillemots gradually declined until about 16:00, then began to increase until about 20:00. The morning peak lasted later during July than during June. Counts of Pigeon Guillemots were made while counting Horned Puffins between 30 July and 6 August; the results are presented in Figure 20. The numbers of Pigeon Guillemots on the plot fluctuated mostly between 10 and 20 birds, but no diurnal rhythm could be detected.

At Novaya Zemlya, U.S.S.R., Uspenski (1956:82) noted that Black Guillemots showed a definite diurnal rhythm. Guillemots were most active during the morning and congregated on shore near nest sites during the

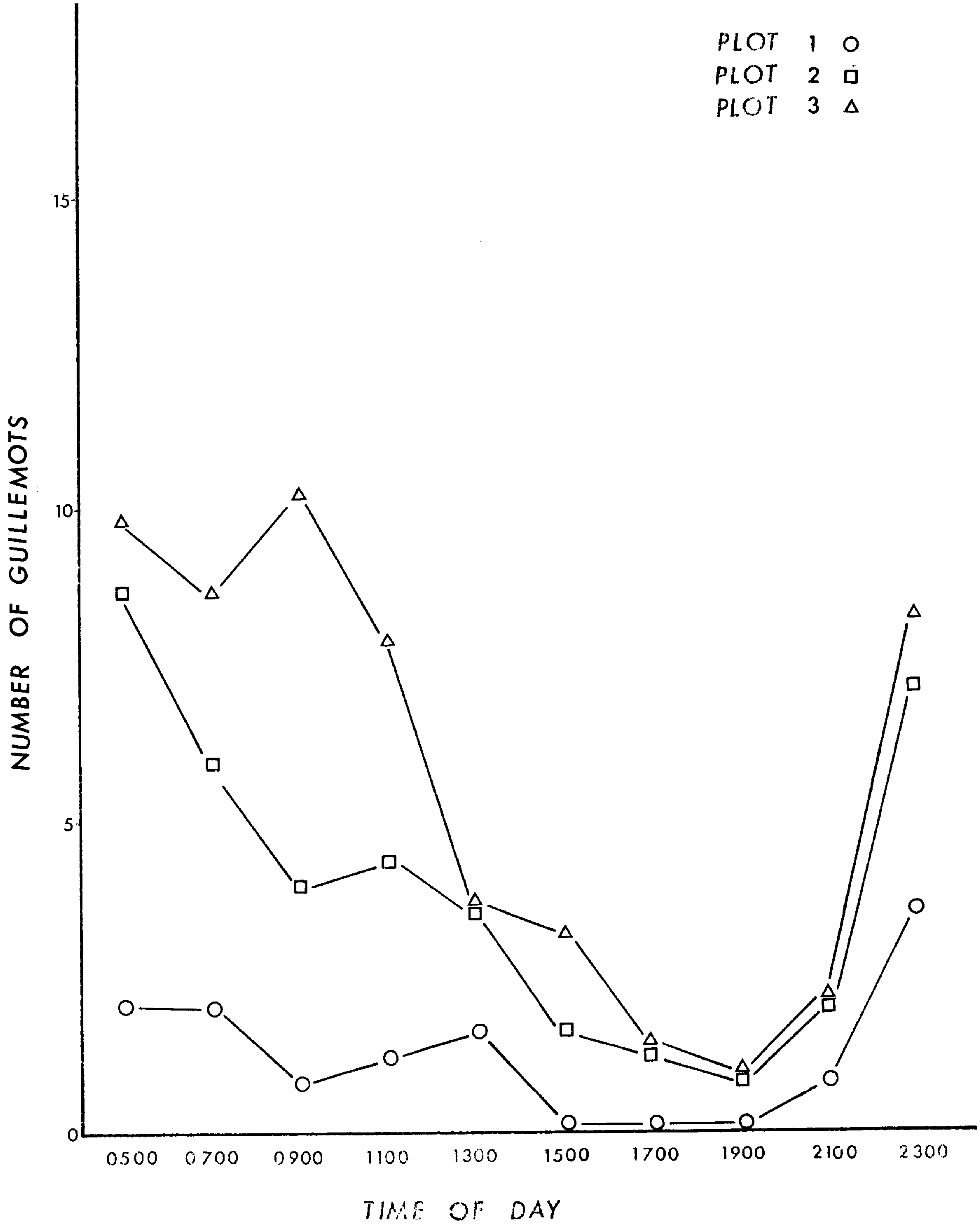

FIGURE 18. Average Number of Pigeon Guillemots Present on the Three Activity Plots at Various Times during the Day between 11 and 27 June 1976 (see also Appendix 4).

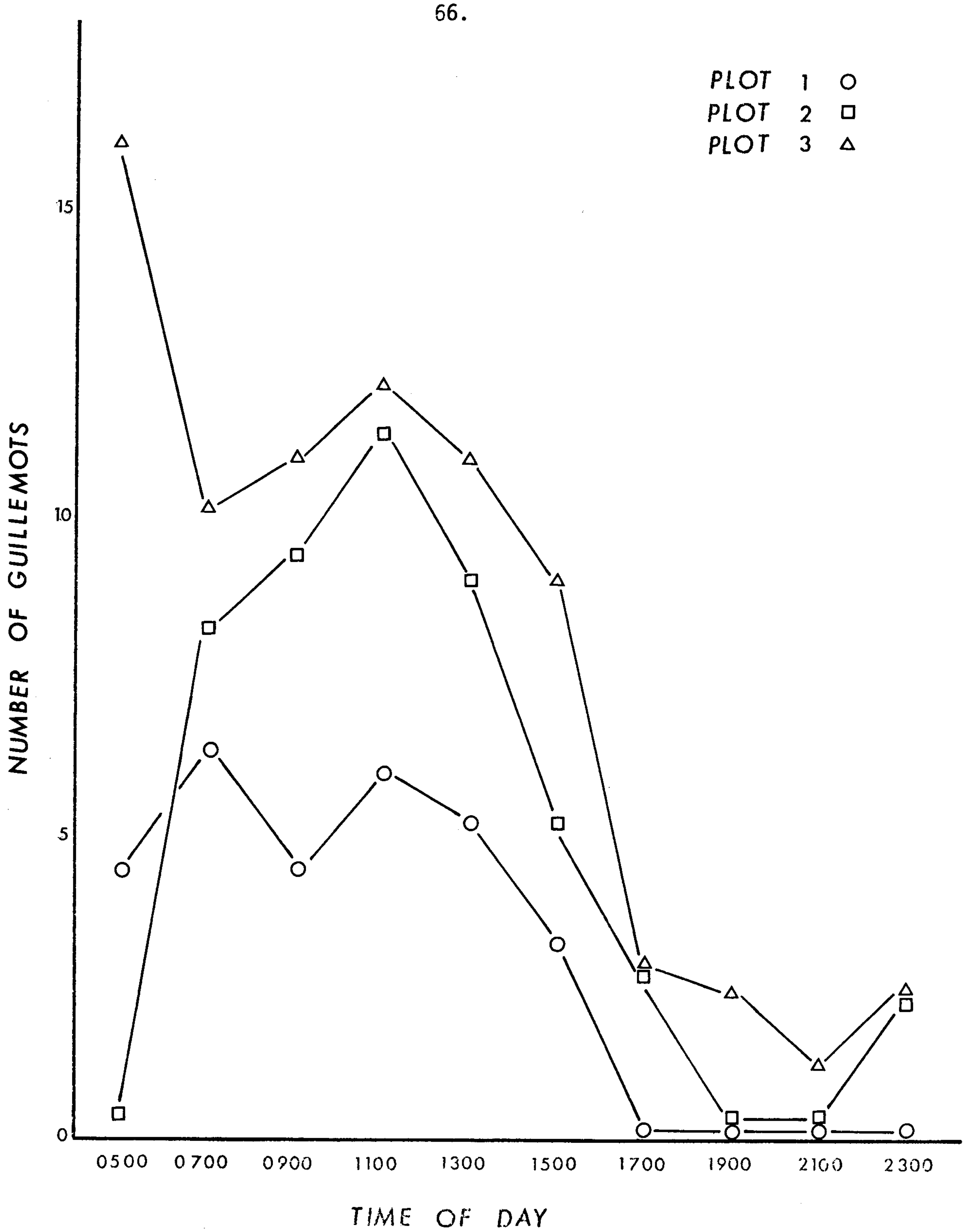

FIGURE 19. Average Number of Pigeon Guillemots Present on the Three Activity Plots at Various Times during the Day between 11 and 19 July 1976 (see also Appendix 4).

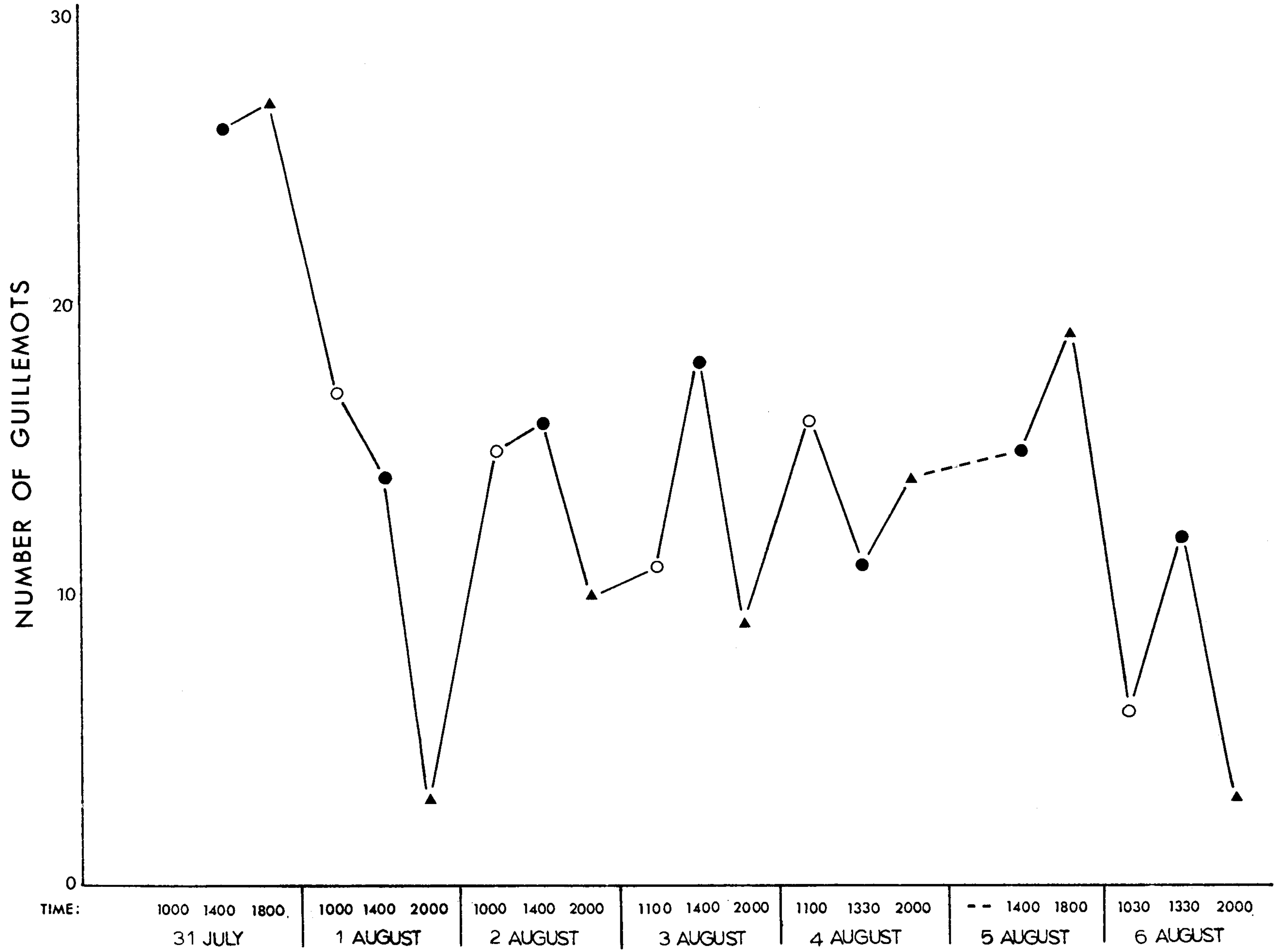

FIGURE 20. Number of Pigeon Guillemots Observed during Daily Plot Censuses Conducted between 31 July and 6 August 1976.

evening and night. Drent (1965:101), working on Pigeon Guillemots at Mandarte Island, British Columbia, found that the length of time guillemots spent at the colony was greatest during the latter half of June and the first half of July; full attendance occurred from dawn to early afternoon. By mid-August only breeding birds remained at the colony all morning. However, Drent found that guillemots (other than incubating or brooding birds) did not spend the night at the colony. Observations of increasing numbers during the evening suggest that guillemots may have spent the night on shore at St. Lawrence Island. No correction factor for the estimates of Pigeon Guillemot numbers was developed because relatively high numbers of birds were present between 10:00 and 12:00, especially during July.

Estimates

Pigeon Guillemots were found in low densities on the lower cliffs; they were virtually absent from the upper cliffs. Because Pigeon Guillemots were not regularly found on the cliffs above 50 m and because the bottom portion of Plot 6 did not reach the water line, this plot was not used when calculating Pigeon Guillemot density.

An estimated 150 Pigeon Guillemots were present on the cliffs at an average density of $0.1/100\ m^2$. However, because Pigeon Guillemots used only the lowest portion of the cliffs for nesting, the density of guillemots is not comparable to that of other cliff-nesting species. Therefore, the density of Pigeon Guillemots is perhaps best presented as 28 Pigeon Guillemots per kilometre of beach between Kongkok Bay and Galuk.

Herring Gulls

One Herring Gull nest was present on a ledge of a large stack just outside of Kongkok Basin. It is estimated that about 2 to 4 Herring Gulls were present in the vicinity of the study area, but none bred on Owalit Mountain.

Breeding Biology

Least Auklets

Breeding Success

Seventy Least Auklet eggs were located and monitored throughout the incubation period. Because eggs were found at various stages of the incubation period, the hatching success determined in this study may be higher than the actual hatching success.

Hatching success of 70 eggs was 49%. However, some egg mortality was due to our disturbance of the nest sites. Five eggs were deserted soon after we discovered them; an additional eight eggs were predated between the time we discovered them and the next time we visited them. Most of the predation was thought to have occurred because of the use of surveyor's tape to mark the nests; the red flagging tape as well as the egg was usually removed by the predator. This procedure for marking nests was subsequently discontinued and cairns were used instead. Predation by Glaucous Gulls and Arctic Foxes was greatly reduced thereafter. Of the 57 eggs that were not immediately deserted or predated, 34 hatched--a hatching success of 60%.

Twelve eggs that failed to hatch were infertile or eggs in which the embryo died, usually at an early stage; four of these eggs were eventually predated. Six eggs were broken either by settling rocks, by predators (egg dropped while predator was attempting to remove it), or by rocks dislodged by me while checking nests. One adult Least Auklet was predated on its egg while incubating; the embryo eventually died.

Movements of short distances from the nest by prefledged young often resulted in my being unable to find the chick. Consequently, determination of the percentage of Least Auklets that fledged was more difficult than determination of hatching success. Of the 34 young that hatched successfully, nine survived to normal fledging age (approximately 32 days) and presumably fledged, seven died or were predated, and the fates of 18 were unknown. Once pre-fledged young leave the nest site, it is not known whether they continue to be fed by their parents. If not, then most, if not all, of the 18 chicks that left their nest before the age of fledging probably died. I suspect that most of these pre-fledging movements of chicks were due to our disturbance. If these birds are omitted from the calculation of fledging success, 56% of the young fledged (n = 16).

The overall breeding success (from egg to fledged chick) of Least Auklets during 1976 was calculated to be 34%. Using this value, the number of young fledged by the estimated 218,000 breeding Least Auklets in Kongkok Basin during 1976 was estimated to be 37,000 chicks.

Growth of Young

The weights of Least Auklet chicks at each day of age is plotted in Figure 21. No attempt has been made to transform the measurements (*cf.* Rickleffs 1967). The average rate of weight-gain during the period of maximum growth (5-24 days of age) was calculated to be approximately 3.7 $\pm$ 0.9 g/day (n = 10). This rate of weight-gain is complicated by the facts that some chicks had just been fed before being weighed and that others, which eventually died, gained very little weight--perhaps due to the death of one or both parents.

Most Least Auklet chicks that were measured attained adult body weight (~90.5g*) at approximately 24 days of age and then lost about 17% of their weight by the time they fledged. Sealy (1968:111) reported that Least Auklets attained 98% of adult body weight at 25 days of age but lost only 10.5% before fledging.

The growth of the primary feathers was less variable among Least Auklet chicks than was weight (Figure 22). The rate of primary development

*See Appendix 5 for weights and measurements of Least and Crested Auklets.

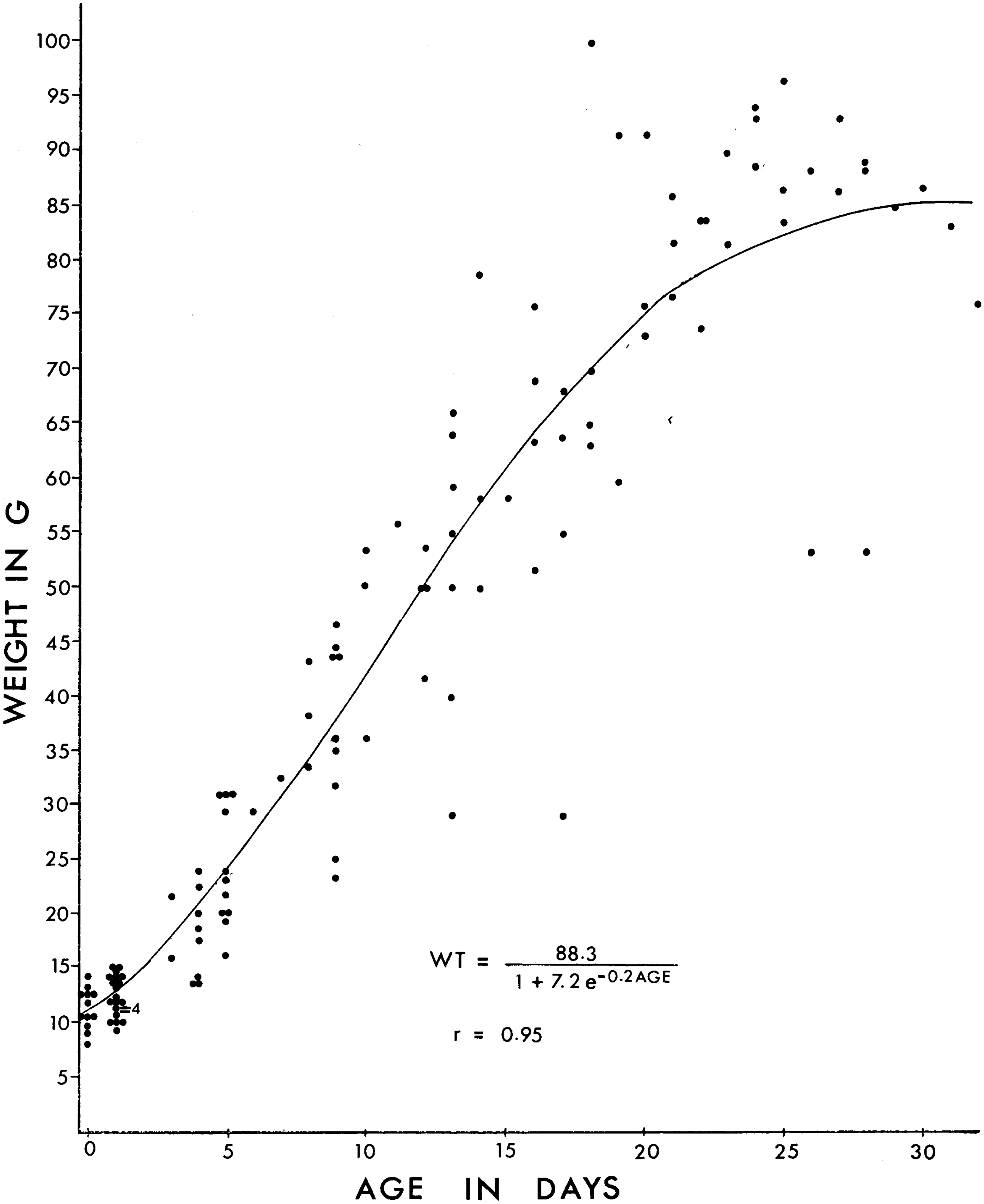

FIGURE 21. Weight of Least Auklet Chicks at each Day of Age during the Nestling Period.

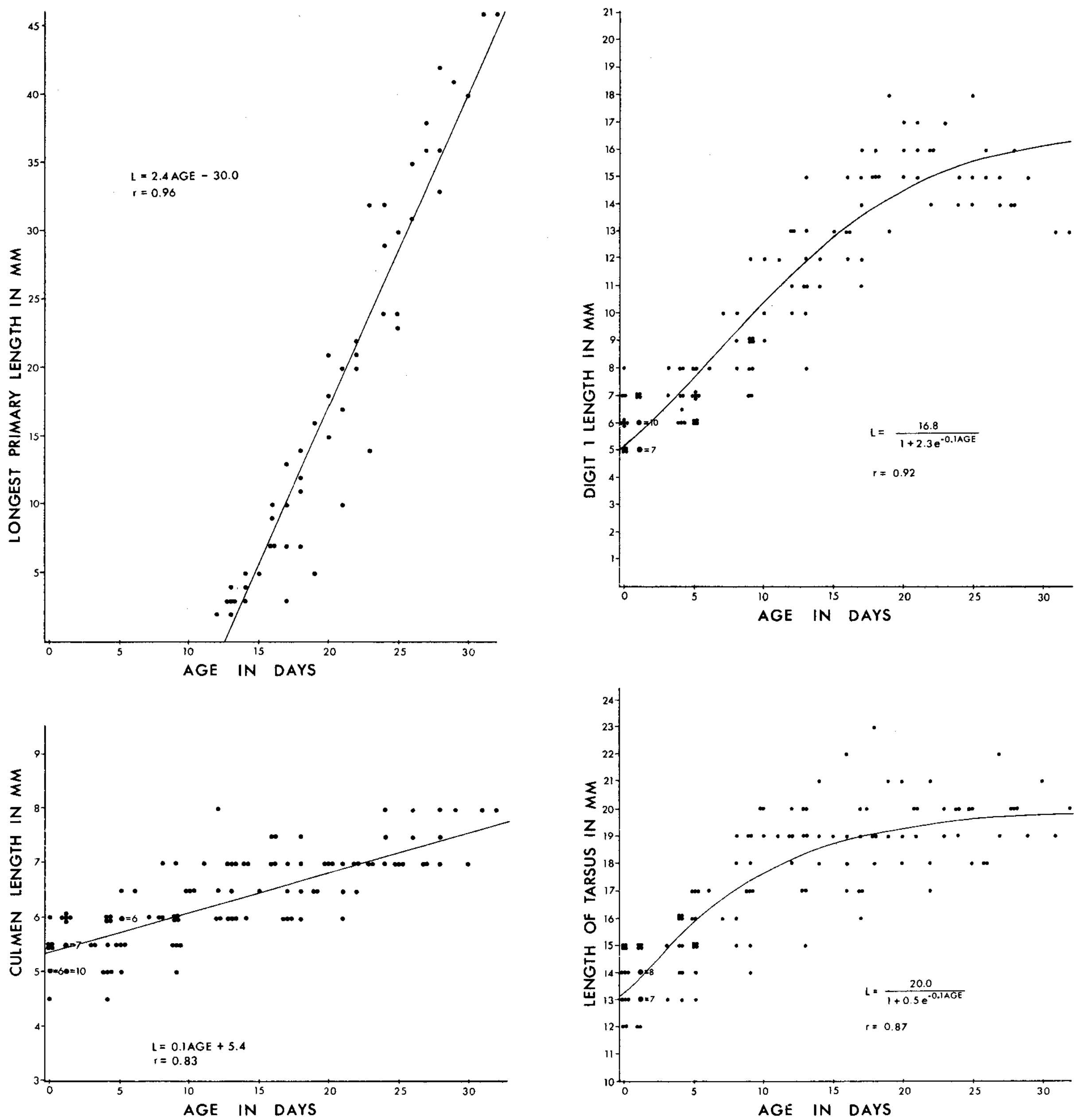

FIGURE 22. Length of Primary, Digit One, Culmen and Tarsus of Least Auklet Chicks at each Day of Age during the Nestling Period.

was quite linear. Eruption of the primaries (i.e., eruption of juvenile feather from sheath, not neossoptile) began at about 11 days of age; the primaries were approximately 80% of adult length (adult length = 59.4 mm) at 31 days of age (fledging). Sealy (1968:114) reported that the length of the primaries in pre-fledged Least Auklets was 88.8% of adult length.

Measurements of first digit, culmen, and tarsometatarsus (tarsus) of young Least Auklets are subject to measurement error and therefore must be interpreted with caution. Digit 1 grew steadily in Least Auklets until about 18 days of age; after that little additional growth occurred (Figure 22). The culmen grew from about 5 mm at age 0 days to between 7 mm and 8 mm--about 75% of adult size--at about 23 days of age (Figure 22). The tarsus grew steadily until the chick was approximately 10 days of age at which time the tarsus was almost fully grown (Figure 22). Until the chick is about 30-days old, walking is its only method of locomotion; therefore, rapid development of the tarsus may be adaptively significant for the survival of young auklet chicks beneath the rocks.

Crested Auklets

Breeding Success

Of the 48 Crested Auklet eggs that were found during 1976, only 11 hatched successfully. However, as with Least Auklets, my activities prevented some eggs from hatching. Six eggs were deserted shortly after being found and five were predated between the time they were found and the first time they were checked. If these eggs are omitted from the sample, 30% of the eggs that were laid hatched. The hatching success of the Crested Auklet (30%) is significantly lower than the hatching success of Least Auklets (60%) ($P < 0.01$; $\chi^2 = 6.894$; df = 1). Failure of eggs to hatch was due to predation (24%), breakage (8%) and infertility or death of the embryo (68%).

As with the Least Auklet, the fledging success of Crested Auklets is difficult to calculate. One Crested Auklet chick was still alive at the end of the study on 3 September but was only 23 days old; another chick was known to have died. The fate of the remaining nine chicks was unknown. Because of the small sample size, no percentage of fledging or of overall breeding success could be calculated for Crested Auklets.

Growth of Young

The weight of Crested Auklet chicks at each day of age for which data are available is presented in Figure 23. Crested Auklet chicks apparently did not have a lower rate of growth during the first few days after hatching than during the rest of the nestling period. The rate of growth over the entire nestling period was approximately 8.9 $\pm$ 1.9 g/day. Due to loss of chicks and an initial small sample size, the oldest chick that was measured was only 23 days old; this chick was only 5.7% below adult weight. However, a 21-day-old chick that was measured weighed only 210 g--78.5% of adult weight (adult weight = 267.1 g). Sealy (1968:111) found that Crested Auklets reached 90.8% of average adult weight in 27 days then lost 11% of their weight before fledging.

Unfortunately, I was able to monitor only two Crested Auklet chicks past 17 days of age. Therefore, I have few data on the growth of primary feathers of Crested Auklet chicks because primaries (shafts) first erupted from their sheath at about 11 days of age. Based on very few measurements, however, the rate of growth appears to be quite linear (Figure 24) and is similar to the pattern of growth of Least Auklet primaries presented above (Figure 22). One 23-day-old Crested Auklet chick had a primary feather that was 33.9% of adult length (adult length = 85.5 mm). This rate of growth is comparable to that of the Least Auklet. By the time that Crested Auklets are ready to fledge, their primaries are about 84.5% fully developed (Sealy 1968:114).

The growth of the first digit of Crested Auklet chicks was less variable than for Least Auklets (Figure 24), perhaps because feathering occurred at a later age in Crested Auklets than in Least Auklets and consequently there was less measurement error. The rate of growth was

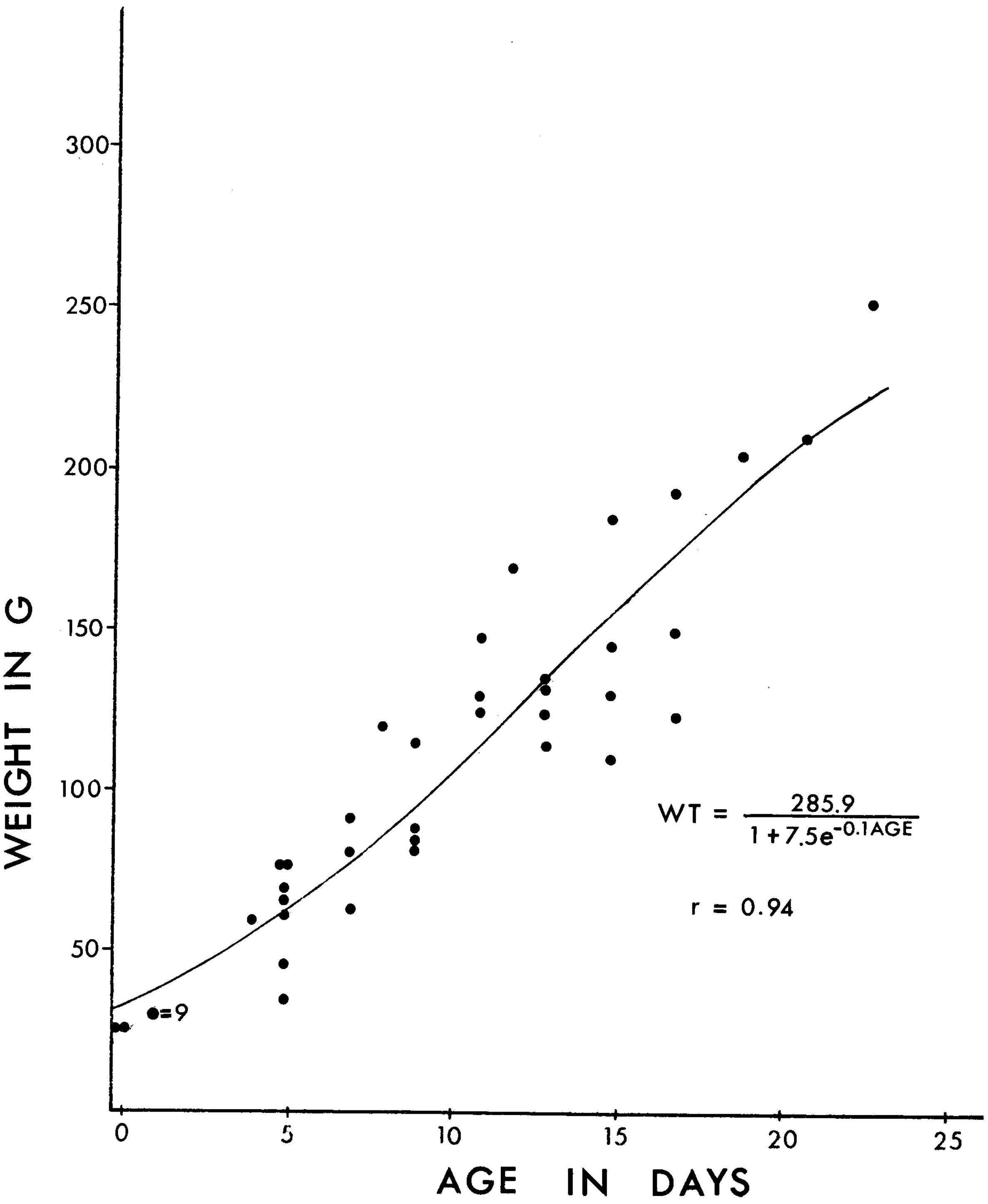

FIGURE 23. Weight of Crested Auklet Chicks at each Day of Age during the Nestling Period.

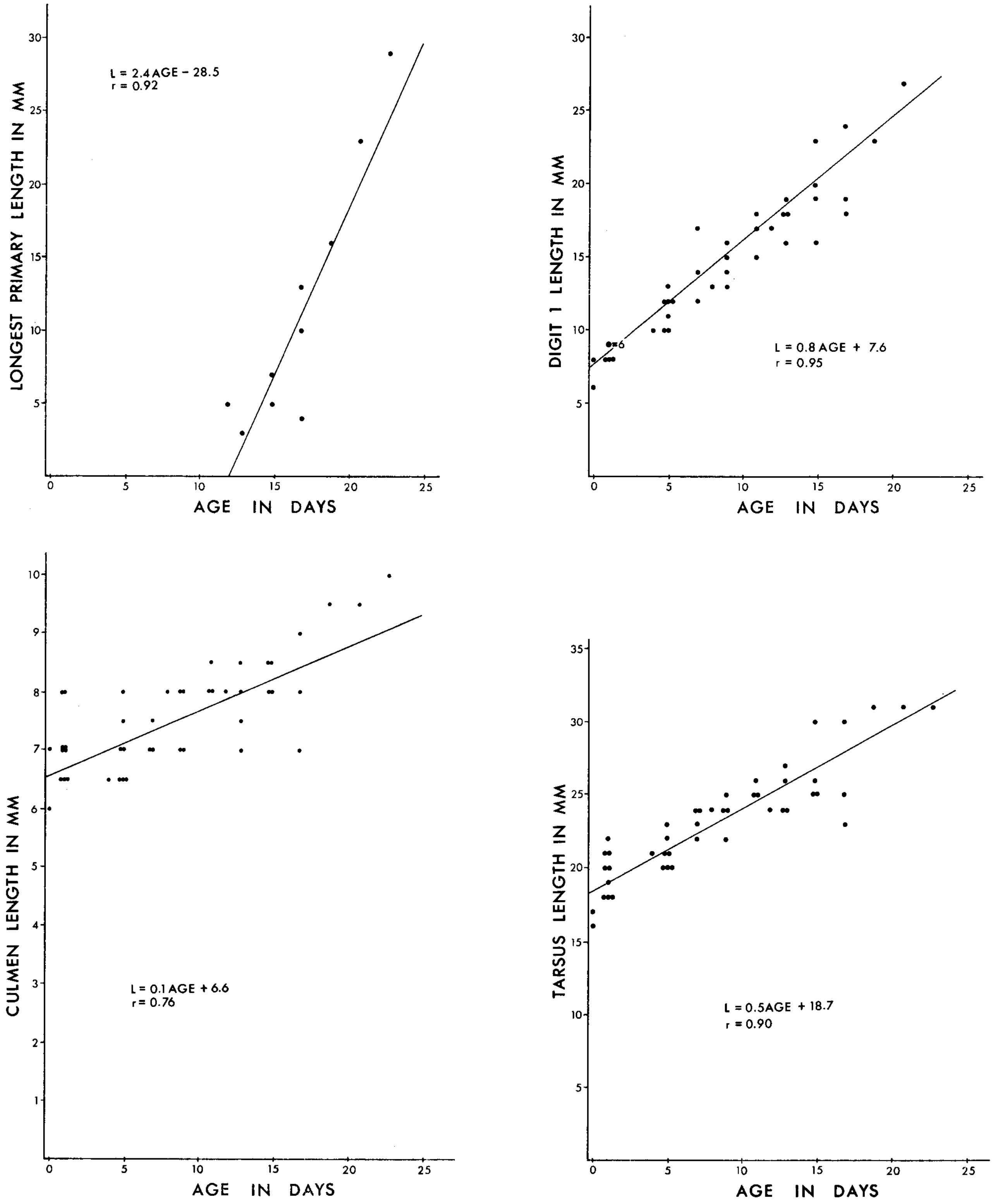

FIGURE 24. Length of Longest Primary, Digit One, Culmen and Tarsus of Crested Auklet Chicks at each Day of Age during the Nestling Period.

apparently linear until the chicks were at least 21 days old. Culmen measurements are difficult to assess. The culmen did not appear to grow substantially during the first two weeks of the nestling period (Figure 24). At hatching, Crested Auklet chicks had a culmen approximately 49% of adult length (adult length = 13.3 mm). At 15 days of age the average length of the culmen was still only 62% of adult length. Much of the growth of the culmen of Crested Auklets may not occur until the period previous to initiation of breeding rather than during their first summer. As with the Least Auklet, Crested Auklet chicks were born with well developed tarsi and underwent rapid growth of this portion of the leg (Figure 24). The tarsi of some chicks reached adult size (28.5 mm) by 15 days of age. For most chicks, however, adult tarsus length is probably not reached until they are about 20 days old.

When the measurements of chicks are taken as a percentage of average adult size, the rates of growth of Least and Crested Auklet chicks during the period of maximum rate of growth were not significantly different (Table 12). This supports the conclusions of Sealy (1968) that the patterns of growth in Least and Crested Auklets are similar.

Murres

The eggs and chicks of Common and Thick-billed Murres are considered together in this section. Seventy-one murre eggs were monitored throughout the incubation period. The presence of an egg on the ledge was usually not confirmed until a varying but unknown stage of the incubation period. Therefore, the calculated hatching success is probably higher than the actual hatching success.

A total of 47 eggs hatched successfully--a hatching success of 66%. This rate of success is not significantly different ($0.1 < P < 0.5$; $\chi^2 = 0.9132$; df = 1) from the 70.5% hatching success recorded at Kongkok Bay during 1972 (n = 200; Johnson pers. comm.). Swartz (1966:632) recorded

TABLE 12. Results of Partial Analysis of Covariance of the Homogeneity of Slope between Regression Lines*. Simple linear regressions were performed on four growth parameters taken as a percentage of average adult size of Least and Crested Auklets and the age of chicks in days.

	Rate of Growth (Slope)				
Growth Parameter (%/day)	Least Auklet	Crested Auklet	F-Value	Degrees of Freedom	Level of Significance
Weight	3.7	3.4	0.6331	1,31	0.50 > P > 0.25
Primary	3.2	2.7	1.4376	1,15	0.25 > P > 0.10
Culmen	0.9	0.9	0.0102	1,27	P > 0.75
Tarsus	2.7	2.3	1.0007	1,24	0.50 > P > 0.25

*Sokal and Rohlf (1969:448).

a hatching success of approximately 75% (n = 183) during 1961 at Cape Thompson, Alaska. The hatching success of murres on Novaya Zemlya, U.S.S.R., was given as 50% (Uspenski 1956:66) (year and number of eggs observed were not given). Thick-billed Murres on Prince Leopold Island in the eastern Canadian Arctic had an 84% hatching success (n = 885) during 1975 (Nettleship 1976b). This hatching success was significantly higher ($P < 0.001$; $\chi^2 = 14.194$; df = 1) than the hatching success on St. Lawrence Island during 1976.

The hatching success of murre eggs was influenced by the date of laying. Table 13 presents the number of eggs laid between 3 July and 18 August according to their fate (hatched *vs* unhatched). The mean laying date of eggs that failed to hatch was 14 July (n = 24); the mean laying date of eggs that hatched successfully was 19 July (n = 47). Eggs that were laid before 9 July had a 54% hatching success, those laid between 9 and 31 July had a 71% hatching success, and those laid thereafter had an 88% hatching success. Eggs that were laid early, therefore, had a lower hatching success than did those that were laid later in the season. This phenomenon was also noted by Birkhead (1976:41) for Common Murres in Wales. He also found that eggs that were laid later than the mean laying date also suffered greater loss. Birkhead attributed the increased rate of loss of eggs laid early and of those laid late to conditions of low murre density which made eggs more vulnerable to predation. Only a few birds would have eggs previous to the peak period of laying; these eggs would be subject to more intensive predation and would have less protection by neighboring murres, most of which would not yet have eggs. Late laying by murres would result in increased egg mortality only if eggs were subject to more predation than were chicks. This appears to be true in the present study, but the small amount of data on predation of eggs and chicks and the low number of eggs that were laid late precludes further analysis.

The fledging success of murres that hatched during 1976 was calculated to be 88% (n=40). This percentage is based on the assumption that chicks of approximately 3 weeks of age that left the ledges had fledged successfully. Only five chicks in my samples were thought to have died before

TABLE 13. Distribution of Laying Dates of Unhatched Versus Hatched Eggs of Murres.

Date Egg Laid Before	Number That Did Not Hatch	Number That Hatched
3 July	8	9
9 July	5	6
18 July	5	12
25 July	4	13
31 July	1	0
4 August	0	6
13 August	0	1
18 August	1	0
Total	24	47
Mean Laying Date	14 July	19 July

they fledged. These chicks were washed off a lower ledge at a very young age during one of two severe storms that occurred during August, 1976. Such storms are thought to be the cause of the occurrence of unattended prefledging chicks at sea (Greenwood cited by Birkhead 1976:26).

The fledging success during 1972 (58%, n=141; S.R. Johnson pers. comm.) was significantly lower than the fledging success during 1976 ($p<0.01$; $\chi^2=10.49$; df=1). Part of this difference may have been due to the fact that murre chicks were measured every second day during 1972, whereas during 1976 no chicks were handled, and disturbance to nesting murres was minimal. Also, the data collected during 1972 on which the 58% estimate of fledging success was based yield a minimum estimate (i.e., chicks that may have moved out of the plot or into unreachable crevices were counted as not fledged when their fate was unknown). Only birds whose fate was known were used to formulate my estimates for 1976.

Uspenski (1956:68) correlated the survival of chicks with average summer temperatures. He presented data on chick mortality and observations on temperature conditions for 3 years at Novaya Zemlya, U.S.S.R. According to Uspenski the summer of 1949 was unusually cold and murre chicks suffered a 68.8% loss. During an average year, 1948, 54.3% of the chicks died. The lowest mortality of chicks (51.7%) occurred during 1950--the warmest of the 3 years. These estimates of chick mortality were probably higher than natural chick mortality because of disturbance by man; Uspenski attributed 60% to 80% of chick mortality during his study to human disturbance.

The overall breeding success (from egg to fledged chick) of murres was estimated to be 61% (n = 66). This compares with a breeding success of only 41% in a disturbed study area during 1972 (Johnson and West 1975: 110). Birkhead (1976:41) found that the breeding success of murres in Wales differed greatly among sub-colonies which were at different densities. High density aggregations (> 10 murres/m^2) had an average breeding success of 87.5%; medium density aggregations (approximately 5.5 murres/m^2) had an average density of 74%; and sparse density aggregations (approximately 2.5 murres/m^2) had a breeding success of 30.8%. During 1976 murres at Kongkok Bay occurred at a density of only 0.4 murres/m^2, yet they had a breeding success comparable to murres at medium density during Birkhead's study. Further study of the breeding success of murres at different densities on St. Lawrence Island is needed in order to determine if reproductive rates of Bering Sea murres are actually higher than the rates of European murres at similar densities. The reproductive effort of murres on Owalit Mountain during 1976 was estimated to be 4850 chicks, based on 61% overall breeding success and a breeding adult population of 15,900 birds.

To avoid disturbance to nest sites, murre chicks were not measured during 1976. The growth and development of murre chicks on St. Lawrence Island are discussed by Johnson and West (1975).

Black-legged Kittiwakes

Results of NOAA-OCSEAP avifaunal studies in the Chukchi and northern Bering seas during 1976 indicated that kittiwakes had poor or no reproductive success at most colonies. The Kongkok Bay colony on St. Lawrence Island was no exception. Many kittiwake pairs built nests and on 7 June, one pair was observed copulating. However, only two clutches (of one egg per clutch) were found in over 50 nests that were checked and only one possible fledgling was seen in the study area.

The failure of kittiwakes to breed cannot be explained on the basis of data from a single colony. By looking at the timing, nature and degree of failure at colonies throughout the Bering and Chukchi seas, factors that led to the breeding failure of Black-legged Kittiwakes during 1976 can perhaps be identified. There was no evidence that kittiwakes (or any other species) at St. Lawrence Island were affected by spring storms that might have reduced or delayed the reproductive effort. It is interesting to note that of those species that were studied at Kongkok Bay, kittiwakes were among the few whose timing of breeding events was not noticeably later than the timing during previous years.

Although few kittiwakes laid eggs, most kittiwake pairs remained at their nests throughout the summer. In stormy weather during July and August, as many as 1000 kittiwakes gathered on Kongkok Lake. This number probably represents most of the kittiwakes that were present in the Kongkok Bay area during 1976. Therefore, although kittiwakes remained attached to nest sites throughout the summer, normal incubation patterns (i.e., amount of time spent at the nest) were apparently altered.

Glaucous Gulls

Nine Glaucous Gull nests were located, seven of which were clustered in a small colony on a medium-sized sea stack. One of these nests was empty. The average clutch size of the remaining eight nests was 2.8 $\pm$ 0.5 eggs (range = 2 to 3). Unfortunately, all nine Glaucous Gull nests became inaccessible after June; therefore no hatching data were obtained. Two eggs from one nest were pipped on 29 June.

Pelagic Cormorants

I was able to obtain clutch sizes from nine Pelagic Cormorant nests, two of which were monitored until the young fledged. The average clutch size was 2.4 $\pm$ 1.33 eggs per nest (range = 1 to 4). The two nests that I was able to follow throughout the nestling phase both had a clutch of four eggs. One of these pairs hatched three eggs, the other hatched two eggs; all five of these chicks fledged.

A count of the number of young/nest was conducted on one census plot between 5 and 22 August. The average number of Pelagic Cormorant chicks per nest during August was 1.5 $\pm$ 1.1 (range = 0 to 3; n = 12 nests). Therefore, if the average clutch size was 2.4 eggs per nest, then the hatching success was approximately 63%. However, because this estimate was based on a very small sample size, and the average clutch size and hatching success were not based upon the same nests, the estimate may be subject to considerable error. The number of Pelagic Cormorant chicks that fledged from Owalit Mountain during 1976 was estimated to be about 225, based on an estimated adult population of 300 and production of about 1.5 chicks per nest.

During 1972, S.R. Johnson (pers. comm.) counted 148 young at 58 nests--a clutch size of 2.6 young per nest. Apparently, Pelagic Cormorants had low breeding success at Kongkok Bay during 1976.

Food Habits and Feeding Areas

The food habits of Least and Crested Auklets at St. Lawrence Island have been thoroughly described by Bédard (1969b). The scope of the present study was not as extensive as this earlier study and, therefore, comparisons with the work by Bédard have been made with caution. Recent studies (Weins and Scott 1975 and others) have stressed the importance of analyzing seabird diets in terms of relative energy content rather than in terms of occurrence of food items.

Estimates of the relative energy content of various food species are usually dependent upon factors that convert measured lengths or partial lengths of organisms to some estimate of energy content (volume, wet weight, dry weight). However, because such conversion factors were only available for some and not all of the food taxa identified, food data have been analyzed in terms of percent occurrence and percent frequency. Percent occurrence is taken to be

$$\frac{\text{\# of stomachs containing a given food taxon}}{\text{\# of stomachs examined}} \times 100.$$

Percent frequency is taken to be

$$\frac{\text{\# of organisms of a given food taxon found in stomachs}}{\text{\# of organisms of all food taxa found in stomachs}} \times 100.$$

Least Auklets

Food Habits

The numbers and taxa of food organisms that were found in the stomachs of 10 Least Auklets collected in Kongkok Bay between 10 and 16 July 1976 are presented in Table 14*. The frequency of occurrence of each major taxon in the stomachs of Least Auklets and the percent occurrence of each taxon in terms of the numbers of individuals as a percentage of the total number of

*A detailed list of food organisms by size classes is found in Appendix 6.

TABLE 14. Numbers of Individuals of Food Organisms Found in Stomachs of Least Auklets of the Kongkok Bay Colony that were Collected between 10 and 16 July 1976.[+]

Amphipods								Decapods		Cumaceans	Copepods		Other Crustaceans	Other Invertebrates	Fish	
Anonyx spp.	*Atylus tridens*	*Calliopiella* spp.	*Ischyrocerus* spp.	*Dulichia* spp.	*Achotropus* spp.	*Metopa* spp.	*Pontoporeia affinus*	Hippolytidea (larvae)	Zoea	*Diastylis bidenticulata*	*Neocalanus plumchrus*	*Calanus marshallae*			Adults	Larvae
	1	8*		6				149	20				P			9
P		2	P					226	7		1					
		11*	1					136	2		1				1	3
			P	6				187	3			2				
		14*		5	1	1	1	103	6	13	1					11
			P	1				96	4						?	
			1+	2				97	1							
								58+	1							1
5	1	1	P				1				3	1		2		
1	1	44*	9	10	2			217	8							2-3

[+]Each line represents the stomach(or gular pouch) contents of one bird. "P" indicates that a particular organism was present but was not measured or counted. No empty stomachs were collected.

*Young from brood pouch not counted.

individuals is presented in Figure 25. The reader is referred to Hartley (1948) and Swanson and Bartonek (1970) for a discussion on the limitations of this type of analysis. Although both amphipods and decapods were found in nearly all Least Auklet stomachs, and copepods and fish were found in the majority of them, decapods were by far the most abundantly consumed food item in terms of numbers; in terms of biomass, decapods probably comprised a still greater proportion of the diet of Least Auklets.

During the early summer periods (previous to July) of 1964-1966, Least Auklets fed primarily on copepods and decapods (Bédard 1969b); copepods apparently made up a much greater proportion of their diet during the early summer periods from 1964-1966 than during 1976 (Table 15). Part of this apparent difference was due to the temporal distribution of the sampling effort; while Bédard (1969b) collected birds throughout the early summer portions of 3 years, I collected Least Auklets only between 10 and 16 July 1976. During Bédard's study, large numbers of copepods and amphipods (amounts varied among years) were eaten by auklets previous to mid-July; decapods formed the major portion of the diet during July.

Copepods were the major food items brought to young Least Auklets by adults during both studies (Tables 16 and 17 and Figure 26). However, the major species from 1964 to 1966 was *Calanus marshallae** whereas, during 1976, *Neocalanus plumchrus* formed the largest portion of the diet of the nestlings.

The fact that *C. marshallae* was not taken by Least Auklets during 1976 may have been due to one or more of the following:

1. Either *N. plumchrus* was very abundant during 1976 or *C. marshallae* was present only in low numbers,
2. *C. marshallae* was abundant but locally distributed off Northwest Cape where Bédard sampled and *N. plumchrus* was abundant but locally distributed at Kongkok Bay where I collected my samples,

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**Calanus marshallae* = *C. finmarchicus*.

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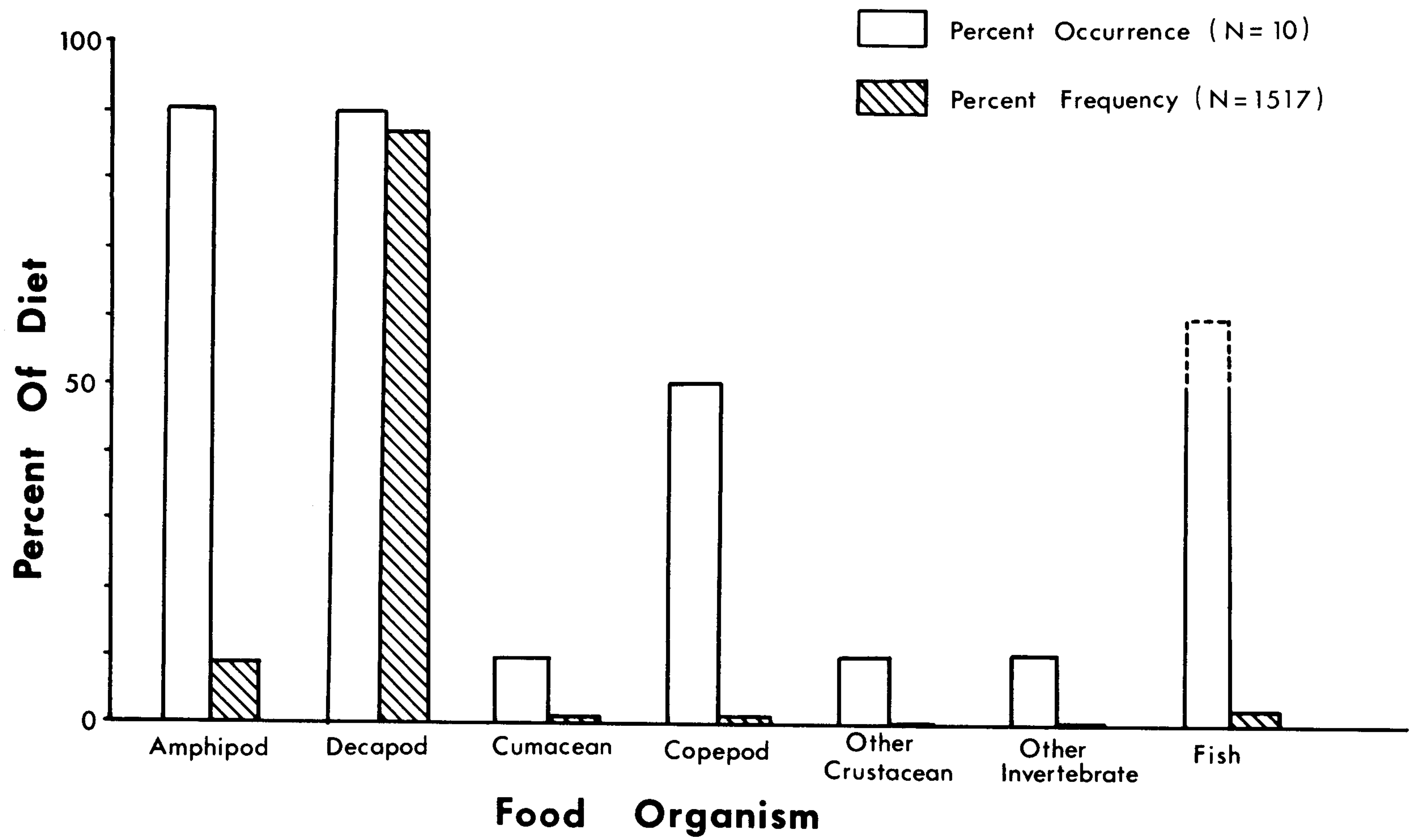

FIGURE 25. Diet of Least Auklets from the Kongkok Bay Colony Collected between 10 and 16 July 1976.

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TABLE 15. Comparison of the Percent Frequency of Various Food Items in the Diet of Least Auklets between the Early Summer Periods of 1964-1966 (n=17580) and 1976 (n=1517). Data for 1964-1966 taken from Bédard 1969b).

Food Item	1964-1966	1976
Amphipods	14	9
Euphausids	1	0
Decapods	34	87
Mysids	2	0
Cumaceans	0	1
Copepods	42	1
Gastropods	2	0
Fish	1	2

TABLE 16. Numbers of Individuals of Food Organisms Found in the Gular Pouches of Least Auklets of the Kongkok Basin Colony that were Collected during Mid-August, 1976.*

Amphipods			Decapods		Mysids		Copepods							Other Crustaceans	Molluscs		Other
Hyperiidae		Other	Pandalidae	Larvae			Adults			Copepodites							
Parathemisto spp.	Other				*Paracanthomysis* spp.	Other	*Neocalanus plumchrus*	*Eucalanus bungii*	*Calanus marshallae*	*Neocalanus plumchrus*	*Neocalanus cristatus*	*Eucalanus bungii*	*Calanus marshallae*		*Limacina helicina*	Other	
2							37			403	5		2				
6		1	6		17	1	33	1		695	6		2	1		P	
2							12	1		299	2		13				
							7		5	191			39			P	
13		2	25		1		120	2	4	1600			3		12	P	
			1			1	73			251			152			P	
1		1	1				76			1137	3		31		4		
10		1+	3	1			67	1	3	914	1	1	30		2	P	P(Plant)
7			6	1	5		49			638	2		18			P	
3						1	13			698		1	9			P	
9	1	4		2		3	61		4	1107	9	1	18	1	8	P	
	3			1			48	1	1	518	3		12				

*Presented as in Table 14.

TABLE 17. Comparison of the Percent Frequency of Various Food Items between the Diets of Least and Crested Auklets during the Chick-rearing Period.[1]

	Least Auklet		Crested Auklet	
	1964-1966 [2]	1976 [3]	1964-1966 [4]	1976 [5]
Amphipods				
Hyperiids I [6]	1.9	0.4	0.4	0.2
II	0.4	0.3	1.4	0.1
III	0.1	<0.1	0.6	0.0
Gammarids I	0.4	0.0	0.0	0.0
II	0.2	0.0	<0.1	0.0
III	<0.1	0.0	0.0	0.0
Decapods [7] I	<0.1	<0.1	<0.1	0.2
II	<0.1	0.4	0.0	0.2
III	0.0	<0.1	0.0	0.0
Caridae I	0.8	0.0	<0.1	0.0
II	2.3	0.0	4.4	0.0
Mysids I	0.0	<0.1	0.0	0.0
II	0.2	0.3	0.4	<0.1
III	<0.1	0.0	0.3	0.0
Copepods				
Neocalanus plumchrus [8] I	0.0	90.5	0.0	96.8
Neocalanus cristatus [8]	1.6	0.3	7.0	0.5
Eucalanus bungii	0.2	0.1	<0.1	0.1
Calanus marshallae [8] I	88.9	3.6	28.7	1.7
Euphausids				
Thysanoessa spp. I	0.3	0.0	0.0	0.0
II	2.2	0.0	4.2	<0.1
III	0.2	0.0	51.8	<0.1
Cumaceans I	0.0	0.0	0.0	0.0
II	0.2	0.0	<0.1	0.0
Gastropods				
Limacina	<0.1	0.4 [9]	<0.1	0.2 [9]
Fish II	0.7	0.0	<0.1	0.1(?)
III	1.7	0.0	0.2	0.0

[1] Data for 1964-1966 from Bédard (1969b)
[2] n=124pouches;87632 food organisms
[3] n=12pouches;9613 food organisms
[4] n=135pouches;20893 food organisms
[5] n=12pouches;8766 food organisms

[6] Size categories are from Bédard (1969b)
I 0.0-7.0 mm
II 7.1-15.0 mm
III 15.0 mm and over

[7] Includes Megalopa stages, not Zoea
[8] Mostly copepodite stage V
[9] Includes unidentified Gastropods

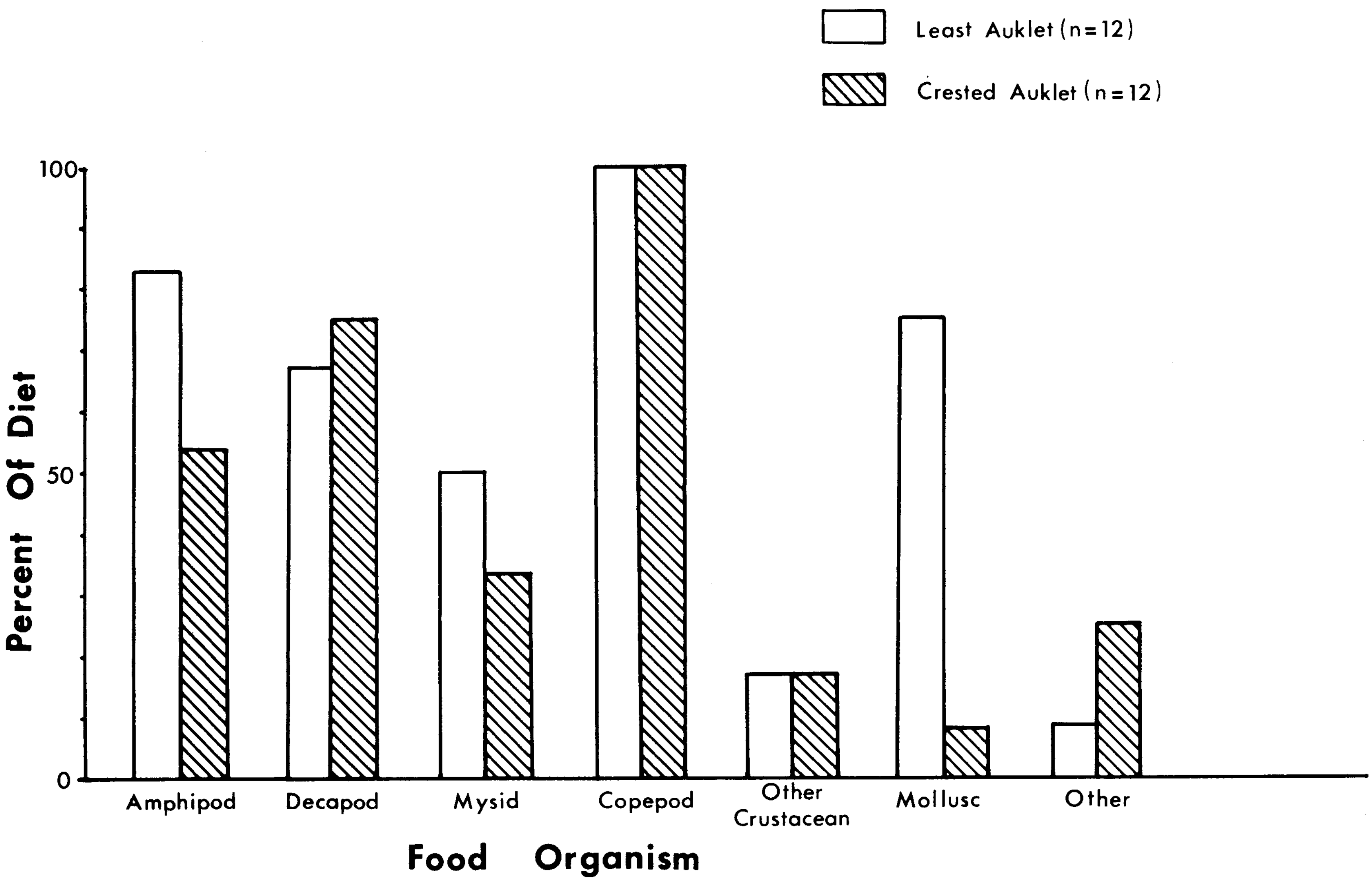

FIGURE 26. Percent Occurrence of Various Food Taxa Fed to Chicks of Least and Crested Auklets from the Kongkok Bay Colony during Mid-August 1976.

3. The identity of *N. plumchrus* or *C. marshallae* was mistaken by either myself or Bédard and they are in fact the same species.

In summary, the food habits of auklets during 1976 appeared to be similar to those presented by Bédard (1969b) for 1964-1966. Collection of birds during the very early portion of the summer was not possible during 1976; during this period, Least Auklets fed primarily on amphipods and mysids during 1964, and on amphipods and copepods during 1965 and 1966 (Bédard 1967). Decapods formed the major portion (in terms of numbers) of the diet during the month of July during all years (1964-1966 and 1976) but copepods formed a substantial portion during the month of July of 1964, 1965 and 1966; amphipods were taken in large numbers during early July 1966 (Bédard 1967). Copepods were the major food items brought to young Least Auklets by adults during August of all years.

Feeding Areas

My observations of Least Auklet feeding behaviour in the Kongkok Bay area differ somewhat from those of Bédard (1969b) of Least Auklets in the Gambell area. Least Auklets that fed in the Kongkok Bay area normally remained within 2 km of shore (Figure 27) and generally fed alone, in pairs, or in very loose aggregations; Least Auklets were never observed feeding in dense flocks as described by Bédard (1969b:1034). As suggested by Bédard (1969b:1034) the major portion of the Kongkok Bay colony apparently feeds off the northwest cape of St. Lawrence Island; my observations suggest that the birds that remain in the Kongkok Bay area probably represent less than 10% of the colony.

Crested Auklets

Food Habits

The stomachs of all Crested Auklets that were collected during 1976 were either empty or contained only a few food organisms (Table 18). Therefore, no analysis of these stomachs has been attempted. Bédard (1967) found that,

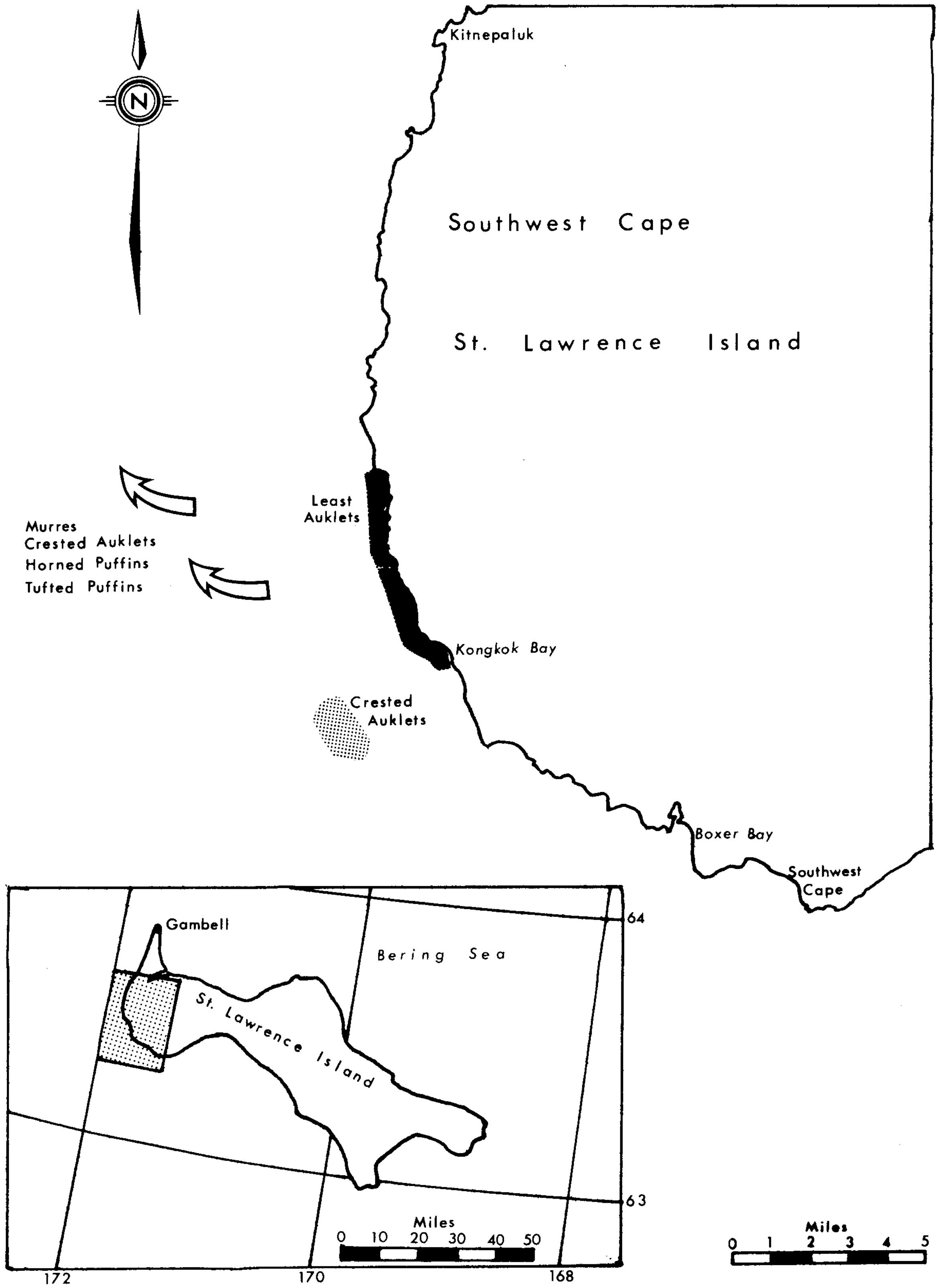

FIGURE 27. Feeding Areas of Seabirds in the Kongkok Bay Area. Insert shows portion of St. Lawrence Island enlarged above.

TABLE 18. Numbers of Individuals and Species of Food Organisms Found in Stomachs of Crested Auklets of the Kongkok Bay Colony that were Collected on 18 July 1976.*

Amphipods			Cumaceans	Molluscs	Other Invertebrates
Anonyx nugax	*Dulchia* spp.	Other	*Diastylis bidenticulata* (Sub-adult)	*Limacina helicina*	
	P				
P					
				1	
				5	
	2	2	2	1	
					1

*Presented as in Table 14. In addition, 12 stomachs were empty, 6 contained grit only, and 2 contained plant material and grit only.

during July, Crested Auklets fed primarily on mysids and euphausids in 1964, euphausids and hyperiids during 1965, and mysids and hyperiids during 1966. Gammarids were also taken in large quantities previous to July, especially during 1966.

Food items that were brought to young Crested Auklets by adults during 1976 included mostly copepods (96.8% by numbers; Tables 17 and 19). During the period from 1964 to 1966, Crested Auklets fed their young primarily euphausids (56.0%) and copepods (35.7%). During the nestling periods of 1964, 1965 and 1966, euphausids comprised 80% to 90% by volume of the content of gular pouches. These data indicate that a noticeable shift in the late-season food source may have occurred during 1976. Almost no euphausids were taken during mid-August 1976. Because a greater expenditure of energy would be required to obtain an equal volume of smaller organisms unless the density of these small organisms is high, or their mobility is less, a shift from euphausids of more than 15.1 mm in length to copepods (of the species *N. plumchrus*) of less than 7.0 mm in length may reflect a great abundance of the copepod, *N. plumchrus*. Also, the facts that both Least and Crested Auklets fed their young primarily on *N. plumchrus* during 1976 and that neither of these species took *N. plumchrus* during 1964-1966 indicates that a "bloom" of this food species had apparently occurred during 1976. Alternatively, a decrease in the availability of euphausids may have necessitated a shift to an alternate food item. Hence, auklets may have been forced to expend extra energy in order to feed their young.

Feeding Areas

As with the Least Auklet, my observations during the summer of 1976 suggest that most Crested Auklets that nest at Kongkok Bay feed in the vicinity of Northwest Cape of St. Lawrence Island (see Bédard 1969b:1034). Those birds that feed in the Kongkok Bay area apparently do so approximately 5 to 8 km or more southwest of Kongkok Bay (Figure 26). A few Crested Auklets join the feeding flights of murres and puffins and head west--perhaps to the coast of the Chukotsk Peninsula, U.S.S.R. (see below).

TABLE 19. Numbers of Individuals of Food Organisms Found in the Gular Pouches of Crested Auklets of the Kongkok Basin Colony that were Collected during Mid-August 1976.*

Amphipods			Decapods		Mysids		Copepods							Other Crustaceans	Molluscs		Other
Hyperiidae		Other	Pandalidae	Larvae			Adults			Copepodites							
Parathemisto spp.	Other				*Paracanthomysis* spp.	Other	*Neocalanus plumchrus*	*Eucalanus bungii*	*Calanus marshallae*	*Neocalanus plumchrus*	*Neocalanus cristatus*	*Eucalanus bungii*	*Calanus marshallae*		*Limacina helicina*	Other	
			1				163	2		880	4		6				
			P				6			510							
			19		1		37			441	5		13	P		P	1(unid. copepod)
2	P						37	1		463	1		11				
2			P				39		1	641	1		20			P	
							55			602		5	13				P(fish?)
			1				23	1		690			4		3		
2			4	1			55			525	14		12	2		P	
2		1	1		1		38	2		880	2		7		2	P	
4						P	49			452	5	1	12			P	
7			5	1			126			1189	6		43		3	P	2
1			3		1		34			549	2		7			P	

*Presented as in Table 14.

Common and Thick-billed Murres

Food Habits

Few food items were found in the stomachs of Common and Thick-billed Murres that were collected from 9 to 18 June 1976. Murres tended to feed at long distances from Kongkok Bay; therefore, I was able to collect birds only as they returned to the breeding cliffs. Due to the high rate of metabolism in murres (Johnson and West 1975) and the rapid rate of digestion of food by seabirds in general (Cottom and Hanson 1938; Tuck and Lemieux 1959; Uspenski 1956; Tuck 1960; Swartz 1966; Johnson, unpublished data), most food ingested by murres at their feeding areas was already digested when I collected the birds near Kongkok Bay.

Table 20 presents a summarized description of the stomach contents of 11 Thick-billed Murres and 7 Common Murres. Because of the small sample size, the two species of murres were combined for analysis. From Table 20 and Figure 28 it can be seen that during mid June, fish and crustaceans (especially amphipods and decapods) were ingested with the greatest regularity.

Invertebrates were taken more frequently by murres in the St. Lawrence Island area than in other areas of the Bering and Chukchi seas (Table 21). The types of invertebrates taken in the St. Lawrence Island area were apparently different from those taken in other areas of the Bering Sea and in the Chukchi Sea; the small data base on which this statement is based, the different years during which the data were collected and the biases in the method of analysis that was used should not be overlooked. Euphausids and "squids" were regularly ingested by murres in the southern Bering Sea-Bristol Bay area; these were the major invertebrates in the murres' diet (Ogi and Tsujita 1973). Squid also comprised a part of the diet of 26% of the murres (primarily Thick-billed Murres) collected near the Pribilof Islands. Amphipods and decapods as well were found to be taken frequently by Common and Thick-billed Murres, respectively, in the Pribilof Island area (Preble and McAtee cited by Storer 1952). Apparently, euphausids and

TABLE 20. Number of Individuals of Food Organisms Found in Stomachs of Murres of the Kongkok Bay Colony that were Collected between 9 and 18 June 1976.*

Species	Amphipods					Cumaceans	Decapods	Other Crustaceans		Other Invertebrates			Other		
	Anonyx nugax	*Atylus tridens*	*Amplesica* spp.	*Parathemisto* spp.	Other	*Diastylis bidenticulata*	*Eualus fabricii*	*Mysis littoralis*	Other	*Spirobis* spp.	Hydrozoa	Araneae	Fish	Plant	Grit
Thick-billed Murre	16	2				3	1								
	3							1							
			3			1	40								
							P			1	1				
							1								
													P	P	P
							P							P	P
									P						P
												1		P	
							P							P	P
													P	P	
Common Murre													P		
							P								
													P		
				P											
													P	P	
	3				P		1(sp)							P	
		1											P		

*Presented as in Table 14. In addition, 12 stomachs were empty, 10 contained plant material only, 1 contained grit only, and 1 contained plant material and grit only.

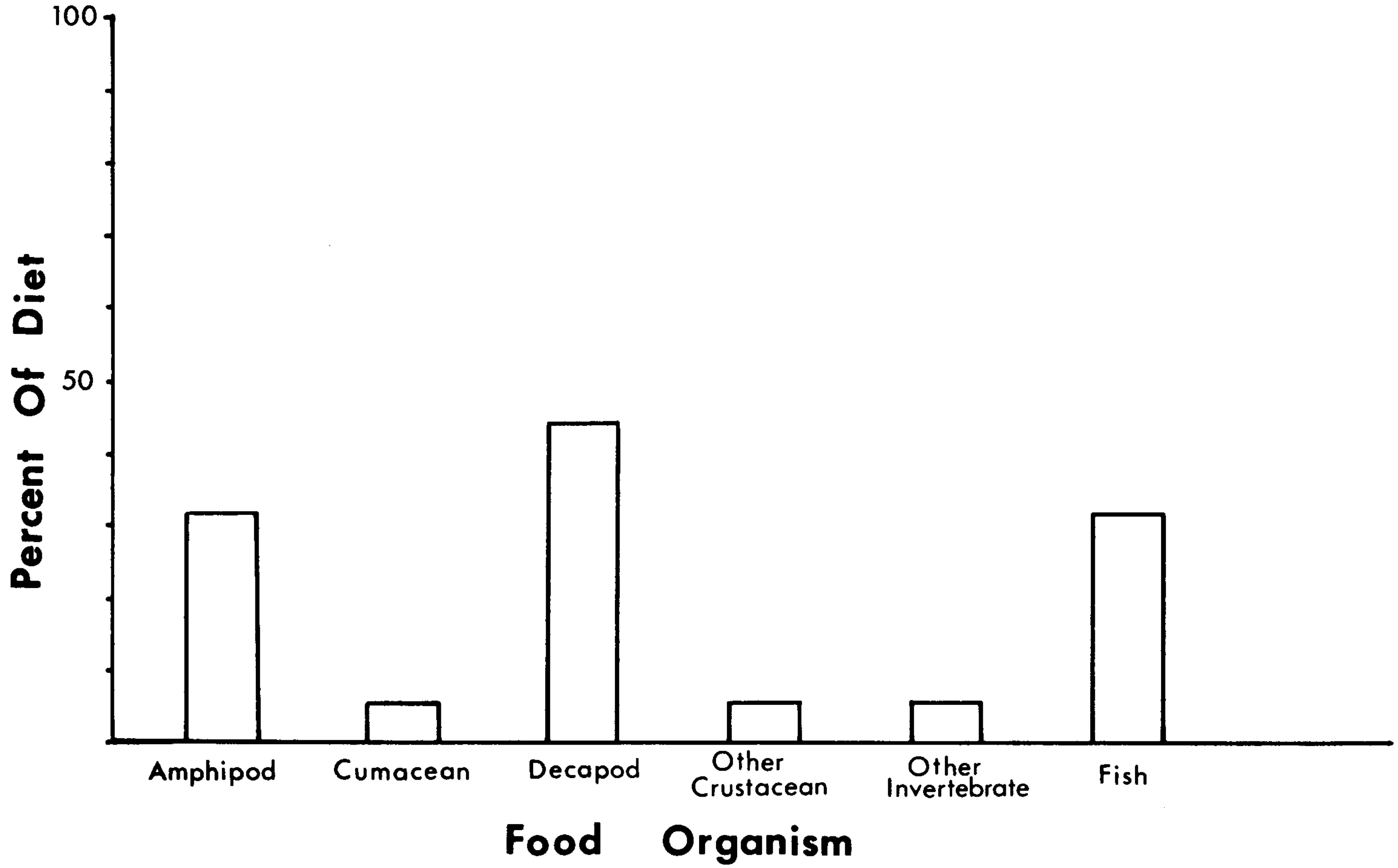

FIGURE 28. Percent Occurrence of Various Food Taxa in the Diet of Murres (n=18) at Kongkok Bay, St. Lawrence Island, between 9 and 18 June 1976.

TABLE 21. Percent Occurrence of Food Organisms in the Diet of Murres in the Bering and Chukchi Seas.

	Bristol Bay[1] (55°-58°N)	Pribiloff Islands[2] (57°N)	St. Lawrence Island[3] (63°N)	Cape Thompson[4] (63°N)
Fish	44	49	33	74
Crustaceans		25	67	
Euphausids	26		0	
Amphipods	2		33	
Decapods		25	44	
Other			22	
Molluscs	12	26	0	
Other Invertebrates			11	
Total Invertebrates			72	25
Other	56		74	52

[1]Ogi and Tsujita (1973).

[2]Preble and McAtee (cited by Storer 1952); data are in terms of percent frequency.

[3]Present study.

[4]Swartz (1966).

"squids" are not part of the diet of murres in more northerly latitudes as no squids were found in specimens from St. Lawrence Island or Cape Thompson. Amphipods and decapods occurred frequently in stomachs of murres collected from St. Lawrence Island waters; organisms from these taxa were eaten less frequently by murres at Cape Thompson (Swartz 1966).

Fish were eaten by a slightly lower percentage of murres in the St. Lawrence Island area than in other areas of the Bering Sea and by a much lower percentage of murres in the St. Lawrence Island area than in the Chukchi Sea.

It is not known whether these apparent differences in the diet of murres at different latitudes are due to different levels of abundance of the various prey items, to seasonal differences in the diet of murres, or are artifacts of the different methods of selecting murres for food habits analysis. It should also be noted that differential digestibility of hard and soft food organisms will result in large biases in stomach content data regardless of the method of analysis.

Feeding Areas

Most murres that nested at Kongkok Bay apparently fed off the northwest cape of St. Lawrence Island or well out to sea (>20 km) in a west and northwesterly direction from Kongkok Bay (Figure 27). During all months of the present study, large southerly flights of murres were observed along the west coast of St. Lawrence Island; these flights were apparently composed of murres which were returning from feeding grounds near Northwest Cape. A lesser number of murres was observed leaving the cliffs of Owalit Mountain and flying in a direct line for the Anadyr Gulf. These birds were often accompanied by either Horned Puffins, Tufted Puffins, Crested Auklets or Parakeet Auklets. Flocks of murres with individual puffins or auklets were also seen on the return flight along the same route. The location to which these birds flew is unknown, but presumably their feeding areas were off the coast of the Chukotsk Peninsula in the Anadyr Straits.

SUMMARY

The timing of the 1976 breeding season was later than average for most of the species that were studied. Table 22 compares the phenology of the 1976 breeding season of species for which comparative information is available with the phenology of these species during earlier years. Large fluctuations in the timing of events during the breeding season are characteristic of birds that breed in arctic areas. The fact that nearly all species of seabirds at Kongkok Bay nested late during 1976 indicates that climatic factors (i.e., prolonged snow-cover on the breeding cliffs) were the probable cause of the retarded season during 1976.

During the last decade, large changes have occurred in the number of seabirds that occupy the cliffs and talus slopes at Kongkok Bay. The estimated numbers of auklets in Kongkok Basin increased 59% from 1966 to 1976. Most of this increase was the result of a 95% increase in the numbers of Least Auklets (to 336,000) whereas Crested Auklets increased by only 18% (to 173,000). The numbers of Common and Thick-billed Murres and Black-legged Kittiwakes that nested at Kongkok Bay during 1976 were substantially lower than the numbers that nested there during 1972. Murres showed a four-fold decrease in numbers from approximately 60,000 in 1972 to about 15,000 in 1976. The number of kittiwakes present during 1976 was only 12.5% of the number present at Kongkok Bay during 1972. Rather than being caused by an actual population decline, the lower numbers of murres and kittiwakes on the nesting ledges may have been caused by birds that failed to breed due to the late season. The numbers of seven other species of seabirds that nested at Kongkok Bay were also estimated; however, the lack of comparative estimates from previous years did not permit me to determine whether their numbers had increased or decreased.

Table 23 presents the estimates of seabird populations at Kongkok Bay during 1976; these estimates are summarized in relation to estimates from other years and at other colonies on St. Lawrence Island.

TABLE 22. Summary of Phenology of the Breeding Season of Seabirds at Kongkok Bay during 1976 and Relation to "Normal" Breeding Chronology.

Event and Species	CHRONOLOGY Normal	1976	COMMENTS
Arrival in St. Lawrence Island Area			
Least Auklets	15-21 May	?	Normal?
Crested Auklets	15-20 May	21 May	Slightly late
Murres	late April	earlier than 14 May	Late?
Black-legged Kittiwakes	29 April-11 May	16 May	Late
Parakeet Auklets	15-20 May	17 May	Normal
Tufted Puffins	early May-4 June	17 May	Normal
Horned Puffins	5-28 May	25 May	Slightly late
Arrival on Cliffs			
Least Auklets	20-24 May	29 May	Late
Crested Auklets	18-24 May	29 May	Late
Murres	?	28 May	Late?
Black-legged Kittiwakes	?	27 May	Normal?
Parakeet Auklets	19-24 May	27 May	Late
Initiation of Laying			
Least Auklets	12-28 June	1 July	Normal or Late
Crested Auklets	14-30 June	1 July	Late
Murres	early to late June	28 June	Slightly late?
Black-legged Kittiwakes	late June	29 June	Normal
Initiation of Hatching			
Least Auklets	15-30 July	25 July	Normal
Crested Auklets	19 July-2 August	2 August	Slightly late
Murres	30 July	31 July	Slightly late
Initiation of Fledging			
Least Auklets	15-28 August	24 August	Normal
Crested Auklets	26 August-5 September	later than 3 September	Slightly late?
Murres	18 August	21 August	Late

TABLE 23. Summary of Nesting Seabird Populations on St. Lawrence Island, Alaska[1].

Species	Location	YEAR ±1957[2]	±1966[3]	1972[4]	1976[5]
Pelagic Cormarant	Owalit Mountain			100[6]	300
Glaucous Gull	Boxer Bay	50			
	Owalit Mountain				24-30
Herring Gull	Koozata Lagoon	100			
	Ivekan Mountain				2-4
Black-legged Kittiwake	Owalit Mountain			2000[6]	1700-1900
Murres	St. Lawrence Island	100,000			
	Owalit Mountain			60,000	16,000
Pigeon Guillemot	Owalit Mountain				150
Parakeet Auklet	Sevuokok Mountain	Few	2000		
	Kaghkusalik Point	Few			
	Savoonga	Very Few			
	Singikpo Cape	Many			
	Tatik Point-Boxer Bay	Many			
	Owalit Mountain				1200-1800
Crested Auklet	Kongkok Basin	500,000 (Kongkok Basin and Ivekan Mountain)	165,000		173,000
	Ivekan Mountain		20,000		
	Reindeer Camp		37,000		
	Ataakas-Kookoolik		185,000		
	Savoonga		34,000		
	Kineegkit		8,000		
	Sevuokok Mountain		72,000		
	Owalit Mountain SW		5,000		
	Owalit Mountain SE				3,000
	Tupurpuk and Sitiilekk		40,000		
	Powooiliak		8,000		
Least Auklet	Sevuokok Mountain	100,000's	111,000		
	Kongkok Basin	500,000	189,000		336,000
	Tatik Point-Boxer Bay	500,000 (does not include Kongkok Basin)	25,000		
	Reindeer Camp		20,000		
	Ataakas-Kookoolik		128,000		
	Savoonga		51,000		
	Kineeghut		14,000		
	Owalit Mountain SW		8,000		
	Owalit Mountain SE				17,000
	Tupurpuk & Sitiilekk		75,000		
	Powooiliak		14,000		
Horned Puffin	Murphy Bay	1000-2000			
	Sevuokok Mountain		1,500		
	Owalit Mountain				600
	Punuk Islands		None		
Tufted Puffin	Punuk Islands	"large populations"	"honey-combed with burrows"		
	Sevuokok Mountain	None	500		
	Tatik Point-Powooiliak	"locally common"			
	Owalit Mountain				750

[1] Numbers are approximations.

[2] Fay and Cade 1959.

[3] Bédard 1969; Sealy and Bédard 1973; Thompson 1967; Sealy 1973

[4] S.R. Johnson pers. comm.

[5] Present study.

[6] Counted on less than 1/3 of Owalit Mountain.

The density of Least Auklets was found to be correlated with the angle of slope of the talus, the distance from the edge of the talus, the depth of scree, the sphericity of the talus boulders and the number of Crested Auklets. The density of Crested Auklets was correlated with the degree to which the talus slope faced the bay, the depth of scree and the size (volume and diameter) of the talus boulders.

Basic data were obtained on the breeding success of Least and Crested Auklets, Common and Thick-billed Murres, and Black-legged Kittiwakes and on the growth rates of Least and Crested Auklets in order to provide baseline data for comparison of the breeding effort of seabirds on St. Lawrence Island during 1976 with the breeding effort of other years and of other areas. Least Auklets hatched 60% of their eggs whereas Crested Auklets hatched only 30% of their eggs. The growth rates of Least and Crested Auklet chicks were not significantly different from each other--Least Auklets gained an average of 3.7 gm/day (4.1% of adult weight), Crested Auklets gained 8.9 gm/day (3.3% of adult weight). The breeding success of murres (from egg to fledged chick) was 61%. Only 4% of the Black-legged Kittiwake nests contained eggs. The nesting failure of kittiwakes during 1976 was apparently widespread throughout the northern Bering and Chukchi seas.

During July, 1976, the main items in the diet of Least Auklets were decapods. Copepods comprised the major portion of the foods that were fed to young Least and Crested Auklets. Presumably, the copepod species, *Neocalanus plumchrus*, was especially abundant during August, 1976. As a result, auklets shifted from the "normal" foods that are taken at this time of year to take advantage of the *N. plumchrus* "bloom". Murres were noted to take mainly fish, amphipods and decapods. Invertebrates were apparently taken in greater numbers by murres in the St. Lawrence Island area than in other areas of the Bering and Chukchi seas.

Relative to other areas in the St. Lawrence Island waters, the Kongkok Bay area is not heavily used by seabirds as a feeding area. Apparently, most seabirds that nested in the Kongkok Bay area fed along the northwest cape of St. Lawrence Island where strong currents through the Anadyr Straits cause extensive mixing and result in very "rich" waters.

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APPENDIX 1. Maximum and Minimum Recorded Temperatures (°C) at Kongkok Bay, St. Lawrence Island, during the Period from 31 May to 1 September 1976.

	TEMPERATURE			TEMPERATURE			TEMPERATURE	
DATE	LOW	HI	DATE	LOW	HI	DATE	LOW	HI
31 May	-1	11	1 July	2	18	1 August	-	-
1 June	1	8	2	0	12	2	-	-
2	0	9	3	3	13	3	15	16
3	-1	11	4	-	-	4	8	18
4	1	6				5	5	20
5	2	5	5–7	2	12	6	-	-
6	1	15				7	5	7
7	0	15	8	1	20	8	-	-
8	1	10	9	1	19	9	-	-
9	-	-	10	1	20	10	3	15
10	-	-	11	5	20	11	-	-
11	-3	13	12	1	21	12	-	-
12	0	19	13	5	25	13	7	15
13	0	12	14	5	23	19	6	13
14–15	3	12	15	4	13	15	4	12
			16	3	10	16	3	13
16	1	3	17	4	10	17	3	13
17	1	7	18	-	-	18	6	13
18	0	11	19	-	-	19	1	13
19	1	14	20	-	-	20	2	15
20	2	11	21	-	-	21	3	16
21	2	18	22	6	16	22	5	14
22	1	12	23	5	14	23	5	13
23	-	-	24	6	14	24	7	14
24	1	10	25	6	16	25	8	15
25	0	18	26	8	19	26	6	18
26	1	23	27	7	20	27	-	-
27	4	22	28	8	16	28	1	14
28	2	15	29	6	14	29	5	13
29	1	11	30	5	14	30	5	16
30	1	20	31	6	16	31	10	15
						1 Sept.	7	17

APPENDIX 2. Number of Counts of Auklets Conducted on 24 Plots between 05:00 and 08:00 from 2 to 19 June 1976. AØ refers to plots on Owalit Mountain. AB refers to plots in Kongkok Basin.

	JUNE																	
PLOT NUMBER	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
AØ 01	1	5		3	4		6											
AØ 02	1	4		3	4		6											
AØ 03		4		3	3		6											
AØ 04		3		3	1		6											
AØ 05	1	4		3	4		6											
AØ 06					3		6											
AØ 07					3		6											
AØ 08					3		6											
AB 01											5	6			2			
AB 02															2			
AB 03												6			2			
AB 04								3			5	5			1			
AB 05												6			1			
AB 06											5	5			1			
AB 07											5	6			1			
AB 08											5	6			1			
AB 09															1		7	7
AB 10															1		7	6
AB 11															1		7	6
AB 12															1		7	6
AB 13															1		7	6
AB 14															1		7	6
AB 15															1		7	6
AB 16															1		7	6

APPENDIX 3. Approximate Areas of Six Cliff Plots on Owalit Mountain and Dates on Which these Plots were Censused.

PLOT NUMBER	AREA*	JUNE					JULY				AUGUST			SEPTEMBER
		8	13	19	25	29	4	9-11	18-19	27	5	13	22	1
1	1070	x	x			x		x	x	x	x	x	x	x
2	2930	x	x			x		x	x	x	x	x	x	x
3	4390		x											
4	1950		x					x						
5	2010		x					x						
6	16140			x	x		x	x	x	x	x			x

*in m^2.

APPENDIX 4

Number of Birds Per Hour on Three Activity Plots
during Each Day of Observations.

MURRE

	4:00–6:00	6:00–8:00	8:00–10:00	10;00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
PLOT 1										
11							22.0	12.4		
12							83.4	55.0		
J 18						302.0	295.7			
U 19				268.0	265.0					
N 24								176.0	147.0	71.6
E 25	248.0	270.0	258.0		124.5			175.0	158.0	
26					116.3	130.8				
27				203.0	182.0	173.5				
AVG	248.0	270.0	258.0	235.5	172.0	202.1	133.7	104.6	152.5	71.6
PLOT 2										
11							5.0	1.0		
12							18.2	13.5		
J 18						85.5	71.0			
U 19				89.0	122.0					
N 24								61.0	55.3	32.2
E 25	115.0	117.5	98.5		82.0			46.0	36.0	
26					41.7	34.0				
27				106.5	60.5	54.5				
AVG	115.0	117.5	98.5	97.7	76.5	58.0	31.4	30.4	45.6	32.2
PLOT 3										
11							9.0	9.3		
12							12.0	12.0		
J 18						59.5	69.7			
U 19				123.7	123.5					
N 24								42.0	36.5	24.0
E 25	53.0	59.5	54.0		37.0			34.0	39.0	
26					36.0	29.0				
27				151.0	23.5	24.0				
AVG	53.0	59.5	54.0	137.3	55.0	37.5	30.2	24.3	37.8	24.0
Time of Day	4:00–6:00	6:00–8:00	8:00–10:00	10;00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00

MURRE

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
PLOT 1											
	4			272.0							
	11				247.5	124.5			230.0	147.5	159.0
J	12		215.0								
U	13	195.0	248.0	230.0	237.0	177.0	163.0	176.0			
L	14				229.0	240.5	225.0	231.0			
Y	15			228.0	137.0						
	19				291.0	286.0	295.0	305.5	138.0		
	AVG	195.0	231.5	243.3	228.3	207.0	227.7	237.5	184.0	147.5	159.0
PLOT 2											
	4			0.0							
	11				146.5	96.0			66.0	84.5	89.0
J	12		175.0								
U	13	113.0	206.0	230.0	147.5	60.5	56.5	47.0			
L	14				197.0	210.0	149.5	137.0			
Y	15			136.0	174.0						
	19				101.0	112.5	134.5	120.0	68.0		
	AVG	113.0	190.5	122.0	153.2	119.8	113.5	101.3	67.0	84.5	89.0
PLOT 3											
	4			0.0							
	11				122.5	59.5			33.0	28.5	27.0
J	12		72.0								
U	13	54.0	55.0	62.0	36.5	35.5	31.0	37.0			
L	14				47.0	60.0	78.0	88.0			
Y	15			88.0	98.0						
	19				55.0	46.5	49.0	46.5	46.0		
	AVG	54.0	63.5	50.0	71.8	50.4	52.7	57.2	39.5	28.5	27.0
Time of Day		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

KITTIWAKE

PLOT 1											
	11							0.0	0.0		
	12							0.0	0.0		
J	18						0.0	0.0			
U	19				0.0	0.0					
N	24								0.0	0.0	0.0
E	25	0.0	0.0	0.0		0.0			0.0	0.0	
	26					0.0	0.0				
	27				0.0	0.0	0.0				
	AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLOT 2											
	11							37.0	47.7		
	12							52.0	43.5		
J	18						34.5	34.7			
U	19				40.3	40.0					
N	24								36.0	34.3	20.4
E	25	48.5	48.5	46.0		87.5			33.0	34.0	
	26					45.7	28.3				
	27				88.5	46.5	52.5				
	AVG	48.5	48.5	46.0	64.4	54.9	38.4	41.2	40.1	34.1	20.4
PLOT 3											
	11							28.0	32.4		
	12							39.6	39.0		
J	18						25.5	29.0			
U	19				71.3	95.5					
N	24								40.0	34.8	18.2
E	25	63.0	82.0	75.0		32.5			24.0	28.5	
	26					17.3	20.5				
	27				44.0	28.8	31.0				
	AVG	63.0	82.0	75.0	57.7	43.5	25.7	32.2	33.9	31.6	18.2
Time of Day		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

KITTIWAKE

PLOT 1

		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
	4			0.0							
	11				0.0	0.0			0.0	0.0	0.0
J	12		0.0								
U	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
L	14				0.0	0.0	0.0	0.0			
Y	15			0.0	0.0						
	19				0.0	0.0	0.0	0.0	0.0		
	AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PLOT 2

		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
	4			0.0							
	11				37.0	57.5			49.0	35.0	38.0
J	12		33.0								
U	13	48.0	45.0	46.0	43.5	39.0	44.5	42.0			
L	14				44.0	54.0	47.0	40.0			
Y	15			53.0	54.0						
	19				13.0	65.5	79.5	96.0	35.0		
	AVG	48.0	39.0	33.0	38.3	54.0	57.0	59.3	42.0	35.0	38.0

PLOT 3

		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
	4			0.0							
	11				26.5	25.5			24.0	24.0	24.0
J	12		30.0								
U	13	32.0	21.0	26.0	20.5	32.5	37.0	32.0			
L	14				47.0	41.0	39.0	33.0			
Y	15			43.0	38.0						
	19				21.0	27.5	33.0	31.5	32.0		
	AVG	32.0	25.5	23.0	30.6	31.6	36.3	32.2	28.0	24.0	24.0

Time of Day: 4:00–6:00, 6:00–8:00, 8:00–10:00, 10:00–12:00, 12:00–14:00, 14:00–16:00, 16:00–18:00, 18:00–20:00, 20:00–22:00, 22:00–24:00

PELAGIC CORMORNT

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
PLOT 1											
	11							0.0	1.0		
	12							1.0	1.0		
J	18						2.0	1.0			
U	19				1.0	1.0					
N	24								3.0	3.0	3.0
E	25	3.0	5.0	3.0		1.5			3.0	3.0	
	26					0.0	0.0				
	27				2.0	0.3	0.0				
	AVG	3.0	5.0	3.0	1.5	0.7	0.7	0.7	2.0	3.0	3.0
PLOT 2											
	11							11.0	12.4		
	12							11.4	9.0		
J	18						14.5	13.3			
U	19				12.7	10.5					
N	24								12.0	12.8	11.0
E	25	11.0	10.0	11.0		9.5			11.0	12.5	
	26					9.3	10.5				
	27				17.5	9.8	9.5				
	AVG	11.0	10.0	11.0	15.1	9.8	11.5	11.9	11.1	12.6	11.0
PLOT 3											
	11							19.0	26.4		
	12							19.4	15.5		
J	18						11.5	17.3			
U	19				13.7	20.0					
N	24								19.0	18.3	14.0
E	25	4.0	2.5	6.5		11.0			34.0	28.5	
	26					19.0	14.3				
	27				16.0	20.8	28.5				
	AVG	4.0	2.5	6.5	14.8	17.7	18.1	18.6	23.7	23.4	14.0
Time of Day		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

PELAGIC CORMORNT

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
PLOT 1											
	4			3.0							
	11				1.5	0.0			0.0	1.5	2.0
J	12		3.0								
U	13	2.0	2.0	2.0	1.0	0.0	0.0	0.0			
L	14				1.0	0.0	0.0	1.0			
Y	15			2.0	2.0						
	19				1.0	0.0	0.0	0.0	0.0		
	AVG	2.0	2.5	2.3	1.3	0.0	0.0	0.3	0.0	1.5	2.0
PLOT 2											
	4			0.0							
	11				10.0	10.0			8.0	10.0	11.0
J	12		12.0								
U	13	9.0	12.0	10.0	8.5	11.0	8.0	8.0			
L	14				9.0	9.0	9.0	8.0			
Y	15			9.0	8.0						
	19				10.0	8.5	8.5	9.5	9.0		
	AVG	9.0	12.0	6.3	9.1	9.6	8.5	8.5	8.5	10.0	11.0
PLOT 3											
	4			0.0							
	11				1.5	2.5			3.0	6.5	8.0
J	12		0.0								
U	13	2.0	2.0	0.0	1.0	0.0	5.5	9.0			
L	14				5.0	11.0	13.0	9.0			
Y	15			4.0	2.0						
	19				13.0	13.0	9.5	15.0	7.0		
	AVG	2.0	1.0	1.3	4.5	6.6	9.3	11.0	5.0	6.5	8.0
Time of Day		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

PARAKEET AUKLET

PLOT 1

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
	11							0.0	0.0		
	12							0.0	0.0		
J	18						0.0	0.0			
U	19				1.3	0.5					
N	24								0.0	0.0	0.0
E	25	10.0	12.0	0.0		1.5			0.0	0.0	
	26					0.0	0.0				
	27				5.5	1.5	0.5				
	AVG	10.0	12.0	0.0	3.4	0.9	0.2	0.0	0.0	0.0	0.0

PLOT 2

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
	11							0.0	0.0		
	12							0.0	0.0		
J	18						0.0	0.0			
U	19				0.0	0.0					
N	24								0.0	0.0	0.0
E	25	0.0	0.0	0.5		0.0			0.0	0.0	
	26					0.0	0.0				
	27				0.0	0.0	0.0				
	AVG	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PLOT 3

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
	11							0.0	0.0		
	12							0.0	0.0		
J	18						0.0	0.0			
U	19				0.0	0.0					
N	24								0.0	0.0	0.0
E	25	0.0	0.0	0.0		2.0			0.0	0.0	
	26					0.0	0.0				
	27				0.5	0.0	0.0				
	AVG	0.0	0.0	0.0	0.3	0.5	0.0	0.0	0.0	0.0	0.0
	Time of Day	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

PARAKEET AUKLET

PLOT 1										
4			12.0							
11				19.5	20.0			0.0	0.0	0.0
J 12		25.0								
U 13	7.0	19.0	15.0	8.5	2.5	2.5	0.0			
L 14				8.0	13.5	6.0	1.0			
Y 15			15.0	24.0						
19				26.0	23.0	22.0	17.0	0.0		
AVG	7.0	22.0	14.0	17.2	14.8	10.2	6.0	0.0	0.0	0.0
PLOT 2										
4			0.0							
11				0.0	0.0			0.0	0.0	0.0
J 12		0.0								
U 13	1.0	0.0	0.0	0.0	0.0	0.0	0.0			
L 14				0.0	1.0	0.0	0.0			
Y 15			0.0	0.0						
19				1.0	0.0	0.0	0.0	0.0		
AVG	1.0	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0
PLOT 3										
4			0.0							
11				0.5	2.5			0.0	0.0	0.0
J 12		0.0								
U 13	0.0	2.0	0.0	0.5	0.0	0.0	0.0			
L 14				0.0	0.0	0.0	0.0			
Y 15			2.0	0.0						
19				3.0	2.0	0.5	1.0	0.0		
AVG	0.0	1.0	0.7	0.8	1.1	0.2	0.3	0.0	0.0	0.0
Time of Day	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

HORNED PUFFIN

PLOT 1

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
	11							9.0	8.3		
	12							30.2	31.0		
J	18						26.5	21.3			
U	19				27.7	35.0					
N	24								30.0	18.5	9.8
E	25	3.0	5.5	22.0		24.0			53.0	44.5	
	26					9.7	11.5				
	27				3.5	3.3	4.0				
	AVG	3.0	5.5	22.0	15.6	18.0	14.0	20.2	30.6	31.5	9.8

PLOT 2

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
	11							0.0	0.4		
	12							1.8	3.5		
J	18						0.0	1.3			
U	19				0.0	0.0					
N	24								2.0	3.3	1.4
E	25	1.0	1.0	1.0		2.0			3.0	4.0	
	26					0.0	0.0				
	27				1.0	0.3	0.0				
	AVG	1.0	1.0	1.0	0.5	0.6	0.0	1.0	2.2	3.6	1.4

PLOT 3

		4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
	11							0.0	1.4		
	12							2.6	3.0		
J	18						1.0	1.0			
U	19				1.7	3.0					
N	24								1.0	8.8	0.6
E	25	0.0	0.0	0.5		2.0			3.0	3.5	
	26					2.7	2.8				
	27				1.0	0.3	0.0				
	AVG	0.0	0.0	0.5	1.3	2.0	1.2	1.2	2.1	6.1	0.6

Time of Day

HORNED PUFFIN

PLOT 1

	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
4			13.0							
11				9.5	11.5			19.0	22.5	10.0
J 12		6.0								
U 13	1.0	3.0	2.0	5.0	1.0	3.5	2.0			
L 14				10.0	13.5	17.0	16.0			
Y 15			12.0	14.0						
19				6.0	13.5	17.0	21.0	18.0		
AVG	1.0	4.5	9.0	8.9	9.9	12.5	13.0	18.5	22.5	10.0

PLOT 2

	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
4			0.0							
11				0.0	1.0			5.0	3.5	5.0
J 12		1.0								
U 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
L 14				0.0	2.5	2.5	0.0			
Y 15			0.0	2.0						
19				4.0	2.0	4.5	3.5	4.0		
AVG	0.0	0.5	0.0	1.2	1.4	2.3	1.2	4.5	3.5	5.0

PLOT 3

	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
4			0.0							
11				2.0	0.5			4.0	2.5	2.0
J 12		1.0								
U 13	1.0	0.0	1.0	1.5	0.5	0.0	0.0			
L 14				2.0	2.5	1.5	3.0			
Y 15			1.0	0.0						
19				3.0	3.5	2.5	1.5	6.0		
AVG	1.0	0.5	0.7	1.7	1.8	1.3	1.5	5.0	2.5	2.0
Time of Day	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

TUFTED PUFFIN

PLOT 1

11							2.0	3.7		
12							11.2	10.0		
J 18						9.5	11.3			
U 19				15.0	22.0					
N 24								10.0	11.3	7.0
E 25	2.5	3.5	13.5		4.0			15.0	17.5	
26					0.0	1.0				
27				0.5	0.3	0.0				
AVG	2.5	3.5	13.5	7.7	6.6	3.5	8.2	9.7	14.4	7.0

PLOT 2

11							0.0	0.0		
12							0.4	0.0		
J 18						0.0	1.3			
U 19				0.0	1.0					
N 24								0.0	0.0	2.0
E 25	0.0	0.0	1.5		2.0			2.0	6.5	
26					0.3	0.0				
27				1.0	0.3	0.0				
AVG	0.0	0.0	1.5	0.5	0.9	0.0	0.6	0.5	3.3	2.0

PLOT 3

11							1.0	2.3		
12							3.8	5.0		
J 18						5.0	5.7			
U 19				11.3	9.5					
N 24								4.0	3.3	3.6
E 25	1.5	2.0	7.5		1.5			8.0	8.0	
26					1.3	0.8				
27				0.5	1.5	1.0				
AVG	1.5	2.0	7.5	5.9	3.5	2.2	3.5	4.8	5.6	3.6
Time of Day	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00

TUFTED PUFFIN

Time of Day	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
PLOT 1										
4			7.0							
11				4.0	4.5			11.0	9.0	7.0
J 12		1.0								
U 13	0.0	1.0	3.0	0.0	0.5	0.0	0.0			
L 14				9.0	13.0	20.5	7.0			
Y 15			8.0	7.0						
19				4.0	13.5	11.5	16.0	12.0		
AVG	0.0	1.0	6.0	4.8	7.9	10.7	7.7	11.5	9.0	7.0
PLOT 2										
4			0.0							
11				1.0	1.0			1.0	0.5	0.0
J 12		0.0								
U 13	0.0	0.0	0.0	0.5	0.0	0.0	0.0			
L 14				0.0	3.0	0.5	0.0			
Y 15			0.0	1.0						
19				0.0	0.5	2.5	2.5	0.0		
AVG	0.0	0.0	0.0	0.5	1.1	1.0	0.8	0.5	0.5	0.0
PLOT 3										
4			0.0							
11				1.5	2.0			1.0	0.0	0.0
J 12		3.0								
U 13	0.0	1.0	1.0	2.0	2.0	2.0	1.0			
L 14				4.0	7.0	7.5	3.0			
Y 15			8.0	7.0						
19				14.0	11.0	7.0	11.0	9.0		
AVG	0.0	2.0	3.0	5.7	5.5	5.5	5.0	5.0	0.0	0.0

PIGEON GUILLEMOT

PLOT 1

June	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
11							0.0	0.0		
12							0.0	0.0		
J 18						0.0	0.0			
U 19				1.7	2.5					
N 24								0.0	0.5	3.4
E 25	1.5	1.5	0.5		1.5			0.0	0.0	
26					1.0	0.0				
27				0.0	0.3	0.5				
AVG	1.5	1.5	0.5	0.8	1.3	0.2	0.0	0.0	0.3	3.4

PLOT 2

June	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
11							0.0	0.1		
12							1.4	1.0		
J 18						0.0	0.7			
U 19				3.3	3.5					
N 24								0.0	2.0	7.0
E 25	8.5	5.5	3.5		4.5			0.0	1.5	
26					3.3	1.8				
27				5.0	1.3	2.0				
AVG	8.5	5.5	3.5	4.2	3.1	1.2	0.7	0.3	1.8	7.0

PLOT 3

June	4:00-6:00	6:00-8:00	8:00-10:00	10:00-12:00	12:00-14:00	14:00-16:00	16:00-18:00	18:00-20:00	20:00-22:00	22:00-24:00
11							0.0	0.1		
12							0.4	0.0		
J 18						3.0	2.0			
U 19				8.0	6.5					
N 24								1.0	2.5	8.0
E 25	9.5	8.5	10.0		1.0			0.0	0.5	
26					3.7	2.8				
27				7.0	2.0	3.0				
AVG	9.5	8.5	10.0	7.5	3.3	2.9	0.8	0.3	1.5	8.0

Time of Day

PIGEON GUILLEMOT

PLOT 1

		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
	4			1.0							
	11				3.5	3.5			0.0	0.0	0.0
J	12		6.0								
U	13	2.0	0.0	3.0	0.0	0.0	0.5	0.0			
L	14				3.0	2.0	0.0	0.0			
Y	15			2.0	3.0						
	19				5.0	4.0	3.5	0.0	0.0		
	AVG	2.0	3.0	2.0	2.9	2.4	1.3	0.0	0.0	0.0	0.0

PLOT 2

		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
	4			0.0							
	11				5.5	6.0			0.0	0.0	1.0
J	12		5.0								
U	13	0.0	3.0	3.0	3.0	4.0	2.5	0.0			
L	14				2.0	1.5	4.5	3.0			
Y	15			11.0	9.0						
	19				9.0	6.0	0.5	0.5	0.0		
	AVG	0.0	4.0	4.7	5.7	4.4	2.5	1.2	0.0	0.0	1.0

PLOT 3

		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
	4			0.0							
	11				9.0	4.5			0.0	0.5	1.0
J	12		0.0								
U	13	8.0	10.0	4.0	5.0	4.0	3.5	2.0			
L	14				2.0	5.5	3.0	0.0			
Y	15			12.0	7.0						
	19				7.0	7.5	7.0	1.5	2.0		
	AVG	8.0	5.0	5.3	6.0	5.4	4.5	1.2	1.0	0.5	1.0
Time of Day		4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00

APPENDIX 5. Sex and Measurements of Specimens and Live-captured Adult Birds at Kongkok Bay, 1976.

SPECIES	DATE	SEX	WEIGHT	WING[1]	PRIMARY	TARSUS	CULMEN
Least Auklet	10 July 1976	M	83g	116mm	56mm	20mm	10mm
		M	92	121	55	18	10
		M	91	121	63	21	10
		F	94	123	58	19	10
		F	106	127	62	19	9
		M	85	121	67	19	10
		M	93	128	61	20	10
		F	84	121	55	20	9
		M	83	127	59	21	10
		M	104	128	58	19	10
	16 July 1976	-	82	122	54	18	7
	28 August 1976	F	88	121	58	20	9
	AVERAGE[2]		90 ± 8	123 ± 4	59 ± 4	20 ± 1	10 ± 1
Crested Auklet	6 June 1976	F	285g		95mm	27mm	12mm
	8 July 1976	F	262	190mm	81	33	13
		M	291	188	87	29	14
		M	291	186	88	27	12
		F	227	172	81	26	18
		M	266	182	84	29	13
		F	239	185	85	29	14
		F	250	181	87	28	15
		F	248	181	79	30	12

APPENDIX 5.(Cont'd)

SPECIES	DATE	SEX	WEIGHT	WING[1]	PRIMARY	TARSUS	CULMEN
Crested Auklet (cont'd)	8 July 1976	M	281g	188mm	87mm	30mm	14mm
		M	281	189	87	30	14
		M	268	175	84	28	13
		-	289	185	81	26	13
		M	266	187	84	29	13
		F	288	188	85	29	12
		M	281	184	85	27	13
		M	270	180	79	30	13
		F	231	187	89	30	18
		F	288	181	82	29	12
		F	258	184	87	26	13
		F	267	178	85	28	12
		M	269	189	92	29	13
		M	250	180	88	27	13
		F	265	181	87	29	12
		-	240	170	91	28	12
		M	273	185	85	27	13
		M	288	185	84	30	14
	AVERAGE M		275 ± 12				
	F		259 ± 21	183 ± 5	86 ± 4	29 ± 2	13 ± 2
Parakeet Auklet	8 July 1976	F	265g	206mm	91mm	21mm	15mm
		M	284	197	92	32	17
Common Murre	8 June 1976	M		264mm	110mm	54mm	58mm
	9 June 1976	M	1000g	267	129	51	
		F	950	271	124	50	54
		M	1000	261	118	55	55
	12 June 1976	-	1150	288	123	44	44
		M	1000	273	122	41	62
		F	1040	290	116	48	45

APPENDIX 5.(Cont'd)

SPECIES	DATE	SEX	WEIGHT	WING[1]	PRIMARY	TARSUS	CULMEN
Common Murre (cont'd)	13 June 1976	M	900g	268mm	111mm	40mm	46mm
		M	950	279	122	39	42
	18 June 1976	M	925	268	123	35	42
		F	1000	277	123	37	43
		M	1050	274	122	37	46
		M	1075	278	116	41	46
		F	900	264	113	36	44
		M	950	276	119	38	44
	10 July 1976	-		280	128	40	44
	AVERAGE		992 ± 70	274 ± 8	120 ± 6	43 ± 7	48 ± 6
Thick-billed Murre	8 June 1976	M		292mm	120mm	54mm	54mm
	9 June 1976	M	1190g	299	131	40	40
		M	815	301	134	40	43
		F	1025	281	122	49	49
		M	1075	289	127	51	53
		M	915	276	121	44	43
		F	1025	286	126	43	41
	10 June 1976	M	1040	299	130	49	55
	12 June 1976	-	925	295	130	47	48
	13 June 1976	M		306	129	43	41
	14 June 1976	F	1025	288	120	39	42
	18 June 1976	F	1050	279	135	49	48
		F	1025	298	124	48	
		F	1025	288	124	43	
		M	1175	295	127	42	45
		F	1050	295	127	40	40
		M	950	282	123	39	
		M	1100	300	128	39	42
		M	1075	282	132	40	
		F	1075	286	129	40	40

APPENDIX 5.(Cont'd)

SPECIES	DATE	SEX	WEIGHT	WING[1]	PRIMARY	TARSUS	CULMEN
Thick-billed Murre (cont'd)	18 June 1976	F	1050g	289mm	119mm	40mm	42mm
		M	1000	287	131	39	38
		M	1050	284	127	38	45
		M	1150	276	126	39	40
		M	1075	288	136	40	42
		M	1025	299	123	41	42
		M	1200	283	126	37	39
		M	1100	202	124	39	39
		M	1150	290	133	35	41
		F	1100	294	137	39	44
	27 July 1976	M	800	292	125	34	37
	AVERAGE		1043 ± 95	287 ± 18	127 ± 5	42 ± 5	43 ± 5

[1]Wing length measured from elbow to tip of longest primary.

[2]No significant difference between the measurements of males and females except where reported otherwise. Average ± one Standard Deviation.

APPENDIX 6. Numbers of Food Organisms by Size Classes Eaten by Murres and Auklets of the Kongkok Bay Colony during 1976.

The methods of measuring and counting food organisms found in the stomachs and sublingual (gular) pouches of the birds that were collected are as follows:

1. Mysids (*Mysis oculata* and *Paracanthomysis kurilensis*).

   Because rostra were frequently broken off, mysids were measured from the anteriomost margin of the eye to the end of the telson. When animals were incomplete, only telsons were counted; the numbers were distributed proportionally among the measured categories when more than 10 telsons were present. When less than 10 telsons were present, the telsons were counted and entered under the 'present' (P) column.

2. Copepods (*Calanus* spp., *Neocalanus* spp., *Eucalanus bungii* and copepodites of all species).

   Adults and copepodites were treated separately. Copepodites were separated into IV and V stages (the adult is the sixth stage).

   Copepods were measured from the anterior part of the cephalosome (forehead) to the proximal fork of the caudal rami (the rami were often broken off). When numbers were large (>200), a random subsample of at least 25% was taken. All individuals in the subsample were measured and specimens in the remaining sample were counted. The specimens that were counted only were distributed into size categories according to the proportions found in the measured specimens of the sub-sample.

   The urosomes of damaged (partial) animals were counted; the numbers were distributed among all species according to the proportions found in the particular sample.

3. Amphipods

i. *Parathemisto* spp. (*japonica & pacifica*).

Parathemisto spp. were measured from the front of the head (not including the antennae) to the end of the telson. The telsons of partial animals were measured to estimate the total length when there were more telsons than heads; when there were more heads than telsons, the head diameter (at its widest point) was used to estimate total length.

ii. Other amphipods

Other amphipods were measured (from the rostrum to the end of the telson) in 3 mm categories. For partial animals, the telsons were measured to estimate total length.

4. Decapods (*Eualus fabricii*, and others).

Adult decapods were measured and counted using the same techniques that were used for amphipods. Larvae (mysis stage) of Hippolytidae and Pandalidae were treated in the same manner as were the mysids except that 1 mm length intervals were used.

Young from brood pouches were *not* counted but marked as present.

5. Cumaceans (*Diastylis bidenticulata*).

Cumaceans were measured from the rostrum to the end of the telson. No partial animals were found.

6. *Limacina helicina*. Only the spiral bodies of these pteropods were found. The diameter at the widest point was measured to the nearest millimetre.

7. Fish. Fish larvae, either Cottidae or Scorpaenidae, were counted but could not be accurately measured because few specimens were complete.

Where bones or otoliths were found, adult fish of unknown species were assumed to have been present. No counts or measurements could be made.

8. The unidentified gastropods could be neither measured nor counted; they were recorded only as 'present'.

9. Plant material and grit (stones etc.) were recorded only as 'present'.

10. Crustacean larvae (protozoea, zoea and megalops, probably of decapods) were counted--all were less than 1 mm in length.

11. Pieces of crustaceans (e.g., legs or antennae) when present without any measurable parts of the species from which they came, were assigned to the lowest possible taxonomic level and recorded simply as 'present'.

APPENDIX 6. Indices for Determining Total Length from Partial Body Length.

Species	Total Length (mm)	Urosome + Telson Length (mm)	Head Diameter (mm)
Parathemisto spp. (last urosome segment + telson & uropods)	0-3	>1	>0.5
	3-6	1-1.75	0.5-1
	6-9	2-2.5	1-1.5
	9-12	2.5-3.25	>1.5
Ischyrocerus spp. (as *Parathemisto*)	6-9	1.5-2	
	9-12	>2	
(*Dulichia* spp.) (as *Parathemisto*)	3-6	>2	
	6-9	2-3	
	9-12	>3	
Calliopiella spp. (telson + uropods)	3-6	0.5-1.3	
	6-9	1.5-2	
	9-12	>2	
Atylus spp. (as *Calliopiella*)	3-6	>1	
	6-9	1-1.75	
	9-12	1.75-2.5	
	15-18	>3	
Anonyx nugax (2 urosome segments + telson & uropods)	3-6	>2.0	
	6-9	2.5-3	
	9-12	3.5-5	
	12-15	>5	
Decapods (*Eualus fabricii*) (last urosome segment + telson & uropods)	12-15	6-7	
	15-18	7-8	
	18-21	8-9	
	21-24	9-10	
	24-27	10-11	
	27-30	11-11.5	
	30-33	11.5-12	
	33-36	12-13	
	36-39	13-14	
	39-42	14-15	
	42-49	>15	
Others	Either complete and, therefore, measured, or no whole specimens were available.		

APPENDIX 6. **Numbers of Each Size Class of Food Organisms Found in Stomachs of Least Auklets.**

Amphipods																									
Anonyx spp. 3-6	*Anonyx* spp. 6-9	*Anonyx* spp. P	*Atylus tridens* 3-6	*Atylus tridens* 6-9	*Atylus tridens* 9-12	*Atylus tridens* 12-15	*Atylus tridens* 15-18	*Calliopiella* spp. 0-3	*Calliopiella* spp. 3-6	*Calliopiella* spp. 6-9	*Calliopiella* spp. 9-12	*Ischyrocerus* spp. 6-9	*Ischyrocerus* spp. 9-12	*Ischyrocerus* spp. P	*Dulchia* spp. 3-6	*Dulchia* spp. 6-9	*Dulchia* spp. 9-12	*Dulchia* spp. 12-15	*Dulchia* spp. P	*Achotropus* spp. 6-9	*Achotropus* spp. P	*Metopa* spp. 6-9	*Pontoporeia affinus* 6-9	*Pontoporeia affinus* 9-12	Other 6-9
							1	*	6	1	1					5	1								
		P							2					P											
								*	7	4		1													
														P	1	2	3								
								*	5	9					1	3		1		1		1	1		
														P	1										
													1	P			1		1						
3	2		1						1					P										1	
	1			1				*	26	16	2	5	4			10					2				3

Decapods						Cumaceans			Copepods			Other Crustaceans	Other Invertebrates	Fish		Plant	Grit
Hippolytidea (larvae) 5-6	Hippolytidea (larvae) 6-7	Hippolytidea (larvae) 7-8	Hippolytidea (larvae) 8-9	Hippolytidea (larvae) P	Zoea	*Diastylis bidenticulata* 3-6	*Diastylis bidenticulata* 6-9	*Diastylis bidenticulata* 9-12	*Neocalanus plumchrus* 3-4	*Neocalanus plumchrus* 4-5	*Calanus marshallae* 3-4			Adult	Larvae		
10	77	59	3		20							P			9		
12	117	85	10	2	7				1								
6	68	60	2		2				1					P	3		P
17	92	72	6		3						2					P	
1	67	33	2		6	1	1	1	1						11		
11	52	30	2	1	4									?		P	
18	51	22	6		1												
	29	24	5	P	1										1		
30	145	42	8	P					2	1	1	1(unid. cumacean)	1(unid. diptera)				P
23	96	93	3	2	8										2-3		P

*Young from brood pouch.

APPENDIX 6. Numbers of Each Size Class of Food Organisms Found in Gular Pouches of Least and Crested Auklets (Amphipods, Decapods, Mysids).
Continued on next page.

Species	Amphipods														Decapods										Mysids							
	Hyperiidae							Other							Pandalidae									Larvae								
	Parathemisto spp.					Other																			*Paracanthomysis* spp.					Other		
	0-3	3-6	6-9	9-12	P	3-6	6-9	3-6	6-9	9-12	12-15	15-18	18-21	P	5-6	6-7	7-8	8-9	9-10	10-11	12-15	24-27	P		3-6	6-9	9-12	12-15	P	9-12	12-15	P
Least Auklets		1	1																													
		4	2											(*Dulchia* spp.) 1			2	2	2						1		15	1				1
			2																													
	1	5	4	3					1	1						4	12	1	3		3	1	1		1							
																	1										1					
		1											(*Atylus tridens*) 1								1											
		5	5						1					1			2	1						1								
		5	1	1																4			2	1			3	1	1			
		3																														1
		6	2	1			1	2	1	1														2							3	
						1	2																	1								
Crested Auklets																1																
																							P									
															3	8	3	5											1			
			2											(*Anonyx* spp.) P																		
		2																					P									
																				1												
	1	1															2		2													
		2							1 (gammarid)														1						1			
		2	2																													P
		5	2															1	1				3									
			1														1	1					1				1					

APPENDIX 6. Numbers of Each Size Class of Food Organisms Found in Gular Pouches of Least and Crested Auklets (Copepods, Other Crustaceans, Molluscs).
Continued from previous page.

Species	Copepods												Other Crustaceans								Molluscs	
	Adults				Copepodites								Euphausiidae					Hippolytidae		Other		
	Neocalanus plumchrus 3-4	*Neocalanus plumchrus* 4-5	*Eucalanus bungii* 6-7	*Calanus marshallae* 3-4	*Neocalanus plumchrus* 3-4	*Neocalanus plumchrus* 4-5	*Neocalanus cristatus* 7-8	*Neocalanus cristatus* 8-9	*Eucalanus bungii* 5-6	*Eucalanus bungii* 6-7	*Calanus marshallae* 2-3	*Calanus marshallae* 3-4	9-12	12-15	15-18	18-21	P	6-9	P		*Limacina helicina* 1-3	Other
Least Auklets	1	36			205	198		5				2										
	1	32	1		427	268		6				2						1				P
	1	11	1		184	115		2				13										
		7		5	118	73						39										P
		120	2	4	1022	578					3										12	P
	52	21			152	99					9	143										P
		76			687	450		3				31									4	
	3	64	1	3	592	322		1		1		30									2	P[1]
	1	48			437	201	2					18										P
		13			485	213			1			9										P
		61		4	768	399	9			1		18							P		8	P[1]
		48	1	1	312	206	2	1				12										
	1	162	2		458	422	4					6										
		6			300	210																
	3	34			320	121	5					13								P		P[2]
	2	35			298	165	1					11										
		39		1	431	210		1				20										P
	4	51			377	225			5			13[3]										
		23	1		488	202						4									3	
	1	54			338	187		14				12	1			1				P		P
		38	2		577	303		2				7									2	P
	3	46			261	191	5					12										P
		126			902	287	6					43									3	P
		34			349	200	2					7										P[4]

[1]Plant remains also present
[2]Also 1 unidentified copepod present
[3]Fish remains also present
[4]Also 2 unidentified organisms present

APPENDIX 6. Numbers of Each Size Class of Species of Food Organisms Found in Stomachs of Crested Auklets.

Amphipods				Cumaceans	Molluscs	Other Invertebrates	Grit
Anonyx nugax	*Dulchia* spp. 6-9	*Dulchia* spp. P	Other 6-9	*Diastylis bidenticulata* 9-12	*Limacina helicina*		
		P					
P							
					1		
					5		
	2		2	2	1		P
						1 (unid. tick)	

APPENDIX 6. Numbers of Each Size Class of Food Organisms Found in Stomachs of Common and Thick-billed Murres.

Species	Amphipods									Cumaceans			Decapods											Other Crustaceans		Other Invertebrates			Other		
	Anonyx nugax				*Atylus tridens*		*Amplesica* spp.	*Parathemisto* spp.	Other	*Diastylis bidenticulata*			*Eualus fabricii* *Eualus fabricii*											*Mysis littoralis*	Other	*Spirobis*	Hydrozoa	Araneae	Fish	Plant	Grit
	6-9	9-12	12-15	P	6-9	9-12	21-24			12-15	15-18	P	12-15	15-18	21-24	24-27	27-30	30-33	33-36	36-39	39-42	42-45	P	27-30		1-5					
Thick-billed Murres	1	9	6			2				2	1										1										
		2	1																												
																								1							
							3					1	1				1	2	5	10	12	9	*								
																							P			1	1				
															1																
																													P	P	P
																							P							P	P
																									P						P
																												1		P	
																							P							P	P
																													P	P	
Common Murres																															
																													P		
																							P								
								P																					P		
		1	2						P		1																		P	P	
					1																									P	
																													P		

*Young from brood pouch.

ANNUAL REPORT

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CHARACTERIZATION OF COASTAL HABITAT FOR MIGRATORY BIRDS

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U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

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INTRODUCTION

This study would complete the characterization of coastal habitats conducted elsewhere on the Alaskan coast by the Alaska Department of Fish and Game under OCSEAP Research Unit 3/4. The region between Cape Newenham and the Bering Straits, which is covered by this study, has long been considered of unique importance to birds, most particularly to several species of waterfowl, shorebirds, and seabirds, which are dependent on estuarine or marine habitat. Four National Wildlife Refuges abut the coast including Nunivak NWR, established in 1929; Hazen Bay NWR, established in 1937; Clarence Rhode NWR, established in 1960; and Cape Newenham NWR, established in 1969. Clarence Rhode NWR has additionally been designated by the Secretary of the Interior as a National Natural Landmark. Three islands, including Egg Island, Sledge Island, and Fairway Rock, all adjacent to the Seward Peninsula, and a coastal area at Bluff on the Seward Peninsula have been recommended by the Secretary of the Interior for inclusion in the existing Bering Sea NWR established in 1909 and encompassing St. Matthew and Hall Islands and adjacent rocks and islets in the central Bering Sea.

The coastline within the region is variable ranging from precipitous marine escarpments of Cape Newenham and Nunivak to tide flats and lowlands of the Yukon Delta where tidal estuaries may extend inland for more than 50 kilometers. Coastal lagoons and barrier islands or spits provide important habitat on Kuskokwim Bay, Nunivak Island, and the Seward Peninsula. The variation in habitat signifies the variety of species and use by birds.

Objectives of this study are:

1. To characterize coastal habitat utilized by marine birds by:

    a. Describing extent and characteristics of unvegetated intertidal beaches.

    b. Describing extent and characteristics of intertidal plant communities.

    c. Identifying, where possible, the maximum limit of tidal influence on terrestrial habitat by mapping the occurrence of drift lines.

    d. Identify ownership status (private or public) and responsible land management agency.

    e. Identify and quantify existing land uses.

2. To characterize use of habitat by birds including:

    a. Identification of principal species.

    b, Identification and/or description of habitat use or dependencies by principal species.

c. Identify relative and/or approximate numbers of birds utilizing habitats seasonally.

3. To identify habitats which may be considered of unique or critical importance to any species considering overall populations of the species relative to the number present, and the availability of similar alternative habitat.

METHODS

This study will depend primarily on existing published and unpublished information including maps and aerial or satellite imagery, and on results from ongoing OCSEAP studies.

Field studies will be confined to aerial surveys and on site studies essential as ground truth for photo interpretation, identification of drift lines, and determining use by smaller species of birds in areas not covered by prior or ongoing studies.

RESULTS AND DISCUSSION

Work during the past quarters has been limited to evaluation of existing literature and unpublished materials. Mapping and analysis of this information will proceed upon completion of field surveys conducted in June, July and August, 1977.

Prior studies of the avifauna and habitats of Cape Newenham and the Yukon Delta have been conducted primarily by the Fish and Wildlife Service and cooperating agencies or institutions and, while most data are available only in the form of unpublished materials, major studies have been completed on a few species and their habitats, e.g. cackling goose (Mickelson, 1975), emperor goose (Eisenhower, 1974, and Eisenhower and Kirkpatrick, in press), arctic and redthroated loons (Peterson, 1976), and glaucous gulls (Strang, 1976). Substantial information on wildlife and habits of the region has been summarized by the Alaska Planning Group, USDI (1974) in Final Environmental Statements describing the proposed Togiak, Yukon Delta, and Alaska Coastal National Wildlife Refuges.

Although the Seward Peninsula is a noted stopping point for both amature and professional ornithologists (who are interested primarily in recording Asiatic species) few published reports are pertinent to the present study, being limited to McGregor (1902) on observations in the Koyuk River System, Bailey (1925, 1926, 1943) on observations near Wales, Cade (1952) from observations on Sledge Island, and Kessel (1968) who provided a checklist for the entire Peninsula. Work presently being conducted by Drury (OCSEAP Research Unit 237/238) thus has major significance to this study in covering avian use of habitat along a major segment of the southern coast. Work by G. F. Shields and L. J. Peyton (OCSEAP Research Unit 458) on the Avian

Community of the Akulik-Inglutalik River Delta, Norton Bay, is also of substantial importance although covering a limited area.

Field Reports on work conducted on the North Delta of the Yukon River by R. D. Jones and M. Kirchhoff are attached as an appendix to this report.

SCHEDULE FOR THIRD AND FOURTH QUARTERS

Activities during the third and fourth quarters will include:

May to August:	Intensive studies of avian use of habitats on the North Delta of the Yukon River.
Late June/July:	Aerial Survey of Coastline with ground checks to provide basis for interpretation of aerial photos and verify published records.
August/September:	Complete mapping of coastal habitats.

APPENDIX

WATERFOWL HABITAT ON THE YUKON DELTA

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and

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Office of Biological Services-Coastal Ecosystems
Anchorage, Alaska

Field Report No. 76-074

Summer 1976

This report provides a preliminary review of progress in field or laboratory activities and is prepared for administrative use within the Fish and Wildlife Service. The interpretations and conclusions presented herein are frequently based on fragmentary data and partial analysis, and are subject to change. For these reasons, information contained in this report should be used or quoted with caution.

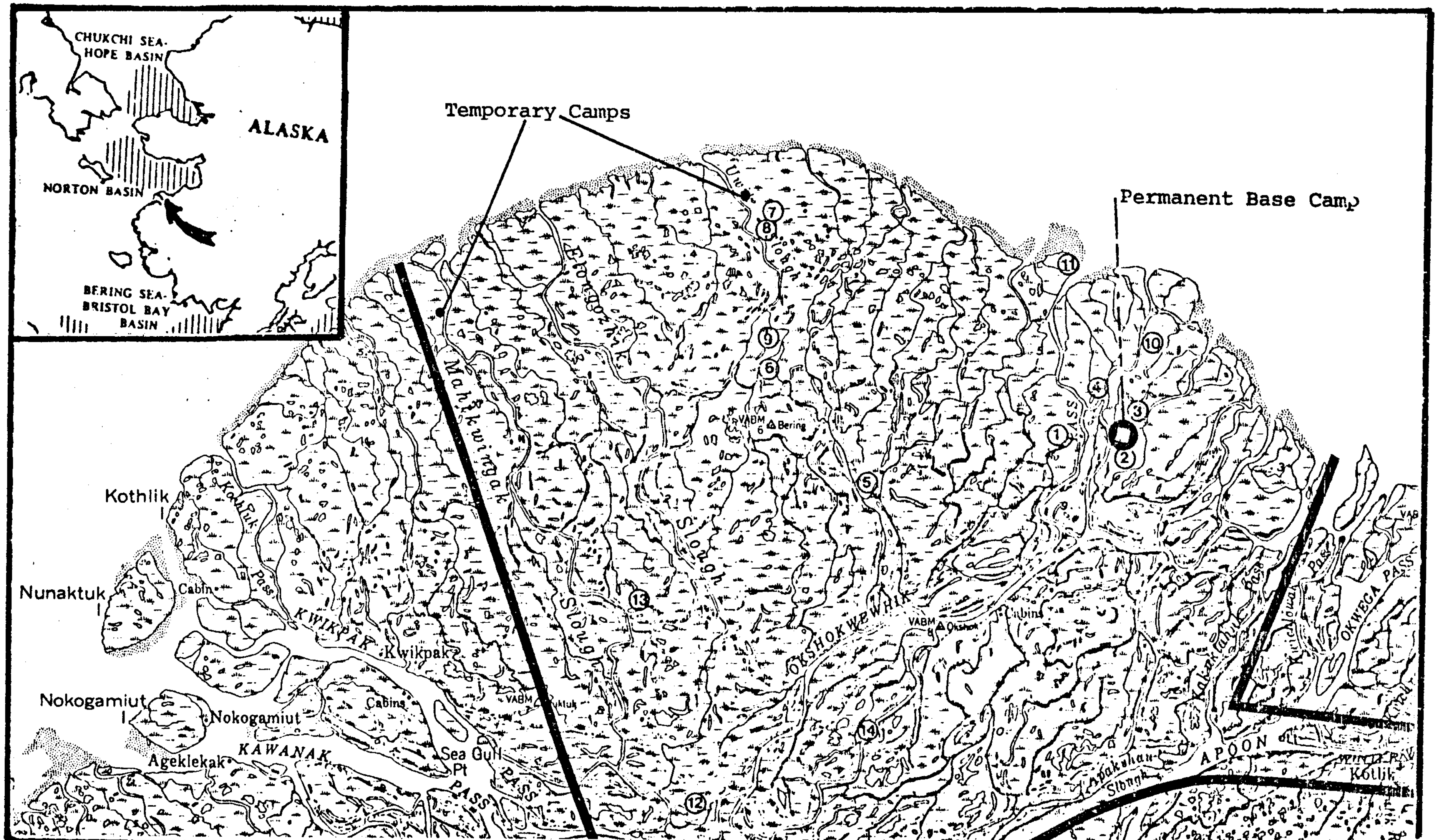

Figure 1. Yukon Delta Study Area. Circled numbers signify lakes and bogs from which pH samples were drawn.

YUKON DELTA

This is a record of studies conducted in summer 1976 on the delta of the Yukon River within the Clarence Rhode NWR. The area studied is approximately bounded by a line connecting the following coordinates and the intervening coast. These coordinates can best be located on the Saint Michael (A-4 and A-5) quadrangle maps 1:63360.

63° 02'N 163° 32'W
63° 01'N 164° 10'W
63° 10'N 163° 40'W
63° 13'N 164° 22'W

A brief visit was made to the villages of Emmonak and Kotlik June 3rd and 4th, followed by an extended period on the delta from June 17th to July 23rd. Exhaustion of the gasoline supply in Kotlik, our source for mail and certain supplies, enforced an early departure from the delta. Transportation was by commercial air to Kotlik, and from there by Grumman sport canoe powered by a six horsepower outboard engine on the waterways provided by the distributaries and sloughs of the Yukon River delta. In the course of the study approximately 750 miles were travelled on the delta.

The delta comprises a deposit of water-born silt and an intricate network of interconnecting distributaries and sloughs. It is flat, with a maximum relief of eight feet above sea level in the area we studied. Since this feature is directly correlated with age, the highest ground is centrally located with a radial slope toward the coast. In the area we studied the coast exhibits two stages of development, erosional and depositional. In the former a cut-bank of about four feet height produces a clear interface between land and water. In the depositional zone the land grades into the water to form an indefinite margin. These differences are clearly visible in aerial photos and satellite imagery. At 63° 13'N 163° 50'W, the mouth of Okshokwewhik Pass, and eastward the coast is erosional. At 1/2 mile north of 63° 15'N 164° 08'W, the mouth of Uwik Slough, and westward the coast is depositional. Between these points lies a transitional zone.

The distributaries and interconnecting sloughs carry the water of the Yukon River seaward with a continuous process of erosion on one hand and deposition on the other. It seems probable that erosion would be a runaway process but for the existence of frozen ground. In some parts of the delta this is a permanent feature, and it may be true for the entire delta but this has not been established. In our campsite at 63° 09'N 163° 48'W the depth to frozen ground was 21 cm. on July 19th.[1] Generally one side of the watercourse erodes leaving a cut-bank, while bars and mudbanks accumulate on the other. The river water carries a heavy load of silt, and is opaque.

Tidal range varies from 2.3 feet at the south mouth of the river (Kwikluak Pass) to 4.0 at the north mouth (Apoon Pass). The influence of the tide is sufficient to reverse the flow during the peak of the flood, most notably during periods of spring tides. We do not know the point on the river at which tidal influence disappears since its effect was noted throughout the area we studied. Despite the tidal influence

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[1] This cannot be interpreted as an absolute measure since the rate of thawing depends upon the insulation quality provided by the vegetative cover.

however, the system is entirely dominated by fresh water; and according to local sources this is true several miles seaward of the delta. The extent of the river's plume, visible on Landsat imagery, suggests that inundations of sea water are rare, but we have not yet conducted tests for salinity. One euryhaline plant, Elymus arenarius mollis, occurs near the coast in a water-born distribution, but the impoverished stature of the plants does not indicate flooding by sea water. The standing water, a ubiquitous feature of the delta, is pigmented a deep rust-red near the coast. We are unable to suggest a source for this pigmentation but its distribution seems correlated with Bering Sea.

Weather records have not been compiled for the delta. According to local information the delta freezes in October, and the ice goes out in late May. December and January are reported to be the coldest months when temperatures drop to minus 40°F. We recorded wind direction and velocity, air temperature, sky conditions, precipitation, and river water temperatures from June 22nd through July 21st. Unfortunately, the available thermometer did not record maximum temperature so our data are incomplete in that regard. The air temperatures varied between a low of 35°F and somewhat higher than 70°F. The river water temperature varied between 12°C and 18°C showing no apparent correlation with local atmospheric temperature. Total recorded precipitation was 0.83 inches. Sky conditions ranged from clear to overcast with the condition known as "broken" prevailing. Though we experienced a breeze most of the time the velocities were low, usually less than 10 mph with a prevailing direction of south southwest. Maximum recorded velocity was 20 mph with gusts to 25. A thunder shower occurred July 5th.

Mr. Eric Hoberg has furnished his weather records compiled in 1973 while working on Flat Island off the south mouth (Kwikluak Pass) of the Yukon River. The period covered by these records extends from June 5 through July 15 with incomplete data for July 6th through 11th during which time heavy rains fell. Hoberg reports a mean temperature of 47.9°F, maximum of 71°F, a minimum of 34°F, and consistently higher wind velocities with a prevailing direction of northwest. An ominous note reads: "On 25 July after the camp was vacated, Flat Island was flooded to a depth well over 2 feet. Winds were reported to exceed 50 miles per hour." This is consistent with warnings offered by residents of Kotlik that storm tides are frequent events on the delta. Such an event concurrent with an oil spill will surely result in widespread pollution of the delta.

Flooding appears to be a way of life along the Yukon River. In spring the ice leaves the river in a succession of water driven "ice jams" that in turn produce a series of floods proceeding stepwise downriver until the delta is passed. In the process large numbers of logs move downriver, many to be stranded along the banks and on the delta. At this time each spring all but the highest spots on the delta lie under water. When the water abates, which it does rapidly once the ice is gone, stranded logs are a conspicuous feature of the landscape. From this spring type of flooding "drift lines" do not form, and if they do form in the fall storm tides, occurring annually in November, the following spring floods wash them away.

In addition to logs, ice floes wash over the delta and may become stranded when the water recedes. Many of these have acquired a load of silt as the ice jam scarified the stream beds. Ablation of such stranded floes deposits the silt over the existing vegetation, and furnishes a laboratory for the study of revegetation. These deposits are common near the coast where the distributaries and sloughs are not lined by willows.

Our research with respect to vegetational patterns was limited to general reconnaisance, and preliminary classification of major typal communities. Although we attempted no systematic sampling, and collected no quantitative data regarding the parameters of these various communities, i.e., density, coverage, dominance, etc. of their component species; our continued contact with the vegetation matrix did lead to tentative groupings and hypotheses regarding environmental controls. These preliminary classifications can later be substantiated and more accurately defined using various vegetative sampling techniques.

We made a purposeful attempt to collect and identify any and all new plants which we encountered through out the field season. Although emphasis was on collection of vasculares, the abundance and distribution of some lichens, bryophytes and algae were also noted. A floristic list (see appendix) of species includes 82 species and subspecies in 30 families. This does not reflect the floristic composition of the delta per se, but only those localized areas where we spent much time. Admittedly incomplete, it is felt that the relatively low number of species is indicative of a florisitically impoverished ecosystem, and probably reflects the homogeniety, geologic youth, and environmental stress characteristic of the outer Yukon delta.

The gross aspect of vegetation structure on the delta is immediately obvious. The vegetation exists in two distinct strata: a ground stratum composed largely of herbaceous specimens (Gramineae and Cyperaceae mostly) not more than 1 to 1.5 meters height, and a stratum of willows and alders in thickets along the banks of the river and its distributaries ranging up to 11 meters in height. The willow - alder community is densest and tallest in the oldest parts of the outer delta. Here it is the dominant community and forms solid dense stands that are difficult to penetrate. Up-river it is replaced by cottonwood (Populus balsamifera). Down-river, that is toward the coast, the density and height of the trees diminishes decrementally to become narrow rows along the waterways and abandoned stream banks with the ground vegetation occupying most of the area; then to isolated, low clumps of bushes; and finally none. The willows (except for ground willows) reach the coast only where it is undergoing erosion.

We provisionally identified eight species of willows. The provisional identification is a recognition of the difficulty inherent in the taxonomy of the genus Salix. We were, however, doubly damned in also having to deal with the genus Carex. To choose the usual capitulation and make no attempt to go beyond the GENERA would leave the major plants unclassified. Salix pulchra is an invading species, commonly found growing in the wetter areas and near the coast. In the older, denser stands S. lanata, S. glauca, and Alnus crispa are present. The tallest willow, S. alaxensis appears in some of the denser stands. We made no concerted effort to determine the age of the willow stands, however a few were examined for a count of annular rings. The oldest specimen proved to be 47 years old, and appeared to be well past its prime.

Close inspection reveals some differentiation within the two gross categories. In the low lying stratum, on the drier[1] levees, the immediate ground surface is densely covered by decumbent (height less than an inch) ground willows (Salix arctolitoralis and to a lesser extent S. ovalifolia)[2]. These two species contribute significantly to binding the soil together on these banks, and in some instances appeared to be the only force preventing large sections of undercut banks from falling into the river. Near the coast, these ground willows are the only plants growing on the banks, but upriver they are mixed with various grasses and some of the more colorful flowering species (Astragalus spp., Primula spp., Pedicularis spp., Petasites frigidus, and Rubus spp.).

Away from the slightly elevated levees the soil becomes wetter, and much of the vegetation grows in standing water. This is the sodden habitat of the Carexes. Two subspecies of Carex aquatilis, and Carex Lyngbyaei occupy the standing water while Eriophorum spp., Carex rariflora, and Carex Ramenskii inhabit the slightly drier "wetlands", often mixed together or with some scattered grasses (Alopecurus spp. and Dupontia fischeri). We found large homogeneous stands of C. Ramenskii in that portion of the coastal area currently undergoing deposition, but not in the eroding segment. This appears a factor in determining distribution of grazing waterfowl, since these birds exhibited a preference for this

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[1] We do not imply real dryness, only a degree of less wetness. We did not find a dry place on the delta.

[2] Classification according to Hulten, 1968, Flora of Alaska and neighboring territories, Stanford Univ. Press.

plant. The effect of localized, intensive grazing pressure was evident both from the river and the air.

Slightly higher ground, i.e., six to eight inches, marking former beach lines and abandoned river banks (personal communication from William Dupre, USGS) furnishes the site for a community of Empetrum nigrum, Myrica gale and Sphagnum. The Sphagnum gives these areas a hummocky appearance. This slight difference in elevation and vegetative type furnishes the favored nesting habitat for waterfowl, shorebirds, gulls and terns.

The dominant herbaceous species found growing on the highest, best drained and developed soils is Calamagrostis canadensis. It is found growing most prolifically around old cabin and camp sites, in clearings among willows on well established levees, and in and around the town of Kotlik. We found no evidence that birds used these dense tall stands of Calamagrostis for nesting.

We wish to emphasize one important trophic relationship in the delta ecosystem. The trophic relationship is decomposition, and the fact of importance is that decomposition borders on the non-existent. We had no means to measure bacterial or fungal activity except to note its retardation in a gross way, but the more obvious decomposers such as beetle and fly larvae were conspicuously absent. Thus the drift logs that are a ubiquitous feature of the entire delta simply lie where flood waters deposit them and become overgrown with vegetation. The slight elevation of the log furnishes lodgement for additional plants, allowing suitable sites for ground nesting birds to evolve. Eventually slow decomposition renders the log a focal point for burrowing microtine rodents which then attract the carnivorous tendencies of the lesser sandhill crane. The cranes in seeking the rodents become an agent of decomposition and tear the log in shreds. This entire process appears to take many years.

The intertidal zone, which may be a very narrow strip on the vertical face of cut banks, or large areas on the gently sloping mud bars and banks, support a distinctive vegetative community. On older portions of the delta where willows and alders do not grow to the water's edge are stands of *Equisetum* spp. or mixed sedges (*C. aquatilis* and *C. Lyngbyaei*). *Caltha palustris* is widely distributed over the delta in standing water and at the river's edge. This plant is used for food by Eskimos who are native to the region. *Ranunculus hyperboreus* and *Potamogeton vaginatus* occur at the river's edge, the former on cut banks and sloping banks with *Potamogeton* restricted to sloping banks. Dense stands of a tall coarse grass, *Arctagrostis latifolia* occupy the intertidal zone in a discontinuous distribution, especially near the coast. The rather tenacious mat produced by this grass tends to retard erosion. At the coast wave action washes these mats onto the beach where they form an effective barrier to erosion. *Hippuris vulgaris* is locally abundant where wave action is not significant.

We have already drawn attention to the restricted diversity in the delta ecosystem, and we now wish to emphasize a particular point of high productivity that may be decisive in waterfowl occupation of the delta. This is in the production of seeds, and their availability to returning waterfowl in spring. We found *Carex* seeds distributed over the whole area that we studied. Apparently the seeds are released from the plants in such a manner that the spring flood distributes them; sometimes diffusely, sometimes in windrows, but so widely that returning waterfowl can find them without difficulty. How this resource actually fits in the pattern of waterfowl occupation and usage of the delta remains to be demonstrated, but it appears to us of high potential.

We noted seed production in both subspecies of Carex aquatilis, C. Lyngbyaei, and C. rariflora. C. Ramenskii does not appear an important seed producer. Seed production in these species may be fairly stable from year to year, but this remains to be demonstrated.

The lakes within four to five miles of the coast have a pH slightly above 7.0 (average of 20 readings = 7.25), but farther inland they become acid. We employed a Hach direct reading colorimeter to determine the pH value, and the two indicator solutions available to us yielded ambiguous readings for the acidic lakes, but suggested a value of about 6.2. The vegetation in and around these bogs is distinctive. It includes dense stands of Equisetum, a carpet of Sphagnum, and one or more of the following species that do not occur in the areas of a higher pH: Menyanthes trifoliata, Vaccinium uliginosum, Thalictrum sparsiflorum, and Potentilla palustris. We assume a gradient exists in the soil as well as the water, but this has not been demonstrated. Presumably the gradient reflects successional processes. The pH of the river water was determined only once, July 12th. On that occasion the tests read 7.1 and 7.2.

We observed 51 species of birds, and Mr. Eric Hoberg observed 60 on a different part of the delta (Flat Island) in 1973. Hoberg's observations cover an earlier period of the summer than ours. The two lists are included in the appendix. The most abundant bird in our area was the pintail duck, at least in tens perhaps hundreds of thousands. During the period of the drakes' molt we were in continuous contact with small parties of four or five to large flocks numbering about 100 as we travelled the distributaries and sloughs of the delta. When the broods appeared they too took to the same waterways and we were in almost continuous contact with female pintails performing the "broken wing act." The next most abundant ducks were green-winged teal and shovelers. Both were common, but less numerous than pintails by about an order of magnitude. These two species proved to be much more secretive nesters than the pintails, and their broods appeared much later. They too moved onto the distributaries with downy broods at the time the pintails were nearing fledging. The only ducks we observed on a lake was a brood of widgeon. Though we saw widgeon frequently they were not common. We saw pairs of greater scaup occasionally, two pairs of mallards, three surf scoters, three black scoters, and one white-winged scoter.

Lesser Canada geese were abundant, in thousands possibly tens of thousands. White-fronted geese were common, but not abundant. We encountered emperor geese frequently because of their penchant for observing us at close range, but they were not common. We observed one pair of black brant with a brood of four.

Arctic and red-throated loons were common. In June we observed them as singles and twos on the lakes and distributaries, and noted they were quite wary. By mid-July they appeared in groups up to ten individuals exhibiting no great wariness. We interpret these as reproducing birds in the first case, and non-reproducing birds in the second. If this is correct we observed a large segment of non-reproducers.

A common and conspicuous bird was the sandhill crane, distributed throughout that portion of the delta we studied. It is doubtful that there were ever more than five consecutive minutes when we did not hear these birds. The frequency with which we observed developing chicks suggests that reproductive success was high on the delta in the case of the cranes.

Specimens of rough-legged and marsh hawks were frequently in view, but not common. We observed one goshawk. An owl, the hawk owl was also frequently seen, but could not be regarded as common.

The ruddy and black turnstones were observed only once, but the rest of the shorebirds were common. These were the common snipe, shy but conspicuous because of its ever-present winnowing call; bar-tailed godwit, noisy and looking like an overgrown mosquito when in flight; dunlin; long-billed dowitcher; semi-palmated sandpiper; and northern phalarope. We were surprised not to find the red phalarope.

The willow ptarmigan was noted several times, but it did not appear common in the area we studied.

The long-tailed jaeger was conspicuous and common. The parasitic jaeger was observed once. None of the gulls were common, but we observed the glaucous-winged gull most frequently. Others were the glaucous gull, herring gull, mew gull, and Sabine's gull. Both Arctic and Aleutian terns were present, and we observed several solitary nests of the Arctic tern.

Four passerines were common. Three of these; the hermit thrush, yellow warbler, and common redpoll nested in the willow-alder thickets. The fourth, savannah sparrow, nested in the open and in the perimeter of the willow-alder thickets. The tree swallows were locally common at Kotlik where numerous nest boxes had been provided. We observed them elsewhere, but much less frequently. The American robin seemed restricted to the vicinity of Kotlik. One pair of ravens produced four fledged young on the area we studied. These departed the nest July 6th. A yellow wagtail was seen once, and the varied thrush twice. We saw rusty blackbirds several times but they were certainly not common. One pair of northern shrikes appeared in mid-July. Lapland longspurs arrived in our area June 23rd and initiated nuptial activity. This they discontinued in a few days and did not reproduce. We cannot suggest what motivated these birds to fly at such a late date to the Yukon delta.

Before leaving the passerines we wish to draw attention to the population of yellow warblers nesting on the delta. We saw them frequently as we travelled the willow-lined waterways, and even discounting the flash of color by which they were made obvious, they must be rated common or possibly abundant. For years a large migration of yellow warblers has been noted and recorded each year in late August and early September at Cold Bay near the western end of the Alaska Peninsula. Numerous species participate in this annual migration, but since many pass at night their identity and numbers may not be known. The plumage of the yellow warbler, however, fluoresces when the bird flies through the beam of a ceilometer light located beside the runway at Cold Bay. In this way the existence of a large migration of yellow warblers has been known, but no one could suggest their origin. We think the discovery of a large population of the flashy little birds on the Yukon delta answers that problem.

We observed one red fox and occasionally saw their tracks. We saw the track of a single, large grizzly bear. We saw extensive sign of the tundra hare and probably caught a glimpse of one in a willow thicket. We saw many microtine rodents, and captured several specimens which represent in our opinion three species. These mammals are abundant except in a strip extending two to three miles inland from the coast. From this strip they are absent. We saw no marine mammals though belukha were being taken by Eskimos off the large passes.

The microtine rodents constitute the major food source for long-tailed jaegers, the hawks and owls, and to a certain extent the cranes. Very likely this is also true for the ravens and shrikes, and we have no doubt it is true for the foxes. We think the distribution of the microtine rodents governs in part the distribution and abundance of mosquitoes, which we found in legions, but more on that subject later.

We found a large population of isopods in the Bering Sea June 20th. These are large (5 cm.), free swimming (though clumsily) animals, and were very conspicuous. Gulls were present on the mud flats at the time, apparently feeding on the isopods. We collected specimens of these plus specimens of a small (2-3 mm.) isopod and a small shrimp. Identification has since been furnished by the National Museum. Both isopods are of the same species, Saduria entomon, and have predaceous habits. It is a circumarctic species inhabiting brackish and fresh water south to central California. Other populations occur in the Baltic and Caspian Seas. The shrimp are Neomysis intermedia, and the specimens we collected were immature. At the time of writing we had not learned more about this species. The adult forms of Saduria soon disappeared, as did the gulls, but the extremely abundant juveniles remained. Each time we visited the coast at low tide we observed ducks feeding on the mud flats, and speculated that they were feeding on these invertebrates. Unfortunately we had no opportunity to collect the birds to verify the speculation.

We examined a few of the many lakes and ponds on the delta, most of which appear to be shallow. Our investigation was not exhaustive, but enough to demonstrate a high productivity. *Myriophyllum spicatum* appears to be present in all, *Hippuris vulgaris* in some, and *Carex aquatilus* and/or *Carex Lyngbyaei* in and around all. No sandy shores exist around any of these lakes, and no elevational change distinguishes the lakes and ponds from the standing water around it. The most abundant invertebrates were a calanoid copepod, and a cladoceran. An anostracan, or fairy shrimp, was abundant in one lake we investigated, and a pair of Arctic terns appeared to be feeding on them. Northern phalaropes were feeding in the same lake, but their feeding seemed more random than that of the terns. *Volvox* was a common algae in this lake, perhaps in most. Insect larvae and pupae, including the ubiquitous mosquito, were abundant in all the lakes and ponds, and we suspect in all the standing water. We found no evidence of fish except in the distributaries of the river, but blackfish (*Dallia pectoralis*) are known to be present in the region.

A gastropod of the genus *Lymneae* was abundant in the area, both in and out of water. Their shells appeared in the pellets of long-tailed jaegers, and both terns and cranes appeared to be feeding on them. We suspect this mollusk to be widely utilized by the birds of the region. A second, less abundant gastropod occupied the same habitat, and a third inhabited the lakes and ponds.

The insect fauna was of restricted diversity. The most abundant, from our viewpoint at least, was the mosquito. The distribution of this pestilential insect was not uniform and we sought reasons without the benefit of detailed knowledge of its life cycle. We are at present unable to identify the species (though we had our own name for them), or to determine if there were more than one; however we collected specimens from which such determinations can be made. These insects were most abundant where the willow thickets gave shelter from the breeze, standing water was close at hand, and abundant microtine rodents were present. Standing water was never far removed, but the insect's range seemed restricted and its density diminished in the older willow stands that were not in standing water. They were least abundant at the coast and in the two to three mile zone uninhabited by microtine rodents.

We found no evidence that the mosquitoes troubled the birds, but that must be confirmed. A cloud of mosquitoes hovered over each of us, but we did not observe this with the birds. The naked altricial nestlings of the "dickey birds" would have no chance in the face of the attack directed on us. Had we been naked or otherwise unprotected their attack would have led directly to madness and exsanguinity. Mercifully no "white sox" (Simuliidae) were added to the plague of mosquitoes.

Other insects include the familiar "cabbage butterfly" Pieris rapae, another larger butterfly which we did not catch, moths, beetles (mostly Carabidae), dipterans, etc. We collected specimens opportunistically, but these have not yet been identified.

We had expected Dupre and Hopkins might be analyzing soil samples, and preferring not to duplicate effort, we undertook no studies of soil nutrients. It turns out that their project does not include this study, so it is one that remains to be accomplished.

Travelling the waterways amongst the rows of willows we developed a sense of sameness, of a wet and green world. The scores of waterlogged willow trunks lying in the water, but exposed at low tide, suggested a mangrove swamp. Sometimes the configuration of the willow stands suggested a hill, but the land lies flat. The charts of the delta are good, though old, and we found our way about without difficulty. There are no obvious landmarks, and until we learned the unobtrusive ones we were constrained to follow the charts closely.

In sum we found the Yukon delta a productive ecosystem supporting significant numbers of waterfowl during the reproductive period of their annual life cycle. The ecosystem is, however, of very restricted diversity. Some of the stresses that lead to this state are recurrent floods, short growing season, frozen ground close to the surface, dominance of an overpowering discharge of fresh water. In addition to low diversity the system is subjected to retarded decomposition. We venture the opinion that little is recycled within the system.

APPENDIX

BIRDS OBSERVED ON THE YUKON DELTA 1976

Red-throated loon
Arctic loon
Whistling swan
Lesser Canada goose
Black brant
Emperor goose
White-fronted goose
Mallard
Pintail
American widgeon
Shoveler
American green-winged teal
Greater scaup
White-winged scoter
Surf scoter
Black scoter
Goshawk
Rough-legged hawk
Marsh hawk
Willow ptarmigan
Sandhill crane
Bar-tailed godwit
Long-billed dowitcher
Ruddy turnstone
Black turnstone
Dunlin
Semi-palmated sandpiper
Northern phalarope
Common snipe
Parasitic jaeger
Long-tailed jaeger
Glaucous gull
Glaucous-winged gull
Herring gull
Mew gull
Sabine's gull
Arctic tern
Aleutian tern
Hawk owl
Tree swallow
Northern raven
American robin
Yellow wagtail
Northern shrike
Varied thrush
Hermit thrush
Yellow warbler
Rusty blackbird
Common redpoll
Savannah sparrow
Lapland longspur

Eric Hoberg's list of birds observed on Flat Island 1973

Common loon
Arctic loon
Whistling swan
Canada goose
Black brant
Emperor goose
Pintail
Green-winged teal
American widgeon
Shoveler
Common eider
King eider
Old squaw duck
Black scoter
Marsh hawk
Rough-legged hawk
Sandhill crane
Semi-palmated plover
Whimbrel
Long-billed dowitcher
Bar-tailed godwit
Ruddy turnstone
Black turnstone
Rock sandpiper
Pectoral sandpiper
Least sandpiper
Semi-palmated sandpiper
Western sandpiper
Common snipe
Red phalarope
Northern phalarope
Long-tailed jaeger
Parasitic jaeger
Pomarine jaeger
Glaucous gull
Glaucous-winged gull
Mew gull
Slaty-backed gull
Black-legged kittiwake
Red-legged kittiwake
Sabine's gull
Arctic tern
Aleutian tern
Short-eared owl
Tree swallow
Northern raven
Ruby-crowned kinglet
Common redpoll
Lapland longspur
Savannah sparrow

20 mile radius of Flat Island

American robin
Varied thrush
Gray-cheeked thrush
Orange-crowned warbler
Wilson's warbler
Fox sparrow
White-crowned sparrow
Golden-crowned sparrow
Tree sparrow
Bank swallow

SPECIES LIST

Equisetaceae

Equisetum fluviatile L.

Equisetum palustre L.

Equisetum arvense L.

Aspidiaceae

Dryopteras dilatata Gray
subsp. *americana*

Potamogetonaceae

Potamogeton vaginatus Turcz.

Juncaginaceae

Triglochin palustris L.

Gramineae

Calamagrostis canadensis Beauv.
subsp. *Langsdorffii* (Link) Hult.

Calamagrostis Holmii Lange

Arctagrostis latifolia (R. Br.) Griseb.
var. *arundinacea* (Trin.) Griseb.

Hierochloe alpina (Sw.) Roem. & Schult.

Hierochloe odorata (L.) Wahlenb.

Alopecurus alpinus Sm.
subsp. *alpinus*

Alopecurus alpinus Sm.
subsp. *glaucus* (Less.) Hult.

Arctophila fulva (Trin.) Anderss.

Dupontia Fischeri R. Br.
subsp. *psilosantha* (Rupr.) Hult.

Festuca rubra L. coll.

Elymus arenarius L.
subsp. *mollis* (Trin.) Hult.

Cyperaceae

Eriophorum angustifolium Honck.
subsp. *subarcticum* (Vassiljev) Hult.

Eriophorum russeolum E. Fries
var. *albidum* Nyl.

Carex aquatilus Wahlenb.
subsp. *aquatilus*

Carex aquatilus Wahlenb.
subsp. *stans* (Drej.) Hult.

Carex Ramenskii Kom.

Carex Lyngbyaei Hornem

Carex rariflora (Wahlenb.) J. E. Sm.

Iridaceae

Iris setosa Pall.
subsp. *setosa*

Salicaceae

Populus balsamifera L.

Salix ovalifolia Trautv.

Salix arctolitoralis Hult.

Salix glauca L.
subsp. *acutifolia* (Hook.) Hult.

Salix glauca L.
var. *glauca*

Salix lanata L.
subsp. *Richardsonii* (Hook.) A. Skvortz.

Salix alaxensis (Anderss.) Cov.
subsp. *alaxensis*

Salix pulchra Cham.

Salix arbusculoides Anderss.

Myricaceae

Myrica gale L.
var. *tomentosa* C. DC.

Betulaceae

Alnus crispa (Ait.) Pursh
subsp. *crispa*

Polygonaceae

Rumex arcticus Trautv.

Caryophyllaceae

Stellaria longipes Goldie

Ranunculaceae

Caltha palustris L.
subsp. *arctica* (R. Br.) Hult.

Anemone Richardsonii Hook.

Ranunculus hyperboreus Rottb.
subsp. *hyperboreus*

Ranunculus Pallasii Schlecht.

Ranunculus lapponicus L.

Thalictrum sparsiflorum Turcz.

Cruciferae

Cardamine pratensis L.
subsp. *angustifolia* (Hook.) O.E. Schulz

Cardamine umbellata Greene

Saxifragaceae

Saxifraga hirculus L.

Rosaceae

Rubus chamaemorus L.

Rubus arcticus L.
subsp. *arcticus*

Rubus arcticus L.
subsp. *acaulis* (Michx.) Focke

Rubus arcticus L.
subsp. *stellatus* (Sm.) Boiv. emend. Hult.

Potentilla palustris (L.) Scop.

Potentilla Egedii Wormsk.
subsp. *Egedii* var. *groenlandica* (Tratt.) Polunin

Leguminosae

Astragalus umbellatus Bunge

Astragalus alpinus L.
subsp. *alpinus*

Astragalus polaris Benth.

Hedysarum alpinum L.
subsp. *americanum* (Michx.) Fedtsch.

Violaceae

Viola epipsila Ledeb.
subsp. *repens* (Turcz.) Becker

Onagraceae

Epilobium angustifolium L.
subsp. *angustifolium*

Holoragaceae

Myriophyllum spicatum L.

Hippuris vulgaris L.

Umbelliferae

Cicuta mackenzieana Raup

Sium suave Walt.

Ligusticum scoticum L.

Angelica lucida L.
subsp. *Hultenii* (Fern.) Calder & Taylor

Heracleum lanatum Michx.

Empetraceae

Empetrum nigrum L.
subsp. *hermaphroditum* (Lange) Hult.

Ericaceae

Vaccinium uliginosum L.
subsp. *alpinum* (Bigel.) Hult.

Primulaceae

Primula sibirica Jacq.

Primula borealis Duby

Trientalis europaea L.
subsp. *arctica* (Fisch.) Hult.

Gentianaceae

Mènyanthes trifoliata L.

Polemoniaceae

Polemonium acutiflorum Willd.

Boraginaceae

Mertensia paniculata (Ait.) G. Don
var. *paniculata*

Scrophulariaceae

Pedicularis verticillata L.

Pedicularis sudetica Willd.
subsp. *interior* Hult.

Pedicularis Oederi M. Vahl.

Valerianaceae

Valeriana capitata Pall.

Compositae

Achillea borealis Bong.

Chrysanthemum arcticum L.
subsp. *arcticum*

Petasites frigidus (L.) Franch.

Senecio congestus (R. Br.) DC.

A WINTER HABITAT SURVEY OF THE YUKON DELTA

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Office of Biological Services-Coastal Ecosystems
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More about the Yukon River delta

A winter visit to the Yukon delta was conducted January 26th through 31st. James Akaran from the Clarence Rhode NW Range and Robert Jones of OBS-CE Anchorage made the visit, arriving in Kotlik on the afternoon of the 26th. The village of Kotlik is located just off Apoon Pass, the northeastern mouth of the Yukon River. From Kotlik we travelled on the delta by snowmobile, approximately 150 miles in various directions.

In common with most of Alaska, the winter has been quite mild on the delta and snow accumulation is less than usual. Unlike the Anchorage area, however, there is a blanket of snow covering the ground, creating a black and white contrast with the abundant willow stands.

During our stay on the delta the wind blew continually from the north with varying velocities up to 35 mph. It was actively reworking the snow, but not uniformly over the delta. Near the outer limit of the willows and beyond is the zone of greatest snow mobility. Here visibility was often reduced to zero by drifting snow, and the absence of relief or any detail in the uniformly white landscape created a new dimension in "white-out" conditions. A curious exception existed at the coast, however, where the snow lay only four inches deep over a layer of ice. Here the still erect stems of *Rumex arcticus* emerged above the snow to furnish detail in the landscape.

The deepest drifts occurred at the outer edge of the willows. Some of these were approximately eight feet deep, but a scant half mile upriver in the denser willow stands drifting was slight and the snow lay uncompacted at no more than four feet deep. In these situations the snow possessed a crystalline structure at the surface, doubtless a product of rain that fell two days before our arrival. This same rain had painted a sheath of ice on all the willows, suggesting that the rain had been accompanied by wind. In Kotlik the snow had formed compact drifts around the buildings.

We measured snow depth, and temperatures at the surface and the bottom of the snow. The surface temperatures were at ambient air temperatures except in protected situations with the sun at its maximum elevation. In these cases the surface temperature of the snow was as much as 5°F. higher than air temperature. Such salubrious circumstances were observed in the interior willow stands. Marked increases of subnivean temperature with increased snow depth were recorded in all but one case. This instance could hardly be described as salubrious. We were on the coast at 63°13'N 163°45'45"W in drifting snow with the wind chill hovering at minus 50°F. Here the ground was covered with a layer of ice topped by four inches of snow, the whole at ambient air temperature. Evidently the coastal zone had been subjected to storm tide flooding at the time of freezing.

The temperatures listed in Fig. 1 go far toward explaining the distribution of microtine rodents as we reported earlier. The subnivean temperatures are, however, somewhat higher than expected in the type of snow encountered, and we cannot at present suggest all the implications.

Surface temperature	Sub-nivean temperature	Snow depth
10°F.	21°F.	2.0 ft
11°F.	24.5°F.	1.5 ft
14°F.	19°F.	1.5 ft
12°F.	26°F.	3.0 ft
12°F.	26°F.	4.0 ft
12°F.	20°F.	0.75 ft
10°F.	26°F.	3.75 ft
14°F.	21°F.	3.0 ft
6°F.	26°F.	4.0 ft
10°F.	10°F.	0.25 ft over ice

Fig. 1 Surface and sub-nivean temperatures at ten locations on the Yukon delta Jan. 28th and 29th, 1977.

We have already reported the presence of tundra hares *Lepus othus*, and must now add the varying hare *Lepus americanus*. The residents of Kotlik were catching them in snares. It should be emphasized that the land and its habitat lying east and south of Kotlik is a transition zone from the sodden marshes of the delta. The charts of the region belie this statement for they show many more lakes and ponds than on the delta, but they also show contours unknown on the delta. The elevations near Kotlik are hardly impressive, on the order of two or three feet, but enough to raise the vegetation out of standing water. Instead of the hydric *Carex* stands, a mesic heath type tundra has developed. The addition of *Lepus americanus* must be accepted in this light, for we do not know if or how far this species extends onto the delta proper. The willow ptarmigan *Lagopus lagopus* is much more abundant on the heath tundra than on the delta.

Four species of birds were observed: goshawk, willow ptarmigan, northern raven, and the black-capped chicadee.

No fishing was in progress during our visit. The residents of Kotlik reported having fished for Arctic cisco *Coregonus autumnalis* just after the freeze at Pastolik, and sheefish *Stenodus leucichthys* in November with gillnets under the ice in Apoon Pass.

Discussions with residents of Kotlik confirmed our suspicion that the distributaries of the Yukon delta become saline in winter. Our informant said this was true at times of highest tides, but how saline the water becomes must await the availability of a salinometer. We do not possess extensive knowledge of bottom contours in the distributaries, but are aware of the existence of deep holes. These would produce pockets of salinity and affect distribution of stenohaline fishes that may be present.

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